# DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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January 29, 2007

The Honorable James A. Rispoli
Assistant Secretary for Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Mr. Rispoli:

The staff of the Defense Nuclear Facilities Safety Board (Board) has observed transuranic (TRU) waste dispositioning activities at Department of Energy (DOE) sites for several years. These activities have included characterization, packaging, and shipping TRU waste to the Waste Isolation Pilot Plant (WIPP). In the process of these reviews, the Board has noted a lack of a consistent approach to operational safety related to TRU waste activities at the generator sites, prior to shipping certified TRU waste drums to WIPP. Because of the nature of the TRU waste activities, worker safety has been the primary concern. Los Alamos National Laboratory is a notable exception, where public safety is also at risk because of the proximity to the site boundary.

The Board notes that your office has issued for review the draft DOE Standard, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. If comprehensively drafted and properly implemented, this Standard should diminish the inconsistencies that currently exist. The enclosed report summarizing several years of observations on TRU waste operations has been prepared by the Board's staff and is provided for your information and use. In particular, the report highlights good practices as well as shortcomings that should be useful in the preparation and review of the draft Standard.

Sincerely,

A. J. Eggenberger
Chairman

c: The Honorable Thomas P. D'Agostino
Mr. Mark B. Whitaker, Jr.

**DEFENSE NUCLEAR FACILITIES SAFETY BOARD**

# Staff Issue Report

December 28, 2006

**MEMORANDUM FOR:** J. K. Fortenberry

**COPIES TO:** Board Members

**FROM:** D. Winters

**SUBJECT:** Worker Protection During Transuranic Waste Operations

The staff of the Defense Nuclear Facilities Safety Board (Board) has been reviewing transuranic (TRU) waste activities at the Department of Energy's (DOE) nuclear facilities for several years. The staff's reviews have focused on proper hazard identification and analysis and the development of appropriate controls. Because of the nature of the TRU waste activities, worker safety has been the primary concern. Los Alamos National Laboratory (LANL) is a notable exception, where public safety is also at risk because of the proximity of these activities to the site boundary. This report documents the staff's observations regarding good practices as well as shortcomings in the handling of TRU waste drums at the various DOE sites.

**Background.** The Waste Isolation Pilot Plant (WIPP) in New Mexico began receiving contact-handled transuranic (CH-TRU) waste for disposal in 1999 and has received more than 5,000 shipments to date. One major site, the Rocky Flats Environmental Technology Site (RFETS), and several small-quantity sites have completed shipment of all their TRU waste to WIPP. Other sites, primarily LANL, the Hanford Site (Hanford), the Savannah River Site (SRS), the Idaho Cleanup Project (ICP), and Oak Ridge National Laboratory (ORNL) continue to characterize and package CH-TRU waste and ship it to WIPP.

The primary hazards faced by workers handling TRU waste drums include drum drops, overpressurizations, fires, and explosions. These accidents can release the radioactive contents of the drums. Although most of the TRU drums contain small quantities of radioactive materials (average loadings are a few curies), nearly all drum populations contain some drums with many hundreds of curies. In addition, a drum explosion in close proximity to workers could cause death or serious injury.

Several fires in TRU drums have occurred around the complex and are discussed in more detail below. A waste drum explosion occurred at the Fernald Site in Ohio in 1991 (Occurrence Reporting and Processing System [ORPS] report EM-ORO--WMCO-FEMP-1991-0004). Although this drum contained uranium rather than plutonium, the explosion hazard is identical. A water-uranium reaction created hydrogen gas that collected in the headspace of the unvented drum. This hydrogen was ignited simply by moving the drum and causing a spark from free

metal inside the drum. Luckily, no workers were seriously injured. However, the explosion was so loud that one worker experienced hearing loss.

The staff's reviews have focused on TRU waste retrieval, characterization, packaging, and shipment activities and programs at various sites across the complex. Site visits and meetings since October 2004 are listed below.

