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AN ANALYSIS OF ENERGY STORAGE AND ITS EFFECTS IN THE PROPOSED NATIONAL RADIOACTIVE WASTE REPOSITORY

J. O. Blomeke, E. Sonder, J. P. Nichols,
S. Lindenbaum, R. S. Dillon, E. D. Arnold and H. F. Soard

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ABSTRACT

Energy stored in solids as a consequence of radiation damage within crystal lattices may be released as this damage is annealed at higher temperatures. Based both on theoretical considerations and experimental measurements, the quantity of energy which could be stored in the proposed salt mine repository is small. Analyses based on upper-limit values of stored energy show that its release under the most pessimistic conditions would have no serious consequences. Some additional work is required, however, to establish actual values for energy storage in the salt and solidified wastes under the transient thermal and radiation conditions that will prevail in the Repository.

1. INTRODUCTION

Stored energy, as used in this report, refers to energy stored in irradiated solids due to the introduction of defects and other disorder which will give a negative contribution to the specific heat of the solid when the latter is warmed subsequent to the irradiation. In some cases (particularly in strongly covalent crystals in which large amounts of energy can be stored), all of the energy can be released with a relatively low initiating temperature since the initial energy release can heat the solid sufficiently to trigger energy releases at successively higher transition temperatures. In the case of long-term storage of radioactive wastes, it is important to know how much energy can be stored at saturation in the materials that will be in the radiation field and thermal environment of the Repository. (We define saturation as that level of damage at which the radiation removes as much energy by radiation annealing as it supplies by radiation damage.) The materials in question are the glass or ceramic boule containing the radionuclides, the metal container, and the surrounding salt. The temperature of the wastes and their containers will be from 600 to 900°C initially and will decrease to less than 500°C in about 10 years, while the temperature of the salt will range between 20 and 350°C, depending on its proximity to the waste and the thermal power of the source. The maximum accumulated radiation dose in salt will range from 2×10^{11} rads adjacent to the wastes to about 82 rads at a distance of 5 ft.

2. A BRIEF REVIEW OF THE LITERATURE

Most previous work has been concerned with two subjects: (1) stored energy in metals produced by irradiation at liquid helium temperatures; (2) study of graphite irradiated at and above room temperature. In copper, a typical metal, the mobility of defects, particularly interstitials, is high enough that approximately half of the stored energy is released between 30 and 50°K. Although there have been no irradiations heavy enough to approach saturation, one can estimate that if there were about 1% Frenkel pairs produced, a total energy of about 10 cal/g would be released between 30 and 50°K or that approximately a total of 20 cal/g could be stored by low-temperature heavy-particle irradiation.[1] Fairly extensive work has been done with graphite. This material, being covalently bonded and having a much higher melting point (and therefore, cohesion) than metals, will release damage at much higher temperatures, retaining some up to 2000°C. For irradiation in the vicinity of room temperature, close to 700 cal/g can be stored; but if the irradiation is performed at 250°C, only one-third of this amount is retained.[2]

With the exception of the above-mentioned work with metals and graphite, very few measurements have been made of stored energy in solids. Kobayashi[3] reports an energy release of 2 to 2-1/2 cal/g between room temperature and 400°C in NaCl that has been heavily irradiated with protons at room temperature. Bunch and Pearlstein[4] have compared the F-center concentration in x-ray irradiated NaCl with the stored energy and give a value of 12.4 eV per F center (4.7×10^{-19} cal/F center). For a saturation concentration of 2×10^{19} F centers/cm^3 (ref. 5), this would yield a saturation stored energy of 4 cal/g.

<u>A Possible Way to Estimate Stored Energy in Other Solids</u>. - It is generally agreed that by far the major part of energy stored in irradiated crystals stems from the creation of point defects. For every atom or ion that has been removed from a normal (minimum energy in a thermodynamic sense) lattice position, the crystal increases its energy by an amount corresponding to the energy of binding of the atom or ion in the crystal. In addition, when an atom or ion is displaced to an interstitial

site the crystal energy may be raised due to resulting strain. The total energy stored is less than the sum of these two effects since there will be some amount of binding of the displaced atoms or ions to lattice atoms or to each other.

In metals where complete relaxation of the electronic structure takes place when an atom is displaced (i.e., where no charged points can be created), both the vacancy and interstitial energies are chiefly elastic and are correspondingly small (for example, ~20 cal/g for copper containing 1% Frenkel pairs). In insulators, particularly covalent crystals, where bonds are broken and electrons are consequently left in free ion- or free atom-like states, the energy stored is much greater. We can estimate what stored energy to expect from these broken bonds by assuming that for each vacancy created, the crystal gains energy equal to the cohesive energy of one atom or ion. The heat of sublimation, which can be measured experimentally and is tabulated in many handbooks, is closely related to the cohesive energy, and can also be used. In Table 1 we list cohesive or sublimation energies for a number of materials to give some idea of the range of energies that might be stored in various materials. The fourth column of the table lists 1% of the cohesive (or sublimation) energies. One expects 1-5% Frenkel pairs to be a saturation value since with such a degree of disorder the crystal either breaks up, becomes amorphous, or is healed by the radiation at the same rate as damage is created. For the case of copper and graphite this reasoning seems to lead to agreement with the measured values. For NaCl, where the saturation vacancy concentration is known to be 0.12%, agreement is also within 50%.

3. EXPERIMENTAL

Sodium Chloride. - Rock salt samples in the vicinity of the waste containers in the Project Salt Vault experiment consist of fairly pure sodium chloride. To ascertain the purity of these samples, gravimetric chloride analyses were performed on unirradiated and irradiated (8×10^7 rads) samples from the mine. Values of 60.4 ± 0.2 and 60.6 ± 0.2% Cl were found, respectively. These values may be compared with the chloride

Table 1. Estimates of Stored Energy in Various Solids at Saturation

Material	Cohesive Energy (K cal/g)[a]	Heat of Sublimation (K cal/g)	Estimated Energy Stored for 1% Frenkel Pairs (cal/g)	Measured Stored Energy (cal/g)	Ref.
Na		1.55	15		6
Cu		1.28	13	20[b]	1,6,7
W		1.14	11		6
NaCl	2.62		26	2-1/2 - 4[c]	3,4,8
MgO	6.00		60		8
Al_2O_3	6.54		65		8
SiO_2	6.66		67		9
Graphite	20 ± 4		200	700	2,9

[a]For ionic solids the cohesive energy is calculated with respect to separated atoms.

[b]The measured value for stage 1 annealing is ~10 cal/g. It is assumed about one-half of the damage anneals in stage 1.

[c]This is for a saturation vacancy concentration of 0.12%.

content of pure NaCl (60.66% Cl). These analyses suggest that for the purpose of stored energy measurements by solution calorimetry, the samples may be considered to be pure water-soluble NaCl.

Stored energy can therefore be measured by determining the difference between the heat of solution of the irradiated and unirradiated samples in a solution calorimeter. Samples of 0.2 g of salt were dissolved in 500 g of water in the solution calorimeter. The literature value for the heat of this dissolution for pure NaCl is 16.48 cal/g. Our measured value for unirradiated rock salt from the Lyons, Kansas mine is 16.2 cal/g.

