Department of Energy
Washington, DC 20585

JUL 23 1996

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW
Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

This letter responds to your March 21, 1996, letter to Dr. Reis. Based on the concerns raised in your letter and your staff's trip report, the Department of Energy (DOE) conducted an assessment of the nuclear criticality programs at the Lawrence Livermore National Laboratory (LLNL). The DOE's review revealed numerous weaknesses in the LLNL nuclear criticality safety program that agree with the deficiencies cited by your staff. In general, the deficiencies involved inadequate staffing levels and resources for the criticality safety group, inadequate oversight of criticality safety related operations, and inadequate quality control mechanisms on the systems that control workstation mass limits in Building 332 (B-332).

Issues in the trip report are addressed individually in the enclosed document. In general, however, we would like to clarify the process by which criticality safety requirements are identified and implemented in B-332.

The DOE criticality requirements are identified in the B-332 Safety Analysis Report (SAR) by reference to DOE Order 5480.24, "Nuclear Criticality Safety," and American National Standards Institute/American Nuclear Society (ANSI/ANS) standards on criticality safety. The B-332 SAR specifies several elements of the facility's criticality safety program (e.g., safe geometry, mass limits, use of the double contingency principle, reflector/moderator limits etc.,) as an administrative control in the Technical Safety Requirements (TSR). Chapter 6 of the SAR, "Prevention of Inadvertent Criticality," lists allowable fissile material mass limits for standard operations, and establishes a process which must be followed if these mass limits are exceeded when other than standard operations must occur. Additionally, the process per DOE Order 5480.21, "Unreviewed Safety Questions," is applied to ensure the operation remains within the authorization basis. In summary, the process is to perform a criticality safety analysis (CSA) to recognized ANSI/ANS standards, perform an Unreviewed Safety Question (USQ) Evaluation or Screening, and implement the controls which the CSA finds necessary using a safety procedure. These requirements compose the facility's authorization basis with respect to criticality safety.

LLNL's internal implementation of these requirements consists of a Facility Safety Procedure (FSP) which controls the standard operations which take place in the facility. The FSP states the mass limits for standard operations consistent with Chapter 6 of the SAR. Operational Safety Procedures (OSPs) are written when an operation is outside the scope of the FSP. In the case of criticality safety, the OSPs also serve as the safety procedures required as part of the process for exceeding mass limits for standard operations delineated in the SAR. Individual CSAs and implementing OSPs are, therefore, part of the authorization basis for B-332. In summary, a valid CSA, OSP, and USQ determination can modify the mass limits for standard operations set in the SAR.

With respect to this background information, one condition discussed in the trip report, specifically B-332 workstation # 6906 procedures and analyses and one condition discovered by the subsequent LLNL evaluation, storage of waste drums in the B-332 increment 3 basement, did not meet the requirements of the facility's SAR or TSRs. Additionally, a number of workstation mass limits were posted to the default limit set in the SAR, but the correct limit was contained in an OSP. This represents a work practice that neither the DOE nor the LLNL finds acceptable. However, they were situations in which the limit was correctly derived and the operators clearly understood what the limit was.

The issues identified were considered significant by the DOE and the LLNL. Consequently, corrective actions have been developed and, in many cases, are already implemented. Immediate actions to correct specific problems are complete. Long-term corrective actions which ensure processes will remain effective in the future are ongoing.

With respect to the LLNL criticality safety program in general, the following corrective actions have been or will be taken:

1) Responsibility for the criticality safety group has been moved so that reporting chain is clearly understood, and it will have the necessary independence from the program to fulfill its required oversight function. A permanent full time section head is being sought for this group;

2) Resources needed for the group have been analyzed. Additional positions will be filled, and funding provided so that adequate coverage of the entire Laboratory can be maintained.

The following actions have been or will be taken with respect to B-332:

1) Building 332 was placed in the administrative standby mode by the LLNL during the DOE review and a thorough assessment, inspection and walkdown of all work areas was conducted. All deficiencies dealing with mass limit postings and safety procedures were corrected. The USQ process was applied to all deficiencies related to the authorization basis. LLNL Senior Management and the Oakland Operations Office (OAK) reviewed these corrections prior to returning to operational mode;

2) The process by which LLNL internal procedures and postings are kept current, was and continues to be improved through a better system of tracking and routine surveillance;

3) The USQ Screening and Evaluation Processes are being strengthened, so that they are triggered by any change in internal procedure or operation; and

4) The OAK Facility Representatives and Nuclear Safety personnel are increasing their routine surveillance of operations, facility conditions and procedures related to criticality safety.

Initial and interim corrective actions have been reviewed by OAK. The facility is now operating in full compliance with DOE criticality safety requirements. OAK officials are currently working with senior LLNL management to ensure that these corrective actions are effective in the longer-term, and are integrated into the LLNL's Safety Management System. The DOE will conduct a followup review to ensure that corrective actions continue to be effective and verify compliance within the next 30 days.

Some of the conditions existing at the LLNL had the potential to become serious problems. We appreciate the role the Board's comments have had in identifying and correcting these conditions. We believe that the corrective actions we have taken, will ensure that the DOE maintains a clear understanding of criticality safety conditions at the LLNL.

Sincerely,

Victor Stello, Jr
Principal Deputy Assistant Secretary
for Safety and Quality
Defense Programs

Enclosure

cc:
M. Whitaker, S-3.1
J. Turner, OAK

RESPONSE TO ISSUES RAISED IN THE DEFENSE NUCLEAR FACILITIES SAFETY BOARD STAFF MEMORANDUM ENTITLED "STAFF REVIEW OF INTEGRATED SAFETY MANAGEMENT AT LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)" DATED JANUARY 29, 1996

The Department of Energy (DOE) and the Lawrence Livermore National Laboratory (LLNL) have carefully considered all of the issues raised by the Defense Nuclear Facilities Safety Board (DNFSB) staff during their visit to LLNL from November 14-16, 1995. Each issue (referred to by the paragraph number in which they appear in the subject memorandum) is addressed below.

ISSUE 1: The letter from the DNFSB, dated March 21, 1996, stated that, "the lack of Department of Energy (DOE's) involvement in the review and authorization of operations that are significantly outside the approved LLNL authorization basis is very troubling."

RESPONSE: Because of this concern and the criticality safety concerns expressed in the subject memorandum, DOE assembled a seven member team of DOE personnel (and one outside expert) with backgrounds in criticality safety and nuclear facility operations, and conducted a review of LLNL's criticality safety program from April 23 to May 3, 1996.

