SCIENCE AND TECHNOLOGY CONTRIBUTIONS TO IMPROVING WORKER SAFETY AND HEALTH

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ABSTRACT

This paper reviews progress that is being made to protect worker safety and health during the deployment of new cleanup technologies at the Department of Energy's (DOE) cold war-legacy waste sites. Senior DOE EM headquarters and site managers have stressed the importance of safety and health in negotiating new contracts and in the conduct of work at EM sites. Three fundamental components of a strong safety culture being institutionalized by EM are systems and procedures, management commitment and engagement, and worker attitudes and involvement. Integrated Safety Management (ISM) is the backbone for the systems and procedures, and the other two components relate to people – how they behave and what they believe in. All six EM-lead sites successfully implemented ISM systems by September 30, 2000. There is a growing understanding that safety and efficiency reinforce each other.

Remediation of DOE's hazardous waste sites requires a broad range of skills, ranging from highly technical analysis of data to the operation of specialized heavy machinery required for the decontamination and decommissioning of contaminated facilities. As a result of a demand for efficient treatment technologies, or to develop treatment methods where none previously existed, new technologies have emerged to make cleanup progress faster, cheaper and safer. While some technologies have been specifically directed at creating a safe work environment, most have improvements in remediation costs and schedules as the primary goals. A survey of these technologies indicates that they have also contributed to worker safety and health.

INTRODUCTION

The purpose of this paper is to review progress that is being made to protect worker safety and health during the deployment of new cleanup technologies at the Department of Energy's (DOE) cold war-legacy waste sites. Remediation of DOE's hazardous waste sites requires a broad range of skills, ranging from highly technical analysis of data to the operation of specialized heavy machinery required for the decontamination and decommissioning of contaminated facilities. As a result of a demand for efficient treatment technologies, or to develop treatment methods where none previously existed, new technologies have emerged to make cleanup progress faster, cheaper and safer. While some technologies have been specifically directed at creating a safe work environment, most have improvements in remediation costs and schedules as the primary goals. A survey of these technologies indicates that they have also contributed to worker safety and health.

The DOE manages the largest environmental remediation program in the world. DOE's Office of Environmental Management (EM) was created in l989 to solve the legacy of wastes, resulting from nuclear weapons production during the previous half-century. Because of the wide diversity of contaminated media and the unique combinations of chemical and radioactive contaminants at DOE sites, the safety and health of remediation workers is one of the highest priorities of EM. Worker safety and health has become even more important as the focus of the remediation programs shifts from characterization of hazards to actual site-cleanup activities.

The quantities of DOE waste and contaminated environmental media that require remediation are large. In total, DOE/EM is responsible for addressing an estimated 5.5 trillion liters of contaminated ground water and 40 million cubic meters of contaminated soil and debris. EM is responsible for safely storing and guarding more than 18 metric tons of weapons-usable plutonium, enough for hundreds of nuclear weapons.

DOE's waste inventory includes over two thousand tons of intensely radioactive spent nuclear fuel, some of which is corroding. EM also is responsible for storage, treatment, and disposal of radioactive and hazardous waste, including over 340,000 cubic meters of high-level waste stored at the Hanford, Idaho and Savannah River sites; and for deactivation and decommissioning of about 4,000 facilities that are no longer needed to support the DOE's mission. In addition, the EM program has responsibility for critical nuclear non-proliferation programs to accept and safely manage spent nuclear fuel from foreign research reactors.

Within DOE, EM's Office of Science and Technology (OST) supports the development of new technologies that, when deployed, will result in faster, safer, and more effective environmental remediation. EM's Office of Safety, Health and Security (OSHS) provides corporate leadership to OST and DOE/EM field components on all aspects of institutionalizing worker safety and health. Staff of both offices jointly establish policy to ensure that safety of new technologies is included in the design process. An example of this is an ongoing effort to develop safety documentation for each new technology.

INTEGRATING SAFETY WITH TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

Senior DOE EM headquarters and site managers have stressed the importance of safety and health in negotiating new contracts and in the conduct of work at EM sites. Three fundamental components of a strong safety culture being institutionalized by EM are systems and procedures, management commitment and engagement, and worker attitudes and involvement. Integrated Safety Management (ISM) is the backbone for the systems and procedures, and the other two components relate to people – how they behave and what they believe in. All six EM-lead sites successfully implemented ISM systems by September 2000.

