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Estimation of Cellulose, Plastic, and Rubber Based on TWBID, Rev. 2.1, Data Version 4.15

ERMS#

Author: Timothy P. Burns 1/26/05
Tim Burns, EES-12 Date
Los Alamos Carlsbad Operations

Technical Review: Beverly A. Crawford 1/26/05
Beverly Crawford, EES-12 Date
Los Alamos Carlsbad Operations

Technical Review: Bill McInroy 1/31/05
Bill McInroy Date
SNL Performance Assessment and
Decision Analysis Department

QA Review: EARL BRADFORD for STEVE DAVIS by Earl Bradford 1/31/05
~~Steve Davis,~~ 6820 Date
SNL Programs Group

Management Review: David C Moody 2/4/05
Dave Moody, EES-12 Date
Los Alamos Carlsbad Operations

Management Review: David Kessel 1/28/05
Dave Kessel, Acting 6820 Date
SNL Carlsbad Programs Group

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1.0 INTRODUCTION

The U. S Department of Energy (DOE) submitted a Compliance Recertification Application (CRA) for the Waste Isolation Pilot Plant (WIPP) to the U. S. Environmental Protection Agency (EPA) in March 2004 (DOE 2004). During the EPA completeness review, a request was made for DOE to provide additional information regarding the weights and volumes of materials placed in the disposal system with the waste (Cotsworth 2004).

> "DOE must provide the volumes and weights of all materials that are placed in the disposal system with the waste containers and must account for their effects or justify why these additional materials are not expected to affect the behavior of the disposal system."

This analysis was conducted to update cellulose, plastic and rubber data provided in section DATA-F-3.5 of the CRA-2004 (DOE 2004). This analysis uses expected final form volumes reported in the TRU Waste Baseline Inventory Database (TWBID), Data Version D.4.15, December 20, 2004 (LANL 2004).

The estimates include both wastes emplaced as of 9/30/2002, and projections of anticipated (to be emplaced) wastes. The projections are based on TWBID data and container counts as determined by Burns (2005). The estimates of CPR materials incidental to the waste emplacement process are based on the use of approved waste container types (with the exception of 5'x 5'x 8' Boxes), and are influenced by the relevant waste emplacement rules, and packaging configuration distribution assumptions. Assumptions regarding the relative distribution of these approved waste packages in the disposal system are made specifically for the purpose of this analysis, and they are listed in Section 2.0

Tables 1 through 3 are summaries of the projected, stored and emplaced volumes determined in the analysis by Burns (2005). Table 4 is a summary of the numbers of containers calculated in the same report. Table 5 provides the CPR results from calculations using the equations in this analysis. The results of this analysis are summarized in Table 6 and compared to previous analyses in Table 7.

The equations that were used to arrive at the calculated values in Tables 5 and 6 are listed in Section 3.0.

This analysis was conducted in compliance with the applicable requirements of the Sandia National Laboratories Quality Assurance Program (QAP); and the requirements of Sandia National Laboratories Nuclear Waste Management Analysis Plan, AP-113, "*Analysis Plan Reconciliation: Compliance Recertification Application,*" Revision 1, September 29, 2004. The analysis and the results are reported consistent with the requirements of Sandia National Laboratories Nuclear Waste Management Procedure, NP 9-1, *Analyses*.

1.1 ACRONYMS

CH	Contact Handled
CPR	Cellulosics, Plastics, and Rubber materials
CRA	Compliance Recertification Application
DOE	U. S. Department of Energy
EPA	Environmental Protection Agency
MgO	Magnesium Oxide
POC	Pipe Overpack Components
POP	Pipe Overpacks
QAP	Quality Assurance Program
RH	Remote Handled
SWB	Standard Waste Box
TDOP	Ten Drum Overpack
TRU	Transuranic
TWBID	TRU Waste Baseline Inventory Database
WIPP	Waste Isolation Pilot Plant

2.0 LIMITATIONS AND ASSUMPTIONS

For the purpose of determining the estimated weights of cellosics, plastics and rubber materials (CPR) incidental to the waste emplacement process, a number of assumptions are made for the purpose of this analysis. The assumptions are listed below.

The applicable *waste container types* (based on those included in TWBID version D.4.15, December 20, 2004) (LANL 2004) include: 55-gallon drums, 85-gallon drums, 100-gallon drums, Ten Drum Overpacks (TDOP's), Standard Waste Boxes (SWB's), and 5'x 5'x 8' Boxes.

