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FOREWORD

Welcome to the eighth volume in the Series on Safety Engineering and Risk Analysis sponsored by the ASME Safety Engineering and Risk Analysis Division. It contains all of the papers presented in technical sessions at the 1998 International Mechanical Engineering Congress and Exposition held in Anaheim, California, November 15-20, 1998. It is the intent of the Division to bring together safety and risk management professionals from many diverse industries and government agencies to share methodologies and applications. The Division also wishes to provide safety engineering and risk analysis information to those who work outside this area.

This volume covers a broad base including manufacturing, decontamination and decommissioning of older facilities, selecting a site for storage of high level waste, and sports and recreation activities. It is encouraging that risk-based methods have now become widely accepted and are used in so many diverse applications.

As before, I look enthusiastically to next year and beyond as these applications continue to grow.

D. W. Pyatt
U. S. Department of Energy

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LEARNING FROM OPERATING EXPERIENCE AT THE DEPARTMENT OF ENERGY

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ABSTRACT

The Office of Environment Safety and Health (EH) within the Department of Energy (DOE) has a program for the analysis of facility operations. Tools used in this study include measures of safety, called "performance indicators," which reports occurrences, and the identification of underlying causes of both desirable and undesirable events, referred to as "lessons learned." The overall goal of the study is the development and continual improvement of a comprehensive integrated safety management system.

INTRODUCTION

A program consisting of occurrence reporting, performance indicators, and published weekly, quarterly and selected topical reports is used as part of an overall strategy to assure the health and safety of the public and workers at DOE's many facilities, including protection of the environment.

ELEMENTS OF THE OPERATING EXPERIENCE PROGRAM

Occurrence Reporting

The Department's ability to understand events occurring at its facilities and learn from them to improve safety and environmental protection is dependent upon the complex-wide Occurrence Reporting and Processing System (ORPS) managed by EH. Recently, ORPS was improved by revising the threshold reporting requirements and eliminating reports that experience has shown to be not important to safety. This process improvement included major customer interaction and resulted in estimated annual savings of over $6M. The Office was awarded the Secretary's Honor Roll Award for quality engineering and later received the National Performance Review (Hammer) Award. Additional analytical functions were integrated into the system to improve the quality and efficacy of the reports.

Performance Indicators

Performance measurement is an essential tool for management systems designed to improve safety. It also helps improve communication with stakeholders, motivate employees and contractors, and improves

decision-making. The DOE Performance Indicator Report, published quarterly, provides senior DOE management with a concise picture of departmental performance in relation to a spectrum of ES&H performance indicators. These indicators not only call attention to events, which have directly affected workers and the environment; they also focus management attention on precursors to events and provide a means of measuring the progress of risk reduction activities.

Three Performance Indicator Reports were released in 1997. The data presented in these reports continues to evolve to better focus on those critical aspects of DOE operations determined to be most safety and risk significant to senior DOE management.

Operating Experience Weekly Summary

Nuclear operating experience shows that a primary way to avoid accidents and improve safety performance is to learn from the experience of others. The similarity of many activities at the various DOE sites presents opportunities to enhance performance, meet environmental, safety, and health objectives, and reduce cost through the application of lessons learned. The Office of Nuclear and Facility Safety publishes the Operating Experience Weekly Summary. This document presents analyses of occurrences or unusual events and disseminates the lessons learned to DOE and commercial facilities. Fifty-two issues were published in 1997 summarizing lessons learned from over 400 events. Safety Notices, alerts and topical reports, which provide more in-depth information on generic or recurring significant safety problems, were also published.
Lessons Learned.

A lessons learned process improvement team is in place, which focuses on the importance of local site involvement in analyzing events, and it publishes lessons learned. The team designed and implemented a network of personnel at each site where they screened events for lessons learned. Summaries of these lessons are loaded to an e-mail list server and automatically distributed to subscribers around the DOE complex.

Outreach Programs

The Office has a significant outreach program to promote safety management through analysis. EH sponsors a field detailee program designed to train field personnel in analysis methods and give them a DOE Headquarters perspective. This program brings field personnel with diverse experience and technical disciplines to Headquarters. The program has been tremendously successful to date and has resulted in benefits to both the HQ office and the field. EH gains invaluable field experience to improve our products. The field organization has exposure to environment, safety and health (ES&H) analysis techniques and becomes familiar with Headquarters business. Plans for detailing HQ personnel to the field are also underway.

