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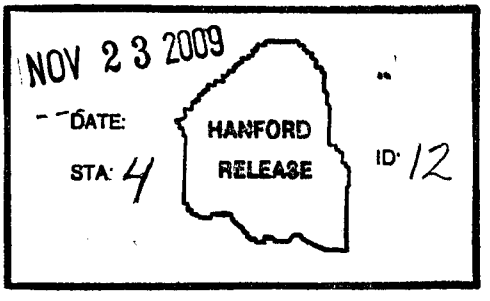
Abstract: This white paper evaluates flammable gas accumulation and pressure buildup in non vented low-level non transuranic (non-TRU) waste (LLW) and mixed waste (MW) drums and boxes containing various waste materials. There are no immediate flammability concerns assuming that storage times for LLW and MW containers are limited to one year and 90 days, respectively. Containers that need to be stored for longer than one year (LLW) or 90 days (MW) should be evaluated for hydrogen accumulation on a case-by-case bases using the methodology employed in this analysis.



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- Design Input
- Basic Assumptions
- Approach/Design Methodology
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WRPS WASTE SERVICES & TANK SAMPLING

Evaluation of Flammable Gas Accumulation and Pressure Buildup in Non-Vented Temporary Storage Waste Containers at WRPS

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Calculation uses software tools ☒ Yes ☐ No (Microsoft Excel 2003)	*Note: If the calculation utilizes software tools they shall be treated as hand calculations and checked as such. Where the whole of the tool results are not included in the calculation, the file containing the calculation shall be completely referenced (including file name, date, and location) and attached to the calculation on electronic media (i.e. CD-Rom, DVD, etc.). The use of macros or functions (i.e. finite element solvers) that can not be exactly verified (i.e. verification of formulas, data and results) by hand are not permitted.*
Analysis checked as if it were a hand calculation **Checker name / Signature** _____ **Date** _____ **Note: No signature is required if software tools are not used.**	
Calculation contains Unverified Assumptions: ☐ Yes ☒ No	*Note: If calculation contains unverified assumptions identify them in the box below.*
Identify and Number Unverified Assumptions: NA	
Results and Conclusions: • One-half of the time to reach 5 vol% hydrogen is greater than one year for all low-level waste	

(LLW) containers, and greater than 90 days for all mixed waste (MW) containers. Therefore, there are no immediate flammability concerns assuming that storage times for LLW and MW containers are limited to one year and 90 days, respectively.

- Containers that need to be stored for longer than one year (LLW) or 90 days (MW) should be evaluated for hydrogen accumulation on a case-by-case bases using the methodology employed in this analysis.
- Container pressures at 5 vol% hydrogen are approximately 1.1 psig if there is no appreciable temperature rise after the containers are sealed.
- If containers are heated by elevated ambient temperatures after sealing, pressures will be correspondingly greater in accordance with the ideal gas law.
- Boxes should be screened to ensure that they can withstand the bounding internal pressure.

See Sections 4.0 and 5.0 for detailed discussion.

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EVALUATION OF FLAMMABLE GAS ACCUMULATION AND PRESSURE BUILDUP IN NON-VENTED TEMPORARY STORAGE WASTE CONTAINERS AT WRPS

1.0 INTRODUCTION

1.1 Purpose

This white paper evaluates flammable gas accumulation and pressure buildup in non-vented low-level non-transuranic (non-TRU) waste (LLW) and mixed waste (MW) drums and boxes containing various waste materials. The subject drums and boxes are loaded and placed in temporary storage by WRPS Waste Services & Tank Sampling (hereafter referred to as "WRPS" for brevity).

The LLW and MW radionuclide source terms and waste characterization data used in this evaluation were provided by WRPS. These container data sets were selected by WRPS personnel as representative of bounding cases in terms of both radionuclide and hydrogenous material contents.

1.1.1 Evaluation Criteria

The chosen storage time criteria for WRPS containers (drums and boxes) is one-half of the time to reach 5 vol%. This criteria is consistent with flammable gas generation guidance given in the *Hanford Sitewide Transportation Safety Document* (TSD) (Reference 6.1), which is based on NUREG-1609 (Reference 6.2) and NRC Information Notice 84-72 (Reference 6.3). The focus of this evaluation is storage rather than transportation; however, the flammable gas criteria applied to package transport are readily transferable to container storage from a safety standpoint.

Note that one-half of the time to reach 5 vol% hydrogen is *not* equivalent to the time to reach 2.5 vol%. Container hydrogen generation rates are not linear due to the non-linear depletion of parent radionuclides and the corresponding non-linear buildup and depletion of daughter products in decay chains. Thus, the ionizing energy source term is not constant over the time period of interest. Deviations from linearity may be small for short times and/or containers with relatively greater hydrogen generation rates, but the non-linearity becomes substantial over longer times.

1.2 Scope

Table 1.2-1 shows the drum and box sizes that were evaluated, along with their radionuclide source term category (LLW or MW) and waste content description.

Table 1.2-1. Scope of Containers, Radionuclide Source Terms, and Waste Descriptions Addressed in this Evaluation

Container description	Radionuclide source term category[1]	Waste content description
10-gal drum	LLW	Soil/fuel/hyd oil
		Steel/paper
	MW	Soil/fuel/hyd oil
		Steel/paper
30-gal drum	LLW	Misc debris
		Soil/fuel/hyd oil
	MW	Misc debris
		Soil/fuel/hyd oil
55-gal drum	LLW	Misc debris
		Soil/fuel/hyd oil
	MW	Misc debris
		Soil/fuel/hyd oil
85-gal drum	LLW	Misc debris
		Rocks/fuel/hyd oil
	MW	Misc debris
		Rocks/fuel/hyd oil
6x2x2 box	LLW	Misc debris
	MW	Misc debris
6x3x3 box	LLW	Misc debris
	MW	Misc debris
8x4x4 box	LLW	Misc debris
	MW	Misc debris
9x5x5 box	LLW	Misc debris
	MW	Misc debris
12x4x4 box	LLW	Misc debris
	MW	Misc debris
16x2x2 box	LLW	Misc debris
	MW	Misc debris

[1] LLW = low-level waste; MW = mixed waste.

Radionuclide source terms are tabulated in Section 7.1 for each container. Container waste characterization data is tabulated in Section 7.2.

1.3 Assumptions and Inputs

The following assumptions apply to this evaluation:

- Containers have no quantifiable leakage paths and are therefore assumed to be tightly sealed.
- Hydrogen is the sole flammable gas of concern.

- The radionuclide source term is intimately mixed with the waste contents. This assumption is made within Radcalc 4.1 (Reference 6.4).
- Waste material volumes reported in the WRPS waste characterization data are the actual volume occupied by the specific material and contain no interstitial void volume.
- There are no sealed inner containers within the drums and boxes, such that the 100% of the calculated container void volume is available for hydrogen accumulation.
- 100% of alpha and beta radioactive decay energy is absorbed within the containers. This is a valid assumption because alpha and beta energy is deposited in materials over very short distances.
- 100% gamma absorption, the most conservative assumption, was used for the 10-gal drums and all boxes because all of these containers were found to require greater than two years to reach 5 vol% hydrogen.
- The 30-gal, 55-gal, and 85-gal drums were evaluated in Radcalc using gamma absorption curves specific to these drum sizes. (Radcalc contains pre-programmed gamma absorption curves for certain containers, including these specific drum sizes.) The use of container-specific gamma absorption curves removes some conservatism, but it provides more precise results for these containers that have greater hydrogen buildup rates than the boxes and the 10-gal drums.
- Radcalc contains a substantial listing of material G-values, but the list is not all-inclusive given the wide variety of possible waste materials. Therefore, G-values were selected for the WRPS waste based on engineering judgment and prior experience of the evaluator. G-value selection is as follows:
    - Paper/plastic/cloth/rubber/wood/absorbent were categorized as "Polyethylene (LDPE)" using uniform alpha/beta/gamma G-values of 3.4 from TRAMPAC (Reference 6.6) for solid organic materials with less than 0.012 W-yr of exposure. TRAMPAC pertains to TRU waste that contains a large fraction of alpha emitters; therefore, use of TRAMPAC G-values for low-exposure (non-matrix depleted) waste provides a conservatively bounding analysis.
    - The G-value for soil was similarly taken from TRAMPAC, where it is given a uniform alpha/beta/gamma G-value of 1.3.
    - The G-value for rocks/gravel also was taken from TRAMPAC, which lists a uniform alpha/beta/gamma G-value of 0.08 for homogeneous solid inorganic materials with unbound absorbed ambient moisture.
    - Fuel/hydraulic oil was modeled as Texaco Regal-A machine oil. Oils in general have a fairly consistent range of G-values, and this particular material listed in Radcalc was judged to be representative of generic fuel/hydraulic oil.
    - All metals (steel, copper, aluminum, lead) were assigned a G-value of zero because metals are considered non-hydrogenous materials. Any minor amounts

of hydrogen that might be contained in steel alloy matrices will not be liberated by ionizing radiation.

2.0 METHODOLOGY

The LLW and MW radionuclide source terms provided by WRPS were evaluated to determine which were bounding for each drum and box size. This was a simple matter of examining the source terms to determine which were largest. Since the source terms are derived using radionuclide-specific scaling factors based on the measured Cs-137 content, those with the largest Cs-137 value were readily identified as the bounding source terms.

The radionuclide source terms, container data, and waste data were entered into Radcalc. Bounding G-values (molecules of H_2 generated per 100 eV of absorbed ionizing radiation) were selected as discussed in Section 1.3 above.

All containers were evaluated for the time necessary to reach 5 vol% hydrogen. That time is cut in half (divided by 2) to determine the allowable storage time at WRPS Waste Services & Tank Sampling.

2.1 Software and Computer Quality Assurance

Radcalc Version 4.1 (Reference 6.4), commonly referred to as Radcalc 4.1 or simply Radcalc, was used to perform the gas generation analyses documented within this report. The Radcalc output files are summarized in Section 7.3.

Radcalc 4.1 was validated and verified for correct installation and functionality, and is approved for use with quality-affecting analyses (Reference 6.5).

3.0 CALCULATIONS

All calculations, with the exception of simple hand calculations, were performed in either Microsoft Excel® or Radcalc 4.1. Minor arithmetic calculations, such as container void and percent void, were performed by adding simple formulas to the WRPS-provided Excel spreadsheets. These calculations are documented in Section 7.2, Waste Characterization Data, and they can be readily verified with a hand calculator.

All Radcalc runs are documented in Section 7.3. Source terms were decayed in Radcalc for 30 days prior to sealing the containers. The purpose of this decay time is to allow Radcalc to build in the decay chain daughter products and to establish secular equilibrium between parent and daughter radionuclides as appropriate. The use of a 30-day decay time is generally-accepted practice for Radcalc usage. In reality, essentially all radioactive waste already contains a full complement of daughter products unless it has been recently subjected to a chemical separation

process. However, waste characterization data necessarily lists only the primary radioisotopes of interest.

4.0 RESULTS

4.1 Hydrogen Buildup Times

Table 4-1 on the following page summarizes the Radcalc results for the times to 5 vol% hydrogen in the containers, along with the allowable storage times (one-half of the time to reach 5 vol% hydrogen). Any times less than one year are also stated in terms of days.

Two 30-gal drums, two 55-gal drums, and one 85-gal drum containing the MW radionuclide source term were found to have allowable storage times (one-half the time to reach 5 vol% H_2) of less than 1 year. These are identified in Table 4-1 by bolded print in the "Allowable storage time" column.

It is important to note that the LLW and MW radionuclide source terms, listed in Section 7.1, are not identical for all containers; e.g., the LLW and MW source terms for the 10-gal drum are unique to that container and are not the same as those for the other drums or the boxes. LLW and MW are general categories only, and source terms are dependent on how much and what type of waste can fit into specific containers.

The percent void volumes shown in Table 4-1 appear to be very large, but it must be remembered that these are true container void volumes that include interstitial void in the packaged waste rather than "freeboard" void existing above the waste level in the container.

Table 4-1. Times to 5 vol% Hydrogen and Allowable Storage Times

Container	Rad source term [1]	Contents	Percent void [2]	Time to 5 vol% hydrogen reported by Radcalc [3] [yr]	Allowable storage time (one-half of the time to 5 vol% hydrogen) [3] [yr]
10-gal drum	LLW	Soil/fuel/hyd oil	78.2	91.6	45.8
"	LLW	Steel/paper	97.1	918	459
"	MW	Soil/fuel/hyd oil	78.2	3.52	1.76
"	MW	Steel/paper	97.1	23.5	11.8
30-gal drum	LLW	Misc debris	71.8	22.0	11.0
"	LLW	Soil/fuel/hyd oil	61.7	37.6	18.8
"	MW	Misc debris	71.8	1.16	**0.579 (211 days)**
"	MW	Soil/fuel/hyd oil	61.7	1.79	**0.897 (327 days)**
55-gal drum	LLW	Misc debris	72.4	11.7	5.83
"	LLW	Soil/fuel/hyd oil	38.3	9.94	4.97
"	MW	Misc debris	72.4	0.699 (255 days)	**0.349 (127 days)**
"	MW	Soil/fuel/hyd oil	38.3	0.628 (229 days)	**0.314 (115 days)**
85-gal drum	LLW	Misc debris	80.8	27.5	13.8
"	LLW	Rocks/fuel/hyd oil	81.8	349	175
"	MW	Misc debris	80.8	1.42	**0.712 (260 days)**
"	MW	Rocks/fuel/hyd oil	81.8	9.92	4.96
6x2x2 box	LLW	Misc debris	85.2	134	67.2
"	MW	Misc debris	85.2	4.57	2.28
6x3x3 box	LLW	Misc debris	87.0	239	119
"	MW	Misc debris	87.0	6.96	3.48
8x4x4 box	LLW	Misc debris	93.8	842	421
"	MW	Misc debris	93.8	21.4	10.7
9x5x5 box	LLW	Misc debris	94.2	1473	737
"	MW	Misc debris	94.2	40.8	20.4
12x4x4 box	LLW	Misc debris	92.2	951	475
"	MW	Misc debris	92.2	24.3	12.1
16x2x2 box	LLW	Misc debris	81.6	255	127
"	MW	Misc debris	81.6	7.39	3.69

[1] LLW = low-level waste; MW = mixed waste.
[2] Void % includes waste interstitial void, which is assumed available for hydrogen accumulation (no sealed inner containers).
[3] Year values rounded to 3 significant figures from the Radcalc output. Allowable storage times shown were determined by dividing unrounded times to 5 vol% (see Radcalc output in Section 7.3) by 2, then rounding to 3 significant figures.

4.2 Container Pressures at 5 vol% Hydrogen

Table 4-2 shows the pressures that would be generated in sealed containers at 5 vol% hydrogen. These pressures bound the container pressures at one-half the time to reach 5 vol% hydrogen by a safety margin of approximately 100%. (See the discussion of hydrogen generation non-linearity in Section 1.1.1.)

Table 4-2. Final Container Pressures at 5 vol% Hydrogen [1]

Pressure if no O_2 generated [2] [psig]	Pressure if O_2 generated from H_2O [2] [psig]
0.736	1.10

[1] Reported pressures do not include adjustment for temperature rise after container is sealed. Final container pressures at a bounding elevated temperature can be calculated using the ideal gas law.
[2] Radcalc reports container pressure without and with O_2 that would be radiolytically generated by moisture in the container in stoichiometric ratio with H_2. The bounding case exists when water is the sole hydrogenous material in the container.

The bounding pressure at 5 vol% hydrogen for all containers is 1.1 psig (lb/in^2 gage). The discussion in the following subsections applies to Table 4-2.

4.2.1 Water vs. No Water in Container

Radcalc calculates two container pressures for a given vol% hydrogen endpoint, depending on the source of the radiolytic hydrogen:

(a) if no water is present; and

(b) if all hydrogen is generated by radiolysis of water.

These represent two extremes for oxygen generation that may accompany hydrogen. Due to the stoichiometry of water (H_2O), one-half mole of O_2 gas will accompany every mole of H_2 gas if water is the sole hydrogenous material in a container. If a drum or box contains other hydrogenous materials such as paper, plastic, fuel oil, etc., but no moisture, then little if any O_2 would be generated since relatively few hydrogen-oxygen bonds exist in other hydrogenous materials compared to water.

In reality, all typical containers have within them at least a trace of moisture from atmospheric humidity, and most non-water hydrogenous materials contain some small fraction of chemical bonds between hydrogen and oxygen. Therefore, the container pressure for a given hydrogen concentration endpoint lies somewhere between these two extremes. A conservative approach is to simply assume that water is present, and then use the higher package pressure from Radcalc for safety documentation purposes.

4.2.2 Independence of Pressure Results on Container Size

Note that Table 4-2 does not list pressures for individual containers (drums and boxes). This is because the container pressure for a given hydrogen concentration endpoint is independent of container volume. The number of moles of H_2 gas needed to reach a given vol% hydrogen concentration increases linearly with container volume. Per the ideal gas law,

$$PV = nRT,$$

where:

P = absolute pressure
V = container volume
n = moles of gas in container
R = ideal gas constant
T = absolute temperature.

Assuming that the container volume is constant (a good assumption for the relatively rigid structure of drums and boxes at low pressures where bulging is negligible), the final container pressure is a simple ratio of the final (condition 2) to initial (condition 1) moles of gas in the container:

$$\frac{P_2}{P_1} = \frac{n_2}{n_1} \Rightarrow P_2 = \left(\frac{n_2}{n_1}\right) P_1 .$$

Therefore, all sealed containers have the same endpoint pressures at 5 vol% hydrogen regardless of their dimensions.

4.2.3 Adjusting for Elevated Temperature

Radcalc assumes a constant standard temperature and pressure (STP) of 0 °C and 1 atmosphere (101.325 kPa) when determining the container pressure. Therefore, the results shown in Table 4-2 include no adjustment for temperature rise after containers are sealed. If containers are loaded and sealed in a relatively cool indoor or early morning environment, and then moved to an unshaded outdoor area for storage, their temperature will obviously increase during daytime hours in the sun.

The final container pressure can be adjusted for a bounding elevated temperature per the ideal gas law, as follows:

$$P_2 = \left(\frac{n_2}{n_1}\right)\left(\frac{T_2}{T_1}\right)P_1$$

where condition 1 is taken at the time of container sealing, and condition 2 is at the bounding maximum temperature and the limiting hydrogen concentration.

