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**Type A Accident  
Investigation Board Report  
on the February 13, 1997,  
Welding/Cutting Fatality  
at the  
K-33 Building, K-25 Site  
Oak Ridge, Tennessee**



On February 14, 1997, I established a Type A Accident Investigation Board to investigate the February 13, 1997, Welding/Cutting Fatality at the K-33 Building, K-25 Site, Oak Ridge, Tennessee. The Board's responsibilities have been completed with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1, *Accident Investigations*.

I accept the findings of the Board and authorize the release of this report for general distribution.



ASSISTANT SECRETARY  
Environment, Safety and Health

## Purpose

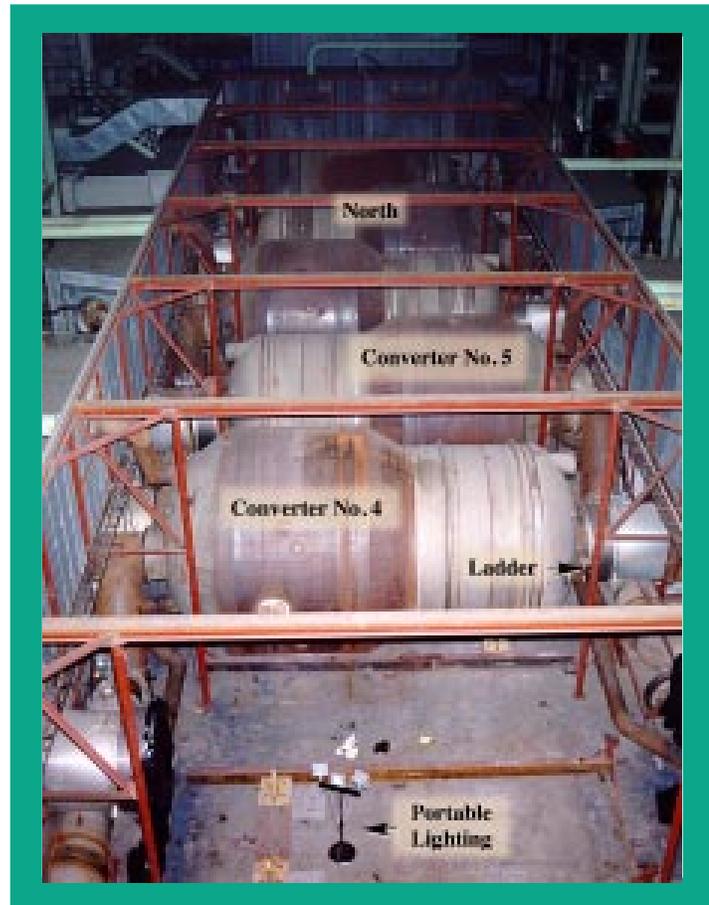
This document presents a management-level summary of the *Type A Accident Investigation Board Report of the February 13, 1997, Welding/Cutting Fatality at the K-33 Building, K-25 Site, Oak Ridge, Tennessee*. The referenced report provides a much higher level of detail and includes a complete presentation of the facts identified, the analysis of these facts, conclusions derived from that analysis, identification of the causal factors underlying the accident, and specification of judgments of need that should be addressed through follow-up action by DOE and its contractors. This companion document provides a more concise review of the facts and conclusions of that report, with special emphasis on management issues arising from the investigation.

## Background

Under contract to the Oak Ridge Operations Office, Lockheed Martin Energy Systems, Inc. (LMES) is decontaminating and decommissioning the K-25 Site. By agreement among the Department of Energy, the United States Enrichment Corporation, LMES, and Lockheed Martin Utility Systems, Inc., spare process equipment needed for the Portsmouth and Paducah facilities is available from K-25. Beginning on February 8, 1997, LMES began to remove selected process equipment from the K-33 Gaseous Diffusion Building, the largest of the K-25 gaseous diffusion process facilities, for use by the United States Enrichment Corporation. The work was similar in many ways to work performed in another K-25 building in 1996 and to the extensive equipment-replacement activities necessary to support operations prior to 1985. Because of these similarities, the work was classified as routine maintenance by LMES, thereby eliminating the requirement for a task-specific work plan.