- ORNL Waste Activities (November 2006)
- LANL Waste Activities (August 2006)
- TRU Waste Activities at ICP (June 2006)
- Authorization Basis Nuclear Safety Workshop (March 2006)
- ORNL Waste Management (February 2006)
- National TRU Waste Program Status (January 2006)
- Richland Operations Office Projects (January 2006)
- New Contractors at ICP (May 2005)
- TRU Waste Program Activities (April - May 2005)
- TRU Waste Drum Handling, SRS (February 2005)
- Current State of Idaho National Laboratory (February 2005)
- Oak Ridge Environmental and Waste Management Activities (January 2005)
- TRU Waste Program at WIPP and LANL (January 2005)
- TRU Waste Retrieval, SRS (November 2004)
- WIPP and National TRU Waste Program Status (October 2004)

**CH-TRU Operations at SRS.** The legacy inventory of TRU waste at SRS included more than 30,000 drums and 2,000 large containers. Operators at SRS have made good progress in reducing this inventory by shipping certified TRU waste drums to WIPP. What remains of this inventory, in addition to newly generated TRU waste, are approximately 10,000 legacy drums and 2,000 large containers. The early shipping campaigns at SRS focused on low-curie drums, so the remaining drums are expected to contain more plutonium, including more plutonium-238, and will be more hazardous.

Prior to 2004, SRS analysts assumed that a drum deflagration accident was not likely in an unvented TRU waste drum. This assumption was based on the belief that in a closed TRU waste drum, oxygen is consumed as hydrogen is generated. However, as more sites processed waste and sampled the headspace of unvented TRU waste drums, the sampling data clearly showed that a small but significant fraction of all unvented drums contained hydrogen and oxygen in concentrations that would support deflagration. Such data are well documented at Idaho (see the report *Idaho National Engineering Laboratory Code Assessment of the Rocky Flats Transuranic Waste*, INL-95/0281, July 1995) and SRS.

In November 2004, SRS analysts declared a positive Unreviewed Safety Question (USQ) (see Occurrence Report SR-WSRC-SW&I-2004-0015) that recognized the hazard posed by potential deflagrations in unvented TRU waste drums. In response, managers at SRS implemented a new suite of safety-related controls to protect workers from such deflagrations. These controls were documented in a Justification for Continued Operations applicable to the TRU waste handling activities.

Specific measures taken to protect workers included personnel exclusion zones during drum movements, a robust blast cage for unvented drums, drum lid restraints, long-handled tools to move workers away from the drums, and "breathing" times for newly vented drums to allow hydrogen to dissipate below the lower flammability limit (4 percent hydrogen by volume). A full listing of controls for a drum deflagration is given in Table 1, which compares the controls used at several sites. The staff notes there is a wide disparity in the control sets used at the different sites.

Also in 2004, SRS analysts declared another positive USQ recognizing a similar deflagration hazard posed by the presence of volatile organic compounds (VOCs). One prevalent source of these VOCs was found to be solvents absorbed into rags that were included in the debris waste. Many of the controls put in place to address the hydrogen deflagration hazard were sufficient to prevent or mitigate the VOC deflagration hazard as well.

The staff believes that the current control set implemented at SRS has been appropriate and should be reviewed by other sites that process unvented drums. The staff also understands that the Savannah River Site is considering modifying their control set in order to accelerate the venting of unvented drums and their subsequent disposal. These modifications and their risk tradeoffs will be evaluated by the staff as they are developed.

**Waste Operations at the Hanford Site.** Previous contractors at the Hanford Site buried large quantities of TRU waste, low-level waste, and low-level mixed waste in dozens of large burial trenches. DOE plans to retrieve most of the TRU waste buried post-1970. To date, Hanford operators have shipped more than 8,500 drums of TRU waste to WIPP, and expect to ship a total of 75,000 drums by 2010. Operators are now retrieving TRU waste from trenches that are part of the Solid Waste Operations Complex (SWOC) in the 200-West area of Hanford.

Worker safety at the SWOC is achieved in part through the safety management programs; safety-significant structures, systems, and components; Technical Safety Requirement (TSR)

administrative controls; and defense–in–depth controls. For example, workers are protected from hazards associated with TRU waste drums through identification of potential hazardous conditions (i.e., suspect or bulging containers) using a container management program. The SWOC safety basis relies on the robustness of the waste container to prevent a release provided the container passes inspection.

