LA-UR-14-26030

Approved for public release; distribution is unlimited.

Title: Updates to Risk Ranking Algorithm for Repackaging Prioritization of
LANL Nuclear Material Storage Containers

Author(s): Hoffman, Jenifer Ann
Prochnow, David Adrian
Smith, Paul Herrick
Teague, Jonathan Gayle
Veirs, Douglas Kirk

Intended for: Report

Issued: 2014-07-31

Disclaimer:

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the Los Alamos National Security, LLC for the National Nuclear Security Administration of the U.S. Department of Energy under contract DE-AC52-06NA25396. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Updates to Risk Ranking Algorithm for Repackaging Prioritization of LANL Nuclear Material Storage Containers

Hoffman, J.A., Prochnow, D.A., Smith, P.H., Teague, J.G., and D.K. Veirs

Background

When the Department of Energy ended the production of nuclear weapons in 1989 the focus of the weapons complex shifted from production to stabilization and remediation. At that time thousands of containers of plutonium-bearing liquids and solids that had been in the manufacturing pipeline needed to be processed and packaged for longer term safe storage. In 1994 and 2000, the Defense Nuclear Facilities Safety Board (DNFSB) issued recommendations 94-1 and 00-1, respectively to accelerate and prioritize the stabilization and disposition of these materials.

Introduction

In response to recommendations 94-1 and 00-1, a risk algorithm was created to prioritize the stabilization and repackaging campaign at Los Alamos National Laboratory (Smith et al, 2007). Risk is calculated as the product of dose and failure probability.

The dose to the worker is estimated using a simple model for indoor airborne dispersion and worker response to the accident. The scenario assumes a maximum storage height of 3 meters for loaded containers. The dose conversion factor (DCF as rem CEDE/g) is the 50 year inhalation dose conversion factor. The respirable release fraction (RRF) is defined as the product of the airborne release fraction, the respirable fraction and the damage ratio. It is applied directly to the MAR to yield the airborne source term.

The failure probability of a package is a function of container robustness (package factor), the reactivity of the contents and the age of the package. The reactivity index is based on 4 hazard characteristics: pyrophoricity, corrosivity, pressure and oxidation expansion. It was assigned by SMEs based on the item description code (IDC), which describes the material matrix.

Several significant modifications to the risk algorithm have been considered and approved by the Nuclear Material Storage and Disposition Board (NMSDB) for implementation. This paper will describe the approved changes, how the changes were implemented, and the software quality testing that was performed, when appropriate. Changes to the risk calculation were quality tested per TA55-PLAN-065. Unless otherwise noted, software quality assurance documentation can be found in SCR_14_001.

Modifications

1. Applied the RRF for oxide to some metal items.

After consideration of past packaging practices, operational experience, and the understanding that plutonium metal oxidizes over time in air, it was determined that the previous assumption that plutonium metal is always in pure metal form was flawed. The assumption was changed in a conservative direction from a worker safety standpoint, and all plutonium metal and alloy items are now assumed to be fully oxidized.

Items identified as alloyed or unalloyed metal or alloyed metal turnings in conjunction with the following material types (Pu-242, Am-241, Am-243, Curium, Pu-239, U-233, Np-237 and Thorium) were assigned an RRF of 0.0006 . Prior to this change, the RRF for these IDCs was 0.000006.

(The code modules effecting these changes were tested in SCR_12_001)

2. Expanded scope of analysis to include all containers with accountable nuclear material at LANL.

All procedures were updated to remove MBA criteria that limited results to TA-55 or the TA-55 vault. This allows the risk algorithm to be applied to all items at LANL.

(These changes were applied to numerous MS SQL Server Stored Procedures. A visual verification of the change was conducted by two individuals.)

3. Used SNMC first loading date from LANMAS to calculate SNMC container age rather than nominal value.

Previously, all SNMC containers were assigned an age of 10 years. At one time, this was a conservative estimate as to how long items had been in SNMCs. This was considered as the age of the container. For other container types, we use the creation date to determine the age of the item. A routine was created that identified the system date of the first MASS or LANMAS transaction in which the container type is identified as an SNMC.

The effect of using SNMC first use date was shown to be a risk reduction of 10.3% in the TA-55 vault.

