Transportation Safety Excellence in Operations Through Improved Transportation Safety Document

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Abstract

A recent accomplishment of the Idaho National Laboratory (INL) Materials and Fuels Complex (MFC) Nuclear Safety analysis group was to obtain DOE-ID approval for the inter-facility transfer of greater-than-Hazard-Category-3 quantity radioactive/fissionable waste in Department of Transportation (DOT) Type A drums at MFC. This accomplishment supported excellence in operations through safety analysis by better integrating nuclear safety requirements with waste requirements in the Transportation Safety Document (TSD); reducing container and transport costs; and making facility operations more efficient.

The MFC TSD governs and controls the inter-facility transfer of greater-than-Hazard-Category-3 radioactive and/or fissionable materials in non-DOT approved containers. Previously, the TSD did not include the capability to transfer payloads of greater-than-Hazard-Category-3 radioactive and/or fissionable materials using DOT Type A drums. Previous practice was to package the waste materials to less-than-Hazard-Category-3 quantities when loading DOT Type A drums for transfer out of facilities to reduce facility waste accumulations. This practice allowed operations to proceed, but resulted in drums being loaded to less than the Waste Isolation Pilot Plant (WIPP) waste acceptance criteria (WAC) waste limits, which was not cost effective or operations friendly. An improved and revised safety analysis was used to gain DOE-ID approval for adding this container configuration to the MFC TSD safety basis.

In the process of obtaining approval of the revised safety basis, safety analysis practices were used effectively to directly support excellence in operations. Several factors contributed to the success of MFC's effort to obtain approval for the use of DOT Type A drums, including two practices that could help in future safety basis changes at other facilities.

1) The process of incorporating the DOT Type A drums into the TSD at MFC helped to better integrate nuclear safety requirements with waste requirements. MFC's efforts illustrate that utilizing the requirements of other disciplines, beyond nuclear safety, can provide an efficient process. Analyzing current processes to find better ways of meeting the requirements of multiple disciplines within a safety basis can lead to a more cost-effective, streamlined process.

2) Incorporating the DOT Type A drums into the MFC TSD was efficient because safety analysts utilized a transportation plan that provided analysis that could also be used for the change to the TSD addendum. In addition, because the plan they used had already been approved and was in use by the Idaho Cleanup Project (ICP) at the INL, justification for the change to the TSD was more compelling. MFC safety analysts proved that streamlining a process can be made more feasible by drawing from analysis that has already been completed.

1. Background

In January 2006 the Idaho National Laboratory (INL) Materials and Fuels Complex (MFC) issued an addendum[1] to the "MFC Transportation Safety Document"[2] (TSD) in response to a potentially inadequacy in the safety analysis (PISA) declaration. The addendum replaced the requirements identified in the TSD for transfers of Hazard Category (HC)-3 or greater quantities of radioactive material using non-Department of Transportation (DOT) compliant packages. It approved the transfer of cask configurations that appeared on an approved cask list. It also approved the transfers of HC-3 or greater quantities of radioactive material using non-DOT compliant packages in accordance with configurations and parameters given in Appendix A of the addendum. The addendum noted that per PLN-2005, now NS-18308,[3] "MFC Work Plan for Safety Basis Upgrade," the TSD would be upgraded to fully resolve the unresolved safety question (USQ). Until the upgraded TSD was approved, the TSD addendum would provide the controls needed to allow transportation activities to continue.

Later in 2006, several issues were revised in the addendum. One improvement in particular provided for a more efficient transportation packaging process. Previously, the MFC TSD addendum did not include the capability to transfer greater-than-HC-3 waste using DOT Type A drums. This proved a problem for facilities at MFC that were packaging waste to send to Waste Isolation Pilot Plant (WIPP), which requires the use of Type A drums for transfer of waste. In order to use the Type A drums, MFC facilities were forced to dilute the waste materials, reducing the waste levels to less-than-HC-3 quantities. This reduced drum waste accumulations, keeping the quantities less-than-HC-3, which allowed the facilities to continue to use the Type A drums. Though this practice allowed operations to proceed, it was inefficient. It resulted in drums being loaded to less than the WIPP Waste Acceptance Criteria (WAC) waste limits, which was not cost effective or operations friendly. To correct this, MFC nuclear safety personnel chose to modify the TSD addendum to gain DOE-ID approval for using DOT Type A drums for greater-than-HC-3 quantities. They worked to integrate nuclear safety requirements with waste requirements to help the TSD addendum more effectively support operations.