The accident occurred at approximately 11:10 a.m. on Thursday, February 13, 1997, at the K-33 Building. The work involved the removal from Cell 7 of six converters scheduled to be shipped to Portsmouth and/or Paducah as spare parts. Exhibit 1 shows a view of the cell where the work was being performed. Although the cell's roof was removed, the lighting in the cell was very poor, and temporary lighting was installed. The physical layout of the equipment in the cell required the welders to work in a constricted space, with very difficult ingress and egress. Converters 2 and 3 had already been removed, and the welder was performing a cutting operation on Converter 4, near the location of the ladder in the photograph, when a spark or a piece of hot metal ignited his anti-contamination coveralls at, or somewhat below, his left knee.

At the time of the accident, the welder was wearing multiple layers of clothing that were not flame-retardant and radiological protective equipment that limited his ability to detect and extinguish the flames quickly. Since the welder was working alone, the flames spread undetected until they were beyond the welder's ability to extinguish them without assistance. By the time a co-worker responded to the emergency and extinguished the fire with a dry chemical fire extinguisher, flames had totally engulfed the welder's body. At approximately 11:46 a.m., he was transported by ambulance to Methodist Medical Center in Oak Ridge, arriving at noon. The welder suffered third degree burns over 95 percent of his body. He was transferred to the Erlanger Burn Center in Chattanooga and died at 10:41 a.m. on February 14, 1997.



**Exhibit 1. View Looking North in Cell 7, K-33 Building**

## Board Appointment

On February 14, 1997, Tara O'Toole, M.D., M.P.H., Assistant Secretary for Environment, Safety and Health, U.S. Department of Energy (DOE), appointed a Type A Accident Investigation Board to investigate the accident, in accordance with DOE Order 225.1, *Accident Investigations*. The Board commenced its investigation on February 17, 1997, completed the investigation on March 14, 1997, and submitted its findings to the Assistant Secretary for Environment, Safety and Health on March 19, 1997.

## Results of the Investigation

### Personal Protection

A Radiological Work Permit issued for the converter removal effort required the use of anti-contamination clothing and a respirator. However, the Board found that neither DOE nor LMES policies require the use of flame-retardant anti-contamination clothing for welding, cutting, or hotwork operations. Exhibit 2 is a photograph of a worker dressed in personal protective equipment similar to that worn by the welder at the time of the accident. As shown in this illustration, the welder's senses of sight and smell would have been severely limited by his mask and the respirator. In addition, the multiple layers of protective clothing would have allowed a fire to burn for some time before the

ensuing heat could be felt. Testing conducted by the Board indicated that there would have been a 65- to -80 second delay before the welder could have detected the ignition of his clothing. After 90 seconds, the flame could not have been extinguished by the welder alone. The Board found that concerns regarding a possible contamination hazard may have caused the use of a level of protective equipment that impeded worker response to the actual, but unrecognized, hazard of clothing ignition.

Although LMES procedure requires a fire watch to be present during welding or cutting operations