There is evidence of positive change occurring in worker attitudes and involvement at our sites. Workers are empowered to become actively involved in work planning efforts, including the assessment of hazards associated with their work. There is no reluctance to stop work because of unsafe conditions, and our sites have created programs to institutionalize worker involvement in work planning and safety. We are encouraging workers to speak up and be heard on safety issues. At Hanford, for example, workers are actively involved in Automated Job Hazards Analysis; this calls for workers to be aware of hazards and to identify those that may have been overlooked by job planners. At the Savannah River Site, a Self-Awareness for Employees Team accomplishes similar activities. At INEEL, workers engage in a behavior observation and feedback process, both designed to encourage anonymous, no-discipline feedback by fellow workers.

During the current year, the National Safety Council (NSC) will measure worker safety culture at our EM sites. This should provide a valuable insight into the workers' perception of and response to our various safety and health initiatives, including those that are related to technology deployments. The National Safety Council has conducted these assessments for more than 200 companies, as well as three DOE facilities (FEMP, RF, SRS), in order to gauge the quality of safety programs. The surveys assess senior management leadership and commitment, supervisory and worker participation, safety support activities, safety support climate, and organizational climate. Results will be analyzed by site, across sites, and against private sector organizations. The results and recommendations from the surveys will be of use in safely managing the EM complex.

We believe that the significant changes in our safety culture at our sites are being reflected in our safety record. DOE's performance indicators (1) for occupational safety and health indicate a total recordable case (TRC) rate of 3.7 cases per 200,000 hours of work (roughly 100 full time workers per year) for the period of 1994-1999. EM has achieved an even more impressive record in FY 2000. The EM average TRC rate reached an all-time low of 1.6 for the third quarter of FY2000. The rate of 1.6 is 27% less than the previous quarter and is significantly below the current DOE average of 2.2. These improvements reflect EM-wide improvements, and not just at a few sites.

Several factors have resulted in the significantly improved safety record. A major thrust of ISM is active worker involvement and participation in workplace safety and health activities and programs. Under ISM, all workers and managers are responsible and empowered to conduct activities safely. As EM began to deploy new cleanup technologies, OST began a partnership with the International Union of Operating Engineers (IUOE) to conduct a human factors assessment (2) of the new technologies. This activity is conducted by the Operating Engineers National HAZMAT Program. The purpose of this effort is to involve workers in the evaluation of safety aspects of new OST technologies before deployment.

The IUOE assessments serve as a basis for interactions between developers and users to reduce or eliminate hazards prior to deployment. These studies continue to evaluate new OST technologies as they become ready for deployment. At present, a pilot program to evaluate the use of technology safety data sheets is underway. If the pilot program leads to full implementation of the data sheets, this documentation would be available whenever new technologies are delivered to users. Similar information, although more qualitative in its assessment of hazards, is already available in Innovative Technology Summary Reports which are issued for new technologies.

SCIENCE AND TECHNOLOGY APPLICATIONS TO CLEANUP

A large amount of documentation exists on the successful deployment of new cleanup technologies by EM's Office of Science and Technology. A recent summary of deployments (3) shows that 449 deployments of OST technologies have been reported at 35 DOE sites since 1991. The pace of deployments has significantly accelerated in the past 3 years as the fruits of science and technology investments have been applied to the actual sites requiring remediation. In addition, 57 deployments of OST-sponsored activities have occurred at 33 non-DOE sites. These include numerous military installations, Superfund sites, and various sites in foreign countries.

What has been the target of OST's technology investments? Large quantities of contaminated soil and water, some of which is migrating to public areas, are targets for remediation. High level nuclear waste, though not as ubiquitous as contaminated soil, is highly toxic, is hard to characterize and treat, and much of it is contained in aging facilities. Large facilities that were formerly used for irradiated spent fuel processing, nuclear reactors, and chemical processing must be dismantled and made safe for the long term. These are but a few examples. Many other intractable problems requiring new technologies are cited in a recent overview of EM's cleanup experience and long term needs.(4)

SAFETY AND HEALTH BENEFITS OF TECHNOLOGY DEPLOYMENT

While new technologies are evaluated for safety, it was recognized early in the development of OST that new technologies can result in significant improvements in the cost and efficiency of cleanup. These same new technologies, in many cases, also turned out to have a positive influence on reducing the potential exposures of remediation workers to safety and health hazards. For example, technologies were developed to enable workers to remotely characterize hazardous environments and eliminate the need for costly laboratory analysis of samples. As work progressed towards actual remediation, the value of remotely operated machinery became apparent. This has served to reduce exposure of remediation workers to toxic and radioactive substances in the work environment. Hart (5) presents examples of safety-enhancing technologies as applied to large-scale decontamination and decommissioning projects.