The Office also assisted in training several Russian engineers from GAN, Russia's Federal Agency for Nuclear and Radiation Safety. Their visit was arranged through the DOE/GAN Cooperative Program on Event Reporting and Analysis, and included training in the EH Operating Experience and Lessons Learned programs. The Russian engineers received hands on training on operating event databases, retrieval, analysis and publication of lessons learned. Future visits are planned to provide technical assistance to develop an occurrence reporting system, upgrade GAN regulations, and provide additional training.

INSIGHTS FROM PERFORMANCE INDICATORS

Twenty-three performance indicators were monitored during calendar year 1997. These indicators are:

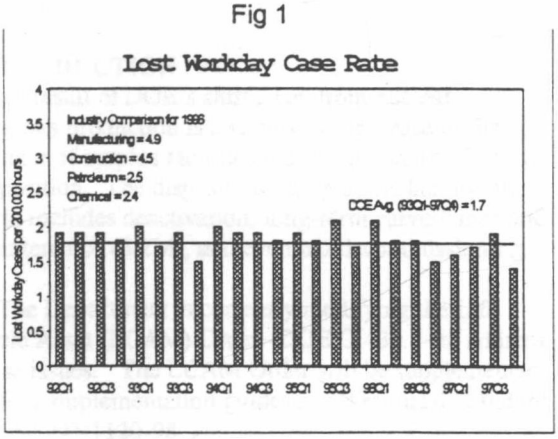
- Lost workday case rate,
- Occupational safety and health cost index,
- Electrical safety,
- Industrial operations safety,
- Chemical hazard events,
- Reportable occurrences of releases to the environment,

- Cited environmental violations,
- Environmental permit exceedances,
- Price-Anderson Amendments Act enforcement,
- Radiation dose to the public,
- Worker radiation dose,
- Radiological events,
- Near misses and safety concerns,
- Inadequate procedures/procedures not followed,
- Safety system actuations,
- Safety equipment degradation,
- Environmental compliance milestones met,
- Open Defense Nuclear Facilities Safety Board (DNFSB) recommendations,
- Enhanced work planning implementation,
- Resolution of spent nuclear fuel and plutonium vulnerabilities,
- Plutonium stabilization issues previously identified,
- Waste generation; and
- Resolution of previously identified highly enriched uranium vulnerabilities.

CONCLUSIONS

Over the past several years, the DOE has experienced a favorable trend in most of the indicators monitored. This observation (Figure 1) is beginning to influence the best outcome indicator of safety performance, that being the Lost Workday Case Rate.

Fig 1



As Figure 1 illustrates, four of the last five quarters have experienced rates below the DOE average over the past six years.

The EH analysis of DOE operational data seeks to answer the question posed by senior management "Are we (DOE) getting safer?" A review of the environment, safety and health indicators over the past several years would lead one to conclude that, indeed DOE is performing better in protecting the workers, public and environment. However, our methods don't account for improbable and rare events, and the question arises, are these trends reflective of improved safety performance or are they due to changes in the type and level of activity within DOE operations? To better discern the influence on safety performance, more data will be needed and new analytical techniques will have to be developed.

REFERENCES

Four Quarterly Performance Indicator Reports for ES&H, 1997.

Fifty-two editions of Operating Experience Weekly Summary: No. 97-1 through 97-52.

DOE Technical Bulletin 97-1, *Lessons Learned in Occurrence Reporting*.

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ENVIRONMENT, SAFETY AND HEALTH CONSIDERATIONS FOR DISPOSITION OF DEPARTMENT OF ENERGY FACILITES

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ABSTRACT

Following the end of the Cold War, the Department of Energy's (DOE) mission has been in transition from designing, testing, and building nuclear weapons to a cleanup mode of environmental restoration and surplus facility disposition. The Office of Environment Safety and Health (EH) has led the development of a standard that addresses health and safety concerns for this new mission. This standard utilizes the numerous regulatory documents developed over many years addressing design, construction and operation of these several thousand facilities. It utilizes the framework of an "integrated safety management" approach.

INTRODUCTION

One result of DOE's shift away from nuclear weapons production is a significant increase in the number of surplus facilities that must undergo facility disposition. The disposition phase of the facility life cycle includes deactivation, long-term surveillance and maintenance (S&M), and eventual decommissioning.

The Department is currently modifying the Life Cycle Asset (LCAM) Order--DOE O 430.1--to address these issues. The LCAM Order will be supplemented by four implementation guides and Technical Standard DOE-STD-1120-98.

