TECHNICAL JUSTIFICATION ADDENDUM FOR PG 8-10

GENERIC DOSE ASSESSMENT FOR DISPOSAL IN A LANDFILL OF INCINERATOR ASH CONTAINING: S-35, Ca-45, Fe-59, P-32, and Tc-99m, USING RESRAD AND NUREG\1500 METHODOLOGY

BACKGROUND

Recently, the Division of Industrial and Medical Nuclear Safety (IMNS) issued a Draft Policy and Guidance Directive (PG 8-10), on disposal of incinerator ash in a landfill, entitled "*Guidance on Disposal of Incinerator Ash as Ordinary Waste, 1996.*" The Policy and Guidance Directive PG 8-10 was based on the Division of Waste Management (DWM) "Generic Assessment" of dose impacts resulting from disposal of incinerator ash in a landfill (e.g., *Generic Dose Assessment for Disposal of Incinerator Ash, 1994*). The DWM generic assessment analyzed dose impacts for over 25 radionuclides commonly present in the incinerator ash. The generic assessment employed RESRAD code (Version 5.0) to evaluate dose impacts from disposal of the ash in the landfill and the IMPACTS BRC code (Version 2.0) for assessment of dose impacts from transportation of the ash. RESRAD dose impact analysis did not include five short-lived radionuclides (e.g., S-35, Ca-45, Fe-59, P-32, and Tc-99m) due to limitation of the RESRAD code version (5.0) which was employed in the generic assessment. In other words, RESRAD version 5.0 could not handle short-lived radionuclides with half-life less than six months. Therefore, the guidance recommended that these five radionuclides be assessed on a case-by-case basis.

Region I recommended that PG 8-10 should address these five radionuclides in terms of generic dose impacts using other appropriate approaches or methodologies (e.g., hand calculations). IMNS staff was requested to conduct analysis of dose impacts for these five radionuclides using methods other than RESRAD.

More recently, a newer version of RESRAD (5.60) was issued which could handle radionuclides with half-lives greater than 30 days. Therefore, to be consistent with the previous analysis, it will be advantageous to use the same dose impact analysis methodology for these five radionuclides (e.g., S-35, Ca-45, Fe-59, P-32, and Tc-99m) as was used for the other 25 radionuclides. Since P-32 and Tc-99m has half-life of 14.3 days and 6.05 hours respectively, dose impacts for only three radionuclides S-35, Ca-45, and Fe-59 will be assessed using the new version of RESRAD code. For bench marking and comparison purposes, duplicate runs

of RESRAD dose analysis were made for each of the beta-emitting radionuclides C-14, Cl-36, and Sr-90. Each RESRAD duplicate run was conducted using the RESRAD code versions 5.00 and 5.60. Table 1 shows the dose impact results using these two versions. As evident in Table 1, RESRAD results for these two version are consistent within 5 to 25% of the total maximum dose value. Version 5.60 values tends to be on the higher dose side in most cases. This could be related to some differences in the soil to plant transfer factors or slight differences in other physical parameters (e.g., distribution coefficient). Nevertheless, this range of dose variation (e.g., 5-25%) should be acceptable for such a generic dose impact analysis.

The NRC has developed NUREG-1500 (*Working Draft Regulatory Guide on Release Criteria for Decommissioning: NRC Staff's Draft for Comment, 1994*) as a conservative screening tool to assess dose impacts from residual contamination for decommissioning. The NUREG-1500 contains dose conversion factors for a large suite of radionuclides (including short-lived radionuclides). The dose conversion factors are included in Tables corresponding to three dose impact scenarios. One of those scenarios is the "resident farmer" scenario. The resident farmer scenario in NUREG-1500 is similar to the family farm scenario of RESRAD. Therefore, the NUREG-1500 resident farmer dose factors have been used to estimate dose impacts of P-32 and Tc-99m. In addition, they were also used as a comparison tool to compare NUREG-1500 dose factors with RESRAD dose results for the three isotopes S-35, Ca-45, and Fe-59.