To document the specific operational parameters necessary to safely transport the waste, the INL created Engineering Design File (EDF)-6981,[4] a supporting reference document to the TSD addendum. The EDF noted that the proposed payload/container configuration for DOT Type A drums at MFC met the parameters and limits already in use in other similar approved MFC inter-facility transfers of HC-3 or greater, i.e., transfers in PLN-1851, "Transport Plan for the Transfer of Waste Containers between RWMC and INTEC, and RWMC and MFC."[5] The proposed payload configuration for DOT Type A drums at MFC incorporated the same parameters and administrative limit values already approved in PLN-1851 for the transfer of CH-TRU waste between INL facilities. According to EDF-6981, "The analysis contained in PLN-1851, demonstrates that the stated transport controls, including TSRs, provide equivalent safety to DOT and NRC requirements." By referencing a plan already approved and in use at the INL, MFC was better able to justify the addition of DOT Type A drums to the TSD.

DOE-ID reviewed and approved the revised safety basis addendum in October 2006, allowing the desired inter-facility transfers of HC-3, contact handled (CH)-transuranic (TRU) waste quantities in DOT Type A drums. This revision allowed for a more cost-effective, streamlined process for facility operations at MFC.

2. Process of Revising the TSD Addendum

The method that MFC used to add DOT Type A drums to the TSD addendum provides a process that can be applied to future similar modifications. Two concepts are especially worthwhile and applicable to any facility looking to modify their safety basis to make their work process more efficient.

1. The process of incorporating the DOT Type A drums into the TSD at MFC helped to better integrate nuclear safety requirements with waste requirements. Nuclear safety was concerned with keeping transportation within the bounds of transportation requirements and cask requirements, while WIPP WAC was concerned with keeping packaging and waste amounts within the required waste limits. These requirements did not always clearly mesh. By considering the requirements and limits all together, safety analysts were able to create a streamlined process that satisfies the nuclear safety basis requirements, as well as WIPP WAC waste limits. The improved process is not only more efficient than the previous process, but also less costly.

   MFC's efforts prove that understanding the requirements of other disciplines, beyond nuclear safety, can provide for a more efficient processes. Analyzing current processes to find better ways of meeting the requirements of several disciplines can lead to a more cost-effective, streamlined process.

2. Incorporating the DOT Type A drums into the MFC TSD took less time and effort than expected because safety analysts found a transportation plan, PLN-1851, which provided analysis that could also be used for the change to the TSD. Because the PLN had already been approved and was in use by the Idaho Cleanup Project (ICP), MFC was able to justify the addition of the DOT Type A configuration to the safety basis.

   MFC learned that streamlining a process can be made more feasible by considering analysis that has already been completed. The safety analysis process can be made easier by taking advantage of work that has already been done. This is extremely effective when the analysis being used is already approved and in use, since this helps to validate the new change.

The next several sections of this paper will more fully detail the two concepts from above by describing the process MFC went through to obtain approval of the revised TSD addendum.

3. Integrated Approach

An integrated approach was essential for operational excellence at MFC and required an intimate knowledge of the WIPP WAC and nuclear safety TSD requirements. The WIPP WAC provided the basis for drum requirements, including contents, sizes, vent, gasket material, and closure requirements. The TSD provided the basis for type of transport vehicle, transfer route, speed of the transport, and nuclear safety analysis. The TSD had to consider measures to reduce a potential radioactive material release, to reduce direct radiation exposure, and to maintain criticality safety during transportation. An integrated approach ensured that the basic requirements of shipping were covered under the TSD, and acceptance of the nuclear operations waste was completed per the WAC of the disposal facility.

Several waste requirements were considered in this process. For example, the Pu-239 fissile grams equivalent (FGE) for nuclear criticality had to be < 200 grams/55 drum. This was to ensure the container would not have the capability to undergo a nuclear criticality. WIPP also required that the calculation included two times the measurement error.