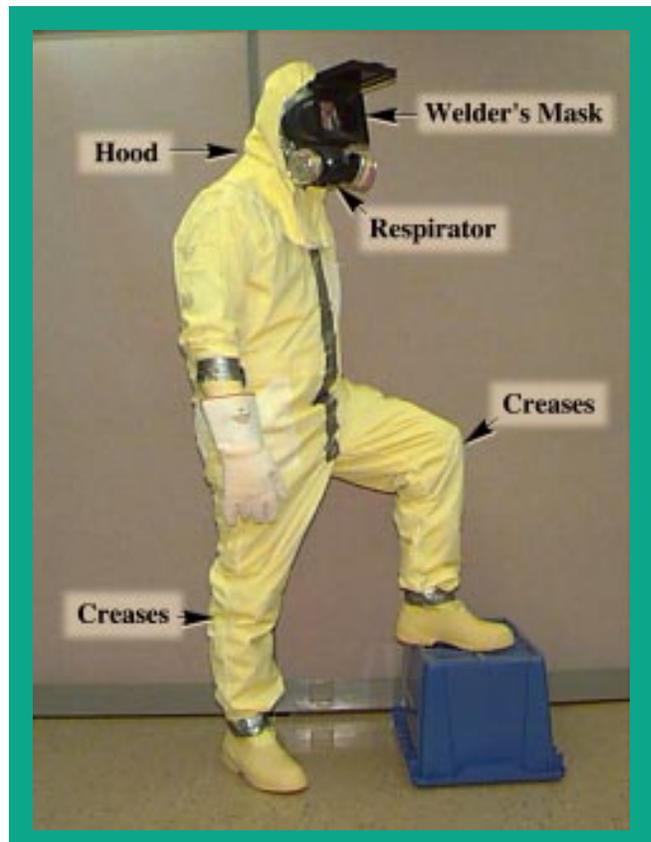


Exhibit 2. Similarly Outfitted Welder

outside an approved shop area, a fire watch was not designated on permits for the work performed on the day of the accident. A fire watch is a designated individual, trained in fire-watch duties, who is dedicated to monitoring the work site for possible fires during welding/cutting activities and for thirty minutes after the work has stopped. Reviews of three previous permits available for work in the cell revealed that two did not have a fire watch identified. The Board found that neither DOE nor LMES policies emphasize personnel safety as a responsibility for a fire watch. For example, these procedures do not indicate the need for the fire watch to (1) maintain line of sight with welders, (2) be at a distance that would enable a timely and effective response, or (3) be trained in personal emergency response techniques and first aid.

The Board concluded that the designation of a fire watch with clear personnel safety responsibilities and/or the use of flame-retardant anti-contamination clothing by the welder would have prevented this fatality. However, as noted below, the Board determined that significant deficiencies must be corrected both in management identification of accident precursors and in the LMES work planning and control program to prevent recurrence of a similar accident.

### Accident Precursors

Interviews revealed that anti-contamination clothing had caught fire during similar work at another facility (K-31) in 1996. More recently, anti-contamination clothing had also caught fire at K-33 due to hot molten metal (slag) dropping/splashing on the clothing. For example, several days before the accident, a welder's bootie caught fire. Further, the day before the accident, the clothing of the welder who was fatally burned in this accident caught fire, burning through both sets of anti-contamination clothing and scorching his general-purpose coveralls. These and many similar incidents were reported

misses" through the Department's occurrence reporting system.

LMES management considered the work being performed at the time of the accident as similar to that performed at K-31 in 1996. Because it had been several years since major removal of equipment was performed, the K-31 work was fully planned and documented to enable application of lessons learned to future similar work. A project report, prepared at the completion of the K-31 work, documented completion of the project and included lessons learned. These lessons learned included the need for developing and using a work plan for future similar work, developing specialized cutting tools, assigning fire watches, and reducing anti-contamination coverall requirements to one pair rather than two pairs during burning/cutting operations. There was no evidence that either the project report or the lessons learned from the K-31 project were used by personnel involved in the K-33 work.

### Work Planning

LMES procedures require a Job Hazards Analysis, describe the process for conducting the analysis, describe the conditions under which a new analysis should be performed, and assign responsibility for performing the analysis to the "supervisor." The process includes assembling a multidisciplinary team of workers and safety professionals, documenting individual work steps for the job, identifying the hazards for each step, and specifying the controls for each hazard. However, the procedures do not clearly identify the individual responsible for ensuring that a Job Hazards Analysis is performed; consequently, no analysis was performed for the K-33 converter removal.

A task-specific work plan was not prepared for K-33 converter removal work. LMES classified the work as "routine maintenance" within the "skill of the craft." LMES procedures do not require a detailed work plan for such efforts.

The work permits prepared for the K-33 converter removal work did not specify alter-native cutting methods, engineered controls, or personal protective equipment to protect workers from sparks or hot slag generated during cutting operations. They also did not contain any provisions to ensure adequate ingress and emergency egress for personnel or equipment. The Board observed that human entry/egress was restricted by the confined space and the equipment configuration.