Significant cost benefits can accompany safety and health improvements due to the deployment of new technologies, but are difficult to quantify. There are many reasons for this. Perhaps most notable is the lack of information concerning worker safety and health exposures from the use of existing baseline technologies. Recently, EM's Environmental Management Advisory Board has observed (6) that, "The inclusion of the costs to the [technology] user to comply with safety and health standards as a consequence of hazards associated with a technology is a factor that is not now considered". Whereas the positive impact on worker safety and health exposures of new technologies is generally qualitatively described, this impact generally has not been factored in to the overall improvement in cost savings or reduced worker exposures. The IUOE conducted a workshop on this issue in November 2000, and the findings should be available soon.

Adding to the quantification quandary, records of worker exposures at DOE sites are aggregated by function and organization, not technology applications. The use of the ALARA (as low as reasonably achievable) concept in the case of radiation exposures in work planning has helped to change this. As the ALARA concept makes its way into the reduction of exposures to non-radioactive hazardous substances, more benefits of improved technologies will be realized. Other aspects of improved work planning consider impacts of equipment set-up, maintenance, training of workers, and decontamination. These measures will assist in quantifying improvement of new technologies, but are not yet readily available beyond the actual site of deployment.

The wide variety of non-radioactive toxic substances in the overall DOE environment, and a large range of toxicological consequences, has complicated the development of a simple formula to aggregate occupational health impacts and costs. Discrepancies exist between levels of risk considered negligible for radiation and for chemical exposures.(7) The problem is not unique to DOE. The Presidential Risk Commission recently recommended (8) "A concerted effort to evaluate and relate the methods, assumptions, mechanisms, and standards for radiation risks to those for chemicals to clarify and enhance the comparability of risk management decisions, especially when both types of hazards are present."

The purpose of the foregoing discussion is to provide background on the importance of recognizing contributions of new technologies to a safer work environment even when health-related cost savings cannot be quantified in detail. Work is continuing to harmonize the control of radiological and chemical hazards in the workplace. However, as we will show in the next section, projections of safer work environments due to new technologies can be made.

EXAMPLES OF SAFER WORK ENVIRONMENTS DUE TO TECHNOLOGY DEPLOYMENTS

A case study of the influence of new technologies on the worker environment was recently reported by Oakley.(9) The study evaluated the potential safety and health impact of 68 first-time technology deployments at DOE sites out of a total of 182 OST deployments in 1999.(3) The database for the 68 first-time 1999 site deployments has been carefully verified with DOE site managers. It represents a good cross-section of EM remediation activities. It is an equally good representation of the array of technologies that have been developed by OST. The results show that innovative science and technology can significantly reduce worker risk. The key observations were:

- Of the 68 new technology deployments, 48 (or 71%) had a moderate to high potential of reducing occupational exposures. This is truly remarkable in that only 4 deployments of one technology (cool suits) were specifically directed at workers themselves. Equally remarkable is that documentation for many of these technologies does not cite worker safety and health as one of the technology's benefits.

- Although 29% of the technologies are estimated not to have a significant change on the occupational exposure of the old baseline, a review of these technologies indicates that they generally apply to situations in which exposures were already low. The advantages of these technologies were primarily those of improved schedule, cost, or product performance.

- As a group, all of the new technologies have the potential to create a safer workplace. None of the newly-deployed technologies appeared to have contributed to a less-safe workplace than previously existed.

Here are some real-life examples of safer technologies in place at DOE sites. As DOE decontaminates its surplus facilities, the potential dangers of airborne materials remain a safety concern for workers. One of these issues is the prevention of Chronic Beryllium Disease, which is caused by exposure to airborne beryllium. Current laboratory-based analytical methods for assessing the quantities of airborne and surface beryllium do not provide the real-time results required to effectively protect workers. The Office of Science and Technology is collaborating with several organizations to develop and field test a real-time monitor to detect beryllium contamination in the air and on surfaces. This eighteen-month project will culminate in a field demonstration of a prototype monitor at the Rocky Flats Environmental Technology Site in late 2001.