Two series of samples were studied by this method. The first series consisted of samples of synthetic NaCl, all cleaved from the same single crystal and irradiated with 2-MeV electrons from the ORNL electron Van de Graaff accelerator. Samples were irradiated at two different dose rates, at a number of temperatures between room temperature and 100°C, and to a number of different total doses. The results are summarized in Fig. 1, where different point symbols are used to indicate the different irradiation conditions. It is clear that the stored energy saturates with dose and that, even for doses up to 10^{11} rads, no more than 2 to 3 cal/g can be stored. These preliminary data suggest that stored energy behaves with respect to irradiation conditions in a fashion similar to that for F-center production. That is, the energy storage becomes greater as the dose rate is increased or the sample temperature during irradiation is lowered.[10]

The second series of samples consisted of rock salt from the Lyons mine, irradiated either with 1- to 2-MeV electrons or in the mine under "Project Salt Vault" conditions. Most of these samples were held at temperatures near or above 200°C during irradiation. It is well known that, at these elevated temperatures, vacancy defects can aggregate. In fact, the yellow color normally present and attributed to single vacancies is not observed in such samples; instead, a deep blue color, which is thought to be due to vacancy aggregates or so-called metal colloid centers, results. In Table 2 we list results of our preliminary measurements from which we can draw the following conclusions:

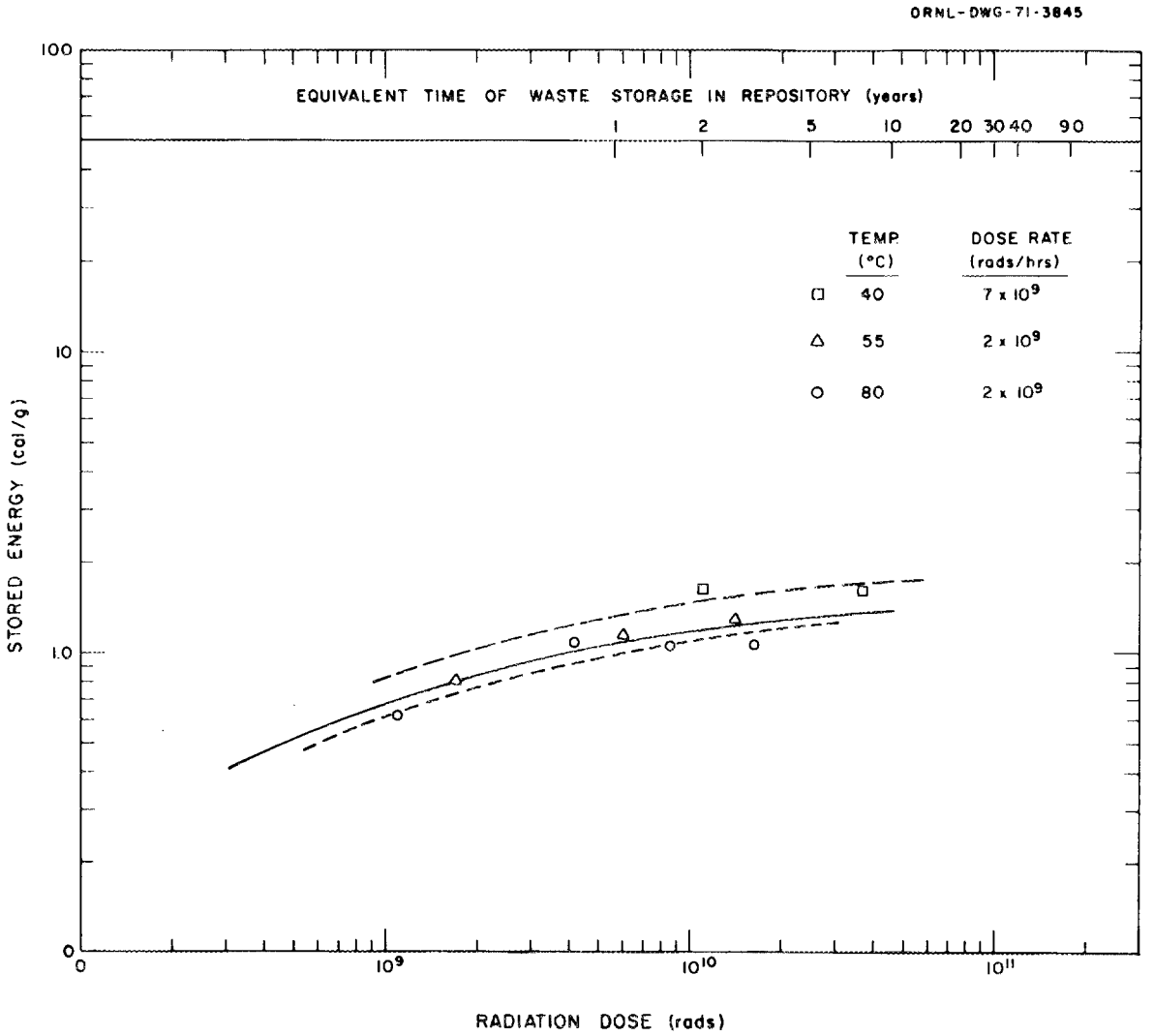

Fig. 1. Stored Energy in NaCl as a Function of Radiation Dose and the Temperature of Irradiation.

Table 2. Stored Energy Measurements in Rock Salt by Solution Calorimetry

Sample	Irradiation Temp. (°C)	Dose (rads)	Stored Energy (cal/g)
	Electron-Irradiated Samples		
V_oA	250 ± 150	10^{11}	14
V_oB	250 ± 150	10^{11}	1.6[a]
V_oC	250 ± 150	10^{11}	7[b]
V_1	225 ± 50	8×10^{10}	3.0
V_2	225 ± 50	2×10^{11}	2.1
V_3	225 ± 50	3×10^{11}	4.3
L_2	210 ± 10	2.5×10^{9}	0.6
L_3	210 ± 10	2.6×10^{10}	5.8
L_5	210 ± 10	7.2×10^{10}	7.5
L_5	210 ± 10	7.2×10^{10}	3.6
L_6	210 ± 10	7.2×10^{10}	2.6
L_6	210 ± 10	7.2×10^{10}	2.2
	Project Salt Vault Samples		
Hole 10 (7-1/2 ft depth)	125	8×10^{7}	0
Hole 4A (11 ft depth)	165-200	9×10^{8}	0
Hole 4B (9-1/2 to 11 ft depth)	165-200	9×10^{8}	0

[a]Heated at 250°C for 7 hr subsequent to irradiation.

[b]Stored at room temperature for 78 days.

1. Samples irradiated at dose rates three or four orders of magnitude higher than the dose rate anticipated in the disposal facility, and to total doses $>10^{10}$ rads, exhibit amounts of stored energy in the range of 2 to 14 cal/g. There is a large variation in the energy stored, even for samples irradiated under identical conditions. It is not yet clear whether this is due to the fact that different pieces of Lyons salt behave differently or whether at these temperatures (at which vacancy cluster nucleation is undoubtedly of a determining character for energy storage) very small variations in impurity content will cause large changes in the relative rates of defect production and annealing. It is of interest that the color of these samples is not uniform; for example, a single piece of irradiated NaCl will have both nearly uncolored and very darkly colored portions.

2. Annealing of irradiated NaCl near or above the irradiation temperature of 250°C causes some of the stored energy to disappear. As shown in Table 2, sample V_oB (which was a piece of V_oA after irradiation) retained only 11% of the stored energy after annealing for 7 hr. This large difference is probably significant, whereas the factor of 2 decrease shown for sample V_oC (which was also a piece of V_oA after irradiation) after standing at room temperature for 78 days may be due to general scatter.

3. Samples irradiated with photons in the salt mine to less than 10^9 rads do not exhibit any significant stored energy. It should be pointed out that most of the irradiation occurred while these samples were warmed from approximately 75 to 150°C, and that only during the last few days of a 500-day irradiation did the samples reach their final high temperature. Thus it is probable that some annealing took place as a result of the final heating.

As a check on our calorimetric measurements, H. Kubota of the ORNL Analytical Chemistry Division has performed differential scanning calorimetry experiments on some of the samples studied by us. He finds 21 ± 6 cal/g for sample V_oA, and 0 ± 4 cal/g for sample 4B. We feel that these results are in substantial agreement with our solution calorimetry values. Also, samples of salt from the experimental holes of Project Salt Vault were supplied to E. J. Zeller of the Kansas State Geological Survey, and he has reported measurements which are in reasonable agreement with ours.[11]

In view of these experimental results, we conclude:

1. At room temperature and at dose rate of 10^{10} rads, only small amounts of energy (~2 cal/g) are stored in rock salt.
2. At higher temperatures, the amount of energy stored may be greater. Some samples of salt irradiated near 200°C stored between 3 and 14 cal/g.
3. Stored energy is released (annealed out) slowly, even at 250°C.