DOSE ASSESSMENT USING RESRAD 5.60

A generic dose assessment for each of the three radionuclides S-35, Ca-45, and Fe-59 was conducted using the same methodology and approach that were employed in the previous DWM staff generic assessment (*Generic Dose Assessment for Disposal of Incinerator Ash in a Landfill*). The source-term and default parameters selected in the present assessment were identical to those used in the generic assessment. Radionuclide concentration in the ash before disposal in the landfill (e.g., before dilution) were assumed to be those concentration values in 10 CFR Part 20, Appendix B, Table II, Column 2. In applying these liquid effluent concentration values to solid ash, staff equated μCi/ml (effluent) to μCi/g (ash). Initial radionuclide concentration in the landfill was assumed to be 1 pCi/g. Actual radionuclide concentrations in the landfill (with thickness 2.5 m) were calculated using three dilution factors each of which corresponding to an individual scenario associated with the number of ash generators. For example, assuming one ash generator, a dilution ratio of 1:15 was selected; assuming five generators, a dilution ratio of 1:3 was selected; and finally, assuming ten generators, a dilution ratio of 2:3 was selected.

It should be noted that a shallow landfill type (e.g., with thickness 2.5 m) was selected because dose impacts for the short-lived radionuclides are expected to be more significant for pathways associated with surface transport and exposure rather than from long-term groundwater transport and exposure of these radionuclides (because of radioactive decay).

Table 2 shows radionuclide effluent concentration in the ash and concentration after disposal in the landfill for three generator scenarios. Using RESRAD methodology, all possible environmental pathways were activated except for the radon pathway which was suppressed in this analysis.

DOSE ASSESSMENT USING NUREG-1500

The annual total effective dose equivalent factors (TEDE's) of NUREG-1500 (Table A-1) for the "residential scenario" were selected to calculate the reasonable maximum dose to a resident on the landfill. This scenario considers exposure pathways from external, inhalation, ingestion, soil ingestion, irrigation/drinking water, and from aquatic food. The basis for the dose impact calculation is the NUREG/CR-5512 (*Residual Radioactive Contamination for Decommissioning, Volume 1, Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent, 1992*). The dose factor corresponds to a concentration of 1 pCi/g of the specific radionuclide in the landfill. Actual concentrations in the landfill after dilution were calculated for the three dilution (generator) scenarios.

RESULTS

RESRAD Results

The results of RESRAD dose impacts using three dilution factors (e.g., three generator scenarios) are given in Table 3. These results indicate that dose impacts from disposal of incinerator ash containing Ca-45 and Fe-59 at 10 CFR Part 20 Appendix B, Table II, Column 2 effluent concentration limits will not have any significant dose impacts. For all generator scenarios (e.g., one-, five-, and ten-generators), the total dose from all pathways for each individual radionuclide did not exceed a fraction of mrem/y for an exposed resident onsite. All selected scenarios and parameters were prudently conservative. For example, a farmer was assumed to establish a residence on the landfill immediately after disposal of the ash at the time of landfill closure. For S-35, the dose was less than 10 mrem/y when one generator disposes ash in the landfill. When the volume of ash disposed in the landfill increases (e.g., five-and ten-generators), the dose could reach a few tens of mrem/yr.

Nevertheless, examining dose variation with time (Figure 1), shows that the total dose after two years of ash disposal will be indistinguishable from background. In other words, dose impact from S-35 could be appreciable, for the scenario evaluated, immediately after placement of waste and drops sharply to zero after two years. Institutional controls over the landfill after its closure (e.g., for two years) should alleviate any concerns regarding dose impacts from S-35.

NUREG-1500 RESULTS

Table 4 shows dose impacts resulting from disposal of incinerator ash containing P-32, S-35, Ca-45, Fe-59, and Tc-99m. These dose impacts correspond to radionuclide concentrations after incinerator ash disposal in the landfill and mixing (dilution) with municipal waste using three dilution (generator) scenarios. Initial radionuclide concentration in the ash was assumed to be those concentration values in 10 CFR Part 20, Appendix B, Table II, Column 2. Table 4 results indicate that, except for Fe-59, dose impacts in all cases are small fractions of mrem/y. Dose impacts from Fe-59 do not exceed a few mrem/y. Examining variation of total dose with time (Figure 2) shows that the total dose from Fe-59 will be indistinguishable from background after two years. Therefore, having institutional control over the landfill for at least two years after landfill closure should alleviate any potential concerns from F-59 dose impacts. It should be noted that there are some variations in the model assumptions and the selected parameters for the impact assessment of RESRAD and NUREG-1500. These variations lead to differences in the dose results as can be seen from Tables 3 and 4. Regardless of these variations, the conclusions are nearly the same. Considering the conservative approaches employed, dose impacts from these short lived radionuclides are relatively small.