Signatures on the work permits for the K-33 converter removal work indicate that some approving authorities did not visually inspect the work area in Cell 7 prior to signing the permits; they also were not present to observe whether work was being performed within the scope of the controls identified to mitigate identified hazards. The Board found that the Industrial Hygiene Department was not notified prior to commencing cutting operations; consequently, industrial hygiene surveys, which were required by the work permits, were not accomplished.

The Board could find no evidence that a pre-job safety meeting that included the Service Supervisor, all the craft disciplines, and appropriate safety personnel assigned to monitor the work was conducted as required.

## Causes of the Accident

The Board identified two root causes<sup>1</sup> for the accident, either of which would have prevented a fatality or serious injury:

- The failure to use flame-retardant anti-contamination clothing.
- The failure to identify a fire watch with appropriate personnel safety responsibilities (see section on Personal Protection above).

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<sup>1</sup> The fundamental causes that, if eliminated or modified, would prevent recurrence of this and similar accidents.

In addition, five contributing causes<sup>2</sup> were identified:

- LMES failed to adequately plan the work, provide adequate procedures, or ensure that existing procedures were implemented.
- Line management responsibility and accountability for safety were not adequately defined for the Oak Ridge Operations Office or LMES, as evidenced by their failure to ensure that workers and supervisors were properly qualified and trained to perform assigned tasks.
- Neither the Oak Ridge Operations Office nor LMES performed sufficient oversight to maintain an awareness of site job hazards, as evidenced by their failure to observe and react to the numerous clothing fires prior to the fatal accident.
- LMES management did not foster an atmosphere that encouraged reporting of incidents; therefore, workers did not report the previous incidents of clothing fires to management.
- Equipment used to protect workers from radiological hazards created an additional fire hazard by limiting the welder's ability to see, smell, or feel the ignition of his clothing and by interfering with his ability to call for help.

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<sup>2</sup> The causal factors that significantly increased the likelihood of the accident without individually causing the accident.



# Analysis of Management Issues

Safety management activities can be grouped into five core safety management functions: (1) define the scope of work; (2) identify and analyze the hazards associated with the work; (3) develop and implement hazard controls; (4) perform work safely within the controls; and (5) provide feedback on adequacy of the controls and continuous improvement in defining and planning the work. Their interrelationships are shown schematically in Figure 1.

These five functions provide the necessary structure for any work activity that could potentially affect the public, the workers, and the environment. The degree of rigor needed to address these functions will vary, based on the type of work activity and the hazards involved. Following is an analysis of work planning and controls for the K-33 converter work applicable to the accident in relation to the five core safety management functions.