Solidified Wastes. - Although no measurements of energy storage in solidified wastes have been made to date, it is quite likely that energy can be stored in some of these materials, and over a wider temperature range than is possible in salt. Zeller *et al.*[12] have measured up to 200 cal/g in olivine (a mineral containing about the same amount of silicate as is present in some of the solidified waste products) when it was irradiated with protons at liquid nitrogen temperatures. However, all of this energy was released below 450°C.

4. ANALYSIS OF THE EFFECTS OF ENERGY RELEASE

Thermal Effects. - A variety of calculations have been made to evaluate the maximum transient temperatures in the salt that could result from an instantaneous release of stored energy. In this study we have evaluated primarily the effect of initial age of the waste, initial thermal power, and the length of time that the cylinder has been stored in the salt. The energy storage has been conservatively

overestimated as 1% of the total deposited photon-neutron energy up to a maximum saturation value of 200 cal/g in the calcined waste and 20 cal/g in the salt.

The calculations of total integrated dose as a function of distance from the waste cylinder (Fig. 2, and the Appendix) were calculated with the ANISN[13] transport code using the $S_{16}P_3$ approximation, 27 energy groups for neutrons, and 20 energy groups for photons. This calculation takes into account the dose from secondary gamma rays as well as the primary gamma rays and neutrons that are generated within the wastes. The photon and neutron sources of typical waste were computed by summing the contributions from several hundred radionuclides.

Due to the linearity of this problem, the thermal effects of an energy release can be decoupled from the decay-heat temperature gradient in the salt at the time of the release. In essence, this decoupling was accomplished by assuming that the temperature in the mine was everywhere zero before the release, and that there were no heat sources existing in the mine. Then, by invoking the principle of superposition, the temperatures calculated by the procedure described below can be added to the decay-heat gradients existing in the mine at the time of release to obtain the total temperature profiles as a function of time and position.

In each of the four cases studied, a one-dimensional finite-difference calculation was made to determine the transient thermal behavior of the temperatures generated by the release. The initial temperature conditions were set to the temperature rise resulting immediately after the energy release. In addition, the boundary at a distance midway between containers was insulated from heat flow. The initial temperature inside the waste container was set at 1638°F, corresponding to an energy release of 200 cal/g in a material with a heat capacity of 0.22 Btu lb^{-1} $°F^{-1}$. The salt temperature extending from the can wall to a point at which 1% of the total integrated dose (Fig. 2) fell below 20 cal/g was set at 166°F. The heat conduction code, HEATING3[14] was used to calculate nodal temperatures at various distances and post-release times, and these temperatures were added to

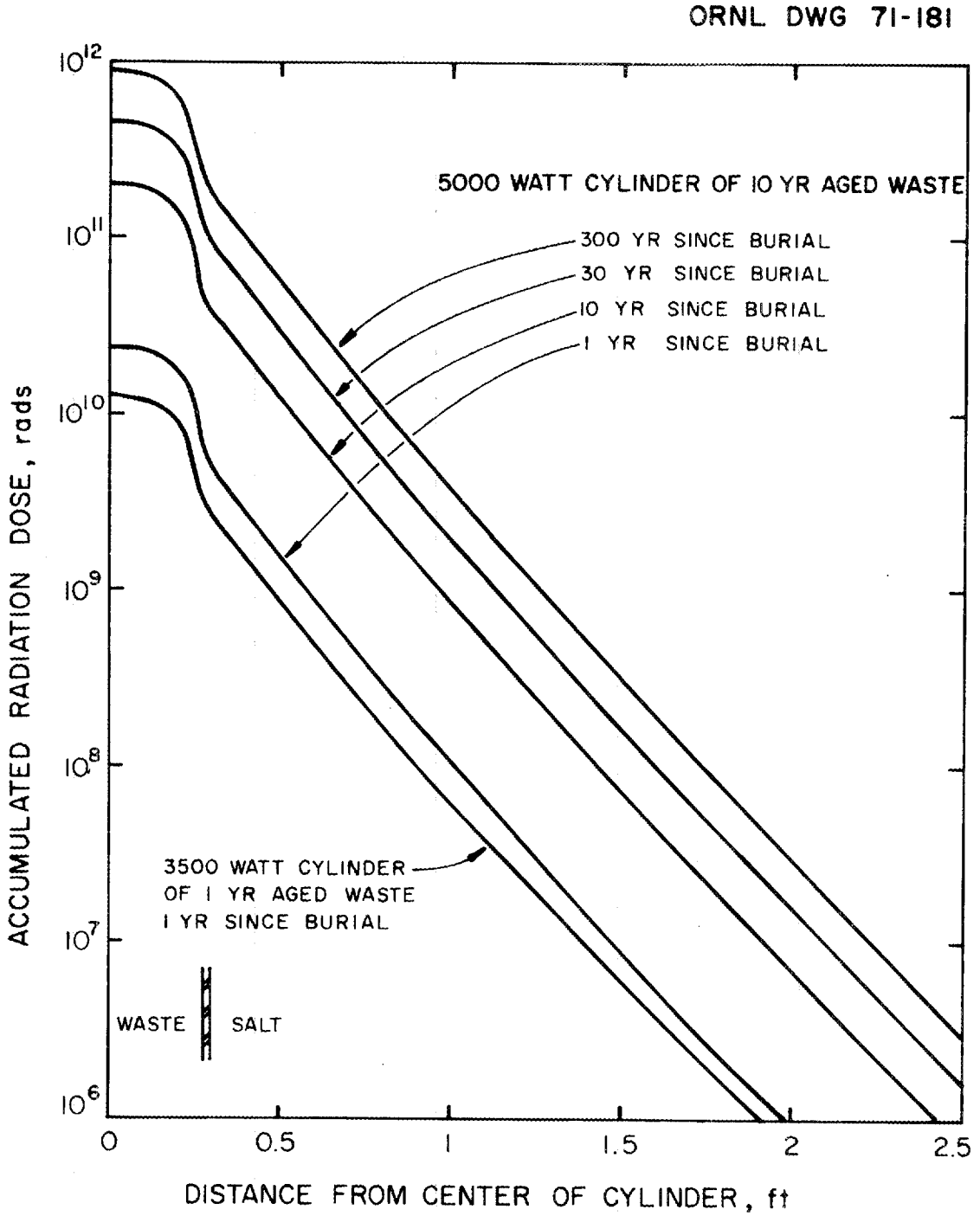

Fig. 2. Accumulated Photon-Neutron Dose in the Horizontal Midplane of Cylinders of Solidified High-Level Waste Buried in Salt. Waste cylinders have inside diameter of 6 in., steel wall thickness of 0.25 in., and active height of 8 ft.

the decay-heat gradients. The results are presented in Figs. 3 through 6, and are summarized in Table 3. Of the cases studied, the maximum thermal effect of a stored energy release occurred under the assumption that a cylinder having initial thermal power of 5000 W and initial waste age of 10 years resulted in an energy release 30 years after burial in the salt (Fig. 4, Table 3). The effect of this release was to cause no melting of the salt and a temperature rise of less than 2°F at 13.5 ft from the center of the cylinder.

Mechanical Effects. - Rapid thermal expansion of the waste and nearby salt resulting from a release of stored energy can potentially result in an explosive release of mechanical energy. An overestimate of the maximum amount of mechanical energy generated can be made by assuming that the expansion occurs reversibly against the ambient overburden of 1000 psi. Table 3 presents the results of estimates of maximum mechanical energy generation for several assumed conditions of mechanical energy release. Materials properties that were used for these calculations are given in Table 4. Thermal expansion of the brine which constitutes 0.5% by volume of the salt was overestimated by assuming that the brine is pure water and using thermodynamic data from steam tables.