The DOE expects the corrective actions taken by LLNL, in response to the DNFSB staff's findings and those of the DOE team, to significantly improve the conduct of operations at the site and reduce the likelihood of recurrences of the types of problems identified.

Building-332 (B-332) Plutonium Facility Safety Analysis Report (approved by DOE) clearly establishes the process by which LLNL determines and implements criticality safety controls (including mass limits). This includes a criticality safety program as an administrative control. This program requires that each operation within the facility that handles more than 220 grams of Pu 239 must conduct a criticality safety analysis (CSA) of that operation and implement the controls defined in the CSA through a safety procedure. Three examples were cited in the DNFSB staff's memorandum where it appeared that LLNL had failed to follow this process. It is important to note that these activities represent operations already described in their respective Safety Analysis Report (SARs).

In the first case, LLNL determined that the DNFSB staff members were correct in noting that LLNL had not followed its internal safety procedures. The workstation #6906 OSP had expired, and the CSA for that operation was not written to current standards and did not reflect the current operation (storage of the material that had been used during the previous authorized operations). Since that visit, LLNL has written a CSA and corresponding OSP covering the storage of this material. The DOE team has reviewed these documents and these activities now meet the administrative controls specified in the SARs for criticality safety.

The second case involved the W48 "cracker" operation. The DOE review team reviewed the CSA and corresponding OSP for the W48 Cracker. The Laboratory's inability to supply this CSA at the time of the staff member's request was probably due to the fact that the LLNL criticality safety group lacked a full time group leader who would be the obvious point of contact for obtaining such documents. More probably, it was due to the group's continuing struggle for resources - they had only recently moved into a common office area with a single location to file their analyses. The Laboratory has taken actions to appoint a full-time group leader and to reconstitute a criticality safety group. It is this failure to provide the DNFSB staff members with the CSA that led to the incorrect conclusion that the default fissile material mass limit of 220 grams had been exceeded without DOE authorization. However, it was subsequently determined that this operation did go through the criticality safety process described earlier.

The third case cited was an operation involving the W79 dissolution workstation development, a nonnuclear operation occurring at Site 300. The mass of LX-10 high explosive (HE) in the W79 HE assemblies is significantly below the 4,000 pound Quantity-Distance weight limit specified in the Operational Safety Requirement (OSR) section of the facility's SAR. The Laboratory has an internal control (defined in the facility's Facility Safety Procedure (FSP)) of only 100 pounds of HE for the individual Cells within the facility. The W79 dissolution process had the potential to exceed the 100-pound cell weight limit because the combination of dissolved LX-10 with the solvent could have created an explosive mixture. The Laboratory developed an OSP authorizing 50 pounds of explosives in the cell, which when combined with the solvent in the workstation, could have generated an explosive mixture weighing approximately 120 pounds. As a point of interest, the mixture generated by the process was subsequently determined to be nonexplosive. Regardless, the OSP provided the proper level of authorization to exceed the internal control limit. No further DOE authorization was required for this operation.

More recently, LLNL identified a fourth case in which operations were occurring without having gone through the process described by LLNL's criticality safety program. The operation involved the storage of waste drums in the B-332 Increment 3 basement without an OSP. This situation has been corrected.

ISSUE 2: Paragraph 3.b.(1). "There have been repeated instances in the last two years where internal and external reviewers could not determine whether <u>any</u> criticality safety analysis, as required by industry standards and DOE Order 5480.24, "Nuclear Criticality", had been performed for operations which had mass limits significantly over those defined in the LLNL guidance documents." Specifically, these include:

Paragraph 3.b.(1)(a). A 1993 LLNL internal audit finding that ten workstations had been allowed to raise their mass limits to 3,000 grams without documented and peer reviewed criticality safety analyses to support these revised mass limits.

RESPONSE: Since LLNL began an extensive program to implement the requirements of DOE Order 5480.24 at the end of 1993, LLNL has engaged in a program to develop and/or document formal criticality safety analyses for its fissile material operations. An LLNL followup audit report dated December 1, 1994, reviewed the status of this issue and the actions taken to resolve it and concluded a peer review with documentation of the analysis was completed.

Paragraph 3.b.(1)(b). A 1995 draft LLNL internal audit finding that, "Although the operating organization stated a criticality safety evaluation was conducted, the appraisal team was not provided formal documentation for the presence of the additional fissile nuclear mass (contained in two 70 gallon drums) in Room 1338 of B-332."

RESPONSE: This statement came from a draft report that had not been reviewed for technical accuracy. During the factual accuracy review, it was determined that a criticality safety analysis for the storage of this material had been performed and verified in a logbook.

Paragraph 3.b.(1)(c). "On the first day of the review, the DNFSB's staff requested, for review, the criticality analyses for two workstations in B-332. The first was the criticality analysis required for the work on the 'W48 cracker.' No evidence of the analysis, its peer review, or any other pertinent criticality analysis was produced prior to the review team departing LLNL two days later. The mass of the fissile material was significantly higher than the standard 220 gram limit and was, in fact, higher than other standard OSP limits (waivers).

The DNFSB's staff also requested the criticality safety analysis for the material in workstation #6906. Although it exceeded the Final Safety Analysis Report/FSP limit by over a factor of ten, it had no current OSP associated with it waiving the authorization basis limits, nor could LLNL produce evidence of a criticality safety analysis being done."

RESPONSE: The criticality analysis for the W48 cracker was subsequently found and reviewed by the DOE Team. A criticality safety analysis for workstation #6906 did exist, but was not written to current standards. Analyses of these issues are contained in paragraphs 3, 4, and 5 of the response to issue 1.

ISSUE 3: Paragraph 3.b.(2). "LLNL has inconsistent definitions of dispersible plutonium in their internal safety documentation. This periodically results in fissile material (Pu 239) over mass conditions (i.e., outside the authorization basis) at the Laboratory."

RESPONSE: The Laboratory revised their definition to be any solid piece containing fissionable material with a total mass $\leq$10g, liquids, gases, solutions, slurries, powders, chips, lathe turnings, filings, hydrides or oxides containing fissionable materials, any fissionable material carried as "box loss", and other fissionable materials so defined in a safety procedure. The revised Health and Safety Manual, Chapter 31, "Criticality Safety,"

contains the revised definition as will the revised FSP (being held until DOE approval of the B-332 SARs update). All OSPs revised since December 1994 have contained the revised definition. Additionally, all B-332 plutonium handlers, facility staff, and other facility workers were briefed on this revised definition on December 21, 1994. Finally, the B-332 Facility Manager issued a policy statement (PuFO Policy 96-1/dkd, dated April 9, 1996) delineating the definition of dispersible fissionable material.