DISPOSITION PHASE OF FACILITY LIFE CYCLE

The disposition phase begins when DOE terminates facility operations for the purpose of a defense, research, or other mission and declares the facility surplus to the Department's needs. Many of the facilities' systems and components (for example, heating, ventilation, air conditioning; fire protection; monitoring) may remain operational during the disposition phase.

For nuclear facilities, deactivation is typically the first activity of disposition that takes place. Deactivation is the process of placing a facility in a safe and stable condition. Part of this process is radiological material control. As a bridge between operations and decommissioning, deactivation may do some final process runs and may perform some decontamination activities. When deactivation is complete, the facility is generally in a passive state where it can be monitored over an extended period with minimal cost.

The final facility disposition is typically decommissioning, where the facility is taken to its ultimate end state through decontamination, dismantlement, or entombment. After decommissioning is complete, residual structures and/or surrounding area may require environmental remediation and/or subsequent long-term monitoring.

Surveillance and maintenance (S&M) functions continue throughout the disposition phases and maintains the safety envelope established over the course of the facility life-cycle. Changes in the facility condition during the course of the disposition process, and corresponding changes in the authorization basis, will necessitate adjustments to S&M functions and activities over time.

Differences Between Facility Operation and Disposition

Facility disposition activities are prone to more uncertainties in terms of the types and complexity of the work and hazards. In general, many of the safety and hazards management concepts are the same for facility operation and site remedial actions. This is summarized in Table 1.

Characteristics of Deactivation, Surveillance and Maintenance and Decommissioning Life Cycle Phases

These three phases in the life cycle of a facility are quite different, and the hazards change accordingly. During the deactivation phase, handling and packaging of hazardous material as it is being readied to be sent to waste handling sites is the main activity. There are still large quantities of radioactive and chemical material stored, although the exact amount and nature may not be known. Public and worker risk is moderate, and contamination of workers is possible.

During S&M, there is less activity, much of the hazardous material has been removed, and the threat to the workers and the public is less. However, equipment, structures and equipment are degraded, and these must be carefully monitored.

During decommissioning, activity picked up again. A fairly large contractor workforce with numbers of subcontractors are in the facility. Even though most of the hazardous material has been removed, the tasks being done are complex and new to many workers. This often can result in physical injuries (e.g., slips, trips and falls).

The hazard profile is shown in Figure 1, for five "scenarios":

- Scenario 1: the expected or planned case with hazardous material present and with little change of plans,
- Scenario 2: a stretched out S&M period twice; between operations and deactivation and between deactivation and decommissioning,
- Scenario 3: a stretched out S&M period following deactivation,
- Scenario 4: a stretched out S&M, going to decommissioning, skipping deactivation phase; and
- Scenario 5: a decommissioning project with no hazardous chemical, toxic or radiological materials.

PROTECTING THE PUBLIC AND WORKERS

Facility disposition activities shall be managed in such a manner to protect the public and work force from radiation and hazardous materials. These activities shall comply with Federal, state, and local laws and regulations. DOE-STD-1120-98 contains guidance for these phases.

Although the health impact on workers and the public may be reasonably similar, (e.g. chance of an acute fatality shortly after exposure, but at relatively high doses, and a lower chance of a "latent" fatality by cancer years later but possibly affecting more people), the regulatory requirements regarding radiological and toxic chemicals is different. Facilities containing sufficient radiological material are subject to nuclear safety requirements. DOE Order 5480.23 requires that a facility be categorized as type 1, 2, or 3 based on the quantity stored. Category 1 facilities are the most hazardous. During post-operations most facilities will be Category 3, the least hazardous. In addition to completing a safety analysis report (SAR), the following nuclear safety requirements pertain:

- technical safety requirements
- unresolved safety questions
- training and certification
- conduct of operations
- maintenance
- quality assurance
- radiation protection

Hazardous chemicals and toxic materials are largely addressed by 29 CFR 1910. This requirement, promulgated by the Occupational Safety and Health Administration (OSHA) and codified as DOE directives, contains a list of specific hazardous chemicals and "threshold" storage amounts before corrective actions are required, (e.g., compliance guidelines). A safety and health program and site-specific safety and health plan are covered by the HAZWOPER portion of 29 CFR 1910.120. In addition, materials somewhat unique to DOE (e.g. beryllium fabrication) are handled on a case-by-case basis.

