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Procedure for Categorizing and Inventorying Waste in Standard Containers

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Abstract: A procedure for quantifying the radioactive material content of standard low specific activity waste containers, based on surface dose rate measurements is given.

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PROCEDURE FOR CATEGORIZING AND INVENTORING
WASTE IN STANDARD CONTAINERS

1.0 INTRODUCTION

The attached procedure is a method for using surface dose rate measurements to categorize and inventory the radioactive waste in a container. This procedure is based on calculations that relate the inventory to the surface dose rate (Gedeon 1996).

2.0 BASIS AND ACCURACY

These calculations (Gedeon 1996) also examined the parameters that affect the surface dose rate-to-radioisotope inventory relationship. This leads to the following conclusions and requirements:

1. The surface dose rate is relatively insensitive to the composition of the waste material; therefore, a single (upper limit composition) curve yields a mildly conservative inventory. This conservative bias accommodates some of the uncertainty associated with the method.
2. For the waste streams evaluated, the surface dose rate is dominated by ^{137}Cs . By assuming the surface dose rate defines the inventory of ^{137}Cs , a conservative bias is introduced into the overall inventory determination and categorization. The greater the surface dose contribution of isotopes other than ^{137}Cs , the greater the bias. These conservative biases generally accommodate the uncertainty of the method.
3. This procedure is only applicable if ^{137}Cs is known to exist in the waste in significant amounts.
4. This procedure should not be used if the waste is known to contain sufficient quantity of other dose dominate isotopes, such as ^{60}Co .
5. Voids, located within otherwise uniformly distributed waste material, will not introduce significant error into the inventory determination.
6. Localized source concentrations, other than those centrally distributed, can be detected by the variation in individual surface dose rate readings from the average. For standard containers, a Max/Avg ratio greater than 2.5 indicates the source distribution to be significantly heterogeneous.

7. If there is reason to believe the inventory is approximately a centrally located point source or other significantly heterogeneous source, it is always conservative to assume the point source option. Alternately the container can be analyzed outside of this procedure as a special case.
8. Measured dose rates are to be contact readings made with a CP meter. The calculations assume that the center of the CP detector volume is approximately 2 inches from the container surface. If an instrument other than a CP is used, care must be taken to ensure that the center of that detector volume is 2 inches from the container surface.
9. The 6 points where the dose rates should be measured are the geometric center of each face of the container. For barrels, four of the measurements should be taken 90° apart on the circumference, half-way along the length of the barrel.
10. For large containers, it may be necessary to take more than 6 readings. An alternative procedure is available for use with 4' x 4' x 8' wood boxes. Specifically, if general contact readings along the length of the box vary by a factor of 2.5 or more, then a 14 point survey should be performed.

The supporting calculations (Bunch) were performed with the MCNP (Monte Carlo N-Particle) computer code (Briesmeister et al 1993, Carter 1994).

3.0 PROCEDURE

1. Enter the curies of each isotope in the waste stream mix in column 2 of Table 1. Attach a reference copy of the Waste Stream Mix to the table or identify an appropriate reference.
2. Sum the curie values in column 2 and enter the value at the bottom of the column in the space for Σ .
3. Normalize the waste stream mix of Category 1 constituents by dividing the curie value of each isotope in column 2 by the sum Σ of column 2. The sum of column 3 should be unity.
4. Obtain the six surface dose rate values and enter these in the work sheet, including information concerning the radiation detector (see item 8, above). An optional 14 point survey work sheet is available for 4' x 4' x 8' wood boxes. This option should be selected if the dose varies along the length of the box by more than a factor of 2.5.

5. Obtain average surface dose rate by summing the six readings (14 readings if that option is selected) and dividing the sum by six (or 14 if applicable). Subtract background. Record corrected average on work sheet.

Note: Convert the corrected average value reading into units R/hr even though they were obtained as cpm, mR/hr, or other.