It is assumed, for the purpose of this analysis and the relevant calculated values, that 30-gallon drums and Pipe Overpacks (POP's) or Pipe Overpack Components (POC's) will be emplaced in the repository as 55-gallon drums. It is also assumed that 80-gallon drums and 83-gallon drums are equivalent to 85-gallon drums. The values used for the relevant calculations reflect these assumptions.

The applicable *waste emplacement units* are: 7-packs, 4-packs, 3-packs, SWB's, TDOP's, 5'x 5'x 8' boxes (nominally), and RH Canisters. It is important to note that in TWBID data version D.4.15, December 20, 2004, there are two RH entries that were not reported in RH canisters. One entry (included in Stored waste) was reported in 55 gallon drums. The second entry (included in projected waste) was reported in 5' x 5' x 8' Boxes. It is understood that the current WIPP infrastructure does not support shipping of RH waste in any form other than RH canisters, and that the WIPP has not yet received regulatory approval to dispose RH waste in any form. For the purpose of this analysis, the wastes represented by these two entries will be treated as

part of the RH canister waste container type. This will ensure completeness of the calculated results, but because these are RH wastes they will have no bearing on the estimate of CPR.

For the purpose of calculations to estimate the weights of cellulosics, plastics and rubber (CPR) materials in emplaced and anticipated waste the following *assumptions* are relevant.

- 7-packs are always comprised of 55-gallon drums only.
- 4-packs are always comprised of 85-gallon drums only (80- and 83-gallon drums are assumed equivalent to 85-gallon drums).
- 3-packs are always comprised of 100-gallon drums only.
- 7-packs (of 55-gallon drums) are always stacked three high.
- RH Canisters will always be placed in a hole in the rib of the repository and do not require CPR emplacement materials during disposal.
- 7-packs, 4-packs, and 3-packs are always emplaced with stretch wrap around them; and each will have both a plastic reinforcing plate on top and a plastic slip sheet on the bottom.
- Each SWB has a cardboard slipsheet.
- Each TDOP, has a cardboard slipsheet placed underneath when emplaced at the bottom of the stack.
- 5'x 5'x 8' boxes will have no cardboard slipsheet underneath them when emplaced.
- 4-packs (of 85-gallon tall drums) will always be stacked two high (Note- Since some 85-gallon drums are "tall" and some are of normal drum height, it is assumed that tall 85 gallon drums will constitute a limiting condition on emplacement packs. This has been accounted for in limiting the number of 4-packs possible in a stack to two).
- 3-packs (of 100-gallon drums) will always be stacked three high.
- SWB's will always be stacked three high.
- TDOP's are always emplaced at the bottom of a stack, and always have one 7-pack stacked on top.
- 5'x 5'x 8' Boxes will always be placed on the bottom of a stack, and will always have one SWB stacked on top.
- Each waste stack (regardless of its specific configuration) has one Supersack of MgO placed on top.
- Each MgO Supersack is emplaced with a cardboard stabilizer, and a plastic slipsheet underneath it.

3.0 CALCULATIONS

The weights of CPR materials introduced incidental to the waste emplacement process can be estimated after the number of each applicable *waste container type* and *waste emplacement units*, and the number of *waste stacks* is determined. Once the number of each waste container type has been determined (both for emplaced waste, and anticipated waste), the number of each waste emplacement unit (as defined

above) can be calculated. The relevant waste container information (both for emplaced waste, and anticipated waste) was calculated in the analysis completed by Burns (2005).

The number of waste stacks must also be determined. This calculation is based (in part) on estimates for anticipated waste, and is influenced by the waste emplacement rules and waste emplacement assumptions. This allows for estimation of the number of Supersacks to be emplaced. This is important because the Supersacks contribute in a significant way to the total plastics weight values.

There are CPR contributions associated with each waste packaging configuration (with the exception of RH canisters), and with each Supersack emplaced. The CPR contribution values are listed by CPR component below, and were reported by Washington TRU Solutions for an earlier analysis (McInroy and Leigh 2004). It is important to note that the weights of these CPR contributing items are known, but the densities are not. Therefore, the final results of this analysis will not include calculated values for volume(s) of CPR. It is also important to note that there are no rubber contributions incidental to the waste emplacement process.

3.1 Cellulosics

Components that contribute to the cellulosics materials calculations are listed below based on their relationship to defined *waste emplacement units* (see section 2), along with their individual weights.

- Supersack cardboard stabilizer—3.447 kg
- SWB cardboard slipsheet—3.719 kg
- TDOP cardboard slipsheet—3.719 kg

3.2 Plastics

Components that contribute to the plastics calculations are listed below based on their relationship to defined *waste emplacement units* (see section 2), along with their individual weights.