INTEGRATED SAFETY MANAGEMENT SYSTEM

DOE recently developed an Integrated Safety Management System (ISMS) that has the following seven guiding principles and five core functions:

Guiding Principles for Integrated Safety Management

The guiding principles are the fundamental policies that guide DOE and contractor actions, from development of safety directives to performance of work. They are:

- Line management responsibility for safety, supplemented with safety policy, enforcement, and independent oversight functions,
- Clear roles and responsibilities within DOE and contractors,
- Competency commensurate with responsibilities for all DOE and contractor personnel,
- Balanced priorities for allocation of resources, programmatic, and operational considerations. Protecting the public, the workers and the environment shall be a priority,
- Identification of safety standards and requirements prior to performing any work,
- Hazard controls tailored to work being performed, and
- Operations authorization shall be clearly established and agreed upon.

Core Functions for Integrated Safety Management

Five core safety management functions provide the necessary structure for any work activity that could potentially affect the public, the workers, and the environment. The functions are:

- Define the scope of work adequately,
- Analyze the hazards associated with the work,
- Develop and implement hazard controls using applicable standards and requirements,
- Perform work within controls and confirm readiness to operate, and
- Provide feedback and continuous improvement.

APPLICATIONS OF ISMS TO DISPOSITION

Work Planning and Hazard Identification

Effective work planning and hazard identification are two important factors influencing safety and health and cost-effective implementation of facility disposition activities. Work planning is very important in this process since the ISMS process tailors voluminous regulatory requirements to the specific job to be performed. Hazard identification is the result of plant audits and surveys, interviews with operations staff, and consideration of unknowns, e.g. may not precisely know the inventory.

Typically, hazard analysis is performed during the planning phases of a project, when a general knowledge of work scope is known, but details have not yet been fully determined. Hazards should include radiological, chemical, and biological materials. One acceptable approach is a process called job hazard analysis (JHA). Once all of this material is assembled, a facility "baseline" is established which evaluates anticipated hazards and their potential consequences. This facility baseline should be updated each time a facility transitions into a new facility disposition phase or when a significant change occurs.

Hazard Controls

Elimination of hazards is the best approach. While seemingly simple, this step may not be obvious until the identification of work and hazards is integrated. Following hazards elimination, the following are used in their order of preference: (1) engineered safety features, (2) administrative controls, and (3) personnel protective equipment. Administrative controls are less desirable since there is a possibility of not following a procedure or the procedure could be misinterpreted. Personnel protective equipment also must be continuously used—often it is uncomfortable--and there is a chance that it is not functioning when needed.

Feedback and Evaluation

Work monitoring and periodic self-assessments are important aspects of a successful safety and health program. Self-assessments are required by a DOE Order. The information from the large number of sites is maintained in a data base, and this information is shared at all sites.

CONCLUSIONS

A standard has been developed for the disposition of DOE's many surplus or outdated facilities. It utilizes an integrated safety management system recently developed by the Department.

REFERENCES

DOE O 430.1, *Life-Cycle Asset Management (LCAM)*, being updated.

DOE-STD-1120-98, *1998, Integration of Environment, Safety and Health into Facility disposition Activities.*