Also at Rocky Flats, there is a major effort to dismantle and dispose of hundreds of plutonium-contaminated gloveboxes. Approximately 900 plutonium-contaminated gloveboxes remain at Rocky Flats. Until recently, the standard method for cutting these gloveboxes into storage and disposal size pieces of hardware included using a Saws-All! -- a method that led to unexpected exposures and difficult working conditions. The answer, we hope, is to use a robot inside an isolating chamber with its own ventilation system. The Remotely Operated Size-Reduction System, as the robot is called, is being developed through a partnership between the Office of Science and Technology and the DOE Rocky Flats Office, and is scheduled for its full scale cold demonstration at the vendor site in November 2000.

In the area of structure dismantlement, we have developed a diamond wire saw that safely and cost-effectively cuts complex metal structures such as reactors, heat exchangers and tanks into more manageable segments. Its remote operation significantly reduces any exposure to highly contaminated and radioactive materials. Simultaneously it reduces cutting costs by over one-third as compared to plasma arc cutting. We have successfully used this technology at the Tokomac Fusion Reactor at Princeton University, the Hanford C Reactor, the Fort St. Vrain Power Plant, and it is scheduled for deployment at the Battelle Columbus (Ohio) Site.
Heat stress is being reduced. This is one of the most significant health and safety risks for cleanup workers, particularly for those who wear protective clothing and other

personal protective equipment. The lightweight Personal Ice Cooling System (PICS) is finding wide application. The system uses ordinary ice to circulate cool water through tubing that is incorporated into a durable and comfortable, full-body garment consisting of a shirt, pants and hood. This technology greatly increases the productivity of workers who must wear protective equipment while in hot environments. By May 2000, the Fernald Team who had first deployed this technology had deployed 96 PICS coolsuit systems to 13 DOE sites.

EM staff are making similar strides to improve technologies to characterize and clean up spills with in-situ and other treatment methods that minimize worker exposures.

CONCLUSIONS

EM management is serious in our commitment to provide new technologies that are safe for our workers. There is already strong evidence that OST technology deployments contribute to improved worker safety and health. We believe that active worker involvement to assess hazards during the technology development and deployment stages is a major factor in creating safer technologies. There is a growing understanding that safety and efficiency reinforce each other.

What is needed to enhance worker safety and health benefits that result from new cleanup technologies? First, improved documentation is needed on the safety and health improvements resulting from new technology deployments. Evaluation of safety documentation to accompany new technologies is underway. Many new OST technologies are already evaluated by the IUOE's HAZMAT program for safety. This has been an important contribution to gaining worker acceptance of new deployments. However, to highlight the safety and health advantages of workplace improvement, it would be desirable to compare the safety and health aspects of the previous baseline with the new technology. Such comparisons should consider safety and health aspects of technology deployment that go beyond the deployment itself, for example, technology set-up, training, and maintenance. Generally, with technologies that are specifically directed at the worker, such as protective equipment or clothing, it is easier to quantify improvements over the baseline.

Most new technologies have not been evaluated for their contribution to safety and health improvement, even though it is apparent that the contribution is significant. This is a natural outcome of the emphasis that has been placed on developing technologies that contribute to cost and schedule improvements. However, this approach results in overlooked advantages of new technologies.

There are notable and praiseworthy exceptions. For example, the DOE's Innovative Technology Summary Report (ITSR) describes the Houdini.(10) Houdini is a remotely operated vehicle that can enter highly radioactive waste tanks. Depending on how it is equipped, the Houdini can be used for a variety of waste characterization and retrieval functions. In this case the ITSR documentation presents an assessment of operational improvements, which are similar to ITSR documentation for other OST technologies (see http://ost.em.doe.gov). However, in the Houdini case, the ITSR also documents the potential for significantly reducing worker radiation exposure. This is an excellent example of how a relatively small effort can highlight a large improvement in worker safety and health. The key ingredient was the knowledge and assessment of the old baseline method vs. the new.

The interrelationships between cost/schedule improvements and safety improvements due to technology deployments are not always clear. One might conclude that the improvements in worker safety and health were by chance. However the experience thus far, as observed in this qualitative study, suggests that cost/schedule improvements stem in large part from the elimination of exposure to a hazard and therefore the elimination of the need for a safety control. Additional analysis would be helpful in confirming if the elimination of hazards, resulting in more streamlined site-specific work packages, contributes significantly to schedule improvements.

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FOOTNOTES

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