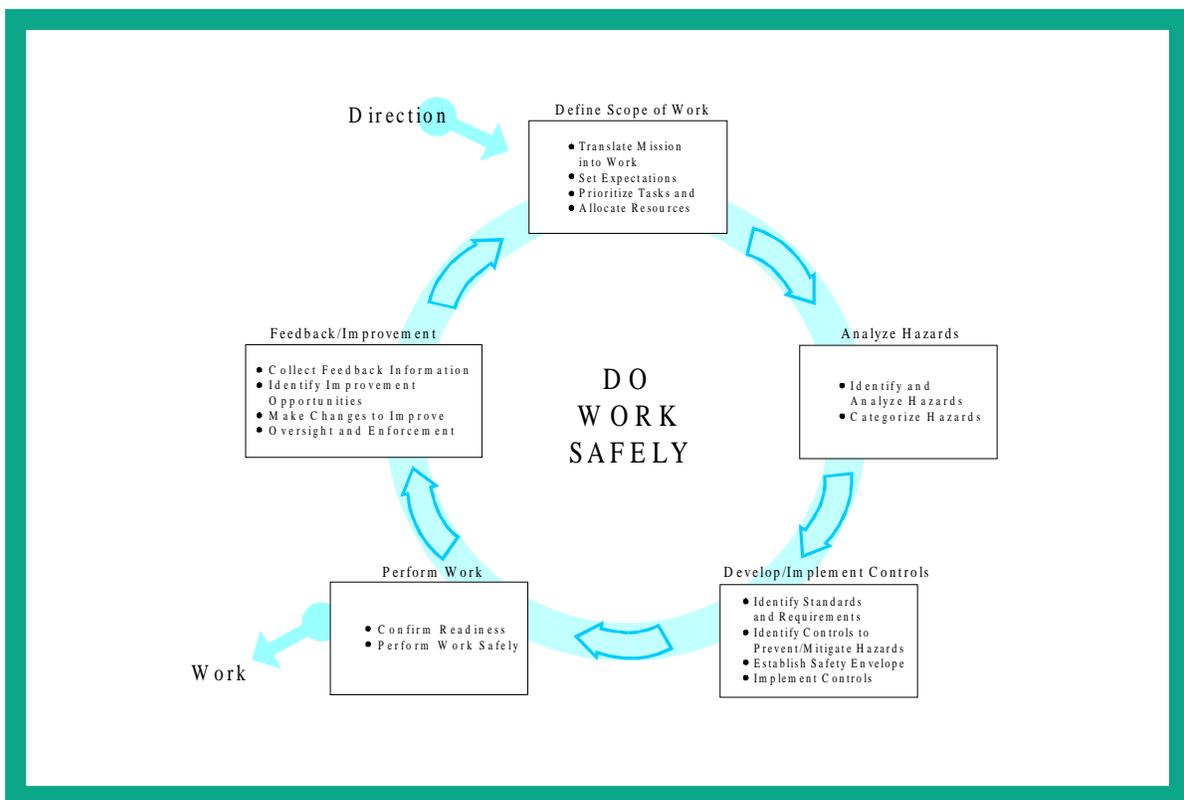


Figure 1. The Five Core Safety Management Functions

## Define The Scope Of Work

A maintenance job request was used by LMES to define the scope of the work to be performed. However, the Board found that line management responsibility and accountability for safety was lacking at both the Oak Ridge Operations Office and LMES. Within the Operations Office, no organization or individual assumed or was assigned responsibility for managing and monitoring the work to be performed at K-33. Within LMES, the Board found that organizations and individuals responsible for the building/facility were not involved in planning the work and therefore were unaware of any impact the work might have on their safety envelope. No single organization within LMES served as a focal point to ensure that all hazards were identified, that permits were prepared in accordance with LMES procedures, and that appropriate hazard controls were put in place. As a result, no complete work package was developed that adequately translated the job mission into work, set safety expectations, and prioritized tasks. In addition, because of a recent reorganization and downsizing, personnel with adequate training or experience were not assigned to the job.

## Identify and Analyze the Hazards Associated With The Work

It is the judgment of the Board that a properly conducted multidisciplinary Job Hazards Analysis, in accordance with LMES instructions and with experienced workers participating, might have identified all hazards to the welder. In this case, because of unclear assignment of responsibility and lack of specific guidance with regard to identifying routine/non-routine work, no Job Hazards Analysis was performed.

It should be noted that the Board conducted a multi-agency search for other instances where a welder died due to ignition of his or her clothing.

Only one incident was identified in private industry, possibly leading to the widespread lack of appreciation regarding the hazards involved in this welding/cutting operation. Since workers had not reported earlier clothing fires, supervisors had not recognized the rather frequent occurrence of such fires, and there was little indication of a similar hazard in the literature. Thus, recognition of the interrelationship between the fire hazard and the personnel protective equipment required for this job would be dependent on the intelligence and forethought of those conducting the analysis.

## Develop and Implement Hazard Controls

It is the judgment of the Board that LMES procedures do not contain adequate criteria for identifying maintenance work that is “routine” versus “non-routine” and/or within the “skill of the craft.” Appropriate criteria are necessary to ensure that a task-specific work plan is prepared, as appropriate, based on the complexity of the work and the hazards present. In this case, the complexity of the work, the welder’s relative unfamiliarity with performing tasks in the prescribed protective equipment, and the significant differences between the K-33 configuration and that of the more recent similar work would seem to make dependence on “skill of the craft” questionable. In addition, some of the hazard controls identified for the work were not implemented.