(For software quality assurance testing, a sampling of fifty SNMC container transaction histories were verified against the calculated first use date.)

4. Revised package factors to account for filtered locking drums, 3013 containers without pedigree, older design and special form factor FSOs, and other certified containers not previously encountered within TA-55 vault. Package factors are identified in tblContainerCategories (Table 1).

(No software quality assurance testing is required since this is a modification to a lookup list table.)

3013 (without pedigree) was added to the container list with a package factor of 0.01. These are 3013s that have little or no supporting documentation. These containers are identified by 'AR' in the LANMAS container type (CONTYPE) field (as opposed to certified 3013s which have 'CERT-3013' in the CONTYPE field).

A new container type and package factor was added for Fuel Storage Outer (FSO) special form containers. The package factor is 0 for these items, which are identified as items that are Pu-238 and have a LOTID starting with 'FSO'.

FSO (older design) was added with a package factor of 0.

Several changes were made to the way drums are binned. A new category was created for 5G and 10G Nuclear Filter Technology (NFT) filtered drums. These containers have a package factor of 0.4. Previously, these containers were binned as SNMCs. Some containers in this category have a filter gasket NCR applied to them and they are given a package factor of 0.6. 20G, 30G, and non-WIPP 55G drums are now considered non-standard unless they get approval from NMSDB.

WIPP Drum was added to the table and has a package factor of 0. These drums are identified by the LOTID prefix 'LA0000'.

ES-3100 was added with a package factor of 0. These containers are identified by 'CERT-ES3100' in the CONTYPE field.

CERT-GPHS was added with a package factor of 0. These containers are identified by 'CERT-GPHS' in the CONTYPE field.

CERT-RHU was added with a package factor of 0. These containers are identified by 'CERT-RHU' in the CONTYPE field.

MOX rods and fuel rods were combined into one category called 'Rods'. Both categories previously had a package factor of 0. This new combined category also has a package factor of 0.

Mound sample containers were added with a package factor of 0.2.

In the past, sealed sources were identified as items with 'SOR' in the CONTYPE field. After discussions with the Radioactive Sealed Source (RSS) team leader, it became apparent that this was not an appropriate way to deal with sealed sources. At this time, the revised methodology only bins items as sealed sources if it has a valid certificate and is listed in the Radioactive Sealed Source database or if there is documentation that the source has been reviewed and approved by the appropriate person (CSE, packaging engineer, e.g.).

Table 1. Container Categories with Package Factor and Manual Compliance

ID	Container Category	Package Factor	Container Subject To Manual	Container Manual Compliant	Action
1	3013 (with pedigree)	0	No	N/A	None
2	Encapsulated	0	No	N/A	None
3	EP-61	0	No	N/A	None
4	Rods	0	No	N/A	None
6	Intrinsically Sealed	0	No	N/A	None
7	Pressure Cooker	0.2	Yes	No	Repack
8	RTG	0	No	N/A	None
9	Sealed Source	0	No	N/A	None
10	SNMC-1	0.4	Yes	No	Repack
11	SNMC-2 (filter gasket NCR)	0.6	Yes	No	Repack
12	SNMC-3 (weld NCR)	0.8	Yes	No	Repack
14	Other Welded Waterbath Can	0	Yes	No	Repack
16	Non-Standard	1	Yes	No	Repack
17	SAVY4000	0	Yes	Yes	Surveillance
18	FSO (special form factor)	0	No	N/A	None
19	FSO (older design)	0	Yes	Yes	Surveillance
20	WIPP DRUM (LA0000 Series)	0	No	N/A	None
21	ES-3100	0	No	N/A	None
22	CERT-GPHS	0	No	N/A	None
23	CERT-RHU	0	No	N/A	None
24	3013 (without pedigree)	0.01	Yes	No	Repack
25	NFT 5G and 10G Filtered Drums	0.4	Yes	No	Repack
26	NFT 5G and 10G Filtered Drums (filter gasket NCR)	0.6	Yes	No	Repack
27	Glovebox	0	N/A	N/A	N/A
28	Dropbox	0	N/A	N/A	N/A
29	Hood	0	N/A	N/A	N/A
30	Mound Sample Containers	0.2	Yes	No	None

- Developed mechanism to identify containers in glove boxes, drop boxes, and hoods (engineered barriers outside Manual scope).