A simplified correction for a bounding elevated container temperature can be made from the Radcalc output pressure as follows:

$$P_{Bounding} = \left(\frac{T_{Bounding}}{T_{Radcalc}}\right)P_{Radcalc}$$

where:

$P_{Bounding}$ = container pressure at bounding elevated temperature, kPa absolute or psia
$P_{Radcalc}$ = container pressure from Radcalc output, kPa absolute or psia
$T_{Bounding}$ = bounding elevated temperature, °K or °R
$T_{Radcalc}$ = Radcalc output STP temperature, 273 °K or 460 °R

Note that the pressures and temperatures in all formulas above are absolute, i.e., psia rather than psig and °K or °R rather than °C or °F. Container gage pressure is then obtained by subtracting 1 atmosphere (101.325 kPa, 14.7 psi) from the absolute pressure.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions are drawn:

- None of the bounding LLW containers reach the hydrogen-based allowable storage time limit (one-half the time to reach 5 vol%) in less than one year. The shortest allowable storage time for any LLW container is 11 years, based on hydrogen buildup.
- None of the bounding MW containers reach the hydrogen-based allowable storage time limit in less than 90 days. The shortest allowable storage time for any MW container is 115 days, based on hydrogen buildup.
- Therefore, assuming temporary storage time limits of 1 yr for LLW containers and 90 days for MW containers, none of the bounding containers stored by WRPS Waste Services & Tank Sampling have an immediate flammability concern.

- The bounding endpoint pressure at 5 vol% hydrogen for all containers is 1.1 psig. Note that this pressure does not include any compensation for a bounding elevated temperature. As explained in Section 4.2.3, pressure buildup will be of greater concern if containers are exposed to hot ambient conditions after they are filled and sealed.
- Pressure buildup is likely not a concern for drums that are generally designed to withstand several psig of internal pressure. Boxes, due to their dimensions and large flat side surfaces, may need be to be structurally evaluated depending on their design criteria because even fractional psig, distributed over a large section of sheet metal, could cause bulging. Container pressure design criteria was not available for this scoping evaluation, therefore no judgment can be made regarding box structural integrity.

5.2 Recommendations

The following recommendations are made based on the outcome of this evaluation:

- Any containers at WRPS that may need to be stored longer than the standard temporary storage time limits (one year for LLW, 90 days for MW) should be evaluated on a case-by-case bases using the Radcalc hydrogen buildup methodology. Most will probably not require any action within a reasonable time period, but some may need to be vented through NucFil vent filters (or equivalent) to negate hydrogen flammability or container pressure concerns.
- Although none of the boxes evaluated herein present a flammability concern, boxes in general should be screened for design pressures. Conservatively, boxes that cannot structurally withstand at least 2 psig internal pressure with an appropriate safety margin should be vented. The criteria of 2 psig is suggested to accommodate additional pressure buildup when boxes are exposed to elevated temperatures after sealing.

5.3 Further Discussion

5.3.1 Conservatism

Note that this evaluation did not apply any conservative multipliers to either the radionuclide source terms or the hydrogenous material contents. General practice for safety analysis documentation is to multiply the bounding data by a realistically justifiable safety factor, e.g., 1.1, 1.5, 2.0, etc., depending on the level of confidence in the bounding input data. The goal of this evaluation was to simply determine if a hydrogen flammability concern could exist based on actual bounding waste container data. However, the bounding radionuclide source term data provided by WRPS is based on scaling factors relative to the Cs-137 content as determined by dose rate readings. It is likely that (a) the dose-to-curie conversion for Cs-137 readings is conservative, and (b) the Cs-137 scaling factors for other radionuclides are also conservative. Therefore, the LLW and MW radionuclide source terms provided by WRPS may already be defensibly conservative and bounding for all possible container contents.

This evaluation has no basis on which to make a judgment regarding the conservatism of the container waste characterization data with regard to the quantities and percentages of hydrogenous materials. The hydrogen generation G-values chosen for this evaluation are appropriately conservative. The greatest conservatism arises from the assumption built into the Radcalc software that the radionuclide source term is intimately mixed with the hydrogenous material. This may be true for wastes such as grouted material where radioisotopes are indeed well-mixed in the waste form. However, unless the degree of mixing can be quantified and bounded, it is difficult to build a case where this conservatism can be reduced. Relatively diverse waste material such as that in the WRPS containers cannot be easily characterized in terms of mixing. The soil/fuel/hydraulic oil waste could actually be fairly well-mixed with its associated radionuclide source term, while the radioactive contamination associated with paper, cloth, plastic, rubber, and wood is likely to be located on the surfaces of these materials with minor sub-surface adsorption.

5.3.2 Risk-Based Hydrogen Limits

During the last revision of the Hanford Sitewide TSD, DOE-RL indicated an interest in risk-based hydrogen limits to alleviate costly and time-consuming operational restrictions for retrieval drums and other legacy waste packages. The result was research and compilation of hydrogen flammability and explosion data that led to the inclusion of TSD Appendix G, Attachment A, which contains recommendations for elevated risk-based hydrogen limits. Table 5.3-1 below is excerpted from that document.

Table 5.3-1. Hydrogen Concentration Limits for Risk-Based Packages from Hanford Sitewide TSD, Revision 1

Package description	Normal-temperature limit (vol%)	Elevated-temperature limit (vol%) *
208 L (55-gal) drums in good condition, known to contain 90-mil liners	16.5	14.0
208 L (55-gal) drums in poor condition, and/or without 90-mil liners	11.6	9.1
General risk-based packages other than 208 L (55-gal) drums	15.0	12.5

* Applies to packages that (a) have been exposed to solar insolation for longer than 30 minutes immediately prior to handling for transport and/or (b) will be exposed to solar insolation for greater than 30 minutes during transport.

Although the lower flammability limit of hydrogen in air is widely given as 4 vol% (Reference 6.7), multiple nuclear industry flammability studies, as well as actual drum explosion testing at other DOE sites, have shown that a 4 vol% hydrogen-air mixture is difficult to ignite

and burns quite poorly. Energetic flame propagation does not occur until significantly greater hydrogen concentrations are reached. Even higher levels are required to approach the point at which a true detonation (explosion) can occur that would rupture a container or blow the lid off a drum. TSD Appendix G, Attachment A, contains detailed discussion on this topic.

These risk-based limits have not yet been applied anywhere at Hanford to the knowledge of this evaluator. Nonetheless, they are brought to the attention of the reader for completeness and for possible consideration when developing a path forward for the WRPS waste containers that are the subject of this evaluation.

6.0 REFERENCES

6.1 DOE-RL, 2006, *Hanford Site Transportation Safety Document*, DOE/RL-2001-36, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

6.2 NUREG-1609, 1999, *Standard Review Plan for Transportation Packages for Radioactive Material*, Spent Fuel Project Office, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C.

6.3 NRC, 1984, *Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation*, Information Notice 84-72, U.S. Nuclear Regulatory Commission, Washington, D.C.

6.4 FSWO-SQA-026, 2009, *Radcalc 4.1 User Manual*, Rev. 0, Energy*Solutions* Federal Services, Inc., Richland, Washington.

6.5 ENG-03.30, Rev. 1, "Installation, and Testing of Acquired Software," EnergySolutions, Engineering and Technology, Richland, WA.

6.6 Westinghouse, 2003, *TRUPACT-II Authorized Methods for Payload Control (TRAMPAC)*, Rev. 19c, Westinghouse TRU Solutions, LLC, Carlsbad, New Mexico.

6.7 CRC, 1982, *Handbook of Chemistry and Physics*, 63rd Edition, CRC Press, Inc., Boca Raton, Florida.

7.0 APPENDICES

7.1 Radionuclide Source Terms

The radionuclide source terms shown in this section were provided via e-mail from M. Pascual to R. Wagner on July 28, 2009. These source terms were subsequently decayed for 30 days in Radcalc 4.1 prior to container sealing. (See discussion in Section 3.0.)

7.1.1 Source Terms for 10-gal Drum

Table 7.1.1-1. Bounding 10-gal Drum LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	2.25E-04	Th-232	7.78E-06
Co-60	1.02E-02	U-234	5.17E-04
Sr-90	9.71E-03	U-235	2.25E-05
Y-90	9.71E-03	Np-237	7.83E-05
Cs-137	1.71E-02	U-238	5.43E-04
Ba-137m	1.61E-02	Pu-238	1.46E-04
Eu-152	8.26E-05	Pu-239	7.59E-04
Eu-154	6.41E-04	Pu-240	1.77E-04
Eu-155	4.69E-05	Pu-241	8.27E-03
Re-187	5.10E-08	Am-241	6.14E-04

Table 7.1.1-2. Bounding 10-gal Drum MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	1.64E-04	Ra-226	5.31E-10
C-14	3.44E-05	Ac-227	1.20E-06
Ni-59	7.89E-06	Ra-228	4.31E-07
Co-60	1.05E-04	Th-229	1.87E-08
Ni-63	7.52E-04	Pa-231	2.53E-06
Se-79	6.34E-06	Th-232	4.56E-08
Sr-90	4.79E-01	U-232	1.21E-06
Y-90	4.79E-01	U-233	4.88E-06
Zr-93	3.07E-05	U-234	3.10E-06
Nb-93m	2.43E-05	U-235	1.25E-07
Tc-99	2.48E-04	U-236	1.20E-07
Ru-106	5.08E-05	Np-237	1.83E-06
Cd-113m	1.20E-04	Pu-238	2.43E-05
Sb-125	9.36E-04	U-238	2.73E-06
Sn-126	1.04E-05	Pu-239	5.11E-04
I-129	9.47E-07	Pu-240	1.04E-04
Cs-134	2.19E-04	Am-241	1.12E-03
Cs-137	2.87E-01	Pu-241	1.23E-03
Ba-137m	2.72E-01	Cm-242	5.02E-10
Sm-151	2.21E-02	Pu-242	1.06E-08
Eu-152	1.08E-05	Am-243	2.46E-07
Eu-154	1.34E-03	Cm-243	3.21E-07

Eu-155	9.96E-04	Cm-244	7.23E-06

7.1.2 Source Terms for 30-gal Drum

Table 7.1.2-1. Bounding 30-gal Drum LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	1.04E-03	Th-232	3.61E-05
Co-60	4.74E-02	U-234	2.40E-03
Sr-90	4.50E-02	U-235	1.04E-04
Y-90	4.50E-02	Np-237	3.63E-04
Cs-137	7.91E-02	U-238	2.51E-03
Ba-137m	7.48E-02	Pu-238	6.77E-04
Eu-152	3.83E-04	Pu-239	3.52E-03
Eu-154	2.97E-03	Pu-240	8.22E-04
Eu-155	2.17E-04	Pu-241	3.84E-02
Re-187	2.36E-07	Am-241	2.85E-03

Table 7.1.2-2. Bounding 30-gal Drum MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	7.61E-04	Ra-226	2.47E-09
C-14	1.60E-04	Ac-227	5.58E-06
Ni-59	3.67E-05	Ra-228	2.00E-06
Co-60	4.90E-04	Th-229	8.69E-08
Ni-63	3.50E-03	Pa-231	1.18E-05
Se-79	2.95E-05	Th-232	2.12E-07
Sr-90	2.23E+00	U-232	5.65E-06
Y-90	2.23E+00	U-233	2.27E-05
Zr-93	1.43E-04	U-234	1.44E-05
Nb-93m	1.13E-04	U-235	5.82E-07
Tc-99	1.15E-03	U-236	5.59E-07
Ru-106	2.36E-04	Np-237	8.49E-06
Cd-113m	5.57E-04	Pu-238	1.13E-04
Sb-125	4.35E-03	U-238	1.27E-05
Sn-126	4.86E-05	Pu-239	2.38E-03
I-129	4.41E-06	Pu-240	4.85E-04
Cs-134	1.02E-03	Am-241	5.22E-03
Cs-137	1.34E+00	Pu-241	5.70E-03
Ba-137m	1.26E+00	Cm-242	2.34E-09
Sm-151	1.03E-01	Pu-242	4.91E-08
Eu-152	5.02E-05	Am-243	1.15E-06
Eu-154	6.23E-03	Cm-243	1.50E-06
Eu-155	4.63E-03	Cm-244	3.36E-05

7.1.3 Source Terms for 55-gal Drum

Table 7.1.3-1. Bounding 55-gal Drum LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	3.48E-03	Th-232	1.20E-04
Co-60	1.58E-01	U-234	8.00E-03
Sr-90	1.50E-01	U-235	3.48E-04
Y-90	1.50E-01	Np-237	1.21E-03
Cs-137	2.64E-01	U-238	8.40E-03
Ba-137m	2.50E-01	Pu-238	2.26E-03
Eu-152	1.28E-03	Pu-239	1.17E-02
Eu-154	9.93E-03	Pu-240	2.75E-03
Eu-155	7.26E-04	Pu-241	1.28E-01
Re-187	7.89E-07	Am-241	9.50E-03

Table 7.1.3-2. Bounding 55-gal Drum MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	2.54E-03	Ra-226	8.23E-09
C-14	5.34E-04	Ac-227	1.86E-05
Ni-59	1.22E-04	Ra-228	6.68E-06
Co-60	1.63E-03	Th-229	2.90E-07
Ni-63	1.17E-02	Pa-231	3.93E-05
Se-79	9.83E-05	Th-232	7.08E-07
Sr-90	7.43E+00	U-232	1.88E-05
Y-90	7.43E+00	U-233	7.57E-05
Zr-93	4.76E-04	U-234	4.81E-05
Nb-93m	3.76E-04	U-235	1.94E-06
Tc-99	3.84E-03	U-236	1.86E-06
Ru-106	7.88E-04	Np-237	2.83E-05
Cd-113m	1.86E-03	Pu-238	3.77E-04
Sb-125	1.45E-02	U-238	4.24E-05
Sn-126	1.62E-04	Pu-239	7.92E-03
I-129	1.47E-05	Pu-240	1.62E-03
Cs-134	3.39E-03	Am-241	1.74E-02
Cs-137	4.45E+00	Pu-241	1.90E-02
Ba-137m	4.21E+00	Cm-242	7.79E-09
Sm-151	3.43E-01	Pu-242	1.64E-07
Eu-152	1.67E-04	Am-243	3.82E-06
Eu-154	2.08E-02	Cm-243	4.98E-06
Eu-155	1.54E-02	Cm-244	1.12E-04

7.1.4 Source Terms for 85-gal Drum

Table 7.1.4-1. Bounding 85-gal Drum LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	3.19E-03	Th-232	1.10E-04
Co-60	1.45E-01	U-234	7.31E-03
Sr-90	1.37E-01	U-235	3.19E-04
Y-90	1.37E-01	Np-237	1.11E-03
Cs-137	2.41E-01	U-238	7.68E-03
Ba-137m	2.28E-01	Pu-238	2.07E-03
Eu-152	1.17E-03	Pu-239	1.07E-02
Eu-154	9.08E-03	Pu-240	2.51E-03
Eu-155	6.64E-04	Pu-241	1.17E-01
Re-187	7.22E-07	Am-241	8.69E-03

Table 7.1.4-2. Bounding 85-gal Drum MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	2.32E-03	Ra-226	7.52E-09
C-14	4.88E-04	Ac-227	1.70E-05
Ni-59	1.12E-04	Ra-228	6.09E-06
Co-60	1.49E-03	Th-229	2.65E-07
Ni-63	1.06E-02	Pa-231	3.59E-05
Se-79	8.98E-05	Th-232	6.46E-07
Sr-90	6.79E+00	U-232	1.72E-05
Y-90	6.79E+00	U-233	6.91E-05
Zr-93	4.35E-04	U-234	4.39E-05
Nb-93m	3.44E-04	U-235	1.77E-06
Tc-99	3.51E-03	U-236	1.70E-06
Ru-106	7.19E-04	Np-237	2.58E-05
Cd-113m	1.69E-03	Pu-238	3.44E-04
Sb-125	1.32E-02	U-238	3.87E-05
Sn-126	1.48E-04	Pu-239	7.23E-03
I-129	1.34E-05	Pu-240	1.47E-03
Cs-134	3.10E-03	Am-241	1.59E-02
Cs-137	4.06E+00	Pu-241	1.73E-02
Ba-137m	3.84E+00	Cm-242	7.11E-09
Sm-151	3.13E-01	Pu-242	1.50E-07
Eu-152	1.53E-04	Am-243	3.49E-06
Eu-154	1.90E-02	Cm-243	4.55E-06
Eu-155	1.41E-02	Cm-244	1.02E-04

7.1.5 Source Terms for 6x2x2 Box

Table 7.1.5-1. Bounding 6x2x2 Box LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	2.35E-03	Th-232	8.10E-05
Co-60	1.06E-01	U-234	5.38E-03
Sr-90	1.01E-01	U-235	2.35E-04
Y-90	1.01E-01	Np-237	8.16E-04
Cs-137	1.78E-01	U-238	5.65E-03
Ba-137m	1.68E-01	Pu-238	1.52E-03
Eu-152	8.60E-04	Pu-239	7.91E-03
Eu-154	6.68E-03	Pu-240	1.85E-03
Eu-155	4.89E-04	Pu-241	8.62E-02
Re-187	5.31E-07	Am-241	6.40E-03

Table 7.1.5-2. Bounding 6x2x2 Box MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	1.71E-03	Ra-226	5.54E-09
C-14	3.60E-04	Ac-227	1.25E-05
Ni-59	8.24E-05	Ra-228	4.49E-06
Co-60	1.10E-03	Th-229	1.95E-07
Ni-63	7.85E-03	Pa-231	2.65E-05
Se-79	6.62E-05	Th-232	4.76E-07
Sr-90	5.00E+00	U-232	1.27E-05
Y-90	5.00E+00	U-233	5.09E-05
Zr-93	3.21E-04	U-234	3.24E-05
Nb-93m	2.53E-04	U-235	1.31E-06
Tc-99	2.59E-03	U-236	1.26E-06
Ru-106	5.30E-04	Np-237	1.91E-05
Cd-113m	1.25E-03	Pu-238	2.54E-04
Sb-125	9.77E-03	U-238	2.85E-05
Sn-126	1.09E-04	Pu-239	5.33E-03
I-129	9.89E-06	Pu-240	1.09E-03
Cs-134	2.28E-03	Am-241	1.17E-02
Cs-137	3.00E+00	Pu-241	1.28E-02
Ba-137m	2.83E+00	Cm-242	5.24E-09
Sm-151	2.31E-01	Pu-242	1.10E-07
Eu-152	1.13E-04	Am-243	2.57E-06
Eu-154	1.40E-02	Cm-243	3.36E-06
Eu-155	1.04E-02	Cm-244	7.55E-05