These estimates show that the maximum amount of mechanical energy generated is conservatively less than the equivalent of 1 lb of TNT. This amount of energy release would result in practically no deformation of the floor of the room above the pot and would constitute no danger to personnel from missiles.

5. CONCLUSIONS

On the basis of the foregoing, we are confident that energy storage under the conditions that will prevail in the repository does not carry any serious implications. We expect to conclude our experimental work related to NaCl by establishing saturation values of stored energy as a function of temperature, radiation dose, and chemical purity. Also, some additional work is required to establish upper-limit values for energy storage in the solidified wastes, and the conditions under which it can be released.

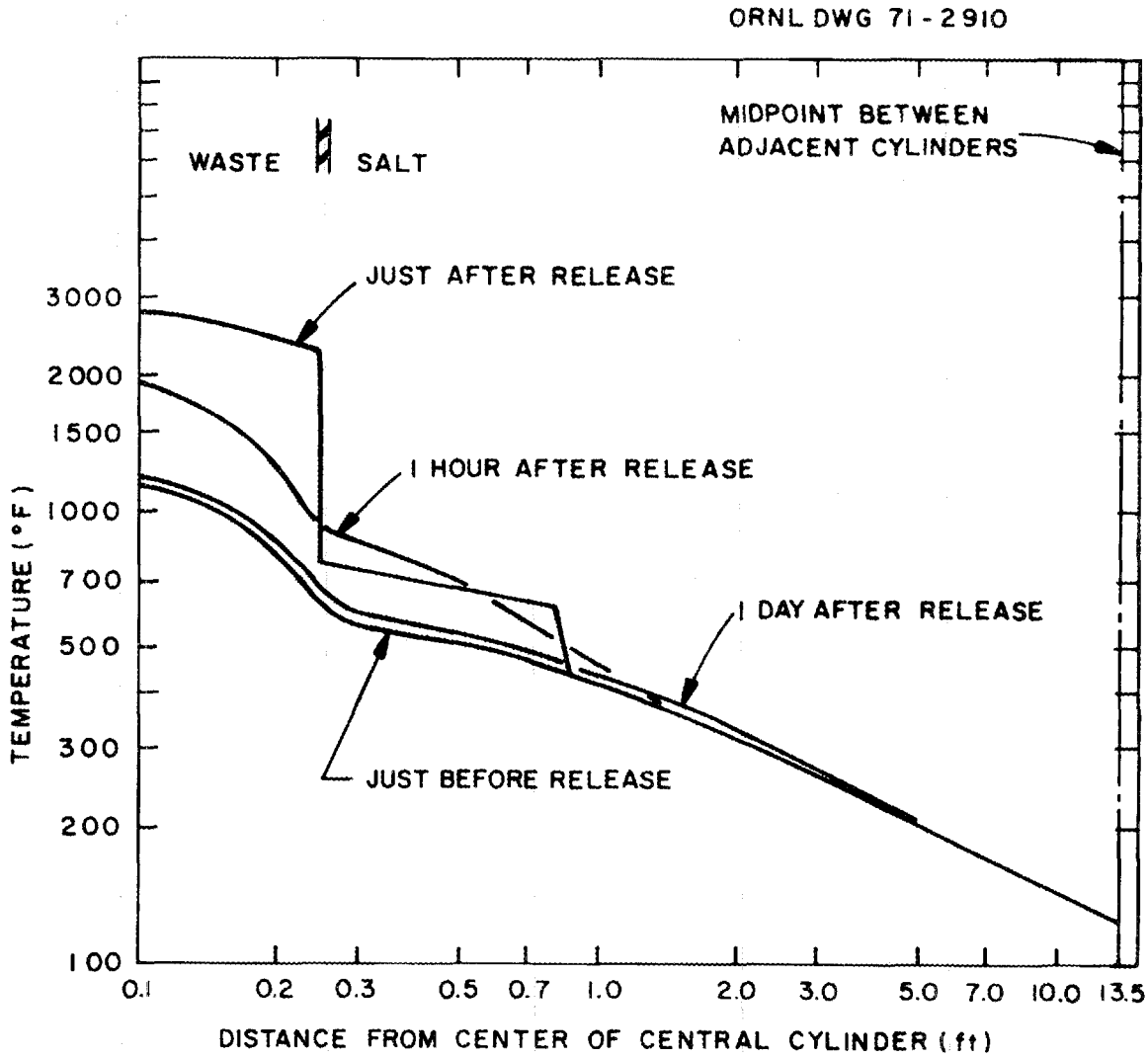

Fig. 3. Estimated Temperature in the Horizontal Midplane of a Cylinder Buried in Salt Just Before, Just After, and at Various Times After a Release of Stored Energy. Waste having initial power of 5000 W and age of 10 years since processing is assumed to have been stored for 1 year. Energy storage is assumed to be 1% of the total deposited photon-neutron energy up to a maximum saturation value of 200 cal/g in the waste and 20 cal/g in the salt.

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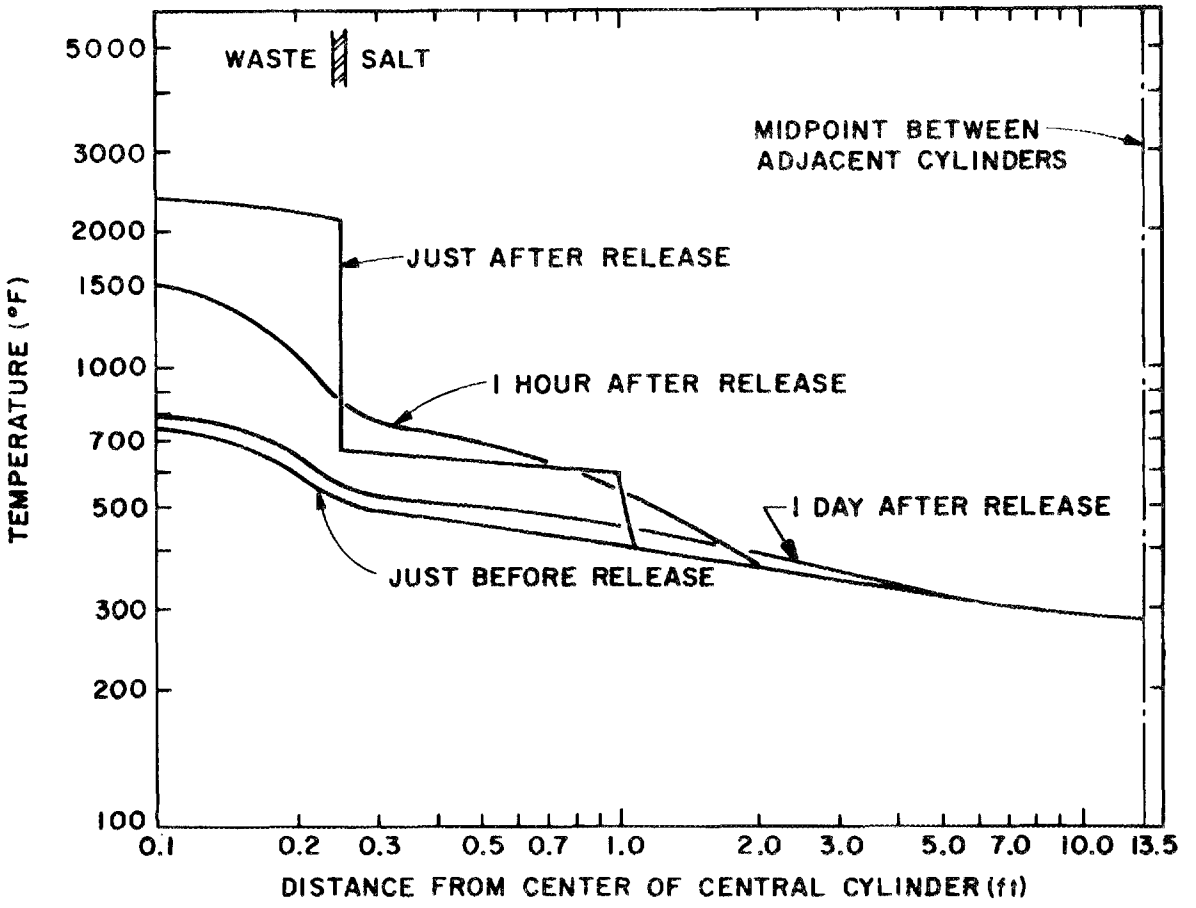

Fig. 4. Estimated Temperature in the Horizontal Midplane of a Cylinder Buried in Salt Just Before, Just After, and at Various Times After a Release of Stored Energy. Waste having initial power of 5000 W and age of 10 years since processing is assumed to have been stored for 30 years. Energy storage is assumed to be 1% of the total deposited photon-neutron energy up to a maximum saturation value of 200 cal/g in the waste and 20 cal/g in the salt.