Items inside gloveboxes, dropboxes or hoods are now assigned a package factor of 0. Locations are identified as GB, DB or hood in the SQL table Locations_wLocTypes.

(No software quality assurance testing is required since this change involved creation of a lookup list table.)

- Developed mechanism to identify ‘Containers Subject to Manual’ and ‘Containers that are Manual Compliant’.

“Containers Subject to Manual” is defined as those containers that are relatively robust and have been thoughtfully designed, have a package factor that is less than 1. These containers are

generally lower in priority for repackaging, and they have not been demonstrated to meet M441.1-1 requirements. Examples include SNMC-1 (Hagan, screw top style containers), filtered locking drums, and Mound Sample Containers. “Containers that are Manual Compliant” is defined as those containers that have received approval from the Los Alamos Field Office as compliant with M441.1-1 requirements, such as SAVY-4000 and Fuel Storage Outer containers.

Both categories are now identified in tblContainerCategories (Table 1). Assignments were made with input from subject matter experts.

(No software quality assurance testing is required since this is a modification to a lookup list table.)

7. Developed calculation to identify containers with materials above Manual thresholds for DMTs

Thresholds (Table 2) are based on A2 values with conservatism added for elements for which presence of ANY measurable amount is considered above threshold (all plutonium, americium, curium, berkelium, californium, and U-233). For mixed material type containers, fractions of all constituent material types and thresholds are considered.

(For software quality assurance testing, check that items above and below threshold for each material type are properly categorized. For mixed material types, compare calculated value against a hand calculation for five items containing enriched uranium mixed with neptunium or lithium.)

Table 2. Threshold values in grams

ID	Detail Material Type	Summary Material Type	MaterialTypeDescr	Threshold
1	11	10	Uranium Depleted in U-235 - <0.21% U-235	1,000,000,000
2	12	10	Uranium Depleted in U-235 - 0.21 to <0.24% U-235	1,000,000,000
3	13	10	Uranium Depleted in U-235 - 0.24 to <0.26% U-235	1,000,000,000
4	14	10	Uranium Depleted in U-235 - 0.26 to <0.28% U-235	1,000,000,000
5	15	10	Uranium Depleted in U-235 - 0.28 to <0.31% U-235	1,000,000,000
6	16	10	Uranium Depleted in U-235 - 0.31 to <0.50% U-235	1,000,000,000
7	17	10	Uranium Depleted in U-235 - 0.50 to <0.60% U-235	1,000,000,000
8	18	10	Uranium Depleted in U-235 - 0.60 to <0.711% U-235	1,000,000,000
9	21	20	Uranium Enriched in U-235 - >0.711% to <0.90% U-235	388,045
10	22	20	Uranium Enriched in U-235 - 0.90 to <1.15% U-235	288,881
11	23	20	Uranium Enriched in U-235 - 1.15 to <1.60% U-235	196,966
12	24	20	Uranium Enriched in U-235 - 1.60 to <2.00% U-235	152,939
13	25	20	Uranium Enriched in U-235 - 2.00 to <2.60% U-235	114,034
14	26	20	Uranium Enriched in U-235 - 2.60 to <2.90% U-235	100,774
15	27	20	Uranium Enriched in U-235 - 2.90 to <3.10% U-235	93,862
16	28	20	Uranium Enriched in U-235 - 3.10 to <3.40% U-235	84,690
17	29	20	Uranium Enriched in U-235 - 3.40 to <3.90% U-235	73,033
18	30	20	Uranium Enriched in U-235 - 3.90 to <4.10% U-235	69,148
19	31	20	Uranium Enriched in U-235 - 4.10 to <5.00% U-235	55,794
20	32	20	Uranium Enriched in U-235 - 5.00 to <10.00% U-235	26,859
21	33	20	Uranium Enriched in U-235 - 10.00 to <20.00% U-235	13,252
22	34	20	Uranium Enriched in U-235 - 20.00 to <35.00% U-235	7,613
23	35	20	Uranium Enriched in U-235 - 35.00 to <45.00% U-235	5,965
24	36	20	Uranium Enriched in U-235 - 45.00 to <80.00% U-235	3,452
25	37	20	Uranium Enriched in U-235 - 80.00 to <92.00% U-235	3,030
26	38	20	Uranium Enriched in U-235 - 92.00 to <94.00% U-235	2,970
27	39	20	Uranium Enriched in U-235 - 94.00% and above U-235	2,831
28	41	40	Plutonium 242 - 20% thru 60%	0
29	42	40	Plutonium 242 - >60%	0
30	44	44	Americium 241	0
31	45	45	Americium 243	0
32	46	46	Curium	0
33	47	47	Berkelium	0
34	48	48	Californium	0
35	51	50	Plutonium - <4.00% Pu-240	0
36	52	50	Plutonium - 4.00 to <7.00% Pu-240	0
37	53	50	Plutonium - 7.00 to <10.00% Pu-240	0
38	54	50	Plutonium - 10.00 to <13.00% Pu-240	0
39	55	50	Plutonium - 13.00 to <16.00% Pu-240	0
40	56	50	Plutonium - 16.00 to <19.00% Pu-240	0
41	57	50	Plutonium - 19.00% and above of Pu-240	0
42	61	60	Lithium Enriched in Li-6 - >Normal to <55.00%	1,000,000,000
43	62	60	Lithium Enriched in Li-6 - 55.00 to <80.00%	1,000,000,000
44	63	60	Lithium Enriched in Li-6 - 80.00% and above	1,000,000,000
45	71	70	Uranium Enriched in U-233 - <5 ppm U-232	0
46	72	70	Uranium Enriched in U-233 - 5 to <10 ppm U-232	0
47	73	70	Uranium Enriched in U-233 - 10 to <50 ppm U-232	0
48	74	70	Uranium Enriched in U-233 - 50 ppm and above U-232	0
49	81	81	Uranium - Normal	509,778
50	82	82	Neptunium 237	76
51	83	83	Plutonium 238	0
52	86	86	Deuterium	1,000,000,000
53	87	87	Tritium	1,000,000,000
54	88	88	Thorium	1,000,000,000
55	89	89	Uranium in Cascade	1,000,000,000