7.1.6 Source Terms for 6x3x3 Box

Table 7.1.6-1. Bounding 6x3x3 Box LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	4.62E-03	Th-232	1.60E-04
Co-60	2.10E-01	U-234	1.06E-02
Sr-90	1.99E-01	U-235	4.62E-04
Y-90	1.99E-01	Np-237	1.61E-03
Cs-137	3.50E-01	U-238	1.11E-02
Ba-137m	3.31E-01	Pu-238	3.00E-03
Eu-152	1.70E-03	Pu-239	1.56E-02
Eu-154	1.32E-02	Pu-240	3.64E-03
Eu-155	9.63E-04	Pu-241	1.70E-01
Re-187	1.05E-06	Am-241	1.26E-02

Table 7.1.6-2. Bounding 6x3x3 Box MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	3.37E-03	Ra-226	1.09E-08
C-14	7.08E-04	Ac-227	2.47E-05
Ni-59	1.62E-04	Ra-228	8.86E-06
Co-60	2.17E-03	Th-229	3.84E-07
Ni-63	1.55E-02	Pa-231	5.21E-05
Se-79	1.30E-04	Th-232	9.39E-07
Sr-90	9.86E+00	U-232	2.50E-05
Y-90	9.86E+00	U-233	1.00E-04
Zr-93	6.32E-04	U-234	6.38E-05
Nb-93m	4.99E-04	U-235	2.57E-06
Tc-99	5.10E-03	U-236	2.47E-06
Ru-106	1.05E-03	Np-237	3.75E-05
Cd-113m	2.46E-03	Pu-238	5.00E-04
Sb-125	1.92E-02	U-238	5.62E-05
Sn-126	2.15E-04	Pu-239	1.05E-02
I-129	1.95E-05	Pu-240	2.14E-03
Cs-134	4.50E-03	Am-241	2.31E-02
Cs-137	5.90E+00	Pu-241	2.52E-02
Ba-137m	5.59E+00	Cm-242	1.03E-08
Sm-151	4.55E-01	Pu-242	2.17E-07
Eu-152	2.22E-04	Am-243	5.07E-06
Eu-154	2.76E-02	Cm-243	6.61E-06
Eu-155	2.05E-02	Cm-244	1.49E-04

7.1.7 Source Terms for 8x4x4 Box

Table 7.1.7-1. Bounding 8x4x4 Box LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	7.72E-03	Th-232	2.67E-04
Co-60	3.50E-01	U-234	1.77E-02
Sr-90	3.33E-01	U-235	7.72E-04
Y-90	3.33E-01	Np-237	2.69E-03
Cs-137	5.85E-01	U-238	1.86E-02
Ba-137m	5.53E-01	Pu-238	5.01E-03
Eu-152	2.83E-03	Pu-239	2.60E-02
Eu-154	2.20E-02	Pu-240	6.08E-03
Eu-155	1.61E-03	Pu-241	2.84E-01
Re-187	1.75E-06	Am-241	2.11E-02

Table 7.1.7-2. Bounding 8x4x4 Box MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	5.62E-03	Ra-226	1.83E-08
C-14	1.18E-03	Ac-227	4.12E-05
Ni-59	2.71E-04	Ra-228	1.48E-05
Co-60	3.62E-03	Th-229	6.42E-07
Ni-63	2.58E-02	Pa-231	8.71E-05
Se-79	2.18E-04	Th-232	1.57E-06
Sr-90	1.65E+01	U-232	4.17E-05
Y-90	1.65E+01	U-233	1.68E-04
Zr-93	1.06E-03	U-234	1.07E-04
Nb-93m	8.35E-04	U-235	4.30E-06
Tc-99	8.51E-03	U-236	4.13E-06
Ru-106	1.75E-03	Np-237	6.27E-05
Cd-113m	4.11E-03	Pu-238	8.36E-04
Sb-125	3.22E-02	U-238	9.39E-05
Sn-126	3.59E-04	Pu-239	1.76E-02
I-129	3.26E-05	Pu-240	3.58E-03
Cs-134	7.52E-03	Am-241	3.86E-02
Cs-137	9.87E+00	Pu-241	4.21E-02
Ba-137m	9.33E+00	Cm-242	1.73E-08
Sm-151	7.61E-01	Pu-242	3.63E-07
Eu-152	3.71E-04	Am-243	8.47E-06
Eu-154	4.61E-02	Cm-243	1.10E-05
Eu-155	3.42E-02	Cm-244	2.49E-04

7.1.8 Source Terms for 9x5x5 Box

Table 7.1.8-1. Bounding 9x5x5 Box LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	1.93E-02	Th-232	6.67E-04
Co-60	8.76E-01	U-234	4.43E-02
Sr-90	8.32E-01	U-235	1.93E-03
Y-90	8.32E-01	Np-237	6.72E-03
Cs-137	1.46E+00	U-238	4.65E-02
Ba-137m	1.38E+00	Pu-238	1.25E-02
Eu-152	7.08E-03	Pu-239	6.51E-02
Eu-154	5.50E-02	Pu-240	1.52E-02
Eu-155	4.02E-03	Pu-241	7.10E-01
Re-187	4.37E-06	Am-241	5.27E-02

Table 7.1.8-2. Bounding 9x5x5 Box MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	1.41E-02	Ra-226	4.59E-08
C-14	2.98E-03	Ac-227	1.04E-04
Ni-59	6.82E-04	Ra-228	3.72E-05
Co-60	9.11E-03	Th-229	1.62E-06
Ni-63	6.50E-02	Pa-231	2.19E-04
Se-79	5.48E-04	Th-232	3.94E-06
Sr-90	4.14E+01	U-232	1.05E-04
Y-90	4.14E+01	U-233	4.22E-04
Zr-93	2.65E-03	U-234	2.68E-04
Nb-93m	2.10E-03	U-235	1.08E-05
Tc-99	2.14E-02	U-236	1.04E-05
Ru-106	4.39E-03	Np-237	1.58E-04
Cd-113m	1.03E-02	Pu-238	2.10E-03
Sb-125	8.09E-02	U-238	2.36E-04
Sn-126	9.03E-04	Pu-239	4.42E-02
I-129	8.19E-05	Pu-240	9.01E-03
Cs-134	1.89E-02	Am-241	9.70E-02
Cs-137	2.48E+01	Pu-241	1.06E-01
Ba-137m	2.35E+01	Cm-242	4.34E-08
Sm-151	1.91E+00	Pu-242	9.13E-07
Eu-152	9.33E-04	Am-243	2.13E-05
Eu-154	1.16E-01	Cm-243	2.78E-05
Eu-155	8.61E-02	Cm-244	6.25E-04

7.1.9 Source Terms for 12x4x4 Box

Table 7.1.9-1. Bounding 12x4x4 Box LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	2.17E-02	Th-232	7.50E-04
Co-60	9.85E-01	U-234	4.98E-02
Sr-90	9.35E-01	U-235	2.17E-03
Y-90	9.35E-01	Np-237	7.55E-03
Cs-137	1.64E+00	U-238	5.23E-02
Ba-137m	1.56E+00	Pu-238	1.41E-02
Eu-152	7.96E-03	Pu-239	7.32E-02
Eu-154	6.18E-02	Pu-240	1.71E-02
Eu-155	4.52E-03	Pu-241	7.97E-01
Re-187	4.92E-06	Am-241	5.92E-02

Table 7.1.9-2. Bounding 12x4x4 Box MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	1.58E-02	Ra-226	5.13E-08
C-14	3.33E-03	Ac-227	1.16E-04
Ni-59	7.63E-04	Ra-228	4.16E-05
Co-60	1.02E-02	Th-229	1.81E-06
Ni-63	7.27E-02	Pa-231	2.45E-04
Se-79	6.13E-04	Th-232	4.41E-06
Sr-90	4.63E+01	U-232	1.17E-04
Y-90	4.63E+01	U-233	4.72E-04
Zr-93	2.97E-03	U-234	3.00E-04
Nb-93m	2.35E-03	U-235	1.21E-05
Tc-99	2.39E-02	U-236	1.16E-05
Ru-106	4.91E-03	Np-237	1.76E-04
Cd-113m	1.16E-02	Pu-238	2.35E-03
Sb-125	9.04E-02	U-238	2.64E-04
Sn-126	1.01E-03	Pu-239	4.94E-02
I-129	9.15E-05	Pu-240	1.01E-02
Cs-134	2.11E-02	Am-241	1.08E-01
Cs-137	2.77E+01	Pu-241	1.18E-01
Ba-137m	2.62E+01	Cm-242	4.85E-08
Sm-151	2.14E+00	Pu-242	1.02E-06
Eu-152	1.04E-03	Am-243	2.38E-05
Eu-154	1.30E-01	Cm-243	3.11E-05
Eu-155	9.63E-02	Cm-244	6.99E-04

7.1.10 Source Terms for 16x2x2 Box

Table 7.1.10-1. Bounding 16x2x2 Box LLW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
K-40	1.73E-02	Th-232	5.97E-04
Co-60	7.85E-01	U-234	3.97E-02
Sr-90	7.45E-01	U-235	1.73E-03
Y-90	7.45E-01	Np-237	6.01E-03
Cs-137	1.31E+00	U-238	4.17E-02
Ba-137m	1.24E+00	Pu-238	1.12E-02
Eu-152	6.34E-03	Pu-239	5.83E-02
Eu-154	4.93E-02	Pu-240	1.36E-02
Eu-155	3.60E-03	Pu-241	6.35E-01
Re-187	3.92E-06	Am-241	4.72E-02

Table 7.1.10-2. Bounding 16x2x2 Box MW Radionuclide Source Term

Radionuclide	Ci	Radionuclide	Ci
H-3	1.25E-02	Ra-226	4.06E-08
C-14	2.63E-03	Ac-227	9.17E-05
Ni-59	6.03E-04	Ra-228	3.29E-05
Co-60	8.05E-03	Th-229	1.43E-06
Ni-63	5.75E-02	Pa-231	1.94E-04
Se-79	4.85E-04	Th-232	3.49E-06
Sr-90	3.66E+01	U-232	9.28E-05
Y-90	3.66E+01	U-233	3.73E-04
Zr-93	2.35E-03	U-234	2.37E-04
Nb-93m	1.86E-03	U-235	9.56E-06
Tc-99	1.89E-02	U-236	9.19E-06
Ru-106	3.88E-03	Np-237	1.40E-04
Cd-113m	9.15E-03	Pu-238	1.86E-03
Sb-125	7.15E-02	U-238	2.09E-04
Sn-126	7.99E-04	Pu-239	3.90E-02
I-129	7.24E-05	Pu-240	7.96E-03
Cs-134	1.67E-02	Am-241	8.58E-02
Cs-137	2.19E+01	Pu-241	9.37E-02
Ba-137m	2.08E+01	Cm-242	3.84E-08
Sm-151	1.69E+00	Pu-242	8.07E-07
Eu-152	8.25E-04	Am-243	1.88E-05
Eu-154	1.02E-01	Cm-243	2.46E-05
Eu-155	7.61E-02	Cm-244	5.53E-04

7.2 Waste Characterization Data

Waste characterization data for drums and boxes was provided via e-mail from M. Pascual to R. Wagner on July 28, 2009. The tables below summarize the relevant data for Radcalc input.

The tables also include the following calculated values based on the provided waste data:

- Container (drum or box) volume, m^3
- Void and Waste volumes, m^3
- Void %.

7.2.1 Waste Data for 10-gal Drum

Table 7.2.1-1. Waste in 10-gal Drum (Steel/Paper)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	0.49032	0.0993	0.527225806
Steel	4.449654	0.9007	0.570468462
Total	**4.939974**	**1.00**	**1.0976943**
Tare weight [kg]	6.35		
Drum volume [m^3]	3.785E-02		
Void volume [m^3]	3.676E-02		
Waste volume [m^3]	1.098E-03		
Void %	97.1%		

Table 7.2.1-2. Waste in 10-gal Drum (Soil/Fuel/Hyd Oil)

Material	Weight [kg]	Weight fraction	Volume [liters]
Soil	16.13516	0.9519	7.334163636
Fuel/Oil	0.81493	0.0481	0.936701149
Total	**16.95009**	**1.00**	**8.2708648**
Tare weight [kg]	6.35		
Drum volume [m^3]	3.785E-02		
Void volume [m^3]	2.958E-02		
Waste volume [m^3]	8.271E-03		
Void %	78.2%		

7.2.2 Waste Data for 30-gal Drum

Table 7.2.2-1. Waste in 30-gal Drum (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	2.27	0.0556	2.440860215
Plastic	13.62	0.3333	14.64516129
Cloth	4.54	0.1111	3.242857143
Rubber	8.172	0.2000	7.429090909
Wood	2.27	0.0556	2.734939759
Absorbent/Poly Pads	0.908	0.0222	0.412727273
Steel	9.08	0.2222	1.164102564
Total	**40.86**	**1.00**	**32.069739**
Tare weight [kg]	15.9		
Drum volume [m^3]	1.136E-01		
Void volume [m^3]	8.149E-02		
Waste volume [m^3]	3.207E-02		
Void %	71.8%		

Table 7.2.2-2. Waste in 30-gal Drum (Soil/Fuel/Hyd Oil)

Material	Weight [kg]	Weight fraction	Volume [liters]
Soil	74.74656	0.9005	33.97570909
Fuel/Oil	8.2628	0.0995	9.497471264
Total	**83.00936**	**1.00**	**43.47318**
Tare weight [kg]	15.9		
Drum volume [m^3]	1.136E-01		
Void volume [m^3]	7.009E-02		
Waste volume [m^3]	4.347E-02		
Void %	61.7%		

7.2.3 Waste Data for 55-gal Drum

Table 7.2.3-1. Waste in 55-gal Drum (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	3.859	0.0500	4.149462366
Plastic	30.872	0.4000	33.19569892
Cloth	7.718	0.1000	5.512857143
Rubber	7.718	0.1000	7.016363636
Wood	3.859	0.0500	4.64939759
Steel	23.154	0.3000	2.968461538
Total	**77.18**	**1.00**	**57.492241**
Tare weight [kg]	21.3		
Drum volume [m^3]	2.082E-01		
Void volume [m^3]	1.507E-01		
Waste volume [m^3]	5.749E-02		
Void %	72.4%		

Table 7.2.3-2. Waste in 55-gal Drum (Soil/Fuel/Hyd Oil)

Material	Weight [kg]	Weight fraction	Volume [liters]
Soil	249.43214	0.9519	113.3782455
Fuel/Oil	12.5985	0.0481	14.99821429
Total	**262.03064**	**1.00**	**128.37646**
Tare weight [kg]	21.3		
Drum volume [m^3]	2.082E-01		
Void volume [m^3]	7.982E-02		
Waste volume [m^3]	1.284E-01		
Void %	38.3%		

7.2.4 Waste Data for 85-gal Drum

Table 7.2.4-1. Waste in 85-gal Drum (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	4.086	0.0455	4.393548387
Plastic	32.688	0.3636	35.1483871
Cloth	8.172	0.0909	5.837142857
Rubber	8.172	0.0909	7.429090909
Wood	4.086	0.0455	4.922891566
Absorbent	0.8172	0.0091	0.104769231
Steel	31.8708	0.3545	4.086
Total	**89.892**	**1.00**	**61.92183**
Tare weight [kg]	35.4		
Drum volume [m^3]	3.218E-01		
Void volume [m^3]	2.598E-01		
Waste volume [m^3]	6.192E-02		
Void %	80.8%		

Table 7.2.4-2. Waste in 85-gal Drum (Rocks/Gravel/Fuel/Hyd Oil)

Material	Weight [kg]	Weight fraction	Volume [liters]
Rocks/Gravel	103.74354	0.9000	47.15615455
Fuel/Oil	11.52706	0.1000	13.72269048
Total	**115.2706**	**1.00**	**60.878845**
Tare weight [kg]	35.4		
Drum volume [m^3]	3.218E-01		
Void volume [m^3]	2.609E-01		
Waste volume [m^3]	6.088E-02		
Void %	81.1%		

7.2.5 Waste Data for 6x2x2 Box

Table 7.2.5-1. Waste in 6x2x2 Box (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	4.6762	0.0303	5.028172043
Plastic	56.1144	0.3636	60.33806452
Cloth	9.3524	0.0606	6.680285714
Rubber	9.3524	0.0606	8.502181818
Wood	9.3524	0.0606	11.26795181
Absorbent	1.87048	0.0121	0.850218182
Steel	63.59632	0.4121	8.153374359
Total	**154.3146**	**1.00**	**100.82025**
Tare weight [kg]	309		
Box volume [m^3]	6.796E-01		
Void volume [m^3]	5.788E-01		
Waste volume [m^3]	1.008E-01		
Void %	85.2%		

7.2.6 Waste Data for 6x3x3 Box

Table 7.2.6-1. Waste in 6x3x3 Box (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	9.1935	0.0249	9.885483871
Plastic	110.322	0.2987	118.6258065
Cloth	18.387	0.0498	13.13357143
Rubber	18.387	0.0498	16.71545455
Wood	11.0322	0.0299	13.29180723
Absorbent/Poly Pads	3.6774	0.0100	1.671545455
Steel	194.7206	0.5271	24.96417949
Lead	3.6774	0.0100	0.325433628
Total	**369.3971**	**1.00**	**198.61328**
Tare weight [kg]	377		
Box volume [m^3]	1.529E+00		
Void volume [m^3]	1.330E+00		
Waste volume [m^3]	1.986E-01		
Void %	87.0%		

7.2.7 Waste Data for 8x4x4 Box

Table 7.2.7-1. Waste in 8x4x4 Box (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	15.37925	0.0250	16.53682796
Plastic	61.517	0.1000	66.14731183
Cloth	15.3906	0.0250	10.99328571
Rubber	30.7585	0.0500	27.96227273
Wood	36.9102	0.0600	44.47012048
Absorbent/Poly Pads	6.1517	0.0100	2.796227273
Steel	449.0741	0.7300	57.57360256
Total	**615.18135**	**1.00**	**226.47965**
Tare weight [kg]	523		
Box volume [m^3]	3.625E+00		
Void volume [m^3]	3.398E+00		
Waste volume [m^3]	2.265E-01		
Void %	93.8%		