- 7-pack top reinforcing plate and bottom slipsheet—15.785 kg
- 7-pack stretch wrap—0.998 kg
- 4-pack top reinforcing plate and bottom slipsheet—14.787 kg
- 4-pack stretch wrap—0.998 kg
- 3-pack top reinforcing plate and bottom slipsheet—14.515 kg
- 3-pack stretch wrap—0.998 kg
- Supersack plastic content (polypropylene)—3.447 kg
- Supersack plastic slipsheet—7.893 kg

3.3 Waste Information-Container Types and Quantities

The number of containers based on scaled repository volume required for calculating CPR incidental to waste emplacement is provided in Burns (2005). The relevant entries in that analysis were organized by relevant container types and summarized for the purpose of this analysis.

Tables 1, 2 and 3 (below) summarize the volumes of waste (stored, projected and emplaced) by waste container type, which are reported in final form in TWBID Rev. 2.1 (LANL 2004) as of the inventory date of September 30, 2004.

Table 1

Projected (to be generated) Waste (as of 9/30/2002)	
Container Type	**Volume (cubic meters)**
55 gallon drums	26,388.342
85 gallon drums	0.000
100 gallon drums	0.000
SWB's	8,115.480
TDOP's	0.000
5' x 5' x 8' Boxes	243.380
RH Canisters	2,056.790
RH in 5' x 5' x 8' Boxes	22.640

Table 2

Stored (in Final Form) Waste (as of 9/30/2002)	
Container Type	**Volume (cubic meters)**
55 gallon drums	24,885.639
85 gallon drums	200.715
100 gallon drums	19,874.760
SWB's	19,465.940
TDOP's	34,191.020
5' x 5' x 8' Boxes	9,927.640
RH Canisters	5,283.096
RH in 55 Gallon Drums	4.576

Table 3

Emplaced Waste (as of 9/30/2002)	
Container Type	**Volume (cubic meters)**
55 gallon drums	7,113.120
85 gallon drums	0.000
100 gallon drums	0.000
SWB's	603.480
TDOP's	0.000
5' x 5' x 8' Boxes	0.000
RH Canisters	0.000

Table 4 (below) lists the number of containers, by waste container type (for stored, projected and emplaced wastes). The values for number of waste containers are calculated using Internal Volume values taken from Burns (2005), Section 3.3. These values are listed here for ease in reference.

$IV_{55GalDr} = 0.208448\ m^3$

$IV_{85GalDr} = 0.3216666\ m^3$

$IV_{100GalDr} = 0.379\ m^3$

$IV_{SWB} = 1.8941354\ m^3$

$IV_{TDOP} = 4.79\ m^3$

$IV_{LgBox} = 5.660003\ m^3$

$IV_{RHCan} = 0.8855477\ m^3$

The values in Table 4 for Total Number of Containers (by waste container type), are based on Volumes that are scaled to a full repository volume. The scaling factors for RH and CH (below) and the data shown in Table 4 are taken from Burns (2005).

$SF_{CH} = 1.502$ (unitless)

$SF_{RH} = 0.861$ (unitless)

Table 4

Conversions-Volume to Numbers of Containers (by Waste Container Type)

Container Type	Stored Volume (m^3)	Projected Volume (m^3)	Emplaced Volume (m^3)	Total Scaled Volume (m^3)	Total Number of Containers (by waste container type)
55 gallon drums	24,885.639	26,388.342	7,113.120	71,639.049	343,654.290
85 gallon drums	200.715	0.000	0.000	200.715	623.985
100 gallon drums	19,874.760	0.000	0.000	19,874.760	52,440.000
SWB's	19,465.940	8,115.480	603.480	32,258.871	17,030.921
TDOP's	34,191.020	0.000	0.000	34,191.020	7,138.000
5' x 5' x 8' Boxes	9,927.640	243.380	0.000	10,293.197	1,817.632
RH Canisters	5,287.672	2,079.430	0.000	7,078.061[1]	7,992.863[1]

[1]Volume and container count include 4.576 m^3 of waste in 55-gallon drums and 19.493 m^3 of waste from 5'x5'x8' Boxes as described in Table 4 of Burns (2005). The number of containers reported is based on 55-gallon drum equivalents packed into RH canisters and is not included in determination of emplacement materials based on current operations procedures.

3.4 Waste Emplacement Units

The number of each type of waste emplacement unit (see section 2) is required to determine the weights of individual cellulosic, plastic and rubber contributions to the total CPR, incidental to the waste emplacement process, for each type of waste emplacement unit. Where applicable, calculated values for number of waste emplacement units were rounded down to the nearest whole number.

