

**IMPACTS OF THE DECEMBER 15, 1997 LEAKAGE OF LOW-LEVEL WASTE
CONTAINERS ON THE DEPARTMENT OF ENERGY'S TRANSPORTATION AND
LOW-LEVEL RADIOACTIVE WASTE PROGRAMS**

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ABSTRACT

On December 15, 1997, a load of low-level radioactive waste bound for the Nevada Test Site, from the Fernald Environmental Management Project (FEMP) in Ohio, was discovered leaking while traveling Interstate 40 near the city of Kingman, Arizona. The driver responded appropriately, notifying the local authorities, the Assistant Emergency Duty Officer at FEMP, and his company. No radioactive contamination was detected by the responders and they determined that the leaking liquid was not hazardous to the health and safety of the public nor damaging to the environment. The waste packages were prepared for transport and returned to FEMP.

As a result of this incident, many evaluations of the Department's transportation and low-level waste programs were conducted and several actions were taken by the Department in the interim. Among the evaluations were a Type B Accident Investigation, the formation of a Container Working Group to review the programs and provide recommendations to the Department for improvements, reevaluation of the low-level waste programs at each site, evaluation of the effects of the high-liquid-content waste on the disposal site, and reevaluation of the waste acceptance criteria, the waste acceptance program, and disposal operations at the Nevada Test Site.

The result of these investigations, reevaluations, and other actions have led to overall improvements in the Department's transportation and low-level waste programs which will be discussed in depth.

BACKGROUND

On December 15th, 1997, the driver of a truck containing seven containers of low-level radioactive waste noticed that the trailer was leaking as he exited from Interstate Highway 40 near Kingman, Arizona. The driver notified local authorities, the Assistant Emergency Duty Officer at Fernald Environmental Management Project (the shipper), and his company of the leak. Local authorities responded to the scene, as did representatives of the state of Arizona.

The Department of Energy (DOE) dispatched a Radiological Assistance Program Team and a support team from Fernald Environmental Management Project to support the Incident Command.

No radioactive contaminant was detected by the responders and they determined that the leaking liquid was not hazardous to the health and safety of the public or damaging to the environment. The Fernald Environmental Management Project Support Team took custody of the shipment, controlled the leaks, and returned the low-level radioactive waste to Fernald.

The incident precipitated many actions throughout the DOE Complex. Following is a summary of the actions and the results.

ACTIONS

Suspension of Low-Level Waste Shipments via "White Boxes" Pending Fernald Investigation

Alvin L. Alm, DOE Assistant Secretary for Environmental Management, issued a memorandum that suspending shipments of low-level waste in CGR Compacting, Inc. 4' x 4' x 7' white metal boxes pending completion of the Fernald Investigation, implementation of appropriate corrective actions, and DOE Headquarters approval of those actions. The investigations are complete and the CGR boxes, with the exception of the Fernald design, are allowed for shipments of radioactive materials.

Type B Accident Investigation Board. In December, 1997, G. Leah Dever, Manager, Ohio Field Office, appointed a Type B Accident Investigation Board to investigate the event. The Board performed an in-depth evaluation of all facets of the operations at the Fernald Environmental Management Project by interviewing management and workers, examining all relative documents and procedures, having samples of the waste containers analyzed, and evaluating the products used in the waste preparation process.

The Board concluded that free liquid in the containers leaked onto the trailer floor, and later out of the trailer when stress fractures (cracks in two of the shipping containers) were widened by the protracted vibration and wear associated with highway transport. The Board further concluded that the initial stress fractures occurred as a result of routine handling of the containers during loading and staging for shipment at Fernald and that the integrity of the other containers now staged for shipment at Fernald should be examined for similar stress fractures. Review of the contractor procurement process revealed that the design weakness that led to the stress fractures was caused by a series of events, including Fluor Daniel Fernald's (FDF) failure to specify appropriate design requirements in a contract with the container manufacturer, to adequately oversee the design modifications made by the manufacturer, and to conduct appropriate tests of the containers.

The presence of significant quantities of free liquid in the containers was unexpected, since a number of actions specifically intended to eliminate free liquid are routinely performed before shipping. The Board reviewed the procedures that specify these actions and their implementation

at Fernald. This review indicated that the amount of liquid that might separate from the material during shipping and handling was not properly analyzed after earlier shipments were identified as having had free liquid form during shipment. In addition, while sorbent material is routinely added to eliminate any free liquid that might appear, the properties of the sorbent used were misunderstood and, therefore, the sorbent material did not serve the intended purpose.