7.2.8 Waste Data for 9x5x5 Box

Table 7.2.8-1. Waste in 9x5x5 Box (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	15.4133	0.0100	16.57344086
Plastic	77.0665	0.0502	82.8672043
Cloth	15.436	0.0101	11.02571429
Rubber	30.8266	0.0201	28.02418182
Wood	46.2399	0.0301	55.71072289
Absorbent/Poly Pads	0.7718	0.0005	0.350818182
Steel	1317.83942	0.8589	168.9537718
Copper	15.4133	0.0100	1.731831461
Aluminum	15.4133	0.0100	5.70862963
Total	**1534.4201**	**1.00**	**370.94632**
Tare weight [kg]	709		
Box volume [m^3]	6.371E+00		
Void volume [m^3]	6.000E+00		
Waste volume [m^3]	3.709E-01		
Void %	94.2%		

7.2.9 Waste Data for 12x4x4 Box

Table 7.2.9-1. Waste in 12x4x4 Box (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	17.28832	0.0098	18.5895914
Plastic	86.4416	0.0492	92.94795699
Cloth	34.57664	0.0197	24.6976
Rubber	51.86496	0.0295	47.14996364
Wood	34.5948	0.0197	41.68048193
Absorbent/Poly Pads	0.8626	0.0005	0.392090909
Steel	1478.15136	0.8419	189.5065846
Copper	34.5948	0.0197	3.88705618
Aluminum	17.28832	0.0098	6.403081481
Total	**1755.6634**	**1.00**	**425.25441**
Tare weight [kg]	1056		
Box volume [m^3]	5.437E+00		
Void volume [m^3]	5.012E+00		
Waste volume [m^3]	4.253E-01		
Void %	92.2%		

7.2.10 Waste Data for 16x2x2 Box

Table 7.2.10-1. Waste in 16x2x2 Box (Misc Debris)

Material	Weight [kg]	Weight fraction	Volume [liters]
Paper	13.7108	0.0100	14.7427957
Plastic	68.554	0.0502	73.71397849
Cloth	27.4216	0.0201	19.58685714
Rubber	41.1324	0.0301	37.39309091
Wood	27.4216	0.0201	33.03807229
Absorbent/Poly Pads	0.68554	0.0005	0.311609091
Steel	1144.8518	0.8388	146.7758718
Copper	27.4216	0.0201	3.081078652
Aluminum	13.7108	0.0100	5.078074074
Total	**1364.9101**	**1.00**	**333.72143**
Tare weight [kg]	616		
Box volume [m^3]	1.812E+00		
Void volume [m^3]	1.479E+00		
Waste volume [m^3]	3.337E-01		
Void %	81.6%		

7.3 Radcalc Runs

The following subsections document output from the Radcalc 4.1 runs that were performed in the course of this evaluation. For brevity, these subsections show only the "Hydrogen/Helium Gas Results" portion of the output.

7.3.1 Radcalc Runs for 10-gal Drum

7.3.1.1 10-gal Drum, LLW Source Term, Soil/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 10-gal\Radcalc & Text Files\5 vol%\Drum, 10-gal, LLW, Soil-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 10-gal drum, bounding LLW rad source term, soil/fuel/hyd oil contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Soil with uniform G values of 1.3 from TRAMPAC.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	2.252E-04	3.184E+01	8.332E-06
Co-60	1.022E-02	9.030E-06	3.781E-04
Sr-90	9.707E-03	7.028E-05	3.592E-04
Y-90	9.707E-03	1.785E-08	3.592E-04
Cs-137	1.706E-02	1.963E-04	6.312E-04
Ba-137m	1.614E-02	2.999E-11	5.971E-04
Eu-152	8.257E-05	4.746E-07	3.055E-06
Eu-154	6.415E-04	2.373E-06	2.373E-05
Eu-155	4.692E-05	9.663E-08	1.736E-06
Re-187	5.101E-08	1.160E+00	1.887E-09
Th-232	7.779E-06	7.094E+01	2.878E-07
U-234	5.169E-04	8.315E-02	1.913E-05
U-235	2.252E-05	1.042E+01	8.332E-07
U-238	5.425E-04	1.614E+03	2.007E-05
Np-237	7.831E-05	1.111E-01	2.897E-06
Pu-238	1.460E-04	8.528E-06	5.403E-06
Pu-239	7.592E-04	1.224E-02	2.809E-05
Pu-240	1.774E-04	7.819E-04	6.565E-06
Pu-241	8.274E-03	7.995E-05	3.061E-04
Am-241	6.142E-04	1.792E-04	2.272E-05
Total Activity:	7.497E-02		2.774E-03

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.02958	m^3
Container Mass:	6.35	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	23.3	kg

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Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.008271	m^3
Waste Mass:	16.95	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.0481	2.8	2.8	2.3	Texaco Regal-A machine oil
0.9519	1.3	1.3	1.3	USER

G Value Data:

G Alpha	G Beta	G Gamma
1.372	1.372	1.348

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 91.57 years
H2 Moles :	0.06877	moles	
H2 Volume :	1541	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.00451	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.001282	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	3.8E-05	%	
He Moles :	5.299E-07	moles	
He Volume :	0.01188	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.421E-08	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.48E-08	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.018	kPa	
Partial Pressure (He):	3.867E-05	kPa	
Partial Pressure (O2):	2.509	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.3	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.1.2 10-gal Drum, LLW Source Term, Steel/Paper, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 10-gal\Radcalc & Text Files\5 vol%\Drum, 10-gal, LLW, Steel & Paper (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 10-gal drum, bounding LLW rad source term, steel & paper contents.
- Paper is modeled as Cellulose.
- "USER" is Steel with zero G value.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	2.252E-04	3.184E+01	8.332E-06
Co-60	1.022E-02	9.030E-06	3.781E-04
Sr-90	9.707E-03	7.028E-05	3.592E-04
Y-90	9.707E-03	1.785E-08	3.592E-04
Cs-137	1.706E-02	1.963E-04	6.312E-04
Ba-137m	1.614E-02	2.999E-11	5.971E-04
Eu-152	8.257E-05	4.746E-07	3.055E-06
Eu-154	6.415E-04	2.373E-06	2.373E-05
Eu-155	4.692E-05	9.663E-08	1.736E-06
Re-187	5.101E-08	1.160E+00	1.887E-09
Th-232	7.779E-06	7.094E+01	2.878E-07
U-234	5.169E-04	8.315E-02	1.913E-05
U-235	2.252E-05	1.042E+01	8.332E-07
U-238	5.425E-04	1.614E+03	2.007E-05
Np-237	7.831E-05	1.111E-01	2.897E-06
Pu-238	1.460E-04	8.528E-06	5.403E-06
Pu-239	7.592E-04	1.224E-02	2.809E-05
Pu-240	1.774E-04	7.819E-04	6.565E-06
Pu-241	8.274E-03	7.995E-05	3.061E-04
Am-241	6.142E-04	1.792E-04	2.272E-05
Total Activity:	7.497E-02		2.774E-03

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.03676	m^3
Container Mass:	6.35	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	11.29	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.001098	m^3
Waste Mass:	4.94	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.0993	3.2	3.2	3.2	Cellulose
0.9007	0	0	0	USER

G Value Data:

G Alpha	G Beta	G Gamma
0.3178	0.3178	0.3178

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 918.4 years
H2 Moles :	0.08595	moles	
H2 Volume :	1927	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.001054	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.0001932	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	0.00027	%	
He Moles :	4.637E-06	moles	
He Volume :	0.1039	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.421E-08	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.153E-08	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.046	kPa	
Partial Pressure (He):	0.0002722	kPa	
Partial Pressure (O2):	2.523	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.1.3 10-gal Drum, MW Source Term, Soil/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 10-gal\Radcalc & Text Files\5 vol%\Drum, 10-gal, MW, Soil-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 10-gal drum, bounding MW rad source term, soil/fuel/hyd oil contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Soil with uniform G values of 1.3 from TRAMPAC.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	1.636E-04	1.702E-08	6.053E-06
C-14	3.444E-05	7.689E-06	1.274E-06
Co-60	1.053E-04	9.308E-08	3.897E-06
Ni-59	7.893E-06	9.888E-05	2.920E-07
Ni-63	7.519E-04	1.332E-05	2.782E-05
Se-79	6.343E-06	1.540E-03	2.347E-07
Sr-90	4.793E-01	3.470E-03	1.773E-02
Y-90	4.793E-01	8.814E-07	1.773E-02
Zr-93	3.071E-05	1.221E-02	1.136E-06
Nb-93m	2.428E-05	1.018E-07	8.984E-07
Tc-99	2.477E-04	1.466E-02	9.164E-06

Ru-106	5.080E-05	1.535E-08	1.880E-06
Cd-113m	1.197E-04	5.329E-07	4.428E-06
Sn-126	1.045E-05	8.462E-04	3.865E-07
Sb-125	9.356E-04	9.017E-07	3.462E-05
I-129	9.471E-07	5.498E-03	3.504E-08
Cs-134	2.187E-04	1.692E-07	8.092E-06
Cs-137	2.870E-01	3.302E-03	1.062E-02
Ba-137m	2.715E-01	5.045E-10	1.005E-02
Sm-151	2.213E-02	8.407E-04	8.187E-04
Eu-152	1.079E-05	6.202E-08	3.993E-07
Eu-154	1.340E-03	4.959E-06	4.959E-05
Eu-155	9.959E-04	2.051E-06	3.685E-05
Ra-226	5.310E-10	5.371E-10	1.965E-11
Ra-228	4.305E-07	1.579E-09	1.593E-08
Ac-227	1.200E-06	1.659E-08	4.439E-08
Th-229	1.868E-08	8.786E-08	6.913E-10
Th-232	4.563E-08	4.161E-01	1.688E-09
Pa-231	2.534E-06	5.365E-05	9.377E-08
U-232	1.214E-06	5.500E-08	4.492E-08
U-233	4.879E-06	5.065E-04	1.805E-07
U-234	3.100E-06	4.986E-04	1.147E-07
U-235	1.251E-07	5.790E-02	4.630E-09
U-236	1.203E-07	1.882E-03	4.449E-09
U-238	2.732E-06	8.129E+00	1.011E-07
Np-237	1.825E-06	2.590E-03	6.754E-08
Pu-238	2.431E-05	1.420E-06	8.994E-07
Pu-239	5.109E-04	8.237E-03	1.890E-05
Pu-240	1.042E-04	4.591E-04	3.855E-06
Pu-241	1.225E-03	1.184E-05	4.534E-05
Pu-242	1.056E-08	2.671E-06	3.908E-10
Am-241	1.122E-03	3.275E-04	4.152E-05
Am-243	2.462E-07	1.233E-06	9.111E-09
Cm-242	5.023E-10	1.517E-13	1.858E-11
Cm-243	3.214E-07	6.556E-09	1.189E-08
Cm-244	7.232E-06	8.888E-08	2.676E-07
Total Activity:	1.547E+00		5.725E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.02958	m^3
Container Mass:	6.35	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	23.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.008271	m^3
Waste Mass:	16.95	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.0481	2.8	2.8	2.3	Texaco Regal-A machine oil
0.9519	1.3	1.3	1.3	USER

G Value Data:

G Alpha	G Beta	G Gamma
1.372	1.372	1.348

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 3.52 years
H2 Moles :	0.06908	moles	
H2 Volume :	1548	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.05258	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.04837	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	8.8E-07	%	
He Moles :	1.219E-08	moles	
He Volume :	0.0002732	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	8.869E-09	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	8.907E-09	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.04	kPa	
Partial Pressure (He):	8.891E-07	kPa	
Partial Pressure (O2):	2.52	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.1.4 10-gal Drum, MW Source Term, Steel/Paper, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 10-gal\Radcalc & Text Files\5 vol%\Drum, 10-gal, MW, Steel & Paper (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 10-gal drum, bounding MW rad source term, steel & paper contents.
- Paper is modeled as Cellulose.
- "USER" is Steel with zero G value.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	1.636E-04	1.702E-08	6.053E-06
C-14	3.444E-05	7.689E-06	1.274E-06
Co-60	1.053E-04	9.308E-08	3.897E-06
Ni-59	7.893E-06	9.888E-05	2.920E-07
Ni-63	7.519E-04	1.332E-05	2.782E-05
Se-79	6.343E-06	1.540E-03	2.347E-07

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Sr-90	4.793E-01	3.470E-03	1.773E-02
Y-90	4.793E-01	8.814E-07	1.773E-02
Zr-93	3.071E-05	1.221E-02	1.136E-06
Nb-93m	2.428E-05	1.018E-07	8.984E-07
Tc-99	2.477E-04	1.466E-02	9.164E-06
Ru-106	5.080E-05	1.535E-08	1.880E-06
Cd-113m	1.197E-04	5.329E-07	4.428E-06
Sn-126	1.045E-05	8.462E-04	3.865E-07
Sb-125	9.356E-04	9.017E-07	3.462E-05
I-129	9.471E-07	5.498E-03	3.504E-08
Cs-134	2.187E-04	1.692E-07	8.092E-06
Cs-137	2.870E-01	3.302E-03	1.062E-02
Ba-137m	2.715E-01	5.045E-10	1.005E-02
Sm-151	2.213E-02	8.407E-04	8.187E-04
Eu-152	1.079E-05	6.202E-08	3.993E-07
Eu-154	1.340E-03	4.959E-06	4.959E-05
Eu-155	9.959E-04	2.051E-06	3.685E-05
Ra-226	5.310E-10	5.371E-10	1.965E-11
Ra-228	4.305E-07	1.579E-09	1.593E-08
Ac-227	1.200E-06	1.659E-08	4.439E-08
Th-229	1.868E-08	8.786E-08	6.913E-10
Th-232	4.563E-08	4.161E-01	1.688E-09
Pa-231	2.534E-06	5.365E-05	9.377E-08
U-232	1.214E-06	5.500E-08	4.492E-08
U-233	4.879E-06	5.065E-04	1.805E-07
U-234	3.100E-06	4.986E-04	1.147E-07
U-235	1.251E-07	5.790E-02	4.630E-09
U-236	1.203E-07	1.882E-03	4.449E-09
U-238	2.732E-06	8.129E+00	1.011E-07
Np-237	1.825E-06	2.590E-03	6.754E-08
Pu-238	2.431E-05	1.420E-06	8.994E-07
Pu-239	5.109E-04	8.237E-03	1.890E-05
Pu-240	1.042E-04	4.591E-04	3.855E-06
Pu-241	1.225E-03	1.184E-05	4.534E-05
Pu-242	1.056E-08	2.671E-06	3.908E-10
Am-241	1.122E-03	3.275E-04	4.152E-05
Am-243	2.462E-07	1.233E-06	9.111E-09
Cm-242	5.023E-10	1.517E-13	1.858E-11
Cm-243	3.214E-07	6.556E-09	1.189E-08
Cm-244	7.232E-06	8.888E-08	2.676E-07
Total Activity:	1.547E+00		5.725E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.03676	m^3
Container Mass:	6.35	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	11.29	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.001098	m^3
Waste Mass:	4.94	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

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Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.0993	3.2	3.2	3.2	Cellulose
0.9007	0	0	0	USER

G Value Data:

G Alpha	G Beta	G Gamma
0.3178	0.3178	0.3178

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 23.5 years
H2 Moles :	0.08592	moles	
H2 Volume :	1926	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.01222	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.00705	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	4.7E-06	%	
He Moles :	8.12E-08	moles	
He Volume :	0.00182	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	8.869E-09	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	8.81E-09	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.044	kPa	
Partial Pressure (He):	4.767E-06	kPa	
Partial Pressure (O2):	2.522	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.2 Radcalc Runs for 30-gal Drum

7.3.2.1 30-gal Drum, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 30-gal\Radcalc & Text Files\5 vol%\Drum, 30-gal, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 30-gal drum, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

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Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	1.044E-03	1.476E+02	3.862E-05
Co-60	4.737E-02	4.186E-05	1.753E-03
Sr-90	4.500E-02	3.258E-04	1.665E-03
Y-90	4.500E-02	8.275E-08	1.665E-03
Cs-137	7.908E-02	9.097E-04	2.926E-03
Ba-137m	7.481E-02	1.390E-10	2.768E-03
Eu-152	3.827E-04	2.200E-06	1.416E-05
Eu-154	2.973E-03	1.100E-05	1.100E-04
Eu-155	2.175E-04	4.479E-07	8.046E-06
Re-187	2.364E-07	5.379E+00	8.749E-09
Th-232	3.606E-05	3.288E+02	1.334E-06
U-234	2.396E-03	3.854E-01	8.866E-05
U-235	1.044E-04	4.830E+01	3.862E-06
U-238	2.515E-03	7.482E+03	9.305E-05
Np-237	3.630E-04	5.150E-01	1.343E-05
Pu-238	6.769E-04	3.953E-05	2.505E-05
Pu-239	3.519E-03	5.674E-02	1.302E-04
Pu-240	8.224E-04	3.624E-03	3.043E-05
Pu-241	3.835E-02	3.706E-04	1.419E-03
Am-241	2.847E-03	8.308E-04	1.053E-04
Total Activity:	3.475E-01		1.286E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.08149	m^3
Container Mass:	15.9	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	56.76	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.03207	m^3
Waste Mass:	40.86	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	30-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.2222	0	0	0	USER
0.7778	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
2.645	2.645	2.645