## Perform Work Safely Within The Controls

A number of actions intended to assure that work is performed within the defined controls were not performed. The most significant included:

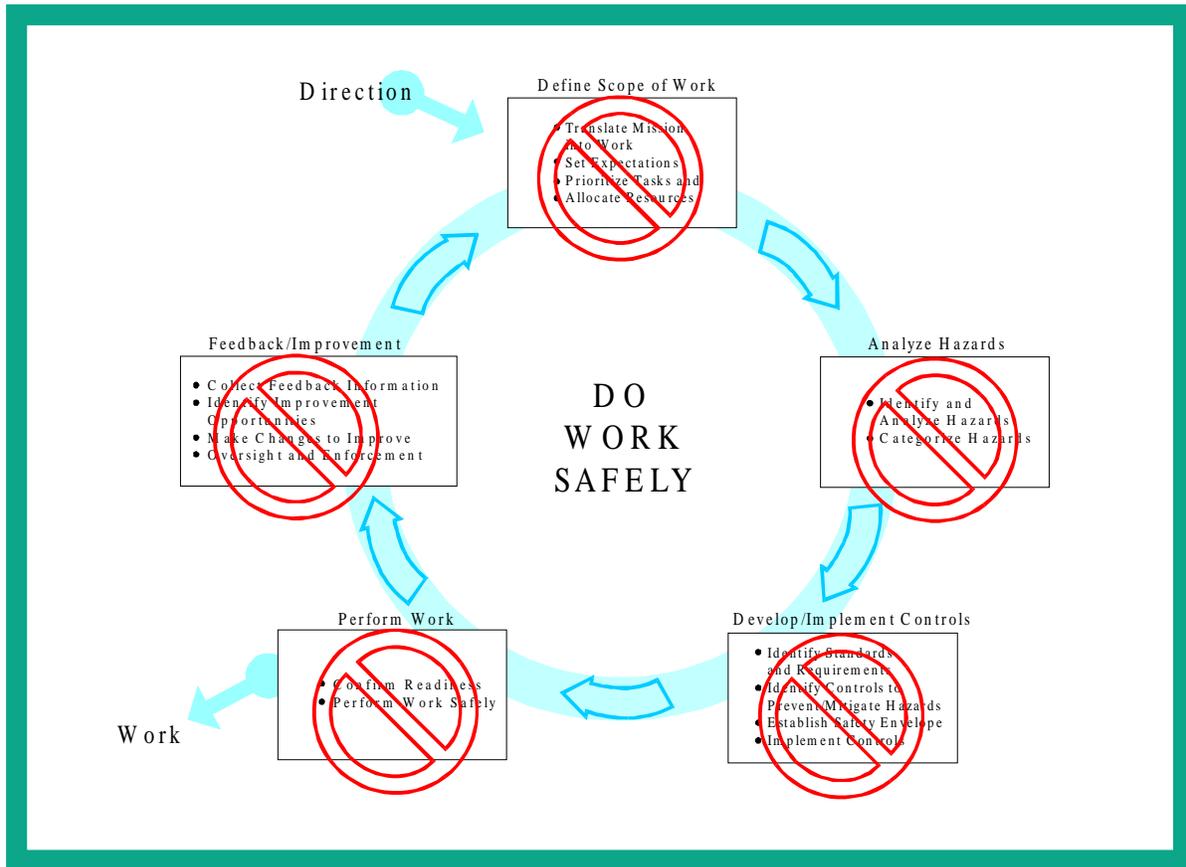
- There was no pre-job briefing on February 13, as required, with all required parties present.

- All signatories to the Welding/Burning/Hotwork Permit were not present to verify that the approved precautions were fully implemented.
- A fire watch, as required by LMES procedures, was not in place.
- Industrial Hygiene Department surveys, required by the work permits, were not conducted prior to commencing cutting operations.