ORNL DWG 71-2909

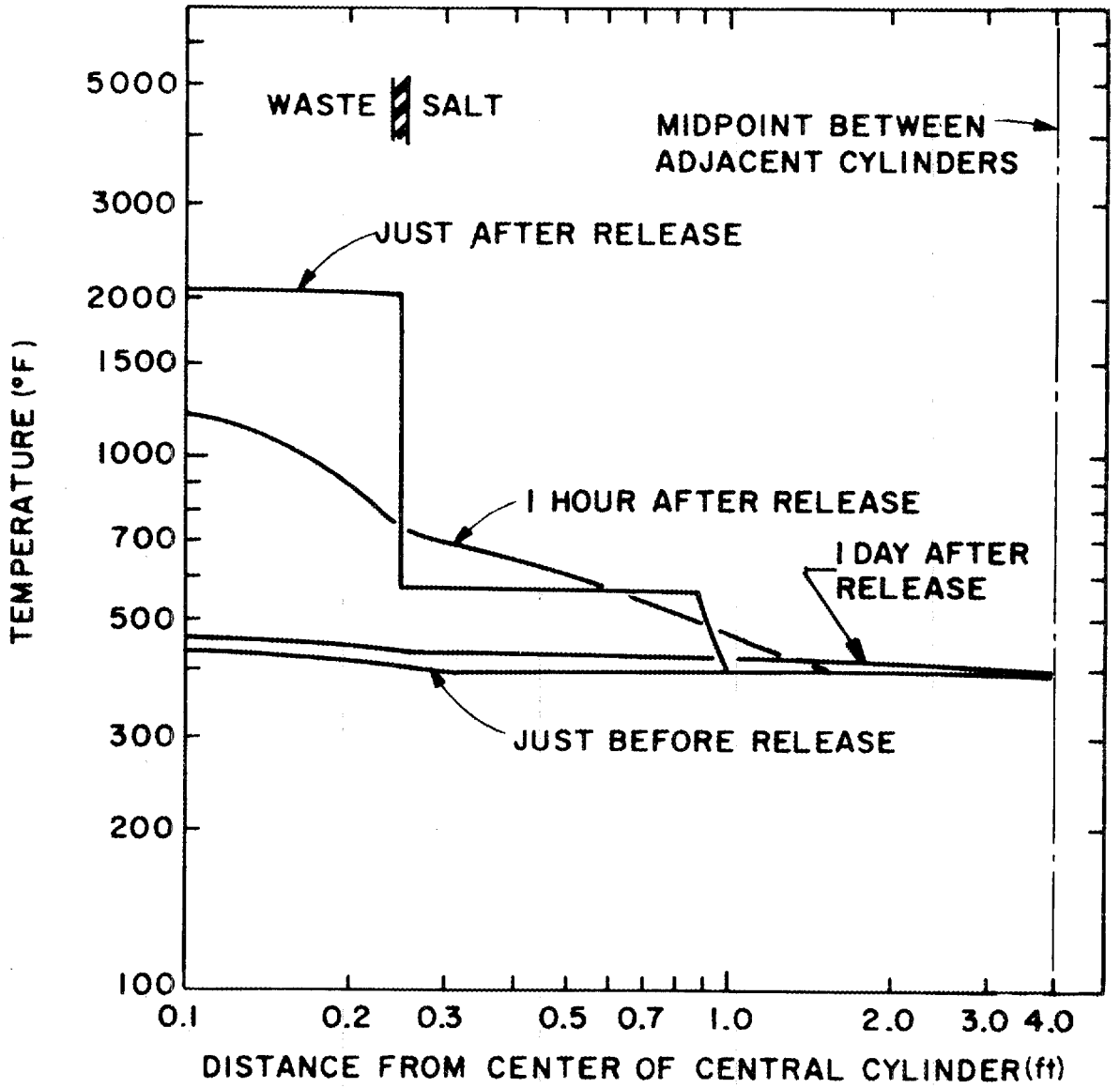

Fig. 5. Estimated Temperature in the Horizontal Midplane of a Cylinder Buried in Salt Just Before, Just After, and at Various Times After a Release of Stored Energy. Waste having initial power of 520 W and age of 10 years since processing is assumed to have been stored for 30 years. Energy storage is assumed to be 1% of the total deposited photon-neutron energy up to a maximum saturation value of 200 cal/g in the waste and 20 cal/g in the salt.