Additionally, from a waste requirements stand point, the Pu-239 Equivalent activity (PE-Ci) had to be ≤80 PE-Ci per 55-gallon drum. This was used to control radiation exposure to workers handling the drum during storage, transportation, and disposal operations. The calculation documented that each container on the shipment was less than 80 grams of Pu-239 equivalent activity, which was documented using radionuclide-specific weighting factors. The majority of radionuclides generated/dealt with at MFC have a weighting factor of 1.0 to 1.1. The calculation used is:

$$\text{Pu-239 FGE} = \sum_{i=1}^{K} A_i / WF_i$$

where the radionuclide gram quantity (Ai) is divided by the weighting factor (WFi) for radionuclides found in Appendix B of the current WIPP WAC for 13 common transuranic radionuclides. Because Am-241 and Pu-239 are the usual transuranic radionuclides at MFC, and have a weighting factor of 1.0, the FGE is easy to calculate, sum, and document. (Note: this calculation requires consideration of the total measurement uncertainty to be expressed in terms of one standard deviation for each drum of waste.)

The previous two examples illustrated waste requirements considered during the revision. The last example is a nuclear safety requirement that had to be integrated with the waste requirements. For this requirement, the material at risk (MAR) was used to calculate an accident analysis for exposure to personnel in a transportation accident from a total effective dose equivalent (TEDE) without controls. The TEDE is the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The deep-dose equivalent for external exposures is the amount of energy of radiation absorbed in matter, such as a person. The committed dose equivalent is the dose equivalent to organs or tissues of reference that an individual would receive from an intake of radioactive material during the 50-year period following the intake. As this paper will discuss in section 4.1, PLN-1851 provided the analysis for the exposure to personnel, and resulted in an MFC transportation control in which the transportation route from the outside the MFC fence is controlled such that members of the public are prevented from approaching the loaded waste payload transport vehicle any closer than 400 meters.

In the end, integrating requirements from the container and container transfer with WIPP WAC and TSD Nuclear Safety requirements resulted in a TSD addendum that adequately meets the requirements of several different disciplines, while also providing a process that adequately supports operations.

4. Utilization of Approved Analysis

4.1 Analysis of Drum Transport

MFC safety analysts addressed several factors when adding the DOT Type A drums to the TSD addendum, including weight limits, removable surface contamination and ALARA, identification and labeling, physical form, and Resource Conservation and Recovery Act (RCRA) TRU waste. An additional factor that required special consideration was MAR. To save time and effort, the safety analysts used MAR analysis from PLN-1851.

As documented in EDF-6981, the transportation of the DOT Type A drum at MFC is bounded by analysis of a multiple waste container breach per PLN-1851, Section 6.4, "Accident and Dose Consequence Analysis." This section estimates the release of radioactive material from an accident involving the transport of 32, 55-gallon waste drums, or two 16-drum equivalent boxes. The dose calculations assume that the containers are loaded with 115.2 Ci (1,852 g) Pu-239 Ci equivalent per truckload. Section 6.4.2 compares the results of the estimated dose consequences to the risk evaluation guidelines (ref. Table 1).

Table 1. Comparison of Does Consequences to Evaluation Guidelines.

Accident	Frequency (without controls)	Co-located Worker at 100 m (TEDE) [a] (rem)	Public at 400 m (TEDE) (rem)	Facility and Co-located Worker Evaluation Guidelines (rem)	Public Evaluation Guidelines (rem)
Multiple waste container breach	Anticipated	1.7E+00	3.5E-01	5.0E+00	5.0E-01
Multiple waste container fire	Unlikely	3.5E+00	7.4E-01	2.5E+01	5.0E+00
a. TEDE = Total effective dose equivalent.					

All estimates fall below public evaluation guidelines, except the multiple container fire dose consequence to the public. The limit for the public evaluation guidelines is 0.5 rem, yet the estimated dose consequence at 400 meters is 0.74 rem. Thus a TSR was required to prevent members of the public from approaching a shipment within 400 meters of the flatbed truck.