3.5 CPR Contribution by Waste Emplacement Unit

The relative CPR contribution by waste emplacement unit type must be calculated for both emplaced waste, and anticipated waste. An entry will be included under container type for Supersacks as they contribute to the CPR as well. It is recognized that Supersacks are not a container type, but they are included in these tables for completeness and accuracy with respect to the final calculated results. The CPR contribution values calculated for each waste emplacement unit type will be used in calculating the total CPR contribution incidental to the waste emplacement process.

The number of waste stacks must be calculated in order to determine the number of Supersacks to be emplaced. This will allow for the calculation of the cellulosics and plastics contribution introduced by the emplaced Supersacks. The number of stacks is arrived at as follows.

T_{7PKST}	Total pure 7-pack stacks (3 high)
T_{SWBST}	Total pure SWB stacks (3 high)
T_{TDOPST}	Total stacks with a TDOP on bottom
T_{3PKST}	Total 3-pack stacks (3 high)
T_{4PKST}	Total 4-pack stacks (2 high)
T_{BOXST}	Total stacks with a 5'x 5'x 8' Box on bottom
T_{STACKS}	Total number of waste stacks
$T_{SUPERSACKS}$	Total number of Supersacks
T_{7PKS}	Total number of 7-packs
T_{TDOP}	Total number of TDOP's
T_{SWB}	Total number of SWB's
T_{BOXES}	Total number of 5'x 5'x 8' Boxes
T_{3PKS}	Total number of 3-packs
T_{4PKS}	Total number of 4-packs
$T_{55's}$	Total number of 55-gallon drums
$T_{85's}$	Total number of 85-gallon drums
$T_{100's}$	Total number of 100-gallon drums

3.5.1 The total number of 7-pack stacks = (the total number of 7-packs – the total number of TDOP's) / 3

$$T_{7PKS} = \frac{T_{55's}}{7}$$

$$T_{7PKSTK} = \frac{T_{7PKS} - T_{TDOP}}{3}$$

This ensures that the appropriate number of 7-packs is decremented from the total, since one 7-pack has been assigned to each TDOP (see section 2)

3.5.2 The total number of SWB stacks = (the total number of SWB's – the total number of 5'x 5'x 8' Boxes) / 3

$$T_{SWBST} = \frac{T_{SWB's} - T_{BOXES}}{3}$$

This ensures that the appropriate number of SWB's (one of which is assigned to be placed on top of every 5'x 5'x 8' Box) is subtracted from the total number of SWB's prior to calculating the number of stacks of pure SWB's.

3.5.3 The total number of TDOP stacks = the number of TDOP's

$$T_{TDOPST} = T_{TDOP}$$

The TDOP's are always placed on the bottom of a stack, and there is never more than 1 TDOP per stack.

3.5.4 The total number of 3-pack stacks = the number of 3 packs / 3

$$T_{3PKS} = \frac{T_{100s}}{3}$$

$$T_{3PKST} = \frac{T_{3PKS}}{3}$$

3-packs *could* be stacked on TDOP's or on SWB's. However, it is assumed for this analysis that the 3-packs will only be stacked 3 high one on top of another. It is also important to remember that we have assumed 3-packs will never be stacked on SWB's, TDOP's, or 5'x 5'x 8' Boxes.

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3.5.5 The total number of 4-pack stacks = the number of 4 packs / 2

$$T_{4PKS} = \frac{T_{85's}}{4}$$

$$T_{4PKST} = \frac{T_{4PKS}}{2}$$

4-packs *could* be stacked on TDOP's, or on SWB's. However, it is assumed for this analysis that the 4-packs will consist of tall 85-gallon containers only stacked 2 high, one on top of another. It is also important to remember that we have assumed 4-packs will never be stacked on SWB's, TDOP's, or 5'x 5'x 8' Boxes.

3.5.6 The total number of 5'x 5'x 8' Box stacks = the number of 5' x 5' x 8' boxes.

$$T_{BOXST} = T_{BOXES}$$

It is assumed here that 5'x 5'x 8' Boxes will always be placed on the bottom of a stack, and only SWB's (1 SWB per stack) would be placed on top of them.