Worker safety is also provided by a container venting system through the use of a nonsparking or grounded drum penetrator (typically cold drilling) that vents the container without causing ignition. This system is credited in the TSR as a safety-significant system. The system also prevents uncontrolled ejection of the drum lid to protect workers from injury and reduces the amount of radioactive material that would be ejected from the drum. Unvented TRU drums that contain plutonium beyond a threshold amount are placed in vented overpacks with lid and bottom restraints, and unvented containers that cannot be overpacked because of bulging require emergency response including emergency venting. Unvented drums are processed through the venting system. After venting and measurement of hydrogen concentration, drums are stored in a staging area for a predetermined period until their hydrogen concentration dissipates below 5 percent.

The staff notes that the hydrogen control level at Hanford is less conservative than that used at other sites. The potential degradation of the TRU waste drums during long periods of storage and burial introduces a tremendous uncertainty in the drum's ability to withstand a deflagration. Also, it is not apparent that the Hanford control level accounts for measurement uncertainty.

The Master Documented Safety Analysis for the SWOC at Hanford states that unvented drums are not expected to have sufficient oxygen levels to allow combustion with any hydrogen present, and it is concluded that drums are not expected to undergo deflagration during removal and transfer. This conclusion is based on "no reported instances of deflagration during handling and transport." According to the safety analysis, DOE complex-wide data show that at levels of hydrogen greater than 15 percent, there is generally little or no oxygen to support deflagration. Recent experiences at ICP and the SRS contradict this conclusion. The staff believes it is appropriate for DOE to update the safety and technical bases to reflect the known existence of flammable mixtures of gases in the headspace of unvented TRU waste drums.

**CH-TRU Operations at ICP.** The staff reviewed TRU waste handling activities at the Advanced Mixed Waste Treatment Project (AMWTP) several times in the past 2 years. Operators at AMWTP continue to retrieve TRU waste drums from earthen bermed above-ground storage, characterize the waste, repackage it if necessary, and prepare packaged waste for shipment to WIPP. The AMWTP still contains more than 30,000 TRU waste drums and boxes, most of which are unvented and a portion of which are deteriorated. Some of these TRU drums are known to generate hydrogen gas. Hydrogen and oxygen have been measured in flammable concentrations in the headspace of TRU drums, and a TRU drum fire occurred at AMWTP in 2003 (ORPS report EM-ID-BNFL-AMWTP-2005-0008).

Drum deflagrations and fires are recognized as anticipated events in safety basis for the AMWTP. The accident analysis concludes that the deflagration accident does not result in consequences that exceed evaluation guidelines for dose to the public, so no safety-class controls are required. Furthermore, the accident analysis concludes that worker risks are low, so no safety-significant controls or specific administrative controls (SACs) are required. The staff does not agree with this conclusion. The staff believes there is the potential for "serious injury" or "significant radiological exposure" from a drum deflagration accident. According to DOE Standard DOE-STD-3009, *Guidelines for the Preparation of Nuclear Facility Documented Safety Analyses*, such consequences require that "safety-significant" controls should be considered.

After another TRU drum fire occurred at Idaho's Accelerated Retrieval Project in 2005 (ORPS Report EM-ID-CWI-RWMC-2005-0012), managers at the AMWTP implemented new process controls, including LEXAN® shields between workers and drums, long-handled tools to move workers away from drums, and drum lid restraining devices for bulged drums (see Table 1). Although these controls added some protection, they were simply process controls, not formal, and were not reviewed and approved by DOE. Furthermore, the staff noted that operators at ICP, unlike operators at other sites, were not measuring hydrogen, oxygen, or VOCs in unvented drums—information essential to analyzing the hazard faced by the workers. The staff discussed these issues with representatives of DOE Idaho Operation Office and the contractor, who agreed verbally to consider formalizing the controls in some manner, such as through the use of SACs.

**CH-TRU Waste Operations at LANL.** Operators at LANL have been shipping TRU waste drums to WIPP for several years. However, the pace of shipments has been slow, and the total inventory of TRU waste at LANL has not changed appreciably. The waste areas at LANL (primarily Technical Area-54) still store more than 20,000 containers holding approximately 120,000 curies of TRU waste.

At LANL, all TRU waste drums retrieved from underground have been vented, with a few exceptions. Most drums are also in reasonably good condition and are required by the LANL authorization basis to provide a safety-class confinement function. Most drums are stored on pallets and secured by steel banding to prevent drops that may breach the drums. In general, the staff believes that the procedures and controls to prevent drum drops and drum deflagrations are adequate to protect the workers.