Analysts at MFC needed to determine if the analysis given in PLN-1851 could also be applied to the transfer of DOT Type A drums at MFC. To determine if the amount of CH-TRU waste used in the scenario from PLN-1851 was greater than or equal to the amount of CH-TRU waste transported to WIPP, they reviewed material profiles and shipping records to identify the historical maximum CH-TRU WIPP payloads. Table 2 shows the results and highlights the maximum amounts of CH-TRU material transferred to WIPP.

Table 2. Watts, Pu-239 Fissile Gram Equivalent and Pu-239 Equivalent Activity (PE-Ci).

Container	Gross Weight (pounds)	mR/hr @ contact	Total ^{235}U (grams)	Total Pu (grams)	Total Ci	Thermal Watts	Pu-239 FGE	PE-Ci
1	169	5	0.00E+00	6.38E+00	7.05E+00	1.76E-02	5.37E+00	3.38E-01
2	165	15	0.00E+00	5.32E+00	5.86E+00	1.47E-02	4.46E+00	2.81E-01
3	205	20	2.32E+01	9.60E+00	8.03E+00	2.60E-02	2.34E+01	1.47E+00
4	160	7	4.50E-01	4.70E+00	4.55E+00	1.37E-02	4.25E+00	2.67E-01
5	179	40	1.85E+01	1.04E+01	8.07E+00	2.75E-02	2.79E+01	1.75E+00
6	160	60	1.24E-02	2.26E+00	2.32E+00	3.83E-02	1.91E+00	1.20E-01
7	150	20	0.00E+00	3.05E+00	2.57E+00	3.29E-02	2.55E+00	1.60E-01
8	136	80	0.00E+00	4.04E-02	1.07E+00	3.62E-02	4.13E-01	2.59E-02
9	162	5	0.00E+00	4.31E+00	1.30E+00	4.26E-02	4.20E+00	2.64E-01
10	143	110	0.00E+00	1.29E+01	2.01E+00	4.04E-02	1.25E+01	7.86E-01
11	127	20	0.00E+00	6.85E+00	1.76E+00	3.90E-02	6.45E+00	4.06E-01
12	134	150	0.00E+00	8.40E-01	7.27E-01	2.45E-02	7.08E-01	4.45E-02
13	129	10	0.00E+00	2.80E-01	1.74E-02	5.40E-04	2.79E-01	1.75E-02
14	169	120	9.60E-01	2.32E+00	1.31E+00	4.26E-02	2.91E+00	1.83E-01

Analysts concluded that none of the CH-TRU payloads transferred to WIPP had ever exceeded the 115.2 Ci (1,852 g) Pu-239 Ci equivalency used to calculate the analysis in PLN-1851. Thus they concluded that the analysis in PLN-1851 was adequate to also apply to the transfer of CH-TRU waste in DOT Type A drums at MFC.

MFC safety analysts incorporated the conclusion from PLN-1851 (that the dose consequences to the public are below evaluation guidelines provided that public access to the transportation route is controlled) by including multiple configuration parameters in the addendum. These included statements such as, “The transport route, including pickup and delivery, will follow the direct route between facilities on paved roads at MFC within the property protected area,” and “Transfers to and from TREAT for the movement of CH-TRU drums shall be identified and controlled such that members of the public are prevented from approaching the loaded waste container transport vehicle any closer than 400 m (1,312 ft).”

In the section where PLN-1851 evaluated payload containers, it concluded that “no safety-significant structure, system, and components (SSCs) are necessary for the waste container transport activity to maintain the consequences to the worker and the co-located worker below evaluation guidelines for any analyzed hazards and accidents” (Section 6.5.1). Thus EDF-6981 also described the payload containers used for the transport of CH-TRU waste at MFC, but went on to cite PLN-1851 to support the exclusion of safety-significant SSCs for the waste container transport activities.

By incorporating the analysis from PLN-1851, as well as the resultant TSR, into the analysis performed for DOT Type A drums at MFC, safety analysts were able to justify the inclusion of the Type A drums in the MFC TSD and minimize the amount of analysis that needed to be performed. The fact that PLN-1851 had already been approved and was in use by ICP helped strengthen the proposal for the use of DOT Type A drums at MFC.