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

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* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 22.01 years
H2 Moles :	0.1907	moles	
H2 Volume :	4274	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.03041	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.01773	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	1.5E-05	%	
He Moles :	5.85E-07	moles	
He Volume :	0.01311	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	6.586E-08	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	6.963E-08	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.049	kPa	
Partial Pressure (He):	1.549E-05	kPa	
Partial Pressure (O2):	2.525	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.2.2 30-gal Drum, LLW Source Term, Soil/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 30-gal\Radcalc & Text Files\5 vol%\Drum, 30-gal, LLW, Soil-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 30-gal drum, bounding LLW rad source term, soil/fuel/hyd oil contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Soil with uniform G values of 1.3 from TRAMPAC.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	1.044E-03	1.476E+02	3.862E-05
Co-60	4.737E-02	4.186E-05	1.753E-03
Sr-90	4.500E-02	3.258E-04	1.665E-03
Y-90	4.500E-02	8.275E-08	1.665E-03
Cs-137	7.908E-02	9.097E-04	2.926E-03
Ba-137m	7.481E-02	1.390E-10	2.768E-03
Eu-152	3.827E-04	2.200E-06	1.416E-05
Eu-154	2.973E-03	1.100E-05	1.100E-04
Eu-155	2.175E-04	4.479E-07	8.046E-06
Re-187	2.364E-07	5.379E+00	8.749E-09
Th-232	3.606E-05	3.288E+02	1.334E-06
U-234	2.396E-03	3.854E-01	8.866E-05
U-235	1.044E-04	4.830E+01	3.862E-06
U-238	2.515E-03	7.482E+03	9.305E-05
Np-237	3.630E-04	5.150E-01	1.343E-05
Pu-238	6.769E-04	3.953E-05	2.505E-05
Pu-239	3.519E-03	5.674E-02	1.302E-04
Pu-240	8.224E-04	3.624E-03	3.043E-05
Pu-241	3.835E-02	3.706E-04	1.419E-03

Am-241	2.847E-03	8.308E-04	1.053E-04
Total Activity:	3.475E-01		1.286E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.07009	m^3
Container Mass:	15.9	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	98.91	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.0437	m^3
Waste Mass:	83.01	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	30-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.9005	1.3	1.3	1.3	USER
0.0995	2.8	2.8	2.3	Texaco Regal-A machine oil

G Value Data:

G Alpha	G Beta	G Gamma
1.449	1.449	1.4

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 37.61 years
H2 Moles :	0.1633	moles	
H2 Volume :	3660	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.01772	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.008397	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	3.1E-05	%	
He Moles :	1.006E-06	moles	
He Volume :	0.02255	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	6.586E-08	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	7.007E-08	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.028	kPa	
Partial Pressure (He):	3.098E-05	kPa	
Partial Pressure (O2):	2.514	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	

Total Pressure (H2 + He + O2 + Air): 108.9 kPa (if H20 present in waste)

7.3.2.3 30-gal Drum, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 30-gal\Radcalc & Text Files\5 vol%\Drum, 30-gal, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 30-gal drum, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	7.610E-04	7.916E-08	2.816E-05
C-14	1.602E-04	3.577E-05	5.927E-06
Co-60	4.899E-04	4.329E-07	1.813E-05
Ni-59	3.671E-05	4.600E-04	1.358E-06
Ni-63	3.498E-03	6.194E-05	1.294E-04
Se-79	2.950E-05	7.164E-03	1.092E-06
Sr-90	2.229E+00	1.614E-02	8.249E-02
Y-90	2.229E+00	4.100E-06	8.249E-02
Zr-93	1.428E-04	5.680E-02	5.285E-06
Nb-93m	1.129E-04	4.733E-07	4.179E-06
Tc-99	1.152E-03	6.821E-02	4.263E-05
Ru-106	2.363E-04	7.141E-08	8.743E-06
Cd-113m	5.567E-04	2.479E-06	2.060E-05
Sn-126	4.859E-05	3.936E-03	1.798E-06
Sb-125	4.352E-03	4.195E-06	1.610E-04
I-129	4.406E-06	2.557E-02	1.630E-07
Cs-134	1.017E-03	7.869E-07	3.764E-05
Cs-137	1.335E+00	1.536E-02	4.940E-02
Ba-137m	1.263E+00	2.347E-09	4.673E-02
Sm-151	1.029E-01	3.911E-03	3.808E-03
Eu-152	5.020E-05	2.885E-07	1.857E-06
Eu-154	6.234E-03	2.307E-05	2.307E-04
Eu-155	4.632E-03	9.541E-06	1.714E-04
Ra-226	2.470E-09	2.498E-09	9.138E-11
Ra-228	2.003E-06	7.345E-09	7.409E-08
Ac-227	5.580E-06	7.716E-08	2.065E-07
Th-229	8.691E-08	4.087E-07	3.216E-09
Th-232	2.123E-07	1.936E+00	7.854E-09
Pa-231	1.179E-05	2.496E-04	4.362E-07
U-232	5.647E-06	2.558E-07	2.089E-07
U-233	2.270E-05	2.356E-03	8.397E-07
U-234	1.442E-05	2.319E-03	5.335E-07
U-235	5.821E-07	2.693E-01	2.154E-08
U-236	5.594E-07	8.753E-03	2.070E-08
U-238	1.271E-05	3.781E+01	4.702E-07
Np-237	8.491E-06	1.205E-02	3.142E-07
Pu-238	1.131E-04	6.603E-06	4.184E-06
Pu-239	2.376E-03	3.832E-02	8.792E-05
Pu-240	4.846E-04	2.136E-03	1.793E-05

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Pu-241	5.700E-03	5.508E-05	2.109E-04
Pu-242	4.913E-08	1.242E-05	1.818E-09
Am-241	5.220E-03	1.523E-03	1.931E-04
Am-243	1.145E-06	5.736E-06	4.238E-08
Cm-242	2.336E-09	7.056E-13	8.644E-11
Cm-243	1.495E-06	3.050E-08	5.532E-08
Cm-244	3.364E-05	4.134E-07	1.245E-06
Total Activity:	7.197E+00		2.663E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.08149	m^3
Container Mass:	15.9	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	56.76	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.03207	m^3
Waste Mass:	40.86	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	30-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.2222	0	0	0	USER
0.7778	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
2.645	2.645	2.645

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 1.157 years
H2 Moles :	0.1897	moles	
H2 Volume :	4253	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.4285	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.4169	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	4.9E-07	%	
He Moles :	1.856E-08	moles	
He Volume :	0.0004161	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	4.125E-08	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	4.139E-08	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.025	kPa	
Partial Pressure (He):	4.917E-07	kPa	
Partial Pressure (O2):	2.513	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.2.4 30-gal Drum, MW Source Term, Soil/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 30-gal\Radcalc & Text Files\5 vol%\Drum, 30-gal, MW, Soil-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 30-gal drum, bounding MW rad source term, soil/fuel/hyd oil contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Soil with uniform G values of 1.3 from TRAMPAC.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	7.610E-04	7.916E-08	2.816E-05
C-14	1.602E-04	3.577E-05	5.927E-06
Co-60	4.899E-04	4.329E-07	1.813E-05
Ni-59	3.671E-05	4.600E-04	1.358E-06
Ni-63	3.498E-03	6.194E-05	1.294E-04
Se-79	2.950E-05	7.164E-03	1.092E-06
Sr-90	2.229E+00	1.614E-02	8.249E-02
Y-90	2.229E+00	4.100E-06	8.249E-02
Zr-93	1.428E-04	5.680E-02	5.285E-06
Nb-93m	1.129E-04	4.733E-07	4.179E-06
Tc-99	1.152E-03	6.821E-02	4.263E-05
Ru-106	2.363E-04	7.141E-08	8.743E-06
Cd-113m	5.567E-04	2.479E-06	2.060E-05
Sn-126	4.859E-05	3.936E-03	1.798E-06
Sb-125	4.352E-03	4.195E-06	1.610E-04
I-129	4.406E-06	2.557E-02	1.630E-07
Cs-134	1.017E-03	7.869E-07	3.764E-05
Cs-137	1.335E+00	1.536E-02	4.940E-02
Ba-137m	1.263E+00	2.347E-09	4.673E-02
Sm-151	1.029E-01	3.911E-03	3.808E-03
Eu-152	5.020E-05	2.885E-07	1.857E-06
Eu-154	6.234E-03	2.307E-05	2.307E-04
Eu-155	4.632E-03	9.541E-06	1.714E-04
Ra-226	2.470E-09	2.498E-09	9.138E-11
Ra-228	2.003E-06	7.345E-09	7.409E-08
Ac-227	5.580E-06	7.716E-08	2.065E-07
Th-229	8.691E-08	4.087E-07	3.216E-09
Th-232	2.123E-07	1.936E+00	7.854E-09
Pa-231	1.179E-05	2.496E-04	4.362E-07
U-232	5.647E-06	2.558E-07	2.089E-07
U-233	2.270E-05	2.356E-03	8.397E-07
U-234	1.442E-05	2.319E-03	5.335E-07
U-235	5.821E-07	2.693E-01	2.154E-08
U-236	5.594E-07	8.753E-03	2.070E-08

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U-238	1.271E-05	3.781E+01	4.702E-07
Np-237	8.491E-06	1.205E-02	3.142E-07
Pu-238	1.131E-04	6.603E-06	4.184E-06
Pu-239	2.376E-03	3.832E-02	8.792E-05
Pu-240	4.846E-04	2.136E-03	1.793E-05
Pu-241	5.700E-03	5.508E-05	2.109E-04
Pu-242	4.913E-08	1.242E-05	1.818E-09
Am-241	5.220E-03	1.523E-03	1.931E-04
Am-243	1.145E-06	5.736E-06	4.238E-08
Cm-242	2.336E-09	7.056E-13	8.644E-11
Cm-243	1.495E-06	3.050E-08	5.532E-08
Cm-244	3.364E-05	4.134E-07	1.245E-06
Total Activity:	7.197E+00		2.663E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.07009	m^3
Container Mass:	15.9	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	98.91	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.04347	m^3
Waste Mass:	83.01	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	30-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.0995	2.8	2.8	2.3	Texaco Regal-A machine oil
0.9005	1.3	1.3	1.3	USER

G Value Data:

G Alpha	G Beta	G Gamma
1.449	1.449	1.4

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 1.793 years
H2 Moles :	0.1642	moles	
H2 Volume :	3681	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.2397	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.2297	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

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He Concentration:	8.8E-07	%	
He Moles :	2.896E-08	moles	
He Volume :	0.000649	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	4.125E-08	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	4.141E-08	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.056	kPa	
Partial Pressure (He):	8.914E-07	kPa	
Partial Pressure (O2):	2.528	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.3 Radcalc Runs for 55-gal Drum

7.3.3.1 55-gal Drum, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 55-gal\Radcalc & Text Files\5 vol%\Drum, 55-gal, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 55-gal drum, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	3.485E-03	4.928E+02	1.289E-04
Co-60	1.581E-01	1.397E-04	5.851E-03
Sr-90	1.502E-01	1.088E-03	5.558E-03
Y-90	1.502E-01	2.762E-07	5.558E-03
Cs-137	2.640E-01	3.037E-03	9.768E-03
Ba-137m	2.497E-01	4.641E-10	9.241E-03
Eu-152	1.278E-03	7.344E-06	4.728E-05
Eu-154	9.926E-03	3.672E-05	3.673E-04
Eu-155	7.260E-04	1.495E-06	2.686E-05
Re-187	7.894E-07	1.796E+01	2.921E-08
Th-232	1.204E-04	1.098E+03	4.454E-06
U-234	7.999E-03	1.287E+00	2.960E-04
U-235	3.485E-04	1.613E+02	1.289E-05
U-238	8.395E-03	2.498E+04	3.106E-04
Np-237	1.212E-03	1.719E+00	4.484E-05
Pu-238	2.260E-03	1.320E-04	8.361E-05
Pu-239	1.175E-02	1.894E-01	4.347E-04
Pu-240	2.746E-03	1.210E-02	1.016E-04
Pu-241	1.280E-01	1.237E-03	4.737E-03
Am-241	9.504E-03	2.774E-03	3.516E-04
Total Activity:	1.160E+00		4.292E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.1507	m^3

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Container Mass:	21.3	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	98.48	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.05749	m^3
Waste Mass:	77.18	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 55-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.3	0	0	0	USER
0.7	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
2.38	2.38	2.38

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 11.65 years
H2 Moles :	0.3511	moles	
H2 Volume :	7870	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.09586	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.06499	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	1.4E-05	%	
He Moles :	1.016E-06	moles	
He Volume :	0.02278	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	2.199E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	2.288E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.029	kPa	
Partial Pressure (He):	1.455E-05	kPa	
Partial Pressure (O2):	2.514	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.3.2 55-gal Drum, LLW Source Term, Soil/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 55-gal\Radcalc &

Text Files\5 vol%\Drum, 55-gal, LLW, Soil-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 55-gal drum, bounding LLW rad source term, soil/fuel/hyd oil contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Soil with uniform G values of 1.3 from TRAMPAC.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	3.485E-03	4.928E+02	1.289E-04
Co-60	1.581E-01	1.397E-04	5.851E-03
Sr-90	1.502E-01	1.088E-03	5.558E-03
Y-90	1.502E-01	2.762E-07	5.558E-03
Cs-137	2.640E-01	3.037E-03	9.768E-03
Ba-137m	2.497E-01	4.641E-10	9.241E-03
Eu-152	1.278E-03	7.344E-06	4.728E-05
Eu-154	9.926E-03	3.672E-05	3.673E-04
Eu-155	7.260E-04	1.495E-06	2.686E-05
Re-187	7.894E-07	1.796E+01	2.921E-08
Th-232	1.204E-04	1.098E+03	4.454E-06
U-234	7.999E-03	1.287E+00	2.960E-04
U-235	3.485E-04	1.613E+02	1.289E-05
U-238	8.395E-03	2.498E+04	3.106E-04
Np-237	1.212E-03	1.719E+00	4.484E-05
Pu-238	2.260E-03	1.320E-04	8.361E-05
Pu-239	1.175E-02	1.894E-01	4.347E-04
Pu-240	2.746E-03	1.210E-02	1.016E-04
Pu-241	1.280E-01	1.237E-03	4.737E-03
Am-241	9.504E-03	2.774E-03	3.516E-04
Total Activity:	1.160E+00		4.292E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.07982	m^3
Container Mass:	21.3	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	283.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.1284	m^3
Waste Mass:	262	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	55-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.9519	1.3	1.3	1.3	USER
0.0481	2.8	2.8	2.3	Texaco Regal-A machine oil

G Value Data:

G Alpha	G Beta	G Gamma
1.372	1.372	1.348

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 9.939 years
H2 Moles :	0.1861	moles	
H2 Volume :	4171	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.05882	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.0405	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	2.3E-05	%	
He Moles :	8.652E-07	moles	
He Volume :	0.01939	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	2.199E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	2.278E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.032	kPa	
Partial Pressure (He):	2.339E-05	kPa	
Partial Pressure (O2):	2.516	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.3.3 55-gal Drum, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 55-gal\Radcalc & Text Files\5 vol%\Drum, 55-gal, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 55-gal drum, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	2.537E-03	2.639E-07	9.385E-05
C-14	5.340E-04	1.192E-04	1.976E-05
Co-60	1.633E-03	1.443E-06	6.043E-05
Ni-59	1.224E-04	1.533E-03	4.528E-06
Ni-63	1.166E-02	2.065E-04	4.314E-04

Se-79	9.835E-05	2.388E-02	3.639E-06
Sr-90	7.432E+00	5.381E-02	2.750E-01
Y-90	7.432E+00	1.367E-05	2.750E-01
Zr-93	4.762E-04	1.893E-01	1.762E-05
Nb-93m	3.765E-04	1.578E-06	1.393E-05
Tc-99	3.840E-03	2.274E-01	1.421E-04
Ru-106	7.877E-04	2.380E-07	2.914E-05
Cd-113m	1.856E-03	8.263E-06	6.866E-05
Sn-126	1.620E-04	1.312E-02	5.993E-06
Sb-125	1.451E-02	1.398E-05	5.368E-04
I-129	1.469E-05	8.525E-02	5.433E-07
Cs-134	3.391E-03	2.623E-06	1.255E-04
Cs-137	4.450E+00	5.119E-02	1.647E-01
Ba-137m	4.210E+00	7.822E-09	1.558E-01
Sm-151	3.431E-01	1.304E-02	1.269E-02
Eu-152	1.673E-04	9.617E-07	6.191E-06
Eu-154	2.078E-02	7.688E-05	7.689E-04
Eu-155	1.544E-02	3.180E-05	5.713E-04
Ra-226	8.233E-09	8.328E-09	3.046E-10
Ra-228	6.675E-06	2.448E-08	2.470E-07
Ac-227	1.860E-05	2.572E-07	6.882E-07
Th-229	2.897E-07	1.362E-06	1.072E-08
Th-232	7.076E-07	6.452E+00	2.618E-08
Pa-231	3.929E-05	8.319E-04	1.454E-06
U-232	1.882E-05	8.528E-07	6.965E-07
U-233	7.565E-05	7.853E-03	2.799E-06
U-234	4.806E-05	7.731E-03	1.778E-06
U-235	1.940E-06	8.978E-01	7.179E-08
U-236	1.865E-06	2.918E-02	6.899E-08
U-238	4.236E-05	1.260E+02	1.567E-06
Np-237	2.830E-05	4.016E-02	1.047E-06
Pu-238	3.769E-04	2.201E-05	1.395E-05
Pu-239	7.921E-03	1.277E-01	2.931E-04
Pu-240	1.615E-03	7.119E-03	5.977E-05
Pu-241	1.900E-02	1.836E-04	7.031E-04
Pu-242	1.638E-07	4.141E-05	6.059E-09
Am-241	1.740E-02	5.078E-03	6.438E-04
Am-243	3.818E-06	1.912E-05	1.413E-07
Cm-242	7.788E-09	2.352E-12	2.881E-10
Cm-243	4.984E-06	1.017E-07	1.844E-07
Cm-244	1.121E-04	1.378E-06	4.149E-06
Total Activity:	2.399E+01		8.877E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.1507	m^3
Container Mass:	21.3	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	98.48	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.05749	m^3
Waste Mass:	77.18	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 55-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.3	0	0	0	USER
0.7	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
2.38	2.38	2.38

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 0.6986 years
H2 Moles :	0.3544	moles	
H2 Volume :	7943	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.306	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	1.285	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	5.3E-07	%	
He Moles :	3.77E-08	moles	
He Volume :	0.000845	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.375E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.379E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.073	kPa	
Partial Pressure (He):	5.397E-07	kPa	
Partial Pressure (O2):	2.537	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.3.4 55-gal Drum, MW Source Term, Soil/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 55-gal\Radcalc & Text Files\5 vol%\Drum, 55-gal, MW, Soil-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 55-gal drum, bounding MW rad source term, soil/fuel/hyd oil contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Soil with uniform G values of 1.3 from TRAMPAC.