GENERAL RESPONSE: Analysis of the issues above finds that there are three causal factors which are related to each. Along with their corrective actions, they are:

1) A lack of responsible attention given to the institutional criticality safety needs of the LLNL;

   Corrective actions:
   a) Reassign responsibility for criticality safety group;
   b) Assign full time section leader;
   c) Analyze additional needs;
   d) Provide additional personnel as necessary; and
   e) Provide additional funding as necessary.

2) Laboratory internal processes which were not effective in positively identifying and tracking the status of operations (specifically in Building 332);

   Corrective actions:
   a) Improve tracking of procedures and their correlation to ongoing operations;
   b) Strengthen Unreviewed Safety Question Processes so that changes in procedures or operations will trigger screening; and
   c) Use of checklist procedure prior commencing fissile material operations.

3) A lack of oversight (both LLNL and DOE) expending adequate time evaluating criticality safety and following through with the resolution of findings;

   Corrective actions:
   a) Increase amount of time spent on facility floor evaluating criticality safety issues and verifying operating parameters related to criticality safety; and
   b) Increase DOE surveillance of facility conditions, operations and procedures related to criticality safety.

Attachment

96/2878

Assessment of the Criticality Safety Program at Lawrence Livermore National Laboratory

April 23 - May 3, 1996

Mark A. Lee, DOE/OAK — Date 5/23/96
Criticality Safety Assessment Team Leader

ACRONYMS

ANS	American Nuclear Society
ANSI	American National Standards Institute
AVLIS	Atomic Vapor Laser Isotope Separator Facility
CAS	criticality alarm system
CoO	Conduct of Operations
CS	criticality safety
CSA	criticality safety analysis
CSU	container storage unit
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOE-HQ	Department of Energy Headquarters
DP	Office of Defense Programs
EH	Office of Environment, Safety and Health
ESHD	Environment, Safety, and Health Division
FSP	facility safety procedure
HWM	Hazardous Waste Management
LLNL	Lawrence Livermore National Laboratory
LSO	Livermore Site Office (DOE)
OAK	Oakland Operations Office
OSP	operational safety procedure
TRU	transuranic
TSR	technical safety requirement
SAIC	Science Applications International Corporation
SAR	Safety Analysis Report
USQD	unreviewed safety question determination

I. Introduction

The DOE Oakland Operations Office (OAK) conducted an assessment of the Lawrence Livermore National Laboratory (LLNL) nuclear criticality safety program from April 23 through May 3, 1996. This assessment was in response to DNFSB staff observations during a review of LLNL's integrated safety management program and criticality safety program conducted from November 14-16, 1995. OAK led a 7 member team of DOE personnel (and one consultant) with backgrounds in criticality safety and nuclear facility operations. (See Appendix 1 for team biographical information.)

The appraisal focused on nuclear criticality safety in LLNL facilities that handle, experiment with, and store significant quantities of fissile material. The appraisal also focused on LLNL management of institutional programs that support or provide oversight for nuclear criticality safety in these facilities.

A. Goals

The goals of the appraisal were:

- To evaluate the adequacy of LLNL's management of its nuclear criticality safety program.
- To evaluate LLNL implementation of DOE Order 5480.24, Nuclear Criticality Safety (the Order for nuclear criticality safety specified in DOE's contract with the University of California) and compare that implementation with the current DOE Order for nuclear criticality safety, DOE Order 420.1, Facility Safety, section 4.3.
- To evaluate the adequacy of recent changes or commitments LLNL has made related to its implementation of and internal oversight of its nuclear criticality safety program.
- To understand the role of nuclear criticality safety requirements on LLNL facilities' authorization bases.

II. Executive Summary

The team toured all LLNL nuclear facilities that handle or store fissile materials. These were: Building 231/233 Storage Vaults, Building 233 Container Storage Unit, Building 251 - Heavy Elements Facility, Building 332 - Plutonium Facility, Building 334 - Hardened Engineering Test Building, Building 490 Complex - Uranium Atomic Vapor Laser Isotope Separator Facility, and the Hazardous Waste Management Complex.

The team noted several criticality safety related deficiencies:

- LLNL's attention to the management of its criticality safety program has been poor. This has resulted in less than adequate staffing, inadequate resources, loss of independence of the criticality safety group from program operations and marginal oversight of criticality safety related operations.
- LLNL was storing a drum containing more fissile material than authorized by the criticality safety analysis and Facility Safety Procedure. (The discovery was made by LLNL as part of the facility's internal SAR review process.)

- There were inadequate quality control mechanisms on the systems that control workstation mass limits in Building 332.

- Personnel in the Hazardous Waste Management Complex and Materials Management Section have not received training or refresher training in accordance with the applicable ANSI/ANS standards.

LLNL has taken immediate steps to address these issues and has committed to a plan of action to address those actions that cannot be immediately remedied.

III. EVALUATION

This evaluation of LLNL's nuclear criticality safety program is divided into four key topical areas. The first section describes the few specific deficiencies related to criticality safety at LLNL that were observed by the team. The second section addresses the team's concern that LLNL's management of criticality safety, left as it is, could potentially result in future criticality safety problems at LLNL. The third section evaluates the adequacy of facility authorization bases with respect to criticality safety. The fourth evaluates DOE/OAK's oversight of criticality safety.

A. Observed Criticality Safety Deficiencies

Due to the team's early identification of and focus on key institutional problems, it was not practical to audit the program against every ANSI/ANS requirement. Therefore, the team did not spend much time investigating whether minor deviations related to criticality safety were being documented, reported and investigated.

1. The quality control mechanisms on the systems that control workstation mass limits in Building 332 are inadequate.

The ANSI/ANS 8.19 requirement states that, "The movement of fissile materials shall be controlled," and, "Appropriate material labeling and area posting shall be maintained specifying material identification and all limits on parameters that are subject to procedural control".