8. Created RRFs for new IDCs.

Two new IDCs were added to LANMAS. IDC C20 is Pu238 sintered pellets and was assigned an RRF of 0.00005. C23 is Pu238 granules and was assigned an RRF of 0.00005. DOE-HDBK-3010 uses a formula to calculate ARF and RF combined. Combined ARF and RF for these material forms is 5.0 E-5. This information appears in the TA-55 DSA in Table 3-38. The calculation used to derive these values is found in HDBK-3010, section 4.3.3.

Reactivity index values for these IDCs were assigned per expert judgment. Both have a total value of 2.61.

(No software quality assurance testing is required since this is a modification to a lookup list table.)

9. Containers on floor locations with unknown or null container categories at TA-55 outside vault and at CMR were assumed to be SNMCs (package factor = 0.4)

Normally, all containers outside the TA-55 vault with unknown or null container types were assumed to be non-standards (package factor = 1). Based on the repackaging campaigns that were performed in 2005 and 2006 timeframe where nuclear materials outside of glovebox enclosures were required to be repackaged or overpacked into SNMCs at both TA-55 and CMR, the package factors are assumed to be 0.4. Packaging procedures at TA-55 (TA55-DOP-091) and CMR (CMR-RD-555) require nuclear material outside of engineered containment boundaries to be stored in SNMC style containers or equivalent.

(SQA testing will verify that the containers outside TA55 vault and at CMR with unknown or null container categories are properly categorized using a summary query.)

10. Items in safes or cages were de-containerized.

Normally, the 'ParentName' field on LANMAS is used to identify a container with several items inside it. In a few instances, the location type (safe, cage, etc) was put into LANMAS as the parent name so that TIDs would be applied to the location for inventory purposes. Since the items are not really containerized, for purposes of assigning risk to containerized items, procedures were written to "decontainerize" these items.

(SQA testing will verify that the correct items were identified for "decontainerization" and that the procedure handled the items appropriately.)