Initial Source Data:

Isotope	Ci	Gm	TBq

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H-3	2.537E-03	2.639E-07	9.385E-05
C-14	5.340E-04	1.192E-04	1.976E-05
Co-60	1.633E-03	1.443E-06	6.043E-05
Ni-59	1.224E-04	1.533E-03	4.528E-06
Ni-63	1.166E-02	2.065E-04	4.314E-04
Se-79	9.835E-05	2.388E-02	3.639E-06
Sr-90	7.432E+00	5.381E-02	2.750E-01
Y-90	7.432E+00	1.367E-05	2.750E-01
Zr-93	4.762E-04	1.893E-01	1.762E-05
Nb-93m	3.765E-04	1.578E-06	1.393E-05
Tc-99	3.840E-03	2.274E-01	1.421E-04
Ru-106	7.877E-04	2.380E-07	2.914E-05
Cd-113m	1.856E-03	8.263E-06	6.866E-05
Sn-126	1.620E-04	1.312E-02	5.993E-06
Sb-125	1.451E-02	1.398E-05	5.368E-04
I-129	1.469E-05	8.525E-02	5.433E-07
Cs-134	3.391E-03	2.623E-06	1.255E-04
Cs-137	4.450E+00	5.119E-02	1.647E-01
Ba-137m	4.210E+00	7.822E-09	1.558E-01
Sm-151	3.431E-01	1.304E-02	1.269E-02
Eu-152	1.673E-04	9.617E-07	6.191E-06
Eu-154	2.078E-02	7.688E-05	7.689E-04
Eu-155	1.544E-02	3.180E-05	5.713E-04
Ra-226	8.233E-09	8.328E-09	3.046E-10
Ra-228	6.675E-06	2.448E-08	2.470E-07
Ac-227	1.860E-05	2.572E-07	6.882E-07
Th-229	2.897E-07	1.362E-06	1.072E-08
Th-232	7.076E-07	6.452E+00	2.618E-08
Pa-231	3.929E-05	8.319E-04	1.454E-06
U-232	1.882E-05	8.528E-07	6.965E-07
U-233	7.565E-05	7.853E-03	2.799E-06
U-234	4.806E-05	7.731E-03	1.778E-06
U-235	1.940E-06	8.978E-01	7.179E-08
U-236	1.865E-06	2.918E-02	6.899E-08
U-238	4.236E-05	1.260E+02	1.567E-06
Np-237	2.830E-05	4.016E-02	1.047E-06
Pu-238	3.769E-04	2.201E-05	1.395E-05
Pu-239	7.921E-03	1.277E-01	2.931E-04
Pu-240	1.615E-03	7.119E-03	5.977E-05
Pu-241	1.900E-02	1.836E-04	7.031E-04
Pu-242	1.638E-07	4.141E-05	6.059E-09
Am-241	1.740E-02	5.078E-03	6.438E-04
Am-243	3.818E-06	1.912E-05	1.413E-07
Cm-242	7.788E-09	2.352E-12	2.881E-10
Cm-243	4.984E-06	1.017E-07	1.844E-07
Cm-244	1.121E-04	1.378E-06	4.149E-06
Total Activity:	2.399E+01		8.877E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.07982	m^3
Container Mass:	21.3	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	283.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.1284	m^3
Waste Mass:	262	kg

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Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	55-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.9519	1.3	1.3	1.3	USER
0.0481	2.8	2.8	2.3	Texaco Regal-A machine oil

G Value Data:

G Alpha	G Beta	G Gamma
1.372	1.372	1.348

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 0.628 years
H2 Moles :	0.1878	moles	
H2 Volume :	4209	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.7689	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.7575	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	9E-07	%	
He Moles :	3.39E-08	moles	
He Volume :	0.0007599	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.375E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.379E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.075	kPa	
Partial Pressure (He):	9.163E-07	kPa	
Partial Pressure (O2):	2.538	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.4 Radcalc Runs for 85-gal Drum

7.3.4.1 85-gal Drum, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 85-gal\Radcalc & Text Files\5 vol%\Drum, 85-gal, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 85-gal drum, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	3.186E-03	4.506E+02	1.179E-04
Co-60	1.446E-01	1.278E-04	5.350E-03
Sr-90	1.374E-01	9.945E-04	5.082E-03
Y-90	1.374E-01	2.526E-07	5.082E-03
Cs-137	2.414E-01	2.777E-03	8.932E-03
Ba-137m	2.284E-01	4.243E-10	8.449E-03
Eu-152	1.168E-03	6.715E-06	4.323E-05
Eu-154	9.077E-03	3.358E-05	3.358E-04
Eu-155	6.639E-04	1.367E-06	2.456E-05
Re-187	7.218E-07	1.642E+01	2.671E-08
Th-232	1.101E-04	1.004E+03	4.073E-06
U-234	7.314E-03	1.177E+00	2.706E-04
U-235	3.186E-04	1.474E+02	1.179E-05
U-238	7.677E-03	2.284E+04	2.840E-04
Np-237	1.108E-03	1.572E+00	4.100E-05
Pu-238	2.066E-03	1.207E-04	7.646E-05
Pu-239	1.074E-02	1.732E-01	3.975E-04
Pu-240	2.511E-03	1.106E-02	9.289E-05
Pu-241	1.171E-01	1.131E-03	4.332E-03
Am-241	8.690E-03	2.536E-03	3.215E-04
Total Activity:	1.061E+00		3.925E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.2598	m^3
Container Mass:	35.4	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	125.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.06192	m^3
Waste Mass:	89.89	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 85-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.3545	0	0	0	USER
0.6455	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
2.195	2.195	2.195

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 27.54 years
H2 Moles :	0.6063	moles	
H2 Volume :	13590	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.08425	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.04327	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	1.8E-05	%	
He Moles :	2.239E-06	moles	
He Volume :	0.05019	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	2.01E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	2.134E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.037	kPa	
Partial Pressure (He):	1.86E-05	kPa	
Partial Pressure (O2):	2.518	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.4.2 85-gal Drum, LLW Source Term, Rocks/Gravel/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 85-gal\Radcalc & Text Files\5 vol%\Drum, 85-gal, LLW, Rocks-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 85-gal drum, bounding LLW rad source term, rocks/gravel/fuel/hyd oil waste contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Rocks/Gravel with uniform G values of 0.08 from TRAMPAC for "Homogeneous solid inorganic materials with unbound absorbed ambient moisture (</=6% by weight) in metal cans."

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	3.186E-03	4.506E+02	1.179E-04
Co-60	1.446E-01	1.278E-04	5.350E-03
Sr-90	1.374E-01	9.945E-04	5.082E-03
Y-90	1.374E-01	2.526E-07	5.082E-03
Cs-137	2.414E-01	2.777E-03	8.932E-03
Ba-137m	2.284E-01	4.243E-10	8.449E-03
Eu-152	1.168E-03	6.715E-06	4.323E-05
Eu-154	9.077E-03	3.358E-05	3.358E-04
Eu-155	6.639E-04	1.367E-06	2.456E-05
Re-187	7.218E-07	1.642E+01	2.671E-08
Th-232	1.101E-04	1.004E+03	4.073E-06
U-234	7.314E-03	1.177E+00	2.706E-04

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U-235	3.186E-04	1.474E+02	1.179E-05
U-238	7.677E-03	2.284E+04	2.840E-04
Np-237	1.108E-03	1.572E+00	4.100E-05
Pu-238	2.066E-03	1.207E-04	7.646E-05
Pu-239	1.074E-02	1.732E-01	3.975E-04
Pu-240	2.511E-03	1.106E-02	9.289E-05
Pu-241	1.171E-01	1.131E-03	4.332E-03
Am-241	8.690E-03	2.536E-03	3.215E-04
Total Activity:	1.061E+00		3.925E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.2609	m^3
Container Mass:	35.4	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	150.7	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.06088	m^3
Waste Mass:	115.3	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 85-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.9	0.08	0.08	0.08	USER
0.1	2.8	2.8	2.3	Texaco Regal-A machine oil

G Value Data:

G Alpha	G Beta	G Gamma
0.352	0.352	0.302

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 349 years
H2 Moles :	0.6097	moles	
H2 Volume :	13670	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.01318	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.003478	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	0.00022	%	
He Moles :	2.724E-05	moles	
He Volume :	0.6106	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	2.01E-07	cm^3/hr	(0 C, 101.325 kPa)

He Rate When Opened: 1.864E-07 cm^3/hr (0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.043	kPa	
Partial Pressure (He):	0.0002253	kPa	
Partial Pressure (O2):	2.522	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.4.3 85-gal Drum, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 85-gal\Radcalc & Text Files\5 vol%\Drum, 85-gal, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 85-gal drum, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	2.316E-03	2.409E-07	8.569E-05
C-14	4.876E-04	1.089E-04	1.804E-05
Co-60	1.491E-03	1.318E-06	5.517E-05
Ni-59	1.117E-04	1.400E-03	4.134E-06
Ni-63	1.065E-02	1.885E-04	3.939E-04
Se-79	8.979E-05	2.180E-02	3.322E-06
Sr-90	6.785E+00	4.913E-02	2.511E-01
Y-90	6.785E+00	1.248E-05	2.511E-01
Zr-93	4.347E-04	1.729E-01	1.609E-05
Nb-93m	3.437E-04	1.441E-06	1.272E-05
Tc-99	3.506E-03	2.076E-01	1.297E-04
Ru-106	7.192E-04	2.173E-07	2.661E-05
Cd-113m	1.694E-03	7.545E-06	6.269E-05
Sn-126	1.479E-04	1.198E-02	5.472E-06
Sb-125	1.325E-02	1.277E-05	4.901E-04
I-129	1.341E-05	7.784E-02	4.961E-07
Cs-134	3.096E-03	2.395E-06	1.146E-04
Cs-137	4.063E+00	4.674E-02	1.503E-01
Ba-137m	3.844E+00	7.142E-09	1.422E-01
Sm-151	3.133E-01	1.190E-02	1.159E-02
Eu-152	1.528E-04	8.780E-07	5.652E-06
Eu-154	1.897E-02	7.020E-05	7.020E-04
Eu-155	1.410E-02	2.904E-05	5.216E-04
Ra-226	7.517E-09	7.604E-09	2.781E-10
Ra-228	6.095E-06	2.235E-08	2.255E-07
Ac-227	1.698E-05	2.348E-07	6.284E-07
Th-229	2.645E-07	1.244E-06	9.787E-09
Th-232	6.460E-07	5.891E+00	2.390E-08
Pa-231	3.588E-05	7.596E-04	1.327E-06
U-232	1.719E-05	7.786E-07	6.359E-07
U-233	6.907E-05	7.170E-03	2.556E-06
U-234	4.388E-05	7.058E-03	1.624E-06

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U-235	1.771E-06	8.197E-01	6.554E-08
U-236	1.702E-06	2.664E-02	6.299E-08
U-238	3.868E-05	1.151E+02	1.431E-06
Np-237	2.584E-05	3.667E-02	9.561E-07
Pu-238	3.441E-04	2.010E-05	1.273E-05
Pu-239	7.232E-03	1.166E-01	2.676E-04
Pu-240	1.475E-03	6.500E-03	5.457E-05
Pu-241	1.735E-02	1.676E-04	6.419E-04
Pu-242	1.495E-07	3.781E-05	5.532E-09
Am-241	1.589E-02	4.636E-03	5.878E-04
Am-243	3.486E-06	1.746E-05	1.290E-07
Cm-242	7.110E-09	2.148E-12	2.631E-10
Cm-243	4.551E-06	9.282E-08	1.684E-07
Cm-244	1.024E-04	1.258E-06	3.788E-06
Total Activity:	2.190E+01		8.105E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.2598	m^3
Container Mass:	35.4	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	125.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.06192	m^3
Waste Mass:	89.89	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 85-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.3545	0	0	0	USER
0.6455	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
2.195	2.195	2.195

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 1.423 years
H2 Moles :	0.6093	moles	
H2 Volume :	13660	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.115	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	1.078	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	5.7E-07	%	
He Moles :	6.995E-08	moles	
He Volume :	0.001568	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.256E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.26E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.06	kPa	
Partial Pressure (He):	5.809E-07	kPa	
Partial Pressure (O2):	2.53	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.4.4 85-gal Drum, MW Source Term, Rocks/Gravel/Fuel/Hyd Oil, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Drum, 85-gal\Radcalc & Text Files\5 vol%\Drum, 85-gal, MW, Rocks-Fuel-Hyd Oil (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 85-gal drum, bounding MW rad source term, rocks/gravel/fuel/hyd oil waste contents.
- Hydraulic Oil & Fuel are modeled as Texaco machine oil.
- "USER" is Rocks/Gravel with uniform G values of 0.08 from TRAMPAC for "Homogeneous solid inorganic materials with unbound absorbed ambient moisture (</=6% by weight) in metal cans."

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	2.316E-03	2.409E-07	8.569E-05
C-14	4.876E-04	1.089E-04	1.804E-05
Co-60	1.491E-03	1.318E-06	5.517E-05
Ni-59	1.117E-04	1.400E-03	4.134E-06
Ni-63	1.065E-02	1.885E-04	3.939E-04
Se-79	8.979E-05	2.180E-02	3.322E-06
Sr-90	6.785E+00	4.913E-02	2.511E-01
Y-90	6.785E+00	1.248E-05	2.511E-01
Zr-93	4.347E-04	1.729E-01	1.609E-05
Nb-93m	3.437E-04	1.441E-06	1.272E-05
Tc-99	3.506E-03	2.076E-01	1.297E-04
Ru-106	7.192E-04	2.173E-07	2.661E-05
Cd-113m	1.694E-03	7.545E-06	6.269E-05
Sn-126	1.479E-04	1.198E-02	5.472E-06
Sb-125	1.325E-02	1.277E-05	4.901E-04
I-129	1.341E-05	7.784E-02	4.961E-07
Cs-134	3.096E-03	2.395E-06	1.146E-04
Cs-137	4.063E+00	4.674E-02	1.503E-01
Ba-137m	3.844E+00	7.142E-09	1.422E-01
Sm-151	3.133E-01	1.190E-02	1.159E-02
Eu-152	1.528E-04	8.780E-07	5.652E-06
Eu-154	1.897E-02	7.020E-05	7.020E-04
Eu-155	1.410E-02	2.904E-05	5.216E-04
Ra-226	7.517E-09	7.604E-09	2.781E-10
Ra-228	6.095E-06	2.235E-08	2.255E-07
Ac-227	1.698E-05	2.348E-07	6.284E-07

Th-229	2.645E-07	1.244E-06	9.787E-09
Th-232	6.460E-07	5.891E+00	2.390E-08
Pa-231	3.588E-05	7.596E-04	1.327E-06
U-232	1.719E-05	7.786E-07	6.359E-07
U-233	6.907E-05	7.170E-03	2.556E-06
U-234	4.388E-05	7.058E-03	1.624E-06
U-235	1.771E-06	8.197E-01	6.554E-08
U-236	1.702E-06	2.664E-02	6.299E-08
U-238	3.868E-05	1.151E+02	1.431E-06
Np-237	2.584E-05	3.667E-02	9.561E-07
Pu-238	3.441E-04	2.010E-05	1.273E-05
Pu-239	7.232E-03	1.166E-01	2.676E-04
Pu-240	1.475E-03	6.500E-03	5.457E-05
Pu-241	1.735E-02	1.676E-04	6.419E-04
Pu-242	1.495E-07	3.781E-05	5.532E-09
Am-241	1.589E-02	4.636E-03	5.878E-04
Am-243	3.486E-06	1.746E-05	1.290E-07
Cm-242	7.110E-09	2.148E-12	2.631E-10
Cm-243	4.551E-06	9.282E-08	1.684E-07
Cm-244	1.024E-04	1.258E-06	3.788E-06
Total Activity:	2.190E+01		8.105E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.2609	m^3
Container Mass:	35.4	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	150.7	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.06088	m^3
Waste Mass:	115.3	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model:	85-Gal Drum

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.9	0.08	0.08	0.08	USER
0.1	2.8	2.8	2.3	Texaco Regal-A machine oil

G Value Data:

G Alpha	G Beta	G Gamma
0.352	0.352	0.302

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

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Hydrogen Gas:

H2 Concentration:	5	%	in 9.921 years
H2 Moles :	0.6108	moles	
H2 Volume :	13690	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.1771	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.1402	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	4E-06	%	
He Moles :	4.875E-07	moles	
He Volume :	0.01093	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.256E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.259E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.052	kPa	
Partial Pressure (He):	4.032E-06	kPa	
Partial Pressure (O2):	2.526	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.5 Radcalc Runs for 6x2x2 Box

7.3.5.1 6x2x2 Box, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 6x2x2\Radcalc & Text Files\5 vol%\Box, 6x2x2, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 6x2x2 box, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	2.346E-03	3.317E+02	8.679E-05
Co-60	1.064E-01	9.406E-05	3.938E-03
Sr-90	1.011E-01	7.321E-04	3.741E-03
Y-90	1.011E-01	1.859E-07	3.741E-03
Cs-137	1.777E-01	2.044E-03	6.575E-03
Ba-137m	1.681E-01	3.124E-10	6.220E-03
Eu-152	8.601E-04	4.943E-06	3.182E-05
Eu-154	6.682E-03	2.472E-05	2.472E-04
Eu-155	4.887E-04	1.007E-06	1.808E-05
Re-187	5.313E-07	1.209E+01	1.966E-08
Th-232	8.103E-05	7.390E+02	2.998E-06
U-234	5.384E-03	8.661E-01	1.992E-04
U-235	2.346E-04	1.085E+02	8.679E-06
U-238	5.651E-03	1.681E+04	2.091E-04
Np-237	8.156E-04	1.157E+00	3.018E-05
Pu-238	1.521E-03	8.883E-05	5.628E-05
Pu-239	7.908E-03	1.275E-01	2.926E-04
Pu-240	1.848E-03	8.144E-03	6.838E-05

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Pu-241	8.618E-02	8.328E-04	3.189E-03
Am-241	6.397E-03	1.867E-03	2.367E-04
Total Activity:	7.809E-01		2.889E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.5788	m^3
Container Mass:	309	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	463.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.1008	m^3
Waste Mass:	154.3	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.4121	0	0	0	USER
0.5879	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
1.999	1.999	1.999