**Provide Feedback On Adequacy of the Controls and Continuous Improvement in Defining and Planning Work**

Neither the Oak Ridge Operations Office nor the LMES line managers had conducted sufficient

oversight to observe the recurring problem of clothing ignition in the K-33 work. Although LMES policy requires reporting incidents such as clothing ignition, LMES management had not created an environment in which workers felt empowered to point out these incidents as they occurred. As a result, management was uninformed about the continuing hazard of clothing ignition and was unable to act to prevent the accident. Furthermore, there was no evidence that lessons learned from similar work performed in 1996 were used to identify and mitigate the hazards of this job. In particular, the need for detailed work planning, the hazard of clothing ignition, the need to reduce the layers of anti-contamination clothing required, and the need for fire watches were not addressed for the work at K-33.



**Figure 2. Core Safety Management Functions as Implemented**

## Summary

An analysis of the facts from this accident investigation leads to the conclusion that the maintenance work planning process and associated controls for the K-33 converter removal work were not adequate. Figure 2 illustrates the five core safety management functions as implemented for this job.

The absence of clearly defined line management responsibility and accountability for safety caused failures in translating the job mission into safe work practices, in setting safety expectations, and in allocating trained and experienced personnel to the effort. Since line management did not ensure that an adequate Job Hazards Analysis was completed before the work began, measures and controls to mitigate the hazards were not developed or implemented. This, in turn, caused the work to be performed without appropriate controls. The requirements for this process were specified in LMES instructions and K-25 Site procedures, but were not implemented during the work. Furthermore, lessons learned from previous work were not adequately evaluated, documented, or incorporated into the planning for K-33 converter removal work. If the problems that workers had previously experienced with anti-contamination clothing catching on fire had been adequately analyzed, and if the lessons learned had been documented, communicated, and appropriately incorporated into the planning for K-33 converter removal work, the accident might have been avoided. More fundamentally, weaknesses in the safety management system allowed the welder's safety to depend on the single mitigating factor of a property-protection-oriented fire watch that was required, but not routinely implemented.

The Board considered the limited history of fatalities associated with the ignition of anti-contamination clothing during welding/cutting operations, the lack of requirements regarding the use of flame-retardant anti-contamination clothing, and the failure of existing fire watch requirements to emphasize

personnel safety responsibilities. Based on these considerations, the Board could not conclude that even a work planning/control process that met the five core safety management functions of the DOE Implementation Plan for Integrated Safety Management would have definitely prevented this accident. However, the Board concluded that without such a structured work planning/control process, as was the case for the work being performed in Building K-33, the opportunity to identify the clothing fire hazard was not provided, thereby assuring that it would not even be considered.

## Conclusions

There are some urgent policy issues with respect to flame retardant clothing and fire watch responsibilities that have to be addressed as a result of this accident. However, the overarching concern stemming from this investigation is the failure to conduct adequate work planning and hazard analyses. Part of this failure may be because classifications assigned to many work activities, i.e., “routine maintenance,” are interpreted by some as obviating the need for sound work planning/control or because of complacency expressed by line management who believe structured work planning is not necessary because “this is a job we have performed thousands of times before.” Another contributor to poor work planning in DOE may be the assumption that such activities require elaborate analysis of the hazards and preparation of a thick report. None of these reasons are accurate, nor do they reflect the policy or guidance the Department has promulgated to date.

The increasing emphasis on decon-tamination and decommissioning activities within the Department and the lessons learned from this accident underline the pressing need to implement a disciplined, analytical, and collaborative focus on work planning, hazards analysis, and hazards control. Future decontamination and decommissioning activities will likely present other opportunities for encountering familiar settings in unfamiliar contexts. If we are to minimize worker injuries and fatalities in the Department’s changing mission, then emphasis must be placed on a multidisciplinary approach to pre-job planning where each step of the work to be done is reviewed for the hazards expected and appropriate controls are put in place.

This report is an independent product of the Type A Accident Investigation Board appointed by Tara O'Toole, M.D., M.P.H., Assistant Secretary for Environment, Safety and Health (EH-1).

The Board was appointed to perform a Type A investigation of this accident and to prepare an investigation report in accordance with DOE Order 225.1, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.