6. Divide the background corrected maximum of the six individual readings by the background corrected average value and enter this on the worksheet as the Max/Avg value.
7. Weigh the waste container and enter this value on the worksheet.
8. Subtract the standard empty container weight from the gross weight obtained in step 7 and enter this net weight value on the worksheet.
9. Using the net weight from step 8, go to the appropriate attached figure for the type of container to determine the Ci of ^{137}Cs per R/hr. If the Max/Avg value in step 6 is equal to or less than 2.5, use the homogeneous (distributed source) curve. If the Max/Avg value from step 6 is greater than 2.5 use the heterogenous (point source) curve, or subject the container to an alternative assay procedure or a case-by-case assessment.
10. Multiply the Ci of ^{137}Cs per R/hr from step 9 by the average surface dose rate value (in R/hr) from step 5. Enter this curie value of ^{137}Cs in column 4 in the ^{137}Cs row of Table 1.
11. Divide the Ci value for ^{137}Cs in Column 4 by the value for ^{137}Cs in column 3 and enter this value in the space for "factor" at the top of column 4. This is the factor for quantifying the curie inventory of other radioisotopes.
12. Multiply each curie value in Column 3 by the normalizing "factor" at the top of Column 4 (see step 11) and enter the resulting value for each isotope in the appropriate row in Column 4.
13. Enter the standard volume of the container on the worksheet.
14. Divide the curie inventory in each row of Column 4 by the standard container volume from the worksheet to obtain the curies per cubic meter for each radioisotope that has a known Category 1 limit.
15. Divide the curie concentration of each isotope in Column 5 by its Category 1 limit listed in Column 6 and enter the resulting value in Column 7 as the fractional contribution of the isotope.

Note: The fractional contributions might vary by several orders of magnitude; therefore, care must be taken in recording each value.

16. Sum the fractional contributions of each isotope in Column 7 to obtain the value for the container. Enter this value at the bottom of Column 7.

Note: Be sure the decimal point for each fractional contribution is correctly taken into account.

WORKSHEET FOR STANDARD CONTAINERS

SURFACE DOSE RATE MEASUREMENTS

Instrument _____ Calib or Cert _____

Surface dose rates

Side 1	_____	
Side 2	_____	Max Reading _____
Side 3	_____	Background (-) _____
Side 4	_____	Max Net value _____
Top	_____	
Bottom	_____	

Sum	_____	divide by 6 = _____
		Background (-) _____
		Average _____

Max/Avg = _____

CONTAINER INFORMATION

Type _____ Empty weight _____ kg Volume _____ m³

Scale information _____

Gross weight	_____	(kilograms)
Empty weight	_____	(kilograms)
Net weight	_____	(use this value in step 9)

OPTIONAL WORKSHEET FOR LARGE WOODEN BOX (4' x 4' x 8')

SURFACE DOSE RATE MEASUREMENTS

Instrument _____ Calib or Cert _____

Surface dose rates*

Side 1	_____	_____	_____
Side 2	_____	_____	_____
Side 3	_____	_____	_____
Side 4	_____	_____	_____
End 1	_____	_____	_____
End 2	_____	_____	_____

Max Reading _____
 Background (-) _____
 Max Net value _____

Sum _____ divide by 14 = _____
 Background (-) _____
 Average _____

Max/Avg = _____

CONTAINER INFORMATION

Type 4' x 4' x 8' wood box Empty weight 277 kg Volume 3.6 m³

Scale information _____

Gross weight _____ (kilograms)
 Empty weight _____ (kilograms)
 Net weight _____ (use this value in step 9)

*Measurements should be taken at 2 foot intervals along the long centerline of the long (4' x 8') faces, and at the center of the end (4' x 4') faces.

Table 1. Calculational Worksheet
(Sheet 1 of 2)

(1) ISOTOPE	(2) WASTE STREAM MIX, Ci	(3) NORMALIZED MIX Ci/Ci	(4) Ci/CONTAINER Factor = _____	(5) Cof (4) + VOLUME	(6) CATEGORY 1 LIMIT Ci/M3	(7) CATEGORY 1 FRACTION (5)/(6)
14C					4.0 E-2	
60Co					7.7 E+1	
79Se					3.8 E-1	
94Nb					2.6 E-3	
90Sr					4.3 E-3	
99Tc					5.6 E-3	
129I					2.9 E-3	
137Cs					6.3 E-3	
154Eu					8.3 E-1	
235U					3.2 E-3	
238U					6.3 E-3	
237Np					1.9 E-4	
238Pu					9.1 E-3	
239Pu					3.6 E-3	
240Pu					3.6 E-3	
241Pu					7.7 E-2	
242Pu					3.8 E-3	
241Am					2.6 E-3	
243Cm					2.5 E-2	