The criticality control workstation mass limits in the computer system used for nuclear material accounting and criticality control were found to be inconsistent with the approved workstation limits listed in the current Operational Safety Procedures. Although this computer system is listed in the Technical Safety Requirements and Building 332 SAR as a nuclear criticality safety control, discussion with several fissile material workers in Building 332 indicated that the primary reliance is on the limits in the OSPs. None indicated knowledge that the workstation limits printed out during material transactions were sometimes different from the OSP limits.

Inspections of Rooms 1050 and 1051 in Building 332 found nuclear criticality safety limit postings that were inconsistent with the current Operational Safety Procedures. These postings were obvious and clearly inconsistent with the OSP. In at least one case, the incorrect posting had been in place for several years. Both operations personnel and criticality safety oversight personnel should have had many opportunities to see and correct the incorrect postings of workstation limits. Both were deficient in their nuclear criticality safety oversight responsibilities.

The review team walked down all operational workstations in B332 and verified that all postings and OSPs have the appropriate mass limits (in the two instances where mass limits were not correctly posted, the team returned to verify that the facility had corrected the posting) and definition of dispersible material (a problem the facility identified in two previous occurrance reports.)

Additionally, during the course of the review, a visitor was issued a nuclear accident dosimetry (NAD) pack that was found to be missing its detectors.

Building 332 management expressed concern over these posting, computer, and dosimetry problems and scheduled a standdown from programmatic activities in order to conduct an internal assessment of the conduct of operations in Building 332. Personnel from outside of the facility organization were part of this review.

To ensure that future revised requirements are implemented, the ES&H teams have committed to brief facility management on changes made to the Health and Safety Manual. Due to this recent timing of this corrective action, the team was unable to determine the effectiveness of its implementation.

2. **Supervisors in the Hazardous Waste Management complex are not providing adequate procedures to provide for criticality safety.**

The ANSI/ANS 8.19 requirement states that, "Supervisors shall develop or participate in the development of written procedures applicable to the operations under their control. Maintenance of these procedures to reflect changes in operations shall be a continuing supervisory responsibility".

In the recent criticality safety incident at LLNL involving the HWM overmass drum, the FSP/OSP requirements were not clearly understood by the material handlers. This was in part because an OSP for the specific storage area was not readily available to the operators.

As a result of these findings, LLNL issued a standard operating procedure that states that, until the Building 233 Container Storage Unit Safety Analysis Report and Facility Safety Procedure are approved, no new containers will be moved into the Building 233 CSU without written approval of the HWM Division Leader and the concurrence of the Hazards Control Team. LLNL is conducting an investigation to better understand the circumstances and factors leading to this incident. LLNL has scheduled a briefing for all HWM technicians to clarify the procedures in place.

3. Hazardous Waste Management (HWM) complex supervisory personnel's knowledge of criticality safety was inadequate.

The ANSI/ANS 8.19 requirement states that, "Each supervisor shall be knowledgeable in those aspects of nuclear criticality safety relevant to operations under his control".

During the course of the appraisal, LLNL discovered a waste drum in a HWM facility containing fissile material in excess of limits defined in the facility's Criticality Safety Analysis. The discovery occurred as part of the facility's internal SAR review process. Supervisory personnel demonstrated inadequate knowledge of the criticality safety requirements in the LLNL Health and Safety Manual. Key supervisory personnel had not had criticality safety training.

In this incident, key supervisory personnel violated LLNL criticality safety procedures by taking action to isolate the drum within the storage facility prior to contacting the LLNL Hazards Control criticality personnel. Prior to isolating the drum, HWM did commission an analysis from a source outside of the Hazards Control Department. This analysis received no formal peer review. This incident illustrates a lack of systematic criticality safety knowledge and training of LLNL supervisory personnel, including management personnel with responsibility for nuclear criticality safety.

As a result of these findings, a Hazards Control criticality safety engineer reanalyzed the drum and this analysis received peer review. The drum was moved into Building 332 where it meets facility criticality safety requirements. LLNL has reviewed their records and verified that there are no other drums in storage exceeding fissile material limits.

4. Fundamental criticality safety training or refresher training has not been required of all personnel who work with significant quantities of fissionable material.

The ANSI/ANS 8.20 requirement states that, "The (training) program is directed toward those who manage, work in, or work near facilities where the potential exists for a criticality accident," and, "All personnel who work in areas where significant quantities of fissionable materials are processed or stored, even though they are not required to handle such materials," and, "Refresher training requirements shall be determined and documented. Such training shall be provided at least every two years."

The assessment focused on fundamental training for criticality safety. Section 31.6 of the LLNL's Health and Safety Manual, Chapter 31 - Criticality Safety states that all personnel and their functional supervisors are required to have biennial training/retraining in the Fundamentals of Criticality Safety if they handle significant quantities of fissionable materials; if they work with or design equipment or devices that contain significant quantities of fissionable materials; or if they work in areas where significant quantities of fissionable materials are processed or stored. LLNL's training course, "Fundamentals of Criticality Safety" (HS3100), is designed to fulfill this requirement.

HS3100, was not required for the HWM personnel in the past. This lack of training (or a biennial refresher) was a contributing factor to the recent incident in which supervisory personnel failed to make the proper notifications or obtain the appropriate authorizations prior to moving the drum which contained excess amounts of enriched uranium. Additionally, AVLIS personnel were not required to take it because FY96 operations did not include enrichment operations. LLNL indicated that the recent revision to Chapter 31 of LLNL's Health and Safety Manual requires HWM personnel to take this course.

Training records of HS3100 for personnel in the Plutonium Facility and Material Management Section were examined. Currently, for the Plutonium Facility, the training requirement of HS3100 depends on the classification of personnel. The categories for the Plutonium Facility are: certified Pu handler, limited Pu handler, Rad Zone Worker 1 (RZWI), and Rad Zone Worker 2 (RZWII). The facility requires that personnel in each of these categories, except RZWII, are required to take the fundamentals of criticality safety training. As of April 22, 1996, all 24 certified Pu handlers and 18 limited Pu handlers were up to date on their training status. Only one out of the 47 RZWI's was not. The non-requirement of HS3100 for RZWII personnel, however, seems to be inconsistent with the training requirements outlined in the most recent version of the H&S Manual Chapter 31 which requires criticality training for, "All personnel who work in areas where significant quantities of fissionable materials are processed or stored, even though they are not required to handle such materials." This was not a requirement in the previous version of the chapter, according to the Pu Facility Training Program Manager.