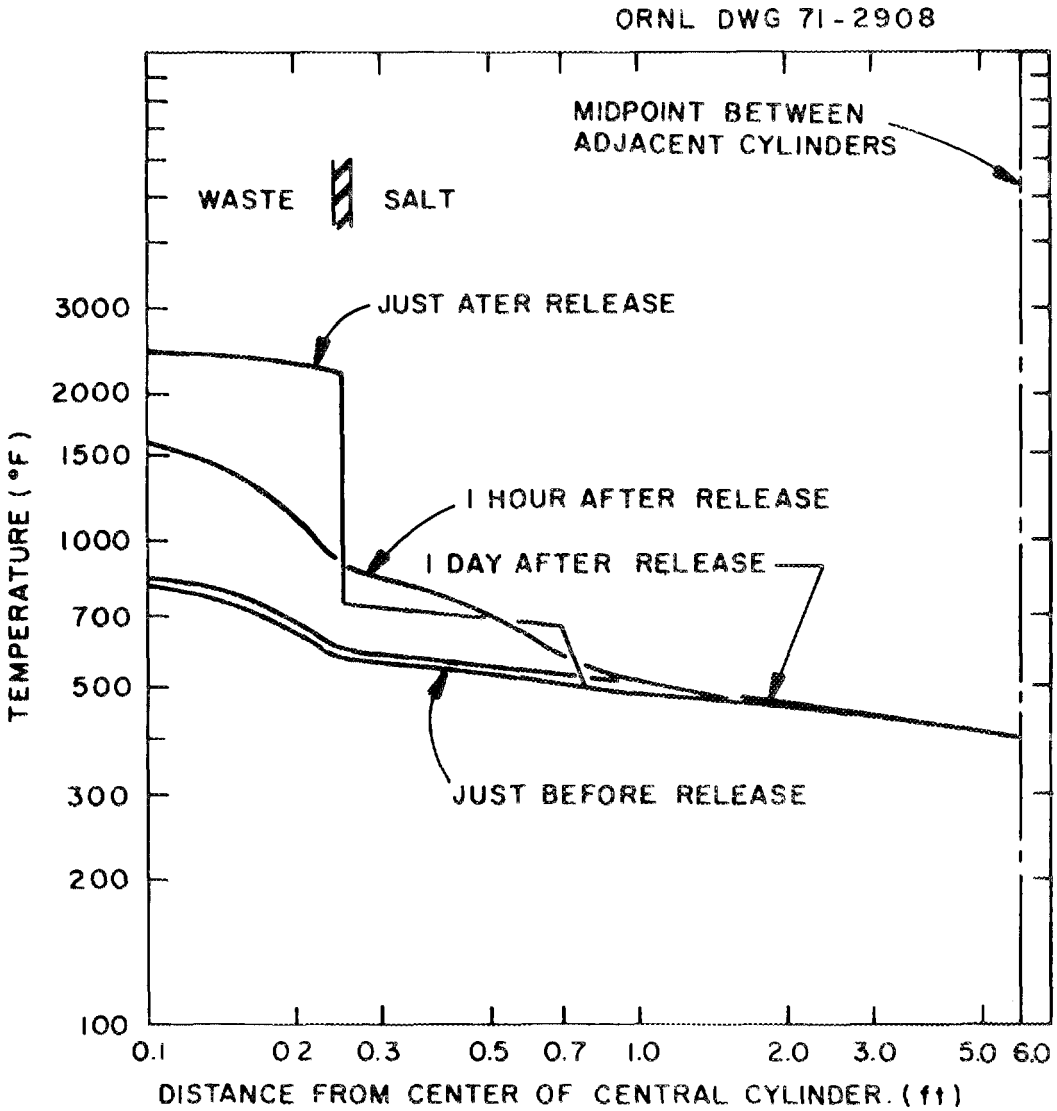

Fig. 6. Estimated Temperature in the Horizontal Midplane of a Cylinder Buried in Salt Just Before, Just After, and at Various Times After a Release of Stored Energy. Waste having initial power of 3500 W and age of 1 year since processing is assumed to have been stored for 1 year. Energy storage is assumed to be 1% of the total deposited photon-neutron energy up to a maximum saturation value of 200 cal/g in the waste and 20 cal/g in the salt.

Table 3. Estimated Maximum Mechanical Energy Release and Temperature Increases That Could Result from Release of Stored Energy Developed by a Waste Cylinder Stored in Salt

Properties of Waste Cylinder[a]				
Initial thermal power, watts	5000	5000	520	3500
Initial age of waste, years	10	10	10	1
Time of storage in salt, years	1	30	30	1
Distance between cylinders, ft	27	27	8	12
Volume Change Due to Thermal Expansion, ft^3				
Waste and salt	0.12	0.36	0.13	0.08
Brine	1.53	5.62	1.79	0.88
Total	1.65	5.98	1.92	0.96
Mechanical Energy Release,[b] equivalent pounds of TNT	0.19	0.69	0.22	0.11
Maximum Temperature Rise, °F				
1 ft from center of cylinder	56	170	150	49
4 ft from center of cylinder	4	7	4	3
Midpoint between adjacent cylinders	0.9	2	4	2

[a]Cylinders are assumed to have diameter of 6 in. and active length of 8 ft.

[b]Assumes 1600 Btu of energy per pound of TNT.

Table 4. Assumed Properties of Calcined Waste and Salt Used for Analysis of Stored Energy Release

Calcined Waste	
Density, lb/ft^3	113
Thermal conductivity, Btu/hr·ft·°F	0.25
Heat capacity, Btu/lb·°F	0.22
Coefficient of cubical expansion, $°F^{-1}$	0.88×10^{-5}
Rock Salt	
Density, lb/ft^3	135
Brine content, vol %	0.5
Thermal conductivity, Btu/hr·ft·°F	1.81
Heat capacity, Btu/lb·°F	0.218
Coefficient of cubical expansion, $°F^{-1}$	0.67×10^{-4}
Melting point, °F	1470
Crushed Salt	
Density, lb/ft^3	95
Brine content, vol %	0.5
Thermal conductivity, Btu/hr·ft·°F	0.36
Heat capacity, Btu/lb	0.218

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APPENDIX

RADIATION DOSE CALCULATIONS

The total accumulated dose to salt and the dose rate as a function of time (up to 100 years after burial) and distance from the centerline of a 6-in.-diam (Schedule No. 40 pipe) waste container are presented in Tables A-1 through A-16. The calculations are described in Section 4. The solidified wastes are from LWR fuel irradiated to 33,000 MWd/metric ton at an average specific power of 30 MW/metric ton, and the fuel is processed 150 days after its discharge from the reactor. Tables A-1 through A-8 are for the case of a container with a thermal power of 7200 W of mixed fission products and actinides that have been decayed for only one year since reprocessing (1.41 years after reactor discharge) at the time of its burial in salt. Tables A-9 through A-16 are for a container of waste evolving 5000 W of thermal power at the time of its burial, 10 years after reprocessing (10.41 years after reactor discharge).

Both of these cases are examples of the maximum power levels for containers of these particular isotopic mixtures that could be buried in salt without subsequently exceeding our preliminary criteria for allowable temperatures within the salt. As such, they represent extreme cases, not typical examples of containers to be received. Doses can be derived from these data for other concentrations of 1- and 10-year-old wastes by merely multiplying these values by the ratio of the respective thermal power levels.

Table A-1. Total Integrated Dose in Salt from Buried 6-in. Waste Pots

Conditions: age upon burial - 1 year after fuel reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Accumulated Dose (rads) Following a Total Decay Time (years) Since Reprocessing								
	2	5	8	10	20	30	50	70	100
0.70	2.8170E+10	7.5667E+10	9.9931E+10	1.1115E+11	1.5144E+11	1.7942E+11	2.1820E+11	2.4208E+11	2.6209E+11
2.10	2.7501E+10	7.3870E+10	9.7558E+10	1.0851E+11	1.4785E+11	1.7516E+11	2.1302E+11	2.3633E+11	2.5587E+11
3.50	2.6198E+10	7.0368E+10	9.2934E+10	1.0336E+11	1.4084E+11	1.6686E+11	2.0293E+11	2.2514E+11	2.4376E+11
4.90	2.3984E+10	6.4419E+10	8.5076E+10	9.4625E+10	1.2893E+11	1.5274E+11	1.8576E+11	2.0610E+11	2.2314E+11
7.00	1.6634E+10	4.4663E+10	5.8973E+10	6.5586E+10	8.9343E+10	1.0583E+11	1.2869E+11	1.4276E+11	1.5456E+11
8.05	8.9125E+09	2.3900E+10	3.1536E+10	3.5062E+10	4.7717E+10	5.6487E+10	6.8626E+10	7.6093E+10	8.2345E+10
8.40	6.5155E+09	1.7464E+10	2.3037E+10	2.5609E+10	3.4841E+10	4.1242E+10	5.0110E+10	5.5563E+10	6.0129E+10
11.20	3.9678E+09	1.0625E+10	1.4005E+10	1.5563E+10	2.1153E+10	2.5029E+10	3.0394E+10	3.3692E+10	3.6453E+10
14.00	2.3207E+09	6.2068E+09	8.1762E+09	9.0836E+09	1.2337E+10	1.4591E+10	1.7709E+10	1.9625E+10	2.1228E+10
24.00	3.9595E+08	1.0493E+09	1.3756E+09	1.5253E+09	2.0602E+09	2.4292E+09	2.9377E+09	3.2488E+09	3.5082E+09
34.00	7.9007E+07	2.0640E+08	2.6847E+08	2.9670E+08	3.9704E+08	4.6583E+08	5.6013E+08	6.1749E+08	6.6511E+08
44.00	1.7362E+07	4.4464E+07	5.7204E+07	6.2922E+07	8.3076E+07	9.6777E+07	1.1544E+08	1.2671E+08	1.3601E+08
54.00	4.1348E+06	1.0323E+07	1.3092E+07	1.4311E+07	1.8558E+07	2.1412E+07	2.5268E+07	2.7577E+07	2.9470E+07
64.00	1.0616E+06	2.5714E+06	3.2061E+06	3.4779E+06	4.4087E+06	5.0253E+06	5.8503E+06	6.3392E+06	6.7363E+06
74.00	2.9279E+05	6.8594E+05	8.3869E+05	9.0176E+05	1.1134E+06	1.2510E+06	1.4330E+06	1.5395E+06	1.6251E+06
84.00	8.6276E+04	1.9521E+05	2.3393E+05	2.4924E+05	2.9924E+05	3.3102E+05	3.7246E+05	3.9632E+05	4.1523E+05
94.00	2.6958E+04	5.9163E+04	6.9606E+04	7.3514E+04	8.5370E+04	9.2652E+04	1.0246E+05	1.0799E+05	1.1229E+05
104.00	8.8530E+03	1.8906E+04	2.1891E+04	2.2949E+04	2.6186E+04	2.8132E+04	3.0577E+04	3.1921E+04	3.2940E+04
114.00	3.0280E+03	6.4332E+03	7.3879E+03	7.6963E+03	8.6158E+03	9.1563E+03	9.8188E+03	1.0171E+04	1.0428E+04
124.00	1.0705E+03	2.2042E+03	2.5021E+03	2.6005E+03	2.8925E+03	3.0627E+03	3.2661E+03	3.3702E+03	3.4429E+03
134.00	3.8890E+02	7.9442E+02	8.9937E+02	9.3440E+02	1.0405E+03	1.1032E+03	1.1766E+03	1.2127E+03	1.2367E+03
144.00	1.4459E+02	2.9526E+02	3.3519E+02	3.4914E+02	3.9341E+02	4.2032E+02	4.5138E+02	4.6629E+02	4.7578E+02
154.00	5.4891E+01	1.1298E+02	1.2936E+02	1.3553E+02	1.5619E+02	1.6917E+02	1.8407E+02	1.9111E+02	1.9548E+02
164.00	2.1455E+01	4.4985E+01	5.2188E+01	5.5146E+01	6.5570E+01	7.2301E+01	8.0017E+01	8.3641E+01	8.5864E+01
174.00	8.4058E+00	1.8049E+01	2.1411E+01	2.2914E+01	2.8425E+01	3.2056E+01	3.6220E+01	3.8170E+01	3.9361E+01