CONCLUSIONS:

Using the RESRAD code (Version 5.60) and NUREG-1500, dose impact assessment for five short-lived radionuclides (e.g., S-35, Ca-45, Fe-59, P-32, and Tc-99m) indicates that dose impacts from all pathways for each of the three radionuclides, P-32, Ca-45, and Tc-99m, do not exceed a fraction of a mrem/y. RESRAD results indicate an appreciable dose from S-35 isotope in ash specifically for five-generators and ten-generators scenarios. The dose in these analyses was on the order of a few tens of mrem/y. Using the dose conversion factors in NUREG-1500 results in estimated doses of a few mrem/y to Fe-59 in ash. Nevertheless, dose impacts from either of these radionuclides become indistinguishable from background two years after waste disposal in the landfill. Therefore, as long as no residence is established on the landfill within two years of waste disposal,

there should be no significant dose impacts from disposal of these short-lived radionuclides in the landfill. Establishing a residence/farm in a municipal waste landfill within two years after disposal or waste placement is considered highly improbable. Therefore, disposal of incinerator ash containing P-32, Ca-45, Tc-99m, S-35, or Fe-59 is acceptable provided the concentrations in the ash do not exceed the 10 CFR Part 20, Appendix B, Table II, Column 2 levels. If more than one radionuclide is present, a sum of the fraction approach should be used to compare against the levels in Part 20, Appendix B.

Table 1: Comparison of RESRAD Incinerator Ash Dose Assessment Results Using RESRAD Code Versions 5.0 and 5.60[1]

Radionuclide	Maximum Dose {DSR_i (mrem/y)/(pCi/g)}	
	RESRAD Version 5.00	RESRAD Version 5.60
C-14	2.17 E +01	2.12 E +01
Cl-36	3.96 E +00	5.25 E +00
Ca-41	NA	2.30 E -02
Ca-45	NA	2.57 E-02
Sr-90	1.56 E +00	1.95 E +00

[1]This comparison was made for RESRAD runs using RESRAD Code Versions 5.0 and 5.60. For each run, the same scenario and the same physical parameters were used. The shallow landfill with a thickness of 2.50 m and a cover of 0.60 m was used as the model for dilution of ash in the landfill.

Table 2: Radionuclide Concentrations in the Ash (Before Dilution) and in the Landfill[2] (After Mixing With Municipal Waste)

Radionuclide	Radionuclide Concentration In Ash (Before Dilution) (pCi/g)	Radionuclide Concentration in Landfill (After Dilution) (pCi/g) at time = 0		
		One Generator	Five Generators	Ten Generators
P-32	9.00	0.6	3.00	6.00
S-35	100.00	6.67	33.33	66.67
Ca-45	20.00	1.33	6.67	13.33
Fe-59	10.00	0.67	3.33	6.67
Tc-99m	1000.00	66.67	333.33	666.67

[2]The thickness of the landfill in this analysis was assumed 2.5 m. For landfill of 8 m thick, there will be an additional dilution by a factor of 3.

Table 3: RESRAD Dose Impacts From All Pathways After Disposal In a Landfill ((After Mixing With Municipal Waste) for Three Dilution Scenarios.

Radionuclide	Radionuclide Concentration In Ash (Before Dilution) (pCi/g)	Estimated Dose to a Residential Farmer (mrem/y)		
		One Generator	Five Generators	Ten Generators
P-32	9.00	NA[3]	NA	NA
S-35	100.00	6.45	31.94	64.54
Ca-45	20.00	7.01 E -02	3.51 E -01	7.02 E -01
Fe-59	10.00	1.93 E -03	9.60 E -03	1.92 E -02
Tc-99m	1000.00	NA	NA	NA

[3]NA means "not analyzed" due to code limitation.

Table 4: NUREG-1500 Dose Impacts From All Pathways After Disposal In a Landfill (After Mixing With Municipal Waste) for Three Dilution Scenarios.