In verifying training records of "Fundamentals of Criticality Safety" (HS3100) for Materials Management Section (MMS), it was learned that all personnel, except clerks, are required to take HS3100. However, the MMS internal requirement for refresher training indicated a repeat frequency of 60 months, rather than the two year requirement of the ANSI standard or the H&S Manual Chapter 31. Therefore, most of the 20 staff who have completed the fundamentals of criticality safety training are not up to date, with only one exception.

The requirement for refresher training is not consistently applied throughout the Laboratory. The 60 months refresher frequency for HS3100 is an MMS internal requirement. Both the laboratory wide database LROCC and the LROCC for the Pu facility indicate that there is no requirement for refresher training for HS3100. The Building 332 training implementation matrix, however, maintains a correct refresher frequency of two years.
It appears that there is lack of a mechanism that can capture training requirements and assure consistency among H&S manual updates, the laboratory wide training database - LROCC, and the divisional/sectional level training implementation matrix.

As a result of this finding, LLNL has committed to revise LROCC and MMS policy to reflect the new two year refresher training requirement in Chapter 31 of the H&S Manual.

5. Portions of the Criticality Safety Training class (HS3100) need improvement.

The ANSI/ANS 8.20 requirement states that, "The effects and applications of the factors that are relevant to criticality safety of operations in the facility shall be explained and illustrated," and that training should also address, "Actions required for violations of criticality safety controls or limits."

The content of HS3100 was checked against ANSI/ANS 8.20-1991. The content of HS3100 has been outlined in the HS3100 Student Course Notes (March 25, 1996) and partially in HS3100 Trainer Preparation Sheet and Lesson Plan (March 26, 1996) (CSAM 96-31). The validation was done by comparison of the standard with the Student Course Notes, CSAM 96-31, and an interview with the HS3100 instructor. All key elements of the reference standard are verified positively with a few exceptions. For example, the standard has a list of 11 control parameters, versus 7 given in the Student Course Notes.

Criticality safety control parameters such as concentration, heterogeneity, density, and enrichment have not been particularly emphasized because most trainees are from the Pu facility where the fissile material is typically weapons grade material. Since more trainees from working environments other than the Plutonium Facility are expected, the effects and applications of some of the control parameters which have not extensively covered (such as heterogeneity and enrichment) become important and should be emphasized.

Table 31.3 of the Chapter 31 of the LLNL's H&S Manual spells out actions required for violations of criticality safety controls or limits. These actions are not specifically outlined in the Student Course Notes. In view of the recent criticality safety mass limit infraction in the Building 233 CSU, proper actions for such situations should be included and emphasized in the training course.

6. The independent review of criticality safety analyses prior to commencement of operations is not always being performed.

The ANSI/ANS 8.19 requirement states that, "Before starting operations, there shall be an independent assessment that confirms the adequacy of the nuclear criticality safety analysis".

The independent review process for CSAs does not meet the ANSI/ANS requirements for an independent assessment prior to start of operations. The current internal procedure CSAM 96-44, "Record of Independent Review" requires independent or peer review if the operation "involves masses and configurations of fissile materials that are outside standard, handbook-like experience or if no past studies of similar masses and configurations exist. This allows operations to proceed with only one criticality safety engineer's judgment being the basis for safety, a clear departure from the ANSI/ANS 8.19 intent.

When independent reviews are conducted, they are generally only simple, paper reviews. No effort is generally made for a detailed, independent review including verification that the field conditions are actually reflected in the analysis.

B. LLNL's Management of Criticality Safety

1. A key concern of the review team is that LLNL's attention to the management of its criticality safety program has been inadequate. This has resulted in inadequate staffing, inadequate resources, loss of independence of the criticality safety group from program operations, and inadequate oversight of criticality safety related operations.

The ANSI/ANS 8.19 requirement states that, "Management shall accept overall responsibility for safety of operations. Continuing interest in safety should be evident".

Nuclear criticality safety awareness was not apparent at the management level. The responsibility for the implementation of a proper criticality safety program resides so low in the management chain that it has allowed the program to deteriorate without upper management involvement and awareness.

Management has not shown adequate interest in criticality safety and has not adequately responded to the fundamental issues raised by the Laboratory's own internal appraisals. Some of the problems noted during this review were called out in a previous LLNL criticality safety audits (See Report of the Criticality Safety Audit for the Plutonium Facility Building 332, dated April 28, 1994).

Management failed to conduct its triennial review of criticality safety between 1989 and 1995. Additionally, the May 1995 triennial review report of the nuclear criticality safety function at LLNL was not produced until 10 months after the audit. Earlier interest in and attention to the results of that appraisal could have limited the deterioration of the nuclear criticality safety program observed during this assessment.

While the criticality safety engineers can and have identified problems, they have not been effective in ensuring that these problems are corrected. Management has given them very little real power to ensure that the suggestions they make are actually implemented. Many criticality safety problems identified by them and by other auditors, such as problems with the Building 332 computer material accounting systems for monitoring and controlling workstation limits, have not been effectively corrected. This apparently stems from lack of senior management attention and the ineffectiveness of the management structure in elevating safety concerns to senior management.

A root cause of the criticality safety problems at LLNL is insufficient criticality safety staff. This problem has been identified by several previous audits but has been allowed by senior LLNL management to deteriorate even more. While LLNL management have authorized the hiring of new criticality safety personnel, these efforts have been ineffective.

LLNL's response to this issue has been to reform the discipline into a group reporting directly to the Hazards Control Department Head and to conduct an aggressive hiring campaign to bring on a group leader and additional staff. As interim measures, temporary staff in the form of three LLNL criticality safety retirees, matrix and/or contractor personnel are being added and, until a permanent Group Leader is selected, the Associate Director for Plant Operations will meet periodically with the Criticality Safety Group to review staffing, funding, core activities, and program support. LLNL has already taken steps to ensure functional

oversight reviews are conducted and reports are published in a timely fashion. Additionally, LLNL has committed to an annual review of the Criticality Safety Program by the Director's Office.

2. Criticality safety staffing levels are inadequate.

The ANSI/ANS 8.19 requirements state that, "Management shall provide personnel skilled in the interpretation of data pertinent to nuclear criticality safety and familiar with operations to serve as advisors to supervision," and, "Management shall provide personnel familiar with the physics of nuclear criticality and with associated safety practices to furnish technical guidance appropriate to the scope of operations".

The lack of staffing has been identified by several previous audits but has been allowed to deteriorate even more.