Table A-2

Dose Rates in Salt from Buried 6-in. Waste Pots at the Time of Their Burial

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	3.8735E + 06	2.2932E + 00	3.1326E - 02	3.8735E + 06
2.10	3.7815E + 06	2.2280E + 00	3.0930E - 02	3.7815E + 06
3.50	3.6023E + 06	2.1095E + 00	3.0211E - 02	3.6023E + 06
4.90	3.2980E + 06	1.9310E + 00	2.9135E - 02	3.2980E + 06
7.00	2.2878E + 06	1.4932E + 00	2.5962E - 02	2.2878E + 06
8.05	1.2267E + 06	1.2082E + 00	2.3773E - 02	1.2267E + 06
8.40	8.9700E + 05	1.0734E + 00	2.5180E - 02	8.9700E + 05
11.20	5.4641E + 05	8.4926E - 01	2.6193E - 02	5.4641E + 05
14.00	3.1981E + 05	6.8539E - 01	2.6242E - 02	3.1981E + 05
24.00	5.4830E + 04	3.5197E - 01	2.3531E - 02	5.4830E + 04
34.00	1.1025E + 04	1.9376E - 01	1.9172E - 02	1.1025E + 04
44.00	2.4482E + 03	1.0945E - 01	1.4625E - 02	2.4483E + 03
54.00	5.9074E + 02	6.2465E - 02	1.0623E - 02	5.9081E + 02
64.00	1.5395E + 02	3.5769E - 02	7.4281E - 03	1.5399E + 02
74.00	4.3128E + 01	2.0480E - 02	5.0381E - 03	4.3154E + 01
84.00	1.2899E + 01	1.1703E - 02	3.3324E - 03	1.2914E + 01
94.00	4.0827E + 00	6.6671E - 03	2.1581E - 03	4.0915E + 00
104.00	1.3541E + 00	3.7848E - 03	1.3727E - 03	1.3593E + 00
114.00	4.6615E - 01	2.1403E - 03	8.5958E - 04	4.6915E - 01
124.00	1.6522E - 01	1.2057E - 03	5.3102E - 04	1.6696E - 01
134.00	5.9907E - 02	6.7659E - 04	3.2416E - 04	6.0908E - 02
144.00	2.2113E - 02	3.7831E - 04	1.9582E - 04	2.2687E - 02
154.00	8.2796E - 03	2.1080E - 04	1.1719E - 04	8.6075E - 03
164.00	3.1363E - 03	1.1707E - 04	6.9559E - 05	3.3229E - 03
174.00	1.1997E - 03	6.4813E - 05	4.0981E - 05	1.3055E - 03

Table A-3

Dose Rates in Salt from Buried 6-in. Waste Pots 2 Years After Fuel Reprocessing

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	2.6332E + 06	2.0577E + 00	2.8109E - 02	2.6332E + 06
2.10	2.5707E + 06	1.9992E + 00	2.7754E - 02	2.5707E + 06
3.50	2.4488E + 06	1.8929E + 00	2.7109E - 02	2.4488E + 06
4.90	2.2418E + 06	1.7327E + 00	2.6143E - 02	2.2418E + 06
7.00	1.5545E + 06	1.3399E + 00	2.3296E - 02	1.5545E + 06
8.05	8.3218E + 05	1.0841E + 00	2.1332E - 02	8.3218E + 05
8.40	6.0820E + 05	9.6318E - 01	2.2594E - 02	6.0820E + 05
11.20	3.7025E + 05	7.6206E - 01	2.3503E - 02	3.7025E + 05
14.00	2.1639E + 05	6.1501E - 01	2.3547E - 02	2.1639E + 05
24.00	3.6716E + 04	3.1583E - 01	2.1115E - 02	3.6716E + 04
34.00	7.2618E + 03	1.7386E - 01	1.7203E - 02	7.2618E + 03
44.00	1.5765E + 03	9.8211E - 02	1.3123E - 02	1.5766E + 03
54.00	3.6970E + 02	5.6051E - 02	9.5322E - 03	3.6976E + 02
64.00	9.3230E + 01	3.2096E - 02	6.6654E - 03	9.3269E + 01
74.00	2.5217E + 01	1.8377E - 02	4.5208E - 03	2.5240E + 01
84.00	7.2874E + 00	1.0501E - 02	2.9902E - 03	7.3009E + 00
94.00	2.2353E + 00	5.9825E - 03	1.9365E - 03	2.2432E + 00
104.00	7.2163E - 01	3.3962E - 03	1.2317E - 03	7.2626E - 01
114.00	2.4295E - 01	1.9205E - 03	7.7132E - 04	2.4564E - 01
124.00	8.4579E - 02	1.0819E - 03	4.7649E - 04	8.6137E - 02
134.00	3.0230E - 02	6.0712E - 04	2.9087E - 04	3.1128E - 02
144.00	1.1031E - 02	3.3946E - 04	1.7571E - 04	1.1546E - 02
154.00	4.0924E - 03	1.8915E - 04	1.0516E - 04	4.3867E - 03
164.00	1.5387E - 03	1.0505E - 04	6.2417E - 05	1.7413E - 03
174.00	5.8495E - 04	5.8158E - 05	3.6773E - 05	6.7988E - 04