The Board determined that the root cause of the event was that the FDF contracting process did not deliver a strong, tight container as required by contract specifications. Four contributing causes were also identified: Continued use of the containers for shipping after design flaws were identified as a result of earlier container failures;

- 1• Lack of understanding of the properties of the waste stream (i.e., that a quantity of free liquid could form during transportation);
- 2• A lack of formality and rigor in contractor oversight between DOE Fernald and DOE Nevada; and,
- 3• A failure to provide the appropriate attention and oversight to these shipments of low-level radioactive waste because of the relatively low potential threat to health and safety.

Fernald Waste Program and Corrective Actions Plan

The objective of the FDF Corrective Action Plan was to ensure that the programmatic risks associated with off-site shipments of waste have been adequately considered in the FDF management systems controlling packaging and transportation activities at the Fernald Environmental Management Project (FEMP). The FDF Corrective Action Plan was developed in response to leaking shipping containers of low-level waste being transported from FDF to the Nevada Test Site (NTS). All shipments of low-level waste from the FEMP were suspended. DOE-Ohio directed DOE-FEMP to require FDF to provide a corrective action plan in response to the specific actions identified within the Type B Accident Investigation Board Report within 45 days. DOE-FEMP directed FDF to submit a corrective action plan addressing the judgements of need and issues identified by the Type B Investigations and other evaluations.

In response to the occurrences and in development of the corrective action plan, FDF has taken the following actions:

The President of FDF chartered the FDF Independent Safety Review Committee (ISRC) to conduct an evaluation of the FDF Waste Management Program in support of developing corrective actions to preclude recurrence.

The FDF President directed the General Manager, Fluor Daniel Government Services Operating Company, to charter an external independent review team to provide oversight during development of the FDF Corrective Action Plan. The team consisted of senior personnel with expertise and experience in the areas of procurement and contracting; waste characterization; packaging and transportation; systems/quality assurance, and Nuclear Regulatory Commission oversight.

The FDF Vice President, Waste Management & Technology Division, established multi-disciplined core teams to lead the initiative for developing corrective actions in response

to the pending Type B Report. In addition, the teams were supplemented by external experts in the areas of structural engineering, waste transportation and packaging, process engineering, and risk analysis.

The President of FDF replaced the FDF Vice President of Waste Management & Technology Division.

The FDF President issued a Presidential Directive for implementation of a Contract and Asset Management Corrective Action Plan. This Presidential Directive requires that FDF engineering processes and FDF Quality Assurance(QA)/Quality Control oversight activities be fully integrated into the FDF procurement process to ensure that programmatic risk is fully addressed not only for procurements regarding waste shipping containers but also for all other FDF procurements.

The FDF Corrective Action Plan was completed.

In response to the identified root cause and contributing factors, FDF has categorized corrective actions into the following major areas:

Waste Container Integrity: Establishes corrective actions to ensure that the management systems associated with use and/or procurement of all shipping containers at the FEMP are adequate to ensure no further incidents regarding container integrity occur during transport of FEMP waste to off-site facilities.

Waste Characterization/Free Liquids: Establishes corrective actions to ensure that a documented technical basis has been established for moisture removal/immobilization in specific FEMP waste matrices to meet disposal facility waste acceptance criteria (WAC) for free liquids.

Waste Program Oversight: Establishes corrective actions required to ensure that the procurement process is integrated with engineering and quality assurance programmatic requirements. In addition, the corrective actions ensure that the appropriate level of rigor is applied to WM self-assessment, QA audits, QA surveillances and inspections, WM tracking and trending, and the corrective action close-out process. The corrective actions formalize a more rigorous process for communication and feedback between FDF, DOE-FEMP, and DOE-NV to ensure that programmatic risk associated with all concerns regarding packaging, shipping, and disposal of waste from the FEMP to NTS have been fully identified and addressed.

Waste Shipping Emergency Response: Establishes the corrective actions required to ensure that the appropriate emergency response program has been implemented for transportation incidents for waste shipments from the FEMP to off-site disposal locations.

Programmatic Readiness for Resumption of Shipping: Establishes a systematic approach for evaluating and categorizing the low-level waste inventory in terms of programmatic

risk. Through the Standard Startup Review process, implementation of corrective actions and readiness to resume shipments were systematically evaluated for each waste category.

Of the original seventy corrective actions identified within the corrective action plan, all were completed by the end of December 1998.

The actual effects of these corrective actions has been to significantly improve the level and rigor of planning for these waste shipment activities. As stated in the Type B Investigation Report, although the actual risks to people and environment were considered during the original operations, the programmatic risk associated with having a container leak during transit was not fully appreciated by DOE. The efforts at the site, coupled with the efforts taken by the Office of Waste Management lead review of acceptable container designs for low-level waste shipment further decrease the probability of a similar event occurring in the future.