11. Use ICRP68 dose conversion factors for 5 micrometer particle size

The risk algorithm initially used ICRP 30 dose conversion factors for workers. The NMSDB voted to implement ICRP 68 dose conversion factors into the algorithm.

The original vault risk ranking methodology was based on ICRP 30 dose coefficients. The vault risk ranking methodology utilized dose conversion factors (i.e., committed effective dose

equivalent per unit of intake) for material type based on previous work by Jordan and Smith (2004). Jordan calculated material type dose conversion factors from the isotopic dose coefficients in Federal Guidance Report 11. Federal Guidance Report 11 was based on ICRP 30.

The LANL transition from ICRP 30 methodology and values to those of ICRP 60 and 68 (dose coefficients for workers) for occupational exposures was part of an overall DOE complex transition that occurred in 2007 through 2008.

Calculations were performed by the NCS group to determine dose conversion factors (Sv/g) based on ICRP 68 inhalation coefficients for 5 micrometer particle size (Sartor, 2014).

With the exception of a few nuclides, the effect of the transition from ICRP 30 to ICRP 68 was a general decrease in effective dose per unit intake (the ICRP 60/68 term effective dose replaced the term effective dose equivalent in ICRP 30) (Figure 1). In other words, dose coefficients tended to decrease, in some cases significantly.

Figure 1. Current dose vs ICRP 68 dose

The overall effect of the transition from ICRP 30 to ICRP 68 was shown to be a risk reduction of 21% in the TA-55 vault (Table 3) and 24% for the entire laboratory inventory.

Table 3. Change in number of containers and amount of risk in the TA-55 vault

		Current DCF	ICRP68 DCF
RiskCategory	ContainerCategory	CountOfItem	CountOfItem
None	3013 (with pedigree)	123	123
None	EP-61	142	142
None	Filtered Locking Drum	3	3
None	FSO (special form factor)	185	185
None	Non-Standard	15	15
None	Other Welded Waterbath Can	6	6
None	INTR Sealed	113	113
None	Rods	36	36
None	RTG	68	68
None	SAVY 4000	204	204
None	Sealed Source	194	194
None	SNMC-1	7	7
High	Non-Standard	2	0
High	SNMC-3 (weld NCR)	2	1
Low	3013 (without pedigree)	63	63
Low	Filtered Locking Drum	139	147
Low	Filtered Locking Drum (filter gasket NCR)	3	4
Low	Non-Standard	177	236
Low	Pressure Cooker	6	9
Low	SNMC-1	2152	2295
Low	SNMC-2 (filter gasket NCR)	145	172
Low	SNMC-3 (weld NCR)	28	66
Medium	Filtered Locking Drum	12	4
Medium	Filtered Locking Drum (filter gasket NCR)	1	0
Medium	Non-Standard	523	466
Medium	Pressure Cooker	3	0
Medium	SNMC-1	619	476
Medium	SNMC-2 (filter gasket NCR)	108	81
Medium	SNMC-3 (weld NCR)	144	107
Very High	Non-Standard		
	TOTAL COUNT	5,223	5,223
	ContainerCategory	SumOfRiskRanking	SumOfRiskRanking
	Filtered Locking Drum (filter gasket NCR)	99	82
	Non-Standard	105,156	79,399
	Pressure Cooker	277	259
	SNMC-2 (filter gasket NCR)	19,540	15,519
	SNMC-3 (weld NCR)	21,882	17,422
	Total Vault Risk Sum	276,973	217,663
	Total Non-Standard Risk Sum	146,953	112,680

REFERENCES

Defense Nuclear Safety Board, Recommendation 1994-1 to the Secretary of Energy, U.S. Department of Energy, May 26, 1994.

Defense Nuclear Safety Board, Recommendation 2001-1 to the Secretary of Energy, U.S. Department of Energy, June 14, 2000.

Sartor, R.F. "ICRP-68 (5 micron) DCFs for Radionuclides and Material Types (MTs)." SBD-CALC-14-SBD-005-R0, June, 2014.

Smith, P.H., Jordan, H., Hoffman, J.A., Eller, P.G. and Balkey, S. "Risk Ranking of LANL Nuclear Storage Containers for Repackaging Prioritization." Operational Radiation Safety, Volume 92, suppl. 2, May 2007.