The authorization bases for TRU waste facilities at LANL note that the most significant public risk is driven by fires caused by seismic events and airplane crashes. Because of the source term in the TRU waste and the proximity of the waste to the site boundary, these fire scenarios result in dose consequences that far exceed evaluation guidelines for dose to the public. Therefore, the authorization bases call for the implementation of several safety-class controls. Operators at LANL have implemented these controls with varying degrees of success.

At LANL, the most effective method of reducing risks to the public and workers posed by the TRU waste is to reduce the TRU waste source term. The staff believes it would be prudent

for DOE to remove TRU waste from LANL in the most expeditious manner consistent with safe operations.

**CH-TRU Operations at ORNL.** At ORNL, CH-TRU waste is stored primarily in approximately 3,500 drums located in several steel buildings known as the Melton Valley Solid Waste Storage Facilities. In previous years, operators transferred liquid waste, vented drums, and other TRU waste containers to the TRU/Alpha Low Level Waste Processing Facility nearby to be processed and prepared for shipment to WIPP. However, most of the remaining drums in storage are unvented and are required to be vented prior to movement.

The staff has reviewed the ORNL TRU waste operations several times in the past two years, and found a reasonably conservative approach in providing for worker protection. Because the drum venting capability at ORNL was just established in 2006, the development of this capability benefited from many of the lessons learned at other DOE sites.

The handling of unvented drums and the drum venting process are accompanied by a reasonable suite of safety controls that serve to provide adequate protection to the workers. For example, in recognition of the hydrogen deflagration hazard, operators are required to measure hydrogen, oxygen, and VOCs in unvented drums as the drums are vented. This activity takes place in an enclosed, remotely-operated trailer. If operators find the hydrogen concentration to be greater than 3.6 percent, then they are required to purge the drum with inert gas until the hydrogen level is reduced to approximately 1 percent. The drum is then staged and allowed to breathe for as long as 45 days. The hydrogen control level of 3.6 percent is based on applying a 10 percent instrument uncertainty to the lower flammability limit of 4 percent. All controls for a potential drum deflagration are listed in Table 1. The staff believes the controls implemented at ORNL are appropriate and adequate.

**Consistency in TRU Waste Activities.** In March 2006, DOE managers established a TRU waste authorization bases workshop and have held several working group meetings since then. DOE also sponsors a TRU Waste Corporate Board that provides direction on complex-wide TRU waste issues. The Board's staff attended many of these meetings and provided informal feedback to DOE on a real-time basis. The DOE efforts have a goal of establishing a consistent process for developing authorization basis documents for TRU waste activities. The staff believes that the observations presented in this report can be useful to DOE in their efforts.

In order to address safety issues related to TRU waste activities and to achieve consistency, DOE managers drafted a new DOE standard in the Fall of 2006. The Standard, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Activities*, entered the review and comment process in late November 2006. The Board's staff is reviewing and will provide comments separately on this standard.