Field Manager Certification of Low-Level Waste Packaging and Transportation Practices

At the request of James M. Owendoff, Acting Assistant Secretary for Environmental Management, all DOE field managers conducted a thorough review of all low-level waste management packaging and transportation practices. These included:

- 1• Implementation of corrective actions based on the evaluation of the Type B Investigation Report;
- 2• The adequacy of the off-site waste shipment programs to ensure lessons learned are captured, feedback mechanisms are used, and improvements are made;
- 3• Confirmation of the effectiveness of sorbents, especially with high moisture content wastes;
- 4• Evaluation of container design criteria to establish sufficiency to allow the stresses of normal operations and handling;
- 5• Ensuring that the waste container performance requirements and design specifications for both filled and empty containers are included in the Requests for Proposals and in the resulting contracts;
- 6• Ensuring that the acceptance process for the containers resulted in containers which met the Department of Transportation (DOT) for the waste streams to be placed into them;
- 7• Ensuring that detailed design drawings for the waste containers received are available for use by persons performing the acceptance inspections so they can verify dimensions and specifications;
- 8• Inspections of the containers already on site to verify they met design/contract specifications;
- 9• Evaluating the DOE oversight functions to ensure that corrective action closeout processes and verification of closure of findings were completed by the contractors.

As a result of this memorandum, extensive evaluations were conducted. Each site set up evaluation teams consisting of federal and contractor personnel to evaluate its waste programs. Procedures were reviewed, containers were inspected, waste characterization data and methods

were analyzed. Where deficiencies were found, they were corrected; when methods of improvement to operations were found, they were incorporated. Upon completion of the effort, each field manager provided certification to the Acting Assistant Secretary that the site had completed the review and provided him with a listing of the results and changes.

Container Working Group (CWG)

The CWG was chartered to "...Develop Guidance for the use of Strong and Tight Containers, and Industrial Packaging for the Transport of Low-Level Waste." This guidance was required as a result of the Fernald Type B Accident Investigation. The guidance was also intended to improve the safety and health factors associated with the transportation of radioactive waste.

To effectively develop guidance for the use of packaging, the complete low-level waste system, (which is comprised of the waste, the container, secondary containment, waste additives, transportation, waste acceptance and verification, disposal, and all related functions), was considered. It was believed that focusing on improvements in only one aspect assumes that the others have no effect. This was believed to be false and could readily lead to a mistaken belief that the system has been significantly improved.

The CWG reviewed the Type B Accident Investigation Report applicable DOE Orders and procedures, and federal regulations pertinent to low-level waste transportation. Procurement became the initial focus, and recommendations were made to ensure that a comprehensive, straightforward process will be in place to achieve development, design, production, and acceptance of containers that meet integrated performance specifications of all affected organizations and meet all federal regulations and DOE Orders. Therefore, many of the recommendations contained in this document pertain to container design and testing. They also have direct impact on improving the procurement process by increasing the integration of operational considerations with engineering, traffic, and quality assurance and control programs.

Current operations were also analyzed, and recommendations were provided to ensure packages in the complex maintain their integrity. Extra diligence must be exercised to prevent any event that would further discredit the Department. Reevaluation of the containers and their operational stresses, the wastes they contain, and the packing and sorbent materials along with the possible addition of liners or use of overpacks would add additional physical barriers and lead to administrative barriers which should provide safe transport of those containers already in the Department's possession. Careful use of these proven containers, until their current supply was exhausted, was encouraged.

The CWG also believed that many of the packages currently in use may meet DOT Industrial Packaging (IP) standards. Testing of the current packages should be accomplished, and if the packages meet the IP standards, their use could continue without additional precautions at the specific DOE site's option. If the decision is made to adopt a standardized family of containers, those that have already been tested and proven could form the nucleus.

The Working Group further believed that one-time inspection and fix cannot ensure prevention of further occurrences. The Department must institutionalize the positive changes and make

them part of its culture. These changes must be deeply ingrained into the Department's processes and procedures.

Each of the recommendations presented in the report was to be considered as a single step in reaching the Department's goal of safer, more effective waste management, which is more acceptable to the general public. The Working Group believed that none of the individual steps, by themselves, allow the goal to be attained. It was found that, although not all specific recommendations for field elements are in practice at each site, most sites employ some or all of them. It was believed that the recommendations will have a significant, positive impact on the overall safety and credibility of the Department's waste programs, but will not have a major impact on each site's day-to-day operations.