3.5.7 The total number of Stacks = the total number of 7-pack stacks (see section 3.5.1) + the total number of SWB stacks (see section 3.5.2) + the total number of TDOP stacks (see section 3.5.3) + the total number of 3-pack stacks (see section 3.5.4) + the total number of 4-pack stacks (see section 3.5.5) + the total number of 5' x 5' x 8' Box stacks (see section 3.5.6).

$$T_{STACKS} = T_{7PKST} + T_{SWBST} + T_{TDOPST} + T_{3PKST} + T_{4PKST} + T_{BOXST}$$

3.5.8 The total number of Supersacks = the total number of stacks (see section 3.5.7).

$$T_{SUPERSACKS} = T_{STACKS}$$

Table 5

Conversions-Numbers of Containers (by Waste Container Type) to Emplacement Units and Waste Stacks							
Container Type/Waste Emplacement Unit Type	**Number of Containers**	**Number of Emplacement Units**	**# of Waste Stacks**	**Cell-ulosics Weight Factor (kg)**	**Cell-ulosics Contri-bution (kg)**	**Plastics Weight Factor (kg)**	**Plastics Contri-bution (kg)**
55 gallon drums/ 7 Packs	343,654.290	49,093	13,985[1]	0	0	16.783[4]	8.24×10^5
85 gallon drums/ 4 Packs	623.985	155	77[1]	0	0	15.785[4]	2.45×10^3
100 gallon drums/ 3 Packs	52,440.000	17,480	5,826[1]	0	0	15.513[4]	2.71×10^5
SWB's/ SWB's	17,030.921	17,030	5,071[1]	3.719	6.33×10^4	0	0
TDOP's/ TDOP's	7,138.000	7,138	7,138[1]	3.719	2.65×10^4	0	0
5' x 5' x 8' Boxes/ 5' x 5' x 8' Boxes	1,817.632	1,817	1,817[1]	0	0	0	0
RH Canisters/ RH Canisters	7,992.863	7,992	N/A	0	0	0	0
Supersacks/ Superstacks	33,914[2]	N/A	33,914[3]	3.447	1.17×10^5	11.340[5]	3.85×10^5

[1] Rounded down to the nearest whole number of stacks
[2] Total number of supersacks to be emplaced
[3] = total number of waste stacks
[4] Contributions from plate, slip sheet, and stretch wrap
[5] Contributions from sack and slip sheet

4.0 RESULTS AND CONCLUSIONS

The results of the analysis are provided in the Summary Tables below (Tables 6 and 7). Table 6 is a summary of the information provided in Table 5 by source (i.e. emplacement materials associated with MgO Supersacks and materials added during emplacement of *waste emplacement units*). Table 7 shows results of this analysis along with the earlier results from Brown (2003), and McInroy and Leigh (2004). The differences (in a comparative sense) are in both cases mainly attributable to:

a) The inventory information (provided by generator facilities) has migrated forward over time.
b) Brown (2003) assumed that the RH waste emplacement process would include a Shield Plug with a significant quantity of Plastic—this is no longer the case (see attachment 1).

In summary, this revised analysis provides the expected Cellulose, Plastic and Rubber (CPR) that includes what has been emplaced and waste that will be shipped to WIPP. The results of this analysis take into account packing configurations used by waste operations personnel at the WIPP site and include emplacement materials that have been determined to apply to 7-packs, 4-packs, 3-packs, SWB's, TDOP's, RH canisters, 5' x 5' x 8' Boxes and MgO Supersacks. Therefore, the CPR reported in this analysis provides the latest estimate of emplacement materials. These calculations were performed using an updated revision of the TWBID database (LANL TWBID D.4.15, LANL 2004) that accounts for the latest information on the TRU inventory.

Table 6

Total CPR Contribution			
CPR Component	From Supersacks (kg)	Derived from Emplacement of Waste Emplacement Units (kg)	Total Cellulose Plastic or Rubber (kg)
Cellulosics	1.17×10^5	8.98×10^4	2.07×10^5
Plastics	3.85×10^5	1.10×10^6	1.48×10^6
Rubber	0	0	

Table 7

Comparative Analysis-Earlier vs. Current Results			
Source Document	***Total Cellulosics* (kg)**	***Total Plastics* (kg)**	***Total Rubber* (kg)**
Brown	1.98×10^5	2.45×10^6	0
McInroy and Leigh	2.15×10^5	1.42×10^6	0
Burns	2.07×10^5	1.48×10^6	0

5.0 RELEVANT PROCEDURES

AP-113, "Analysis Plan for Inventory Reconciliation: Compliance Recertification Application". Sandia National Laboratories Nuclear Waste Management Program Analysis Plan, September 29, 2004.

NP 9-1, "Analyses," Sandia National Laboratories Nuclear Waste Management Program Procedure, August 29, 2001.

6.0 REFERENCES

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