Radionuclide	Radionuclide Concentration In Ash (Before Dilution) (pCi/g)	Estimated Dose to a Resident Farmer (mrem/y)		
		One Generator	Five Generators	Ten Generators
P-32	9.00	6.72 E -03	3.36 E -02	6.72 E -02
S-35	100.00	7.14 E -02	3.56 E -01	7.13 E -01
Ca-45	20.00	3.42 E -02	1.71 E -01	3.43 E -01
Fe-59	10.00	3.14 E -01	1.56 E +00	3.13 E +00
Tc-99m	1000.00	1.53 E -02	7.67 E -02	1.53 E -01

Figure 1:

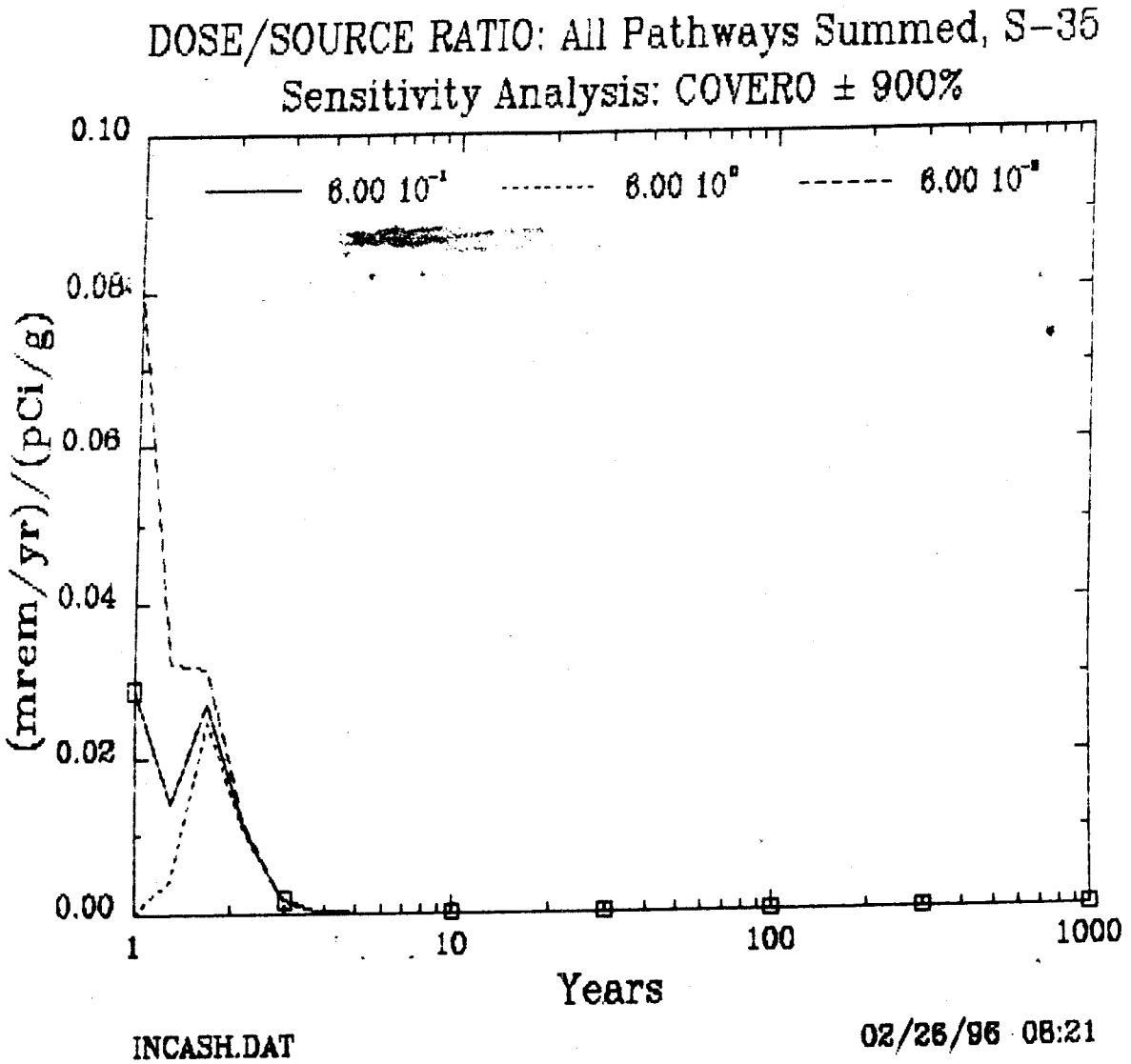