DOE O 5480.23, 1991, *Safety Analysis Reports.*

29 CFR 1910.120 *Hazardous Waste Operations and Emergency Response.*

DOE P 450.4, 1996, *Safety Management System Policy.*

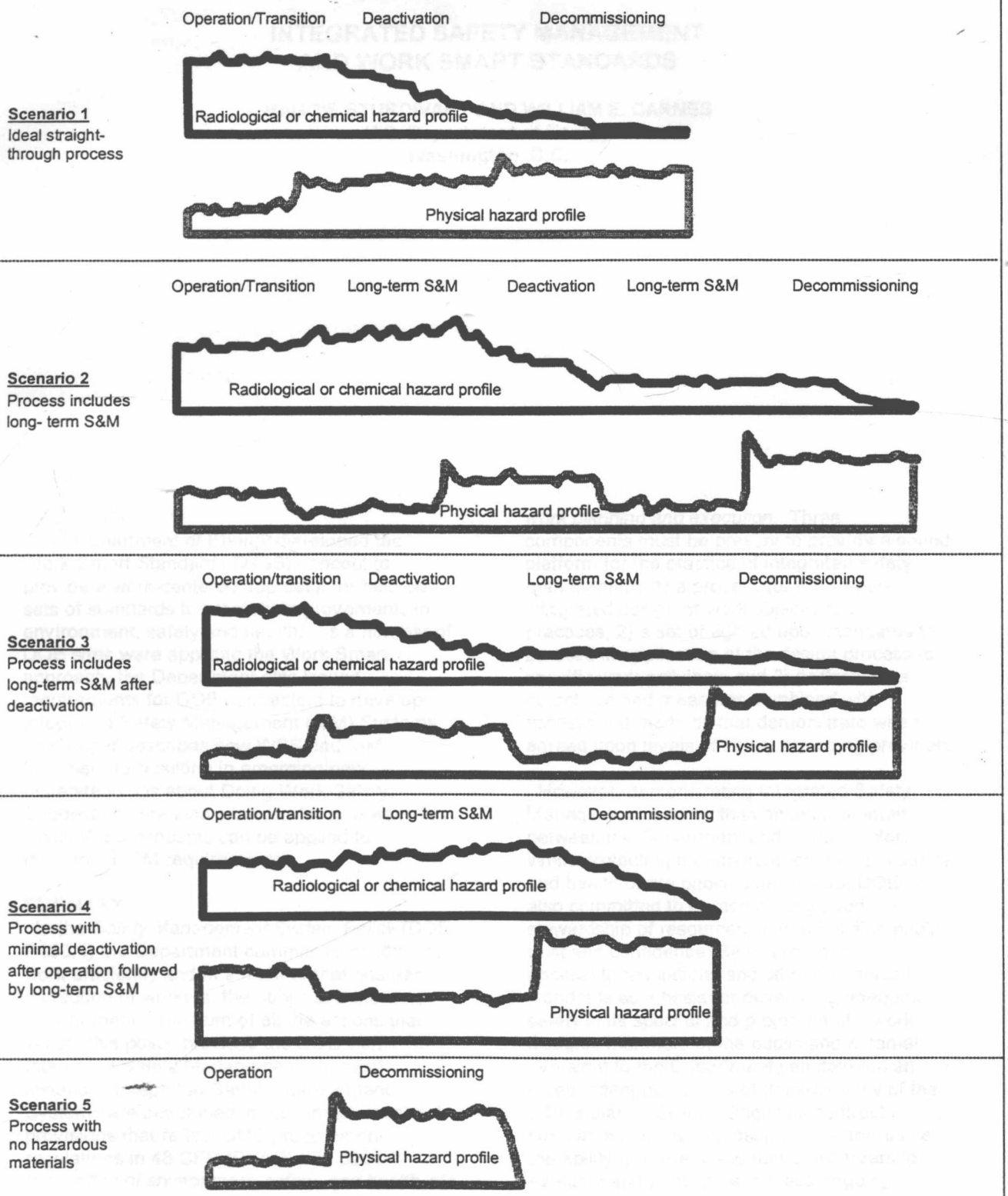
DOE G 450.4-1, 1997 *Integrated Safety Management System Guide for use with DOE 450.4.*

Table 1. Comparison of Disposition and Operation

	Disposition	Operation
S&H Regulatory Framework	Refinements and clarification of DOE directives and external regulations	Established by existing DOE directives and external regulations
Hazard Profile	Frequently changing; not well characterized; more unrecognized hazards	Stable; well characterized
Work Planning	Task oriented; frequently entering new tasks; first of the kind tasks; one time tasks; short team tasks	Routine; focused on operation and maintenance
Hazards Analysis	Dynamic; mainly task oriented	Operation oriented; generally stable
Work Force Experience	New mission; limited experience	Familiar with facility operation and routine work
Contract Management	More short-term subcontractor involvement	Contractor managed and operated

Figure 1 - Facility Disposition Phases

Some major disposition scenarios and their relative hazard profiles



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INTEGRATED SAFETY MANAGEMENT AND WORK SMART STANDARDS

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ABSTRACT

The Department of Energy developed the Work Smart Standards (WSS) concept to provide a work-centered approach for tailored sets of standards to promote improvements in environment, safety and health. As a number of DOE sites were applying the Work Smart approach, the Department also issued requirements for DOE contractors to develop Integrated Safety Management (ISM) Systems. This paper describes how WSS and ISM together are resulting in emerging new understandings about Doing Work Safely. Suggestions are also provided for new ways in which WSS concepts can be applied to implement ISM requirements.