With the current staffing level, only two criticality safety engineers are actually overseeing operations and performing the bulk of the criticality safety actions supporting work at LLNL. One criticality safety engineer has essentially 100% responsibility for Building 332 (although he does have a contractor to assist him in the development of criticality safety analyses as part of the DOE Order 5480.24 implementation plan). He has multiple responsibilities including reviewing the facility, ensuring that controls are being followed, preparing the criticality safety analyses for the facility, and criticality safety training. This is clearly more work that one individual, no manner how good, can effectively do. It is inevitable that some things will be missed. One additional criticality safety engineer has been primarily dedicated to the support of other DOE facilities and operations.

Due to the current low number of criticality safety engineers, it is not possible for them to provide both the criticality safety support to operations and the necessary oversight functions.

Existing criticality staff have not been provided adequate resources to sustain the quality and capabilities of the staff and the long term support of fissile material operations at LLNL. Workloads on criticality safety staff are too high to allow updating/validating codes and the computers they operate on, and keeping staff current on criticality safety technology. Furthermore, insufficient staffing and resources limit participation in DOE professional conferences, national standards committees, etc. Insufficient resources will also make it difficult for LLNL to provide staff to DOE when needed for reviews such as the HEU Vulnerability Study, audits of other facilities, etc.

LLNL's response to this issue is to conduct an aggressive hiring campaign to bring on a group leader and additional staff. As interim measures, temporary staff in the form of three LLNL criticality safety retirees, matrix and/or contractor personnel are being added.

3. The Criticality Safety Function within the Hazards Control Department at LLNL is not structured to ensure that fissile material operations can be safely conducted.

The ANSI/ANS 8.19 requirement states, "Management shall assign responsibility and delegate commensurate authority to implement established policy."

The current Hazards Control Organization is not structured to support a criticality safety function as recommended by ANSI/ANS 8. In a strong effort to achieve consistency in the way the laboratory implements its various safety disciplines, the effectiveness of the criticality safety staff has been seriously diminished. Additionally, the responsibility for the implementation of criticality safety resides at a very low level within the management chain at LLNL. This results in many layers of management between the criticality safety staff and senior management. Middle management has apparently not understood the seriousness of the situation, has allowed the situation to deteriorate, and has not been effective in communicating the problems to senior management. As a result, senior management has not been made aware of problems that have surfaced in the field.

The Laboratory does not have strong criticality safety leadership. While the Laboratory, in the past, has had strong criticality safety managers who could work around the impediments of the current structure, the present program does not.

The current structure assures that the criticality safety function is not independent of operations. (See item # 4 below for a more detailed discussion on this issue.)

The need for criticality safety support for many of the laboratory facilities is not properly defined. Some fissile material operations (such as the Uranium Atomic Vapor Laser Isotope Separation (AVLIS) and Hazardous Waste Management (HWM) facilities) are not adequately supported by the criticality safety group in its current organizational structure.

LLNL's response to this issue is to reform the discipline into a group reporting directly to the Hazards Control Department Head and to conduct an aggressive hiring campaign to bring on a group leader and additional staff (some of whom will support HWM and AVLIS operations).

4. Criticality safety function is no longer independent of operations.

The ANSI/ANS 8.1 and 8.19 requirements state that, "These specialists should be, to the extent practicable, administratively independent of process supervision," and, "This function should, to the extent practicable, be administratively independent of operations".

Laboratory management has permitted the criticality safety function to deteriorate to the point that it is no longer independent of operations.

The criticality safety function staff has to solicit funds from operations to perform their day-to-day functions. Funding for the criticality safety engineering staff, their administrative staff, and their computer support is provided directly by operating departments. It is evident that the criticality safety staff has to go to Operations for moneys for basic criticality safety needs. This gives Operations influence over what analyses are done and the extent of those analyses.

Operations personnel participate in the annual performance reviews of the criticality safety engineers. This places the criticality safety engineers in a very awkward position. The operations management and staff for which they have mandated oversight responsibility have a direct input to decisions affecting their careers.

LLNL is taking steps to immediately restore the independence of the group. These include both a reorganization of the discipline into a group reporting directly to the Hazards Control Department Head and to directly fund them through "block" funding.

5. **The effectiveness of the oversight responsibility of the criticality safety group is limited. Management systems in place are not effective in ensuring that the criticality safety problems identified result in senior management attention and correction of the problems.**

The ANSI/ANS 8.1 and 8.19 requirements state that, "Operations shall be reviewed frequently (at least annually) to ascertain that procedures are being followed and that process conditions have not been altered so as to affect the nuclear criticality safety analysis. These reviews shall be conducted, in consultation with operating personnel, by individuals who are knowledgeable in nuclear criticality safety and who, to the extent practicable, are not immediately responsible for the operation," and, "The staff shall conduct or participate in audits of criticality safety practices and compliance with procedures as directed by management".

A key responsibility of the nuclear safety function in the ANSI standards and a key tenet of nuclear criticality safety is that the nuclear criticality safety function provides effective, independent oversight of operations. This concept includes adequate staff to oversee operations and identify problems, and adequate authority to ensure that criticality safety problems identified are corrected - both of which have been previously identified in this report as being poor.

The LLNL reorganization of the discipline into a group reporting directly to the Hazards Control Department Head should improve the effectiveness of the group's oversight of programmatic operations. Additionally, LLNL has committed to an annual review of the Criticality Safety Program which will be performed by the Director's Office to determine the health and quality of the program and the adequacy of resources provided to the group.

C. The role of nuclear criticality safety requirements on LLNL facilities' authorizations bases.

A recent letter from the Defense Nuclear Facilities Safety Board (DNFSB), expressed a concern that LLNL was conducting fissile material operations outside of the envelope defined by their respective authorization bases without DOE review or approval. Three significant operations were sited as examples where DNFSB staff members had made the observation that work had been or was being conducted outside of the scope of the authorization bases and that, additionally, two of the operations in Building 332 (the W48 cracker and workstation #6906) lacked the required criticality safety analyses. The letter also described the Board's concerns with LLNL's criticality safety program.

The review team reviewed LLNL's response to these issues as well as specifically looking at the documentation and workstations in question.