The following is a synopsis of the recommendations contained in this report:

- A more regimented, participative container procurement process
- Require the use of IP specifications as a minimum for the shipment of Low Specific Activity (LSA) waste
- Ensure compliance with the DOT test for determination of solids for materials being transported
- Ensure compliance with DOT regulations, DOE Orders, and receiving site's WAC for all newly generated wastes
- Reevaluation of containers, waste forms, and additives used to ensure stabilized waste
- Additional preventive measures to be used with packages currently in the complex
- Standardization of packaging specifications
- Waste verification at the receiving site
- Independent verification of corrective actions resulting from recommendations and the 6 February EM-1 memorandum
- Enhanced reporting of container breaches

Status on Container Working Group Recommendations

The near and long-term recommendations, as referenced in the CWG Report, are going through additional independent review by DOE Senior Transportation Executive Forum (STEF). The purpose of this additional review is to obtain concurrence by those Program Offices, within the Department, for recommendations that will have an impact on their prospective programs.

The review validated that the long-term recommendations do fall within the purview of STEF, thus, additional teams were assigned to perform tasks, such as, cost benefit analysis. The review team(s) are scheduled for complete there tasks by May 1999. The results of their effort will dictate the implementation effort. Within a year DOE is expected to start full implementation. The recommendation relating to IP standards for packaging, as an example, will require tremendous coordination within the DOE complex to implement successfully.

All near term recommendations have been assigned to Environmental Management (EM) Program, for execution. EM is expected to issue additional guidance to the DOE Field Offices. The field offices will start the process of incorporating applicable elements, within their specific contracts, to ensure implementation at the worker level. Depending on contract arrangements, it may also take up to one year to fully implement these recommendations.

Evaluation of the Effects of Increased Moisture on the Disposal Site

A panel of independent scientists was convened by the DOE to assess the performance impacts of disposal of low-level radioactive waste from the FEMP. A resulting outgrowth of investigations of the transportation incident was the recognition that the waste was transported and disposed in stress-fractured metal boxes and some of the waste contained excess moisture (high volumetric water contents). The panel was charged with determining whether disposal of this waste in the Area 5 radioactive waste management site on the NTS has impacted the conclusions of the completed performance assessment.

The panel was assembled from a list of candidates that was submitted to the DOE/EM, the DOE/Headquarters and representatives of the state of Nevada. The following criteria were used to select candidates for participation on the independent panel:

- Multi-disciplinary background with established expertise in one or several of the fields of performance assessment, risk assessment, vadose-zone hydrology, geology of the NTS, engineering, chemistry and health physics/risk-dose assessment.
- Demonstrated experience and familiarity with risk assessment and performance assessment studies for disposal of low-level radioactive waste.
- Limited or no current involvement in the ongoing disposal operations or contractor studies of the low-level radioactive waste sites sponsored by the DOE. However, some prior exposure to and understanding of these programs is desirable to avoid delays from the acquisition of background information necessary to conduct the panel studies.
- Knowledge of the hydrologic and geologic setting of the NTS and the alluvial basins of Yucca Flat and Frenchmen Flat.
- Priority was given to qualified researchers living in or associated with research institutions located in the state of Nevada.

- Availability for required panel activities during an approximate 30-day period.

A series of questions were developed by the panel to assess performance impacts. These questions are categorized into three topics: 1) the performance impacts from reduced container integrity, 2) the impact of reduced container integrity on subsidence of waste in the disposal pits and, 3) the performance impacts of excess moisture. No performance or subsidence impacts were noted from disposal of the Fernald waste. The impacts of excess moisture were assessed through simulation modeling of the movement of moisture in the vadose zone assuming high water contents ("wet waste") for different percentages of the waste inventory. To evaluate sensitivity to different percentages of waste inventory with excess moisture, simulation modeling of moisture redistribution in alluvial deposits of the vadose zone was conducted. No performance impacts were noted for either the base-case scenario (ambient conditions) or a scenario involving subsidence and flooding of the waste cells. The absence of performance impacts results from the extreme conservatism used in the Area 5-performance assessment and the robust nature of the disposal site. The combination of the arid climate, low moisture content of the valley-fill alluvium and the considerable depth to the water table results in an exceptionally viable site for disposal of low-level radioactive waste.

Review of Nevada Waste Program

As a result of the Fernald Type B investigation, several reviews of the Nevada Waste Operations were conducted. They included the Radioactive Waste Acceptance Program (RWAP), the Nevada Test Site Waste Acceptance Criteria (NTSWAC), the DOE/NV Waste Management Division (WMD) Notification Requirements and Processes, and the Shipment Receiving Activities at the Radioactive Waste Management Sites. Teams consisting of federal and contractor personnel from the Nevada Operations Office and other DOE sites throughout the complex were assembled to conduct the reviews and to recommend any corrective actions they deemed appropriate.