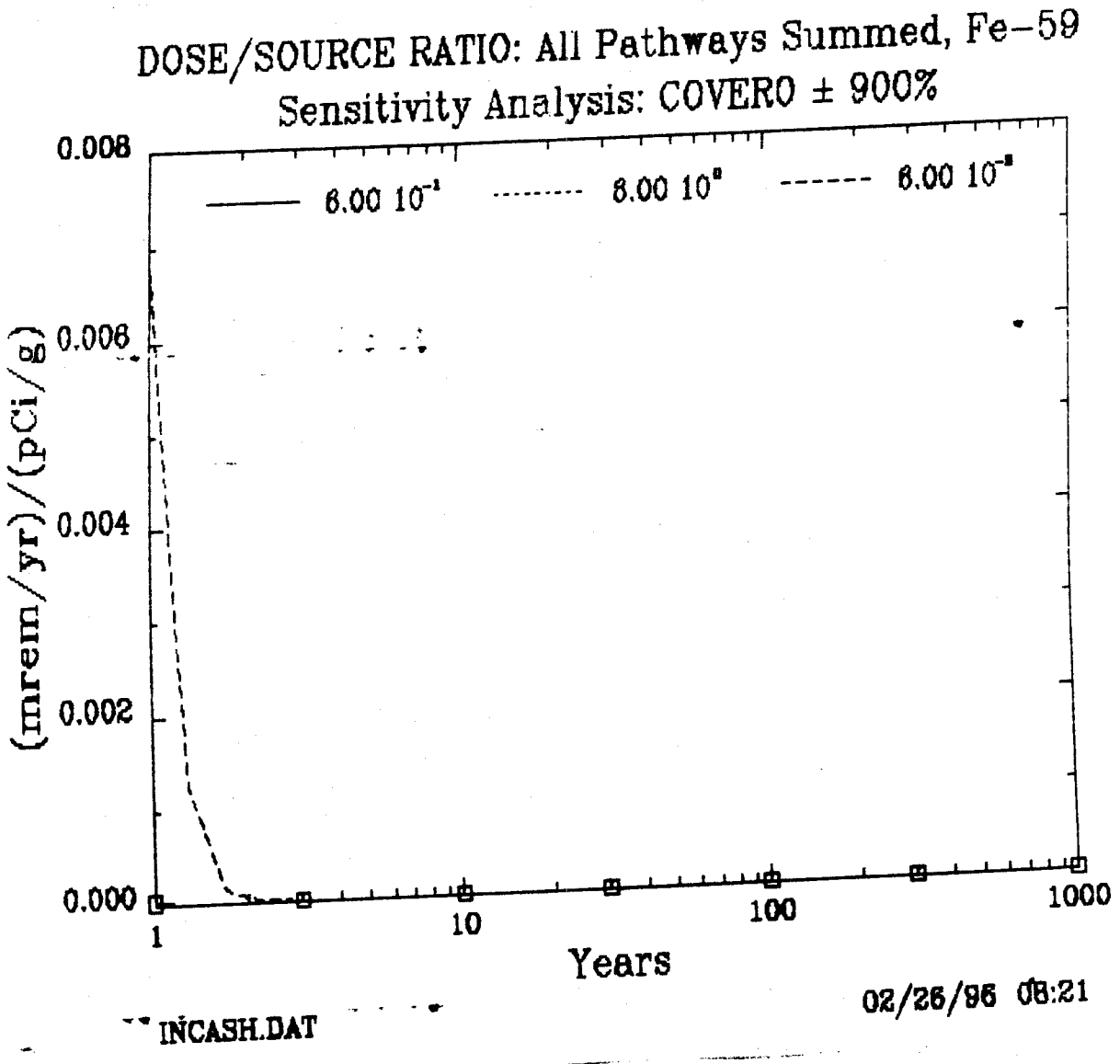

DOSE/SOURCE RATIO: All Pathways Summed, S-35
Sensitivity Analysis: COVER0 ± 900%
6.00 10⁻¹
6.00 10⁰
6.00 10⁻⁸
0.10
0.08
0.06
0.04
0.02
0.00
(mrem/yr)/(pCi/g)
1
10
100
1000
Years
INCASH.DAT
02/26/96 08:21

Figure 2:


DOSE/SOURCE RATIO: All Pathways Summed, Fe-59
Sensitivity Analysis: COVERO ± 900%
6.00 10⁻¹
6.00 10⁰
6.00 10⁻²
0.008
0.006
0.004
0.002
0.000
(mrem/yr)/(pCi/g)
1
10
100
1000
Years
02/26/96 08:21
INCASH.DAT