LLNL agreed that Board staff members were correct in that the workstation #6906 Operational Safety Procedure had expired and the criticality safety analysis for that operation was out of date, not up to current standards, and did not reflect the current operation (storage of the material that had been used during the previous authorized operations). Since the Board staff members' visit, LLNL developed a criticality safety analysis and corresponding OSP covering the storage of this material and the review team looked at these documents. Additionally, the review team reviewed every workstation in Building 332 containing fissile material to assure that these operations were within the envelope defined by the facility's authorization basis which describes the process for determining and implementing criticality safety controls within Building 332. However, it should be noted that as part of the LLNL assessment (discussed in section III.A.1), LLNL identified the storage of several waste drums in the basement of Increment 3 as lacking the required OSP.

This DOE review team also reviewed the Criticality Safety Analysis and corresponding Operational Safety Requirements for the W48 Cracker. LLNL's inability to supply this criticality safety analysis at the time of the Board staff member's request was probably due to the fact that the LLNL criticality safety group lacked a full time group leader who would be the obvious point of contact for obtaining such documents. Also, due to the group's continuing struggle for resources discussed earlier in this report, they had only recently moved into a common office area and the CSAs were not yet located in a single location. These criticality safety analyses form a key part of the process, defined in the SAR and approved by DOE, which determine and implement criticality safety controls (including mass limits) for specific operations within Building 332. It is LLNL's failure to provide Board staff members with this CSA that led the Board to the incorrect conclusion that the default fissile material mass limit of 220 grams had been exceeded without DOE authorization. However, because this operation did go through the process described in the SAR, it did not exceed SAR mass limits nor was it an operation without DOE approval.

The third example sited, operations involving W79 dissolution workstation development, was a non-nuclear operation occurring at Site 300. The mass of LX-10 high explosive (HE) in the W79 HE assemblies is significantly below the 4,000 pound Quantity-Distance weight limit specified in the Operational Safety Requirement (OSR) section of the facility's SAR. However, LLNL has an internal control of only 100 lbs of HE for the individual Cells within the facility. It is this more restrictive, but internal, level of authorization that the OSP referenced. No further DOE authorization was required for this operation. The

review team was satisfied with this and felt that any further review of this issue did not fall within the scope of the appraisal.

The team went on to review the criticality safety aspects of the Safety Analysis Reports (SARs) for most facilities and found that they were well written, thoroughly covered the hazards existing in each facility, and analyzed the potential consequences associated with their hazards. These, together with the associated Technical Safety Requirements for the facilities, constitute adequate bases for DOE to assume the residual risks and authorize operation. Table 1 - gives the status of SAR documentation for each of LLNL's facilities that handle fissile material in excess of 220 grams.

Facility Safety Procedures (FSPs) provide generic (facility-wide) operating plans which implement the controls specified in the facilities' authorization bases. Operational Safety Procedures are then issued to address safety related controls for individual operations in a manner consistent with a facility's SAR and FSP. In general, if an operation can be performed within the restrictions of the facility FSP, an individual OSP is not needed. This permits low-hazard, routine procedures to be conducted without further formal documentation, but provides for generation of OSPs for operations exceeding amounts of fissile material prescribed in the FSP. For example, in building 332, work involving workstation limits of less than 220g of ^{239}Pu may be performed under the Bldg. 332 FSP, whereas operations involving more than 220 grams must have their own approved OSPs. This system provides a graded approach to safety documentation.

Before an OSP can be issued, a criticality safety analysis (CSA) must be performed by qualified personnel to determine that the activity under consideration will always be subcritical with an adequate margin of safety. In these analyses, assurance is made that the "double contingency principle" is adhered to. CSA's examined were of good quality. It is important to note that this process as described in the SAR has the approval of the DOE Oakland Operations Office. Thus, these operations are being conducted with DOE approval.

The team reviewed the newest (4/1/96) version of Chapter 31, Criticality Safety of the LLNL Health and Safety Manual. The chapter is a clear expression of overall policies and procedures for the LLNL Criticality Safety Program. This chapter is based upon the requirements of DOE Order 5480.24, which is LLNL's current contractual criticality safety requirement. It is noted that while DOE 5480.24 has been replaced DOE-wide by DOE 420.1 which in turn is to be replaced by 10 CFR 830.330, conversion to the newer order and rule will not be a difficult matter, since these regulations are based upon the ANSI/ANS-8 series of criticality safety standards.

Table 1 - Safety Analysis Reports:

Bldg.	Title	Cat	Type	Status
332	Plutonium Facility	2	5480.23	DOE Approval 3/95
231/233	Materials Management	3	5480.23	SAR in review/ approval process
251	Heavy Element Facility	3	5480.23	DOE Approval 12/94
490	AVLIS	3	BIO	Approved BIO 8/95
A612/514, 233	Waste Treatment & Storage Facilities	3		Draft SARs in review
334	Hardened Engineering Test Facility	3	5480.23	Final Draft in revision
239	High Energy Radiography Facility	Rad.	5480.23	DOE Approval 10/94

D. DOE OAK Oversight of Nuclear Criticality Safety

DOE/OAK's oversight of criticality safety program has been inadequate. While day to day DQE oversight in LLNL nuclear facilities has increased in the last year, there has been little oversight attention paid specifically to the criticality safety program. Past walkthroughs and reviews (one in 1994 and one in 1995) have focused on operational issues and failed to identify institutional concerns identified earlier in this report that are the root cause of these problems. Additionally, OAK has not evaluated any of the three LLNL restructurings of the LLNL criticality safety program that have occurred during the last five years.

To address this issue, OAK will ensure that daily operations receive additional oversight through the OAK facility representative program. This program had already made plans prior to this review to provide additional coverage of Building 332. In addition, OAK has committed additional personnel resources to the oversight of LLNL's institutional criticality safety program.

Appendix 1 - Biographical Summaries of Assessment Team

William Bell

Mr. Bell served in the US Navy for four years on two nuclear submarines. During that time he was assigned as a Division Officer for all nuclear related divisions and was responsible for the operation and maintenance of the division's systems. He has over eleven years of commercial nuclear utility design experience, including both primary and balance of pant systems, and was certified by the utility to perform Unreviewed Safety Question Determinations and Evaluations in accordance with 10CFR50.59. He has been with DOE for more than six years and was qualified as a Facility Representative at K-Reactor, Savannah River Site (SRS). He also participated in the K-Reactor restart effort, including assisting in the preparation of a Safety Evaluation Report and a Readiness Assessment. He also participated in evaluating the contractor's Operational Readiness Evaluation for the H-Tank Farm High Level Radioactive Waste Evaporator at SRS. He is currently a qualified Facility Representative for the Los Alamos Critical Experiments Facility at Los Alamos National Laboratory. Mr. Bell has a Bachelor's Degree in Physics from the Florida Institute of Technology and a Masters Degree in Nuclear Engineering from the University of Florida.