SUMMARY

In the *Safety Management System Policy* (DOE P450.4) the Department commits to conducting work efficiently and in a manner that ensures protection of workers, the public and the environment. The sum of all the actions that satisfy this policy provides the DOE with Integrated Safety Management. In most instances Integrated Safety Management Systems are developed in response to contract provisions that reflect DOE procurement regulations in 48 CFR (DEAR) 970.5204-2, *Integration of environment, safety, and health into work planning and execution.* Three components must be present to provide a sound platform for the practice of integrated safety management: 1) a process for the safety-integrated design of work objectives and practices; 2) a set of agreed upon standards to be used in application of the design process to specific work activities; and 3) performance objectives and measures combined with assessment methods that demonstrate when agreed upon levels of safety are being provided.

However, demonstrating Integrated Safety Management is more than an internal affair between the Department and its contractors. While protecting the environment and the safety and health of the public and workers, DOE is also committed to demonstrating good stewardship of resources, and to building public trust and confidence. By incorporating applicable regulations and other recognized standards as a basis for developing adequate safety in its specific and programmatic work designs, members of the public and external oversight to the Department can develop an independent perception of the adequacy of the DOE's plans. By including in its contract standards objective measures of performance, the ability of present and future observers to evaluate and participate in these ongoing

challenges is enhanced. The DOE *Safety Management System Policy* presupposes active and continuing Openness Programs for dialogue with various constituents for the Department's activities.

At each DOE location the system for delivery of safety-integrated work designs and practices must successfully engage both a diverse and talented work force and an inquisitive and demanding public. The Department has deliberately adopted a standards-based approach to safety management that is intended to: allow for good judgment in work design and resource allocation; create consistency and stability of expectations and accountability; permit judgment to be exercised at the level appropriate to effective innovation; and help people do their jobs through teamwork.

Within the overall context of Integrated Safety Management, the significance of Work Smart Standards is that the *Necessary and Sufficient Closure Process* (DOE M450.3-1) can be used to demonstrate conclusively that an agreed upon, tailored, and standards-based definition of work, hazards, and expected controls exists. The appropriately implemented Work Smart set of standards and requirements provides fully adequate protection of workers, the public and the environment while getting the mission work of the contract done. The *Closure Process* can be applied at the contract, facility or activity level; in all circumstances it is expected that Work Smart Standards, faithfully developed, can be relied upon to lead to work performance that satisfies the dual imperative of the *Safety Management System Objective - Do Work Safely*.

Satisfied sites emphasize that the effective application of the *Closure Process* provided many first hand experiences of how to enhance integration, both within the Responsible (contractor) Organization, and between DOE and contractor management. Improved communications and better understanding of the respective DOE and Contractor roles and responsibilities for the completion of the contracted mission are often reported as collateral benefits that come from the intense interactive effort required to define the work and to agree upon Work Smart Standards for the safe performance of that work.

The Integrated Safety Management policy states that direct involvement of workers during the development and implementation of safety management systems is essential for success. The *Closure Process* requires systematic involvement of interdisciplinary teams of workers. Through use of those who are the most knowledgeable of the actual work and hazards, and by the process of tailored work design, the set of performance expectations for a particular piece of work becomes Work Smart. Specific features of the *Closure Process* directly support top-down Line Management in the tailored application of its safety responsibilities. Other features tap the work-centered practical experience of local workers who will use the selected standards. The management control structure of the process distinguishes between two important and distinct vantage points during work design. This is reflected in the differing roles and responsibilities assigned to the Convened Group and to the Identification and Confirmation Teams.

The demonstrated skills, knowledge and abilities of the DOE work force are derived from many collective years of experience with the types of hazards characteristic of the Department's mission. For many routine activities this experience has been codified in formally promulgated standards such as are found in the DOE Directives System. Many federal, state and local regulations establish mandatory performance or process objectives that are based upon the contents of these standards. For non-routine activities, guidance documents contain best practice standards that, while falling short of providing prescriptive requirements, communicate what is known at the edge of formalized consensus standards.

For those engaged in exploratory work design, the standards-based approach encourages the integration of both practical knowledge and all forms of received wisdom. In the standards-based approach to Integrated Safety Management, the expectations of involved workers are addressed with standards identification processes that are tailored to the specific characteristics of the work. Such processes will develop an interdisciplinary perspective on each work activity that is appropriate to the level of work control responsibility for that work. For many routine activities this will be the level of the individual researcher, crafts person or technician. As