# Table 1. Comparison of Controls for Deflagration of Unvented Drums+

| Location | Material at Risk | Frequency | Unmitigated Consequence | | | Safety Significant Controls | Other Controls | H2 Control | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | Pu-239 Equiv Ci | | Worker | Onsite | Offsite | | | vol% | |
| ORNL - Melton Valley Solid Waste Storage Facilities | 392 (1 max loaded drum) | Anticipated | High | High | Low | • Non-Sparking Drum Penetrator Tip<br>• Drum Purging System<br>• Drum Vent<br>• Grounding Mat<br>• Spill Pallet - *<br>• HEPA Filter<br>• Portable Unit<br>• Drum Handling Equipment<br>• Lid Restraint - * | • Procedures and Training - #<br>• Movement Restrictions - * | 3.6 | |
| INL - Advanced Mixed Waste Treatment Project | 154.6 (1 max loaded drum) | Extremely Unlikely | Not evaluated: No personnel in venting structure | Low 16 rem | Low 0.55 rem | • None | • Procedures and Training - #<br>• Movement Restrictions<br>• Remote Penetration in Venting Enclosure - *<br>• Industrial Hygiene Program<br>• Conduct of Operations<br>• Procedures of Training<br>• Ignition Source Control<br>• Fire Suppression - #<br>• Maintenance - #<br>• Radiation Protection Program - #<br>• Personal Protective Equipment<br>• Emergency Preparation | Not measured | Inconsistent use of frequencies/consequences |
| | Average drum | Unlikely | Low 11 rem | Low 0.35 rem | Low 0.013 rem | | | | |
| SRS - Solid Waste Management Facility | 1170 several drums involved in deflagration | Anticipated | Moderate | Moderate 49 rem | Low 0.1 rem | • Drum Venting System Cabinet<br>• DVS Filtration Ductwork<br>• DVS Blast Shield<br>• Forklift Design - &<br>• Engineered Transport Box - &<br>• Hoist Shield - & | • Nitrogen Inerting<br>• Procedures and Training - #<br>• Emergency Preparation - #<br>• Fire Response - #<br>• Slow Drill Speeds<br>• Vehicle Restrictions - &<br>• Personnel Restrictions - &<br>• Standoff Distances - & | 4.0 | |
| Hanford - Solid Waste Operations Complex | 82.5 (1 drum) This is not a max but is justified as conservative as drums with higher TRU tend to have multiple containments or stable matrices | Anticipated | High or Moderate such that controls are required for worker protection | Moderate | Low 0.057 rem | Drum Venting System—Three Types<br>Type 1<br>• Cold Drilling<br>• Grounding/Bonding<br>• Confinement/Distance<br>Type 2<br>• Non-Sparking Penetrator<br>• Lid Restraint or Physical Barrier<br>• Distance/Shielding<br>Type 3<br>• Cold Drilling<br>• Grounding/Bonding<br>• Lid Restraint<br>• Remote Activation/Distance | • Vented overpacks may be used for drums with >33 PE-Ci | 5.0 | Additional admin controls required for certain higher risk drums |
| LANL TA-54 Area G | 300 | Beyond Extremely unlikely | | | High 30 rem | • TRU Waste Container (Safety Class) | • Installed and Inspected Vents<br>• Overpacks | N/A | All drums either already vented or overpacked at LANL |

+ - Deflagration accident used as one example. Each facility evaluates all credible accidents.

* - Specific Administrative Control in TSRs

# - Other TSR Administrative Control

& - Additional Justification for Continued Operations Controls (SRS Only)

# References for Table 1.


**ORNL**

**Documented Safety Analysis (DSA):** *Documented Safety Analysis for the Melton Valley Solid Waste Storage Facilities*, DSA-OR-MVSWSF-0019, Rev. 8A, January 2006
**Technical Safety Requirements (TSR):** *Technical Safety Requirements for the Melton Valley Solid Waste Storage Facilities*, TSR-OR-MVSWSF-0018, Rev. 8B, February 2006

**INL**

**DSA:** *Idaho National Laboratory Advanced Mixed Waste Treatment Project Documented Safety Analysis,* AMWTP-RPT-DSA-02, DRAFT Rev. 4, June 2006
**TSR:** *Technical Safety Requirements Advanced Mixed Waste Treatment Project,* AMWTP-RPT-ESH-03, DRAFT Rev. 6, June 2006

**SRS**

**Safety Analysis Report (SAR):** *Savannah River Site Solid Waste Management Facility Safety Analysis Report*, WSRC-SA-22, Rev. 5, January 2005
**TSR:** *Technical Safety Requirements Savannah River Site Solid Waste Management Facility*, WSRC-TS-65-19, Rev. 9, October 2005
**Justification for Continued Operations (JCO):** *Solid Waste Management Facility Handling and Processing of Flammable Containers on SWMF TRU Waste Pads; Justification for Continued Operation,* WSRC-TR-2004-00618, Rev. 9, September 2006

**Hanford**

**DSA:** *Master Documented Safety Analysis for the Solid Waste Operations Complex,* HNF-14741, Rev. 2A, April 2005
**TSR:** *Technical Safety Requirements for the Solid Waste Operations Complex,* HNF-15280, Rev. 2A, April 2005

**LANL**

**DSA:** *TA-54 Area G Documented Safety Analysis,* ABD-WFM-001, Rev. 0, April 2003
**TSR:** *Technical Safety Requirements for the Technical Area 54, Area G*, ABD-WFM-002, Rev. 0, April 2003