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 134.3 years
H2 Moles :	1.353	moles	
H2 Volume :	30330	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.06909	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.01715	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	3E-05	%	
He Moles :	8.082E-06	moles	
He Volume :	0.1812	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.48E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.505E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.045	kPa	
Partial Pressure (He):	3.013E-05	kPa	
Partial Pressure (O2):	2.522	kPa	(if H20 present in waste)

Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.5.2 6x2x2 Box, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 6x2x2\Radcalc & Text Files\5 vol%\Box, 6x2x2, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 6x2x2 box, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	1.708E-03	1.776E-07	6.319E-05
C-14	3.595E-04	8.027E-05	1.330E-05
Co-60	1.100E-03	9.716E-07	4.068E-05
Ni-59	8.239E-05	1.032E-03	3.048E-06
Ni-63	7.850E-03	1.390E-04	2.904E-04
Se-79	6.621E-05	1.608E-02	2.450E-06
Sr-90	5.003E+00	3.623E-02	1.851E-01
Y-90	5.003E+00	9.201E-06	1.851E-01
Zr-93	3.206E-04	1.275E-01	1.186E-05
Nb-93m	2.535E-04	1.062E-06	9.378E-06
Tc-99	2.586E-03	1.531E-01	9.567E-05
Ru-106	5.303E-04	1.603E-07	1.962E-05
Cd-113m	1.249E-03	5.563E-06	4.623E-05
Sn-126	1.091E-04	8.834E-03	4.035E-06
Sb-125	9.767E-03	9.413E-06	3.614E-04
I-129	9.887E-06	5.739E-02	3.658E-07
Cs-134	2.283E-03	1.766E-06	8.447E-05
Cs-137	2.996E+00	3.447E-02	1.109E-01
Ba-137m	2.834E+00	5.266E-09	1.049E-01
Sm-151	2.310E-01	8.776E-03	8.547E-03
Eu-152	1.127E-04	6.475E-07	4.168E-06
Eu-154	1.399E-02	5.176E-05	5.177E-04
Eu-155	1.040E-02	2.141E-05	3.847E-04
Ra-226	5.543E-09	5.607E-09	2.051E-10
Ra-228	4.494E-06	1.648E-08	1.663E-07
Ac-227	1.252E-05	1.732E-07	4.634E-07
Th-229	1.950E-07	9.172E-07	7.216E-09
Th-232	4.764E-07	4.344E+00	1.763E-08
Pa-231	2.645E-05	5.601E-04	9.788E-07
U-232	1.267E-05	5.741E-07	4.689E-07
U-233	5.093E-05	5.287E-03	1.884E-06
U-234	3.236E-05	5.205E-03	1.197E-06
U-235	1.306E-06	6.044E-01	4.833E-08
U-236	1.255E-06	1.964E-02	4.645E-08
U-238	2.852E-05	8.486E+01	1.055E-06
Np-237	1.905E-05	2.704E-02	7.050E-07
Pu-238	2.538E-04	1.482E-05	9.389E-06
Pu-239	5.333E-03	8.599E-02	1.973E-04

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Pu-240	1.088E-03	4.793E-03	4.024E-05
Pu-241	1.279E-02	1.236E-04	4.733E-04
Pu-242	1.103E-07	2.788E-05	4.079E-09
Am-241	1.171E-02	3.419E-03	4.334E-04
Am-243	2.571E-06	1.287E-05	9.511E-08
Cm-242	5.243E-09	1.584E-12	1.940E-10
Cm-243	3.356E-06	6.844E-08	1.242E-07
Cm-244	7.550E-05	9.278E-07	2.793E-06
Total Activity:	1.615E+01		5.976E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	0.5788	m^3
Container Mass:	309	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	463.3	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.1008	m^3
Waste Mass:	154.3	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.4121	0	0	0	USER
0.5879	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
1.999	1.999	1.999

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 4.567 years
H2 Moles :	1.349	moles	
H2 Volume :	30240	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.8026	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.7205	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	6.1E-07	%	
He Moles :	1.648E-07	moles	
He Volume :	0.003693	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	9.258E-08	cm^3/hr	(0 C, 101.325 kPa)

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He Rate When Opened: 9.298E-08 cm^3/hr (0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.03	kPa	
Partial Pressure (He):	6.144E-07	kPa	
Partial Pressure (O2):	2.515	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.6 Radcalc Runs for 6x3x3 Box

7.3.6.1 6x3x3 Box, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 6x3x3\Radcalc & Text Files\5 vol%\Box, 6x3x3, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 6x3x3 box, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Lead with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	4.624E-03	6.539E+02	1.711E-04
Co-60	2.098E-01	1.854E-04	7.764E-03
Sr-90	1.993E-01	1.443E-03	7.375E-03
Y-90	1.993E-01	3.665E-07	7.375E-03
Cs-137	3.503E-01	4.030E-03	1.296E-02
Ba-137m	3.314E-01	6.158E-10	1.226E-02
Eu-152	1.695E-03	9.745E-06	6.273E-05
Eu-154	1.317E-02	4.873E-05	4.873E-04
Eu-155	9.633E-04	1.984E-06	3.564E-05
Re-187	1.047E-06	2.383E+01	3.875E-08
Th-232	1.597E-04	1.457E+03	5.910E-06
U-234	1.061E-02	1.707E+00	3.927E-04
U-235	4.624E-04	2.140E+02	1.711E-05
U-238	1.114E-02	3.314E+04	4.122E-04
Np-237	1.608E-03	2.282E+00	5.949E-05
Pu-238	2.999E-03	1.751E-04	1.109E-04
Pu-239	1.559E-02	2.513E-01	5.768E-04
Pu-240	3.643E-03	1.605E-02	1.348E-04
Pu-241	1.699E-01	1.642E-03	6.286E-03
Am-241	1.261E-02	3.680E-03	4.666E-04
Total Activity:	1.539E+00		5.696E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	1.33	m^3
Container Mass:	377	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	746.4	kg

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Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.1986	m^3
Waste Mass:	369.4	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.5371	0	0	0	USER
0.4629	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
1.574	1.574	1.574

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 238.5 years
H2 Moles :	3.112	moles	
H2 Volume :	69750	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.1072	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.02379	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	4.4E-05	%	
He Moles :	2.769E-05	moles	
He Volume :	0.6206	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	2.917E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	2.821E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.049	kPa	
Partial Pressure (He):	4.492E-05	kPa	
Partial Pressure (O2):	2.525	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.6.2 6x3x3 Box, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 6x3x3\Radcalc & Text Files\5 vol%\Box, 6x3x3, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 6x3x3 box, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Lead with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	3.365E-03	3.501E-07	1.245E-04
C-14	7.085E-04	1.582E-04	2.621E-05
Co-60	2.167E-03	1.915E-06	8.017E-05
Ni-59	1.624E-04	2.034E-03	6.007E-06
Ni-63	1.547E-02	2.739E-04	5.723E-04
Se-79	1.305E-04	3.168E-02	4.828E-06
Sr-90	9.860E+00	7.139E-02	3.648E-01
Y-90	9.860E+00	1.813E-05	3.648E-01
Zr-93	6.317E-04	2.512E-01	2.337E-05
Nb-93m	4.995E-04	2.093E-06	1.848E-05
Tc-99	5.095E-03	3.017E-01	1.885E-04
Ru-106	1.045E-03	3.158E-07	3.867E-05
Cd-113m	2.462E-03	1.096E-05	9.109E-05
Sn-126	2.149E-04	1.741E-02	7.952E-06
Sb-125	1.925E-02	1.855E-05	7.121E-04
I-129	1.948E-05	1.131E-01	7.209E-07
Cs-134	4.499E-03	3.480E-06	1.665E-04
Cs-137	5.904E+00	6.792E-02	2.184E-01
Ba-137m	5.585E+00	1.038E-08	2.067E-01
Sm-151	4.552E-01	1.729E-02	1.684E-02
Eu-152	2.220E-04	1.276E-06	8.214E-06
Eu-154	2.757E-02	1.020E-04	1.020E-03
Eu-155	2.049E-02	4.220E-05	7.580E-04
Ra-226	1.092E-08	1.105E-08	4.041E-10
Ra-228	8.856E-06	3.248E-08	3.277E-07
Ac-227	2.468E-05	3.412E-07	9.131E-07
Th-229	3.844E-07	1.807E-06	1.422E-08
Th-232	9.387E-07	8.561E+00	3.473E-08
Pa-231	5.213E-05	1.104E-03	1.929E-06
U-232	2.497E-05	1.131E-06	9.240E-07
U-233	1.004E-04	1.042E-02	3.714E-06
U-234	6.376E-05	1.026E-02	2.359E-06
U-235	2.574E-06	1.191E+00	9.524E-08
U-236	2.474E-06	3.871E-02	9.153E-08
U-238	5.621E-05	1.672E+02	2.080E-06
Np-237	3.755E-05	5.328E-02	1.389E-06
Pu-238	5.001E-04	2.920E-05	1.850E-05
Pu-239	1.051E-02	1.694E-01	3.888E-04
Pu-240	2.143E-03	9.445E-03	7.930E-05
Pu-241	2.521E-02	2.436E-04	9.328E-04
Pu-242	2.173E-07	5.495E-05	8.039E-09
Am-241	2.308E-02	6.737E-03	8.541E-04
Am-243	5.066E-06	2.537E-05	1.874E-07
Cm-242	1.033E-08	3.121E-12	3.823E-10
Cm-243	6.612E-06	1.349E-07	2.447E-07
Cm-244	1.488E-04	1.828E-06	5.505E-06
Total Activity:	3.183E+01		1.178E+00

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

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Container Data:

Container Void Volume:	1.33	m^3
Container Mass:	377	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	746.4	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.1986	m^3
Waste Mass:	369.4	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.5371	0	0	0	USER
0.4629	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
1.574	1.574	1.574

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 6.957 years
H2 Moles :	3.118	moles	
H2 Volume :	69890	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.245	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	1.056	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	8E-07	%	
He Moles :	4.975E-07	moles	
He Volume :	0.01115	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.824E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.831E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.059	kPa	
Partial Pressure (He):	8.071E-07	kPa	
Partial Pressure (O2):	2.529	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.7 Radcalc Runs for 8x4x4 Box

7.3.7.1 8x4x4 Box, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 8x4x4\Radcalc & Text Files\5 vol%\Box, 8x4x4, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 8x4x4 box, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	7.722E-03	1.092E+03	2.857E-04
Co-60	3.504E-01	3.096E-04	1.297E-02
Sr-90	3.329E-01	2.410E-03	1.232E-02
Y-90	3.329E-01	6.121E-07	1.232E-02
Cs-137	5.850E-01	6.730E-03	2.165E-02
Ba-137m	5.534E-01	1.028E-09	2.048E-02
Eu-152	2.831E-03	1.627E-05	1.048E-04
Eu-154	2.200E-02	8.138E-05	8.139E-04
Eu-155	1.609E-03	3.314E-06	5.952E-05
Re-187	1.749E-06	3.979E+01	6.472E-08
Th-232	2.668E-04	2.433E+03	9.870E-06
U-234	1.773E-02	2.851E+00	6.558E-04
U-235	7.722E-04	3.573E+02	2.857E-05
U-238	1.860E-02	5.535E+04	6.883E-04
Np-237	2.685E-03	3.810E+00	9.935E-05
Pu-238	5.008E-03	2.924E-04	1.853E-04
Pu-239	2.603E-02	4.197E-01	9.632E-04
Pu-240	6.084E-03	2.681E-02	2.251E-04
Pu-241	2.837E-01	2.742E-03	1.050E-02
Am-241	2.106E-02	6.146E-03	7.792E-04
Total Activity:	2.571E+00		9.512E-02

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	3.398	m^3
Container Mass:	523	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	1138	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.2265	m^3
Waste Mass:	615.2	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

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Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.73	0	0	0	USER
0.27	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.918	0.918	0.918

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 842.4 years
H2 Moles :	7.944	moles	
H2 Volume :	178100	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.1045	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.01939	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	9.2E-05	%	
He Moles :	0.0001472	moles	
He Volume :	3.3	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	4.872E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	4.003E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.045	kPa	
Partial Pressure (He):	9.349E-05	kPa	
Partial Pressure (O2):	2.522	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.7.2 8x4x4 Box, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 8x4x4\Radcalc & Text Files\5 vol%\Box, 8x4x4, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 8x4x4 box, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	5.624E-03	5.850E-07	2.081E-04
C-14	1.184E-03	2.643E-04	4.381E-05
Co-60	3.621E-03	3.200E-06	1.340E-04
Ni-59	2.713E-04	3.399E-03	1.004E-05
Ni-63	2.585E-02	4.577E-04	9.564E-04
Se-79	2.180E-04	5.295E-02	8.067E-06
Sr-90	1.648E+01	1.193E-01	6.096E-01
Y-90	1.648E+01	3.030E-05	6.096E-01
Zr-93	1.056E-03	4.197E-01	3.906E-05
Nb-93m	8.347E-04	3.498E-06	3.088E-05
Tc-99	8.514E-03	5.041E-01	3.150E-04
Ru-106	1.746E-03	5.277E-07	6.461E-05
Cd-113m	4.114E-03	1.832E-05	1.522E-04
Sn-126	3.591E-04	2.909E-02	1.329E-05
Sb-125	3.216E-02	3.100E-05	1.190E-03
I-129	3.256E-05	1.890E-01	1.205E-06
Cs-134	7.518E-03	5.815E-06	2.782E-04
Cs-137	9.866E+00	1.135E-01	3.650E-01
Ba-137m	9.333E+00	1.734E-08	3.453E-01
Sm-151	7.607E-01	2.890E-02	2.814E-02
Eu-152	3.710E-04	2.132E-06	1.373E-05
Eu-154	4.607E-02	1.705E-04	1.705E-03
Eu-155	3.424E-02	7.051E-05	1.267E-03
Ra-226	1.825E-08	1.846E-08	6.753E-10
Ra-228	1.480E-05	5.428E-08	5.476E-07
Ac-227	4.124E-05	5.702E-07	1.526E-06
Th-229	6.423E-07	3.020E-06	2.376E-08
Th-232	1.569E-06	1.431E+01	5.804E-08
Pa-231	8.712E-05	1.844E-03	3.223E-06
U-232	4.173E-05	1.891E-06	1.544E-06
U-233	1.677E-04	1.741E-02	6.206E-06
U-234	1.066E-04	1.714E-02	3.942E-06
U-235	4.302E-06	1.990E+00	1.592E-07
U-236	4.134E-06	6.469E-02	1.530E-07
U-238	9.392E-05	2.794E+02	3.475E-06
Np-237	6.275E-05	8.904E-02	2.322E-06
Pu-238	8.357E-04	4.880E-05	3.092E-05
Pu-239	1.756E-02	2.832E-01	6.498E-04
Pu-240	3.581E-03	1.578E-02	1.325E-04
Pu-241	4.213E-02	4.071E-04	1.559E-03
Pu-242	3.631E-07	9.182E-05	1.343E-08
Am-241	3.858E-02	1.126E-02	1.427E-03
Am-243	8.465E-06	4.239E-05	3.132E-07
Cm-242	1.727E-08	5.215E-12	6.388E-10
Cm-243	1.105E-05	2.254E-07	4.088E-07
Cm-244	2.486E-04	3.055E-06	9.199E-06
Total Activity:	5.319E+01		1.968E+00

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	3.398	m^3
Container Mass:	523	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	1138	kg

Waste Data:

Waste Form:	Normal
Waste State:	Solid

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Waste Volume:	0.2265	m^3
Waste Mass:	615.2	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.73	0	0	0	USER
0.27	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.918	0.918	0.918

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 21.39 years
H2 Moles :	7.951	moles	
H2 Volume :	178200	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.214	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.7349	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	1.6E-06	%	
He Moles :	2.545E-06	moles	
He Volume :	0.05704	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	3.049E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	3.033E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.049	kPa	
Partial Pressure (He):	1.616E-06	kPa	
Partial Pressure (O2):	2.525	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.8 Radcalc Runs for 9x5x5 Box

7.3.8.1 9x5x5 Box, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 9x5x5\Radcalc & Text Files\5 vol%\Box, 9x5x5, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 9x5x5 box, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Copper + Aluminum with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	1.931E-02	2.731E+03	7.145E-04
Co-60	8.763E-01	7.744E-04	3.242E-02
Sr-90	8.324E-01	6.027E-03	3.080E-02
Y-90	8.324E-01	1.531E-06	3.080E-02
Cs-137	1.463E+00	1.683E-02	5.413E-02
Ba-137m	1.384E+00	2.572E-09	5.121E-02
Eu-152	7.081E-03	4.070E-05	2.620E-04
Eu-154	5.501E-02	2.035E-04	2.035E-03
Eu-155	4.023E-03	8.287E-06	1.489E-04
Re-187	4.374E-06	9.951E+01	1.619E-07
Th-232	6.671E-04	6.084E+03	2.468E-05
U-234	4.433E-02	7.130E+00	1.640E-03
U-235	1.931E-03	8.936E+02	7.145E-05
U-238	4.652E-02	1.384E+05	1.721E-03
Np-237	6.715E-03	9.529E+00	2.485E-04
Pu-238	1.252E-02	7.313E-04	4.634E-04
Pu-239	6.510E-02	1.050E+00	2.409E-03
Pu-240	1.522E-02	6.705E-02	5.630E-04
Pu-241	7.096E-01	6.856E-03	2.625E-02
Am-241	5.267E-02	1.537E-02	1.949E-03
Total Activity:	6.429E+00		2.379E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	6	m^3
Container Mass:	709	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	2243	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.3709	m^3
Waste Mass:	1534	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.8789	0	0	0	USER
0.1211	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.4117	0.4117	0.4117

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 1473 years
H2 Moles :	14.04	moles	
H2 Volume :	314800	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.1172	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.02018	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	0.00021	%	
He Moles :	0.000605	moles	
He Volume :	13.56	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.218E-06	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	9.323E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.051	kPa	
Partial Pressure (He):	0.0002176	kPa	
Partial Pressure (O2):	2.525	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.8.2 9x5x5 Box, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 9x5x5\Radcalc & Text Files\5 vol%\Box, 9x5x5, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 9x5x5 box, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Copper + Aluminum with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	1.414E-02	1.471E-06	5.232E-04
C-14	2.977E-03	6.647E-04	1.102E-04
Co-60	9.105E-03	8.046E-06	3.369E-04
Ni-59	6.823E-04	8.548E-03	2.524E-05
Ni-63	6.500E-02	1.151E-03	2.405E-03
Se-79	5.483E-04	1.331E-01	2.029E-05
Sr-90	4.143E+01	3.000E-01	1.533E+00
Y-90	4.143E+01	7.619E-05	1.533E+00
Zr-93	2.655E-03	1.056E+00	9.822E-05
Nb-93m	2.099E-03	8.796E-06	7.766E-05