4.2 Criticality

Criticality was another area where MFC analysts were able to use analysis from PLN-1851. Analysis of fissile loading was given in the PLN-1851, which states that each shipment (truckload) must be limited to a maximum of 32 drums (Appendix B, B.2.1.1) with the following load limits:

- Load limit of ≤ 1,500 g of Pu-239 fissile gram equivalency (FGE) per truckload (TSR, PLN-1851, Section 7, 2a).

This limit given is much higher than any amount of TRU-CH material that would be transported at MFC. Transport of TRU-CH waste at MFC must meet the WIPP criticality safety requirement of:

- Fissile loading of ≤200 g of Pu-239 FGE per waste container (EDF-6981, Section 8).

This limit falls within the limit given in PLN-1851, making the criticality analysis performed in PLN-1851 also valid for the MFC TSD. PLN-1851, Appendix B, includes an inadvertent criticality section, which states: "A criticality safety evaluation that addresses storage of waste drums containing fissile material at the RWMC indicates that criticality in a storage array of 55-gal drums is not a credible event for waste drums containing up to 380 g of Pu-239 fissile gram equivalent (FGE) if the storage array contains no more than 500 drums. The maximum number of drums in any single shipment will be limited operationally to 32 drums, or two 16-drum-equivalent waste boxes." PLN-1851 goes on to conclude: "Criticality safety evaluations have been completed supporting the storage of fissile-bearing waste containers. These analyses can be applied to support the transport of these waste containers."

One area that MFC differed from PLN-1851 was for criticality safety during transport. PLN-1851, Appendix B, documents flooding as a potential initiator of a radioactive material release. To minimize the consequences of a flood, PLN-1851 directs that if flooding is occurring or if flooding is forecast to occur within the next six hours, the shipment shall be cancelled. Yet flooding at MFC is estimated as unlikely and the probability of a flood within the MFC fenced area resulting in a release of radioactive material is much less because of the number of employees in the area who would detect flooding. EDF-6981 references DSA-001-SW,[6] the "ANL-W Standardized Documented Safety Analysis," Section 1.5.3, which notes that locally intense rain presents the only natural flood threat to MFC nuclear facilities and flooding is unlikely because the dry and porous ground can absorb the moisture. Because of the short distance between MFC facilities and the unlikely probability of flooding, the control from PLN-1851 was unnecessary and was not adopted for MFC CH-TRU transports.

Though not all of the critically analysis from PLN-1851 was used for the MFC TSD analysis, safety analysts were able to sift through the analysis given to find aspects that could be applied to MFC. Once more, using existing analysis helped to lessen the amount of analysis performed for the change to the MFC TSD.

5. Conclusions and Summary

Though this paper is specific to the revision made to the MFC TSD, the methods that were used could be applied to other modifications to facility safety basis. These methods help to support excellence in operations in several ways.

- By integrating requirements from other fields of concern, such as waste requirements, safety analysts can help to make processes more efficient and economical. It's good to evaluate current process to determine if changes to the safety basis can better support work in operations, while still meeting all the necessary safety basis requirements.

- By using completed analysis from an approved process/facility and applying it to a new processes/facility, safety analysis can cut down on the amount of new analysis they have to complete. Using analysis that is already approved and in use provides strong evidence to support conclusions.

The work at MFC to create and revise the TSD addendum is a good example of these practices. It proves that safety analysis can support operations to keep work moving efficiently and better meet the goals of everyone involved.

6. References

1. W7500-0688-ES-ADD-1, "Evaluation of the Safety of the Situation for the Condition of the MFC Transportation Safety Document," Idaho National Laboratory.

2. W7500-0688-ES, "ANL-W Transportation Safety Document," Idaho National Laboratory, Rev. 3, November 22, 2004.

3. NS-18308, "MFC Work Plan for Safety Basis Upgrade," Idaho National Laboratory, Rev. 1, May 23, 2006.

4. EDF-6981, "MFC Inter-Facility Transport of CH-TRU in DOT Type A Drums," Idaho National Laboratory, Rev. 1, July 20, 2006.

5. PLN-1851, "Transport Plan for the Transfer of Waste Containers between RWMC and INTEC, and RWMC and MFC," Idaho Cleanup Project, Rev. 0, April 1, 2005.

6. DSA-001-SW, "ANL-W Standardized Documented Safety Analysis," Idaho National Laboratory.