RWAP

The RWAP team concluded that no deficiencies or observations identified during the review directly contributed to the Fernald incident. They did discover two deficiencies: 1) that there was no objective evidence that instruction or documented administrative controls existed for the work processes related to the Low-Level Waste Information System databases activities being performed by the RWAP, and 2) a documented process controlling the RWAP evaluation and incorporation of shipment discrepancies into waste acceptance activities was not evident.

The team also noted twelve observations and five recommendations. Observations are considered areas of concern where process improvements should be considered to preclude potential non-compliance and require a response describing the corrective actions but do not require root cause analysis or action to prevent recurrence. The recommendation resulting from the observations were: 1) evaluating the need for a lessons learned program for disseminated to the generating sites, 2) evaluate the need for clarification of when waste profiles are to be submitted and ensure the NTSWAC reflects this, 3) the RWAP team attend formal root cause analysis training so they can better evaluate Corrective Action Plans, 4) ensure the correct personnel be included on distribution for approval letters and notification of program changes by

establishing and maintaining formalized distribution lists, and 5) the RWAP procedures should be revised to clarify the roles of the Functional Leads and Key Staff when performing biennial evaluation of auditor and functional qualifications.

NTSWAC

The review team concluded that the criteria contained within the current NTSWAC was consistent with the current disposal regulations and did not contribute to the Fernald incident. The team did recommend improvements to the NTSWAC to add clarity and to aid in precluding similar incidents in the future. Among these recommendations were that guidance be developed for high moisture content wastes, change the Suspending or Withdrawing Approval section to include examples of discrepancies that could result in suspensions, revise the Waste Criteria section to include a general compliance statement that waste shall be managed and transported in accordance with federal, state, and local regulations and requirements, and several others concerning waste characterization and transportation methodologies. The accepted recommendations will be incorporated into the next revision of the NTSWAC which is anticipated to be published by April 1999.

WMD Notification Requirements and Processes

While the team concluded that notifications requirements of the time were followed, clarifications were needed for future notifications that fall outside the Occurrence Reporting System. Among the notifications that should be made were any significant events as described in the 1997 memo from Secretary Peña. In addition, WMD needed to develop guidance for personnel reporting or courtesy notification to management and the DOE/NV Emergency Operations Center. Further investigation led to the conclusion that the State should also be notified of any significant events that might be related to the transportation or management of radioactive waste bound to the NTS for disposal.

As a result, a formal WMD notification protocol was formulated and implemented. Specific notifications and formats were designated to reduce the possibility that pertinent information is omitted and that a key person or office might be missed.

Low-Level Waste Shipment Receiving Activities.

A thorough review of operational procedures and operations of the NTS RWMS's shipment receiving activities was conducted. This was done by document reviews, interviews with management and staff personnel, and observing activities as they were performed by trained personnel. The deficiencies identified were that there was 1) a lack of a documented process for actions to be taken upon the discovery of shipment discrepancies in regards to notifying generators and DOE/NV and 2) that there was no objective evidence that the work processes incorporated controls for ensuring that radionuclide inventories of packages are being compared against the radionuclide inventories identified on approved waste profiles.

In addition, there were several observations such as lack of updated procedures, lack of a documented process for verification of pre-shipment notification data against the approved waste profiles, and currency of other procedures. Again, none of the observations highlighted critical

items but pointed out items that needed to be corrected to improve overall efficiency and accuracy.

The management and operating (M&O) contractor proceeded to correct the deficiencies by designing and implementing procedures for notifications and verifications of waste package contents against approved waste stream profiles. The M&O also initiated actions to ensure all procedures were current and available for use by operations personnel.

CONCLUSION

The Fernald Leaking Waste Container incident resulted in a multitude of actions throughout the complex which has improved the overall effectiveness and safety of the Departments Waste Management and Transportation Programs.

The actions included:

- A complete review and revision of Fernald's LLW program with changes in personnel and procedures;
- Recommendations from the Container Working Group that could significantly improve the transport of all wastes, institutionalize many of the practices in use by the DOE, and possibly prevent the occurrence of a similar incident through early reporting of "precursor" events;
- Re-evaluation of all sites' LLW programs with certifications of these evaluations and statement of corrective actions;
- Re-evaluation of the disposal site's capability by an external review group;
- Improvements in operating procedures at the disposal site, and;
- Improved reporting and communications between the disposal and generating sites.

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