Al Evans

Mr. Evans is a Ph.D nuclear physicist in the Office of Basic Energy Sciences in Office of Energy Research. Prior to his assignment to ER, he worked for Defense Programs in the Office of Weapons Research, Development, and Testing. Before coming to the Department of Energy, he worked at the Los Alamos National Laboratory Critical Experiments Facility and the Nuclear Safeguards Division. Prior to that he conducted research at the U.S. Naval Ordinance Laboratory. In 1989 he was the Chairman for the Defense Programs committee to study requirements for continued operations of the Los Alamos Critical Experiments Facility. In 1990 he chaired the committee to appraise criticality safety in Defense Programs facilities. In 1992 he was a member of the radiological safety appraisal team (Office of Nuclear Energy) for the High Flux Isotope reactor at Oak Ridge National Laboratory. Since 1993 he has been a member of the DOE Nuclear Critical Experiments Steering Committee. Mr. Evans has a Ph.D. in Nuclear Physics from the University of Maryland.

Dennis Galvin

Mr. Galvin is a general engineer with the office of Engineering and Operations Support for Defense Programs. He joined the Department of Energy as a technical intern in 1991. As an intern for two and one-half years, he assisted on several engineering assessments, including assisting facility representatives at Rocky Flats for five months and assisting the resident inspectors at the Susquehanna Steam Electric Station for nine months. For the past one and one-half years, he has provided criticality safety support to Defense Programs. Mr. Galvin has a BS in nuclear engineering from Penn State University.

Adolf S. Garcia

Mr. Garcia has, as a Senior Nuclear Safety Specialist for the Idaho Operations Office, Managed DOE's INEL Criticality Safety Program since January 1995. He has twenty years of experience in criticality safety, including four years as a member of Argonne National Laboratory's Criticality Hazards Control Committee and six years as a charter member of Argonne National Laboratory's Nuclear Facility Safety Committee. He has conducted numerous Criticality Safety Assessments for DOE Headquarters and various DOE contractors. Included in these were a Technical Safety Assessment (TSA) of the Lawrence Livermore National Laboratory Plutonium Building, a TSA of the SRP Uranium Canyon, the criticality safety section of the Tiger Team Assessment of Lawrence Livermore National Laboratory, an Operational Readiness Evaluation for DOE-ID for fuel transfers at the ICPP (Idaho), an Assessment of Interim Storage of Plutonium Solutions in F-Canyon and Mark-31 Targets in L-Basin at the Savannah River Site, and an Operational Readiness Review of the FB-Line Facility at the Savannah River Site. He is a charter member of DOE-EH's Nuclear Criticality Technology and Safety Project, and the DOE-EH Criticality Issues Resolution Committee. He provides advisory support in criticality safety issues for DOE Headquarters EM- 4. He has been a member of Subcommittee 8 (ANSI/ANS Criticality Safety Standards) for more than ten years and is presently chairman of the American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors (ANSI/ANS 8.1). He has a BS in General Studies with major in Nuclear Engineering and MS in Nuclear Engineering from Louisiana State University.

Teh Hsieh

Mr. Hsieh is a nuclear safety and natural phenomena hazard specialist for the Oakland Operations Office. He joined DOE at the Savannah River Site (SRS) and worked on the K-Reactor Restart Special Project. He managed for DOE SRSPO (Restart Special Project Office) the K-Reactor SAR Upgrade Program on Chapter 15 Transient and Accident Analyses and the Severe Accident Assessment Program. Prior to Joining DOE, he conducted research of compact nuclear reactors for space applications and space nuclear power systems for NASA at Jet Propulsion Laboratory. Before transferring to DOE/OAK, he worked on the safety requirements for the New Production Reactor (NPR) which included consideration of beyond design basis accidents for both HTGR and HWR. Mr. Hsieh has a PhD in Nuclear Engineering from UCLA and a Master's Degree in Nuclear Engineering from University of Cincinnati.

Mark Lee - Team Leader

Mr. Lee is a nuclear safety specialist for the Oakland Operations Office. He has 11 years of experience in the areas of radiological controls, nuclear emergency planning, safety documentation and safety analysis consisting of: four years DOE experience in nuclear safety and operations with the Oakland Operations Office, and seven years experience as a civilian engineer for the naval nuclear propulsion program. He led the review team for the Readiness Assessment for the LLNL Plutonium Facility. He also led the review team for a multi-disciplinary appraisal of ES&H at LLNL. Mr. Lee attended the University of Missouri-Rolla where he earned a BS in Physics which included extensive studies in Nuclear Engineering.

Douglas A. Outlaw

Mr. Outlaw is a PhD nuclear physicist with a broad safety-related background that includes university teaching, experimental nuclear physics research at a DOE accelerator laboratory and over 17 years of experience in safety analysis and assessment of non-reactor nuclear programs and activities for DOE, NRC, and NASA. Most recently, his efforts have included assisting DOE headquarters in the development of nuclear safety guidance, review of specific nuclear safety concerns at DOE facilities, and serving as a nuclear facility safety expert to DOE for Technical Safety Appraisals and operational Readiness Reviews of DOE facilities. other recent related activities have included criticality safety analyses, probabilistic risk assessments, hazards evaluations, accident consequence modeling, and the preparation of accident analysis portions of safety analysis reports, environmental assessments, and environmental impact statements for DOE, NASA, and others. He is currently serving as a Senior Program Manager and Senior Scientist at SAIC. Dr. outlaw served as a technical expert in the areas of safety analysis, criticality safety, engineering support, and other safety-related areas for facility reviews of DOE Defense Programs facilities. Between 1991 and 1993, Dr. Outlaw served as a technical expert in eight DOE-HQ/DP-67 sponsored Technical Safety Appraisals of DOE major facilities, including Mound Laboratories, Lawrence Livermore National Laboratories, the Pantex Plant, the Nevada Test Site, and the Kansas City Plant. Since 1993, Dr. Outlaw has served on Operational Readiness Reviews for Zone 4 at Pantex and F-Canyon at the Savannah River Site. Among the areas for which Dr. Outlaw had the lead were safety analysis, criticality safety, emergency preparedness, and engineering support.