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Tc-99	2.141E-02	1.268E+00	7.922E-04
Ru-106	4.391E-03	1.327E-06	1.625E-04
Cd-113m	1.035E-02	4.607E-05	3.828E-04
Sn-126	9.031E-04	7.315E-02	3.341E-05
Sb-125	8.088E-02	7.795E-05	2.993E-03
I-129	8.187E-05	4.753E-01	3.029E-06
Cs-134	1.891E-02	1.462E-05	6.995E-04
Cs-137	2.481E+01	2.854E-01	9.180E-01
Ba-137m	2.347E+01	4.361E-08	8.684E-01
Sm-151	1.913E+00	7.268E-02	7.078E-02
Eu-152	9.329E-04	5.362E-06	3.452E-05
Eu-154	1.159E-01	4.287E-04	4.287E-03
Eu-155	8.609E-02	1.773E-04	3.185E-03
Ra-226	4.590E-08	4.643E-08	1.698E-09
Ra-228	3.722E-05	1.365E-07	1.377E-06
Ac-227	1.037E-04	1.434E-06	3.837E-06
Th-229	1.615E-06	7.595E-06	5.976E-08
Th-232	3.945E-06	3.597E+01	1.460E-07
Pa-231	2.191E-04	4.638E-03	8.106E-06
U-232	1.049E-04	4.755E-06	3.883E-06
U-233	4.218E-04	4.378E-02	1.561E-05
U-234	2.679E-04	4.310E-02	9.914E-06
U-235	1.082E-05	5.005E+00	4.002E-07
U-236	1.040E-05	1.627E-01	3.846E-07
U-238	2.362E-04	7.027E+02	8.739E-06
Np-237	1.578E-04	2.239E-01	5.838E-06
Pu-238	2.101E-03	1.227E-04	7.775E-05
Pu-239	4.416E-02	7.121E-01	1.634E-03
Pu-240	9.006E-03	3.969E-02	3.332E-04
Pu-241	1.059E-01	1.024E-03	3.920E-03
Pu-242	9.130E-07	2.309E-04	3.378E-08
Am-241	9.701E-02	2.831E-02	3.589E-03
Am-243	2.129E-05	1.066E-04	7.876E-07
Cm-242	4.342E-08	1.311E-11	1.606E-09
Cm-243	2.779E-05	5.668E-07	1.028E-06
Cm-244	6.252E-04	7.683E-06	2.313E-05
Total Activity:	1.338E+02		4.949E+00

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	6	m^3
Container Mass:	709	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	2243	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.3709	m^3
Waste Mass:	1534	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:

Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.8789	0	0	0	USER
0.1211	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.4117	0.4117	0.4117

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 40.79 years
H2 Moles :	13.98	moles	
H2 Volume :	313400	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.369	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.5315	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	4.3E-06	%	
He Moles :	1.207E-05	moles	
He Volume :	0.2706	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	7.667E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	7.501E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.03	kPa	
Partial Pressure (He):	4.343E-06	kPa	
Partial Pressure (O2):	2.515	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.9 Radcalc Runs for 12x4x4 Box

7.3.9.1 12x4x4 Box, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 12x4x4\Radcalc & Text Files\5 vol%\Box, 12x4x4, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 12x4x4 box, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Copper + Aluminum with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	2.170E-02	3.069E+03	8.029E-04
Co-60	9.848E-01	8.702E-04	3.644E-02

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Sr-90	9.354E-01	6.773E-03	3.461E-02
Y-90	9.354E-01	1.720E-06	3.461E-02
Cs-137	1.644E+00	1.891E-02	6.083E-02
Ba-137m	1.555E+00	2.890E-09	5.754E-02
Eu-152	7.957E-03	4.573E-05	2.944E-04
Eu-154	6.181E-02	2.287E-04	2.287E-03
Eu-155	4.521E-03	9.312E-06	1.673E-04
Re-187	4.916E-06	1.118E+02	1.819E-07
Th-232	7.497E-04	6.836E+03	2.774E-05
U-234	4.981E-02	8.013E+00	1.843E-03
U-235	2.170E-03	1.004E+03	8.029E-05
U-238	5.228E-02	1.555E+05	1.934E-03
Np-237	7.546E-03	1.071E+01	2.792E-04
Pu-238	1.407E-02	8.218E-04	5.207E-04
Pu-239	7.316E-02	1.180E+00	2.707E-03
Pu-240	1.710E-02	7.535E-02	6.326E-04
Pu-241	7.973E-01	7.704E-03	2.950E-02
Am-241	5.918E-02	1.727E-02	2.190E-03
Total Activity:	7.224E+00		2.673E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	5.012	m^3
Container Mass:	1056	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	2812	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.4253	m^3
Waste Mass:	1756	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.8714	0	0	0	USER
0.1286	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.4372	0.4372	0.4372

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:
H2 Concentration: 5 % in 950.8 years

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Engineering and Technology

H2 Moles :	11.72	moles	
H2 Volume :	262700	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.1398	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.02549	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	0.0002	%	
He Moles :	0.0004609	moles	
He Volume :	10.33	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.369E-06	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.106E-06	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.046	kPa	
Partial Pressure (He):	0.0001984	kPa	
Partial Pressure (O2):	2.523	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.9.2 12x4x4 Box, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 12x4x4\Radcalc & Text Files\5 vol%\Box, 12x4x4, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 12x4x4 box, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Copper + Aluminum with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	1.581E-02	1.645E-06	5.850E-04
C-14	3.329E-03	7.432E-04	1.232E-04
Co-60	1.018E-02	8.996E-06	3.767E-04
Ni-59	7.629E-04	9.558E-03	2.823E-05
Ni-63	7.268E-02	1.287E-03	2.689E-03
Se-79	6.131E-04	1.489E-01	2.268E-05
Sr-90	4.633E+01	3.354E-01	1.714E+00
Y-90	4.633E+01	8.519E-05	1.714E+00
Zr-93	2.968E-03	1.180E+00	1.098E-04
Nb-93m	2.347E-03	9.835E-06	8.683E-05
Tc-99	2.394E-02	1.417E+00	8.858E-04
Ru-106	4.910E-03	1.484E-06	1.817E-04
Cd-113m	1.157E-02	5.151E-05	4.280E-04
Sn-126	1.010E-03	8.179E-02	3.736E-05
Sb-125	9.043E-02	8.716E-05	3.346E-03
I-129	9.154E-05	5.314E-01	3.387E-06
Cs-134	2.114E-02	1.635E-05	7.821E-04
Cs-137	2.774E+01	3.191E-01	1.026E+00
Ba-137m	2.624E+01	4.876E-08	9.710E-01
Sm-151	2.139E+00	8.126E-02	7.913E-02
Eu-152	1.043E-03	5.995E-06	3.859E-05
Eu-154	1.295E-01	4.793E-04	4.793E-03

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Eu-155	9.626E-02	1.983E-04	3.562E-03
Ra-226	5.132E-08	5.191E-08	1.899E-09
Ra-228	4.161E-05	1.526E-07	1.540E-06
Ac-227	1.160E-04	1.603E-06	4.290E-06
Th-229	1.806E-06	8.492E-06	6.682E-08
Th-232	4.411E-06	4.022E+01	1.632E-07
Pa-231	2.449E-04	5.186E-03	9.063E-06
U-232	1.173E-04	5.316E-06	4.342E-06
U-233	4.716E-04	4.895E-02	1.745E-05
U-234	2.996E-04	4.819E-02	1.108E-05
U-235	1.209E-05	5.597E+00	4.475E-07
U-236	1.162E-05	1.819E-01	4.301E-07
U-238	2.641E-04	7.857E+02	9.771E-06
Np-237	1.764E-04	2.503E-01	6.528E-06
Pu-238	2.350E-03	1.372E-04	8.693E-05
Pu-239	4.938E-02	7.962E-01	1.827E-03
Pu-240	1.007E-02	4.438E-02	3.726E-04
Pu-241	1.184E-01	1.145E-03	4.383E-03
Pu-242	1.021E-06	2.582E-04	3.777E-08
Am-241	1.085E-01	3.165E-02	4.013E-03
Am-243	2.380E-05	1.192E-04	8.806E-07
Cm-242	4.855E-08	1.466E-11	1.796E-09
Cm-243	3.107E-05	6.337E-07	1.150E-06
Cm-244	6.990E-04	8.590E-06	2.586E-05
Total Activity:	1.496E+02		5.533E+00

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	5.012	m^3
Container Mass:	1056	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	2812	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.4253	m^3
Waste Mass:	1756	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.8714	0	0	0	USER
0.1286	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.4372	0.4372	0.4372

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:			
H2 Concentration:	5	%	in 24.29 years
H2 Moles :	11.71	moles	
H2 Volume :	262500	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.625	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.9208	cm^3/hr	(0 C, 101.325 kPa)
Helium Gas:			
He Concentration:	3.4E-06	%	
He Moles :	8.107E-06	moles	
He Volume :	0.1817	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	8.572E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	8.51E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:			
Partial Pressure (H2):	5.042	kPa	
Partial Pressure (He):	3.491E-06	kPa	
Partial Pressure (O2):	2.521	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)

7.3.10 Radcalc Runs for 16x2x2 Box

7.3.10.1 16x2x2 Box, LLW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 16x2x2\Radcalc & Text Files\5 vol%\Box, 16x2x2, LLW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 16x2x2 box, bounding LLW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Copper + Aluminum with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
K-40	1.729E-02	2.445E+03	6.398E-04
Co-60	7.847E-01	6.934E-04	2.903E-02
Sr-90	7.454E-01	5.397E-03	2.758E-02
Y-90	7.454E-01	1.371E-06	2.758E-02
Cs-137	1.310E+00	1.507E-02	4.847E-02
Ba-137m	1.239E+00	2.303E-09	4.585E-02
Eu-152	6.340E-03	3.644E-05	2.346E-04
Eu-154	4.926E-02	1.822E-04	1.822E-03
Eu-155	3.603E-03	7.420E-06	1.333E-04
Re-187	3.917E-06	8.910E+01	1.449E-07
Th-232	5.974E-04	5.448E+03	2.210E-05
U-234	3.969E-02	6.385E+00	1.469E-03
U-235	1.729E-03	8.002E+02	6.398E-05
U-238	4.166E-02	1.239E+05	1.541E-03

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Np-237	6.013E-03	8.532E+00	2.225E-04
Pu-238	1.121E-02	6.548E-04	4.149E-04
Pu-239	5.830E-02	9.399E-01	2.157E-03
Pu-240	1.362E-02	6.004E-02	5.041E-04
Pu-241	6.354E-01	6.139E-03	2.351E-02
Am-241	4.716E-02	1.376E-02	1.745E-03
Total Activity:	5.757E+00		2.130E-01

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	1.479	m^3
Container Mass:	616	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	1981	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.3337	m^3
Waste Mass:	1365	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.8689	0	0	0	USER
0.1311	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.4457	0.4457	0.4457

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 254.6 years
H2 Moles :	3.437	moles	
H2 Volume :	77040	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	0.1136	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	0.02499	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

He Concentration:	0.00016	%	
He Moles :	0.0001094	moles	
He Volume :	2.453	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	1.091E-06	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	1.049E-06	cm^3/hr	(0 C, 101.325 kPa)

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Pressure When Opened:			
Partial Pressure (H2):	5.016	kPa	
Partial Pressure (He):	0.0001597	kPa	
Partial Pressure (O2):	2.508	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.3	kPa	
Total Pressure (H2 + He + O2 + Air):	108.8	kPa	(if H20 present in waste)

7.3.10.2 16x2x2 Box, MW Source Term, Misc Debris, 5 vol% H_2

Radcalc 4.1: U:\TOC\WRPS Gas Generation Task, 07-09\Reorganized Data & Radcalc Runs\Box, 16x2x2\Radcalc & Text Files\5 vol%\Box, 16x2x2, MW, Misc Debris (5 vol% H2).rad

Performed By: R Wagner
Checked By: B Willis

========== Input Information ==========

Comments:
Time to 5 vol% H2 for sealed 16x2x2 box, bounding MW rad source term, miscellaneous debris waste contents.
- Paper/plastic/cloth/rubber/wood/absorbent are labeled "Polyethylene (LDPE)" and modeled as Solid Organic Materials, W-hr < 0.012, with uniform G values of 3.4 from TRAMPAC
- "USER" is Steel + Copper + Aluminum with G values of 0.

Initial Source Data:

Isotope	Ci	Gm	TBq
H-3	1.250E-02	1.301E-06	4.627E-04
C-14	2.633E-03	5.878E-04	9.740E-05
Co-60	8.051E-03	7.115E-06	2.979E-04
Ni-59	6.033E-04	7.559E-03	2.232E-05
Ni-63	5.748E-02	1.018E-03	2.127E-03
Se-79	4.848E-04	1.177E-01	1.794E-05
Sr-90	3.664E+01	2.653E-01	1.356E+00
Y-90	3.664E+01	6.737E-05	1.356E+00
Zr-93	2.347E-03	9.333E-01	8.685E-05
Nb-93m	1.856E-03	7.778E-06	6.867E-05
Tc-99	1.893E-02	1.121E+00	7.005E-04
Ru-106	3.883E-03	1.173E-06	1.437E-04
Cd-113m	9.148E-03	4.074E-05	3.385E-04
Sn-126	7.985E-04	6.468E-02	2.955E-05
Sb-125	7.152E-02	6.893E-05	2.646E-03
I-129	7.240E-05	4.203E-01	2.679E-06
Cs-134	1.672E-02	1.293E-05	6.185E-04
Cs-137	2.194E+01	2.524E-01	8.117E-01
Ba-137m	2.075E+01	3.856E-08	7.679E-01
Sm-151	1.691E+00	6.426E-02	6.258E-02
Eu-152	8.249E-04	4.741E-06	3.052E-05
Eu-154	1.025E-01	3.790E-04	3.791E-03
Eu-155	7.612E-02	1.568E-04	2.817E-03
Ra-226	4.059E-08	4.106E-08	1.502E-09
Ra-228	3.291E-05	1.207E-07	1.218E-06
Ac-227	9.170E-05	1.268E-06	3.393E-06
Th-229	1.428E-06	6.716E-06	5.284E-08
Th-232	3.488E-06	3.181E+01	1.291E-07
Pa-231	1.937E-04	4.101E-03	7.167E-06
U-232	9.280E-05	4.204E-06	3.434E-06
U-233	3.729E-04	3.872E-02	1.380E-05
U-234	2.369E-04	3.811E-02	8.766E-06
U-235	9.565E-06	4.426E+00	3.539E-07
U-236	9.192E-06	1.438E-01	3.401E-07

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U-238	2.089E-04	6.214E+02	7.727E-06
Np-237	1.395E-04	1.980E-01	5.162E-06
Pu-238	1.858E-03	1.085E-04	6.875E-05
Pu-239	3.905E-02	6.296E-01	1.445E-03
Pu-240	7.963E-03	3.509E-02	2.946E-04
Pu-241	9.368E-02	9.051E-04	3.466E-03
Pu-242	8.073E-07	2.042E-04	2.987E-08
Am-241	8.578E-02	2.503E-02	3.174E-03
Am-243	1.882E-05	9.425E-05	6.964E-07
Cm-242	3.839E-08	1.160E-11	1.420E-09
Cm-243	2.457E-05	5.012E-07	9.091E-07
Cm-244	5.528E-04	6.794E-06	2.046E-05
Total Activity:	1.183E+02		4.376E+00

* Radionuclides with an A1/A2 fraction of less than 0.001 will not be shown in the output.

Container Data:

Container Void Volume:	1.479	m^3
Container Mass:	616	kg
Mass of solid beryllium, lead, graphite, and hydrogenous material enriched with deuterium:	0	kg
Gross Mass:	1981	kg

Waste Data:

Waste Form:	Normal	
Waste State:	Solid	
Waste Volume:	0.3337	m^3
Waste Mass:	1365	kg
Mass of solid lead:	0	kg
Mass of solid beryllium, graphite, and hydrogenous material enriched with deuterium:	0	kg
Waste Void Volume:	0	m^3

Decay Time Data:

Time to decay source before sealing:	30	day
Hydrogen gas target:	5	%

Gamma Absorption Model:
Gamma Abs Model: 100% Gamma Absorption

G Value Materials Data:

Wt. Fraction	G Alpha	G Beta	G Gamma	Material Name
0.8689	0	0	0	USER
0.1311	3.4	3.4	3.4	Polyethylene (LDPE)

G Value Data:

G Alpha	G Beta	G Gamma
0.4457	0.4457	0.4457

G values calculated from the list of materials (above).

========== Hydrogen/Helium Gas Results ==========

* Hydrogen gas calculations are made at the end of the user-specified seal time.

Hydrogen Gas:

H2 Concentration:	5	%	in 7.387 years
H2 Moles :	3.467	moles	
H2 Volume :	77710	cm^3	(0 C, 101.325 kPa)
H2 Rate When Sealed:	1.31	cm^3/hr	(0 C, 101.325 kPa)
H2 Rate When Opened:	1.1	cm^3/hr	(0 C, 101.325 kPa)

Helium Gas:

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He Concentration:	2.8E-06	%	
He Moles :	1.963E-06	moles	
He Volume :	0.04399	cm^3	(0 C, 101.325 kPa)
He Rate When Sealed:	6.779E-07	cm^3/hr	(0 C, 101.325 kPa)
He Rate When Opened:	6.804E-07	cm^3/hr	(0 C, 101.325 kPa)

Pressure When Opened:

Partial Pressure (H2):	5.058	kPa	
Partial Pressure (He):	2.863E-06	kPa	
Partial Pressure (O2):	2.529	kPa	(if H20 present in waste)
Total Pressure (H2 + He + Air):	106.4	kPa	
Total Pressure (H2 + He + O2 + Air):	108.9	kPa	(if H20 present in waste)