Table 1. Calculation Worksheet
(Sheet 2 of 2)

(1) ISOTOPE	(2) WASTE STREAM MIX, Ci	(3) NORMALIZED MIX Ci/Ci	(4) Ci/CONTAINER Factor = _____	(5) Col (4) × VOLUME	(6) CATEGORY 1 LIMIT Ci/M3	(7) CATEGORY 1 FRACTION (5)/(6)
244Cm					2.3 E-1	
245Cm					2.1 E-3	
	Σ =	1.000				f =

Figure 1. Dose Rate to Curie Conversion Factor 55 Gal. Drum

Figure 2. Dose Rate to Curie Conversion Factor 85 Gal. Drum

Figure 3. Dose Rate to Curie Conversion Factor 3' x 3' x 6' Metal Box

Figure 4. Dose Rate to Curie Conversion Factor 2' x 2' x 6' Metal Box

Figure 5. Dose Rate to Curie Conversion Factor 5' x 5' x 9' Metal Box

Figure 6. Dose Rate to Curie Conversion Factor 5' x 5' x 6' Metal Box (LMB III)

Figure 7. Dose Rate to Curie Conversion Factor 4' x 4' x 8' Wood box

Figure 8. Dose Rate to Curie Conversion Factor 4' x 4' x 7.5' Metal Box

Figure 9. Dose Rate to Curie Conversion Factor 4' x 4' x 8' Wood Box

4.0 REFERENCES

- Gedeon, S. R. et al, "Basis for Dose Rate to Curie Assay Method", WHC-SD-WM-RPT-267, Westinghouse Hanford Company, Richland, Washington, 99352, dated October 1996.
- Briesmeister, J. F., Editor, "MCNP -- A General Monte Carlo N-Particle Transport Code. Version 4A", LA-12625, Los Alamos National Laboratory, Los Alamos, New Mexico, dated 1993.
- Carter, L. L. and R. A. Schwarz, "Certification of MCNP Version 4A for WHC Computer Platforms", ECN 186710, dated January 4, 1994.

CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW

DOCUMENT REVIEWED Procedure for Categorizing and Inventorying Waste in Standard Containers

AUTHOR(s) S. R. Gedeon

I. Method(s) of Review

- ☒ Input data checked for accuracy
- ☒ Independent calculation performed
 - ☐ Hand calculation
 - ☒ Alternate computer code: ISOSHALD
- ☐ Comparison to experiment or previous results
- ☐ Alternate method (define) _____

II. Checklist (either check or enter NA if not applied)

- ☒ Task completely defined
- ☒ Activity consistent with task specification
- ☒ Necessary assumptions explicitly stated and supported
- ☒ Resources properly identified and referenced
- ☒ Resource documentation appropriate for this application
- ☒ Input data explicitly stated
- ☒ Input data verified to be consistent with original source
- ☒ Geometric model adequate representation of actual geometry
- ☒ Material properties appropriate and reasonable
- ☒ Mathematical derivations checked including dimensional consistency
- ☒ Hand calculations checked for errors
- ☒ Assumptions explicitly stated and justified
- ☒ Computer software appropriate for task and used within range of validity
- ☒ Use of resource outside range of established validity is justified
- ☒ Software runstreams correct and consistent with results
- ☒ Software output consistent with input
- ☒ Results consistent with applicable previous experimental or analytical findings
- ☒ Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
- ☒ Conclusions consistent with analytical results and established limits
- ☒ Uncertainty assesment appropriate and reasonable
- ☐ Other (define) _____

III. Comments:

IV. REVIEWER: JV Nelson

DATE: 10/28/96

DISTRIBUTION SHEET

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		Date October 11, 1996			
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