Table A-4

Dose Rates in Salt from Buried 6-in. Waste Pots 5 Years After Fuel Reprocessing

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	1.1735E + 06	1.7974E + 00	2.4553E - 02	1.1735E + 06
2.10	1.1456	1.7463E + 00	2.4243E - 02	1.1456
3.50	1.0913	1.6534E + 00	2.3679E - 02	1.0913
4.90	9.9898E + 05	1.5135E + 00	2.2836E - 02	9.9898E + 05
7.00	6.9214	1.1704E + 00	2.0349E - 02	6.9214
8.05	3.6955	9.4699E - 01	1.8633E - 02	3.6955
8.40	2.6978	8.4133E - 01	1.9736E - 02	2.6978
11.20	1.6378	6.6565E - 01	2.0530E - 02	1.6378
14.00	9.5464E + 04	5.3721E - 01	2.0568E - 02	9.5464E + 04
24.00	1.5857	2.7587E - 01	1.8444E - 02	1.5857
34.00	3.0338E + 03	1.5187E - 01	1.5027E - 02	3.0339E + 03
44.00	6.2798E + 02	8.5787E - 02	1.1463E - 02	6.2808E + 02
54.00	1.3817	4.8960E - 02	8.3263E - 03	1.3823
64.00	3.2151E + 01	2.8036E - 02	5.8221E - 03	3.2185E + 01
74.00	7.9088E + 00	1.6052E - 02	3.9489E - 03	7.9288E + 00
84.00	2.0585	9.1728E - 03	2.6119E - 03	2.0603
94.00	5.6708E - 01	5.2257E - 03	1.6915E - 03	5.7399E - 01
104.00	1.6505	2.9665E - 03	1.0759E - 03	1.6909
114.00	5.0538E - 02	1.6776E - 03	6.7374E - 04	5.7405E - 02
124.00	1.6185	9.4503E - 04	4.1621E - 04	1.7546
134.00	5.3845E - 03	5.3031E - 04	2.5408E - 04	6.1689E - 03
144.00	1.8486	2.9652E - 04	1.5348E - 04	2.2986
154.00	6.5118E - 04	1.6522E - 04	9.1853E - 05	9.0825E - 04
164.00	2.3423	9.1759E - 05	5.4520E - 05	3.8051
174.00	8.5721E - 05	5.0800E - 05	3.2121E - 05	1.6864

Table A-5

Dose Rates in Salt from Buried 6-in. Waste Pots 10 Years After Fuel Reprocessing

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	5.7391E + 05	1.4874E + 00	2.0318E - 02	5.7391E + 05
2.10	5.6030	1.4451E + 00	2.0061E - 02	5.6030
3.50	5.3376	1.3682E + 00	1.9595E - 02	5.3376
4.90	4.8860	1.2525E + 00	1.8897E - 02	4.8860
7.00	3.3839	9.6850E - 01	1.6839E - 02	3.3839
8.05	1.8036	7.8364E - 01	1.5419E - 02	1.8036
8.40	1.3157	6.9621E - 01	1.6332E - 02	1.3157
11.20	7.9693E + 04	5.5083E - 01	1.6989E - 02	7.9693E + 04
14.00	4.6395	4.4455E - 01	1.7021E - 02	4.6395
24.00	7.6441E + 03	2.2829E - 01	1.5262E - 02	7.6443E + 03
34.00	1.4387	1.2567E - 01	1.2435E - 02	1.4388
44.00	2.9036E + 02	7.0990E - 02	9.4858E - 03	2.9044E + 02
54.00	6.1563E + 01	4.0515E - 02	6.8901E - 03	6.1610E + 01
64.00	1.3599	2.3200E - 02	4.8179E - 03	1.3627
74.00	3.1186E + 00	1.3283E - 02	3.2677E - 03	3.1352E + 00
84.00	7.4182E - 01	7.5906E - 03	2.1614E - 03	7.5157E - 01
94.00	1.8311	4.3243E - 03	1.3998E - 03	1.8883
104.00	4.6946E - 02	2.4548E - 03	8.9034E - 04	5.0291E - 02
114.00	1.2510	1.3882E - 03	5.5753E - 04	1.4456
124.00	3.4645E - 03	7.8202E - 04	3.4442E - 04	4.5909E - 03
134.00	9.9575E - 04	4.3884E - 04	2.1025E - 04	1.6448
144.00	2.9623	2.4537E - 04	1.2701E - 04	6.6861E - 04
154.00	9.0876E - 05	1.3673E - 04	7.6010E - 05	3.0362
164.00	2.8629E - 05	7.5932E - 05	4.5116E - 05	1.4968
174.00	9.2223E - 06	4.2038E - 05	2.6580E - 05	7.7840E - 05

Table A-6

Dose Rates in Salt from Buried 6-in. Waste Pots 30 Years After Fuel Reprocessing

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	2.7992 E + 05	6.9337E - 01	9.4716E - 03	2.7992 E + 05
2.10	2.7329	6.7365E - 01	9.3519E - 03	2.7329
3.50	2.6036	6.3782E - 01	9.1345E - 03	2.6036
4.90	2.3833	5.8385E - 01	8.8092E - 03	2.3833
7.00	1.6500	4.5148E - 01	7.8498E - 03	1.6500
8.05	8.7678 E + 04	3.6531E - 01	7.1879E - 03	8.7678 E + 04
8.40	6.4053	3.2455E - 01	7.6134E - 03	6.4053
11.20	3.8765	2.5678E - 01	7.9196E - 03	3.8765
14.00	2.2535	2.0723E - 01	7.9345E - 03	2.2535
24.00	3.6832 E + 03	1.0642E - 01	7.1148E - 03	3.6833 E + 03
34.00	6.8498 E + 02	5.8585E - 02	5.7968E - 03	6.8504 E + 02
44.00	1.3602	3.3093E - 02	4.4220E - 03	1.3606
54.00	2.8226 E + 01	1.8887E - 02	3.2119E - 03	2.8239 E + 01
64.00	6.0629 E + 00	1.0815E - 02	2.2459E - 03	6.0760 E + 00
74.00	1.3416	6.1923E - 03	1.5233E - 03	1.3493
84.00	3.0510 E - 01	3.5385E - 03	1.0076E - 03	3.0965 E - 01
94.00	7.1272 E - 02	2.0158E - 03	6.5252E - 04	7.3940 E - 02
104.00	1.7112	1.1444E - 03	4.1505E - 04	1.8671
114.00	4.2294 E - 03	6.4713E - 04	2.5990E - 04	5.1364 E - 03
124.00	1.0783	3.6455E - 04	1.6056E - 04	1.6034
134.00	2.8417 E - 04	2.0457E - 04	9.8012E - 05	5.8675 E - 04
144.00	7.7534 E - 05	1.1438E - 04	5.9208E - 05	2.5112 E - 04
154.00	2.1912	6.3737E - 05	3.5433E - 05	1.2108 E - 04
164.00	6.4089 E - 06	3.5397E - 05	2.1032E - 05	6.2838 E - 05
174.00	1.9355	1.9597E - 05	1.2391E - 05	3.3924

Table A-7

Dose Rates in Salt from Buried 6-in. Waste Pots 50 Years After Fuel Reprocessing

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	1.7132E + 05	3.2407E - 01	4.4269E - 03	1.7132E + 05
2.10	1.6727	3.1485E - 01	4.3709E - 03	1.6727
3.50	1.5935	2.9811E - 01	4.2693E - 03	1.5935
4.90	1.4587	2.7288E - 01	4.1173E - 03	1.4587
7.00	1.0097	2.1101E - 01	3.6689E - 03	1.0097
8.05	5.3590E + 04	1.7074E - 01	3.3595E - 03	5.3590E + 04
8.40	3.9143	1.5169E - 01	3.5584E - 03	3.9143
11.20	2.3680	1.2001E - 01	3.7015E - 03	2.3680
14.00	1.3755	9.6857E - 02	3.7084E - 03	1.3755
24.00	2.2374E + 03	4.9739E - 02	3.3253E - 03	2.2374E + 03
34.00	4.1343E + 02	2.7382E - 02	2.7093E - 03	4.1346E + 02
44.00	8.1433E + 01	1.5467E - 02	2.0668E - 03	8.1451E + 01
54.00	1.6735	8.8273E - 03	1.5012E - 03	1.6745
64.00	3.5531E + 00	5.0548E - 03	1.0497E - 03	3.5592E + 00
74.00	7.7553E - 01	2.8942E - 03	7.1197E - 04	7.7914E - 01
84.00	1.7360	1.6538E - 03	4.7092E - 04	1.7572
94.00	3.9817E - 02	9.4217E - 04	3.0498E - 04	4.1108E - 02
104.00	9.3627E - 03	5.3486E - 04	1.9399E - 04	1.0092
114.00	2.2607E - 03	3.0246E - 04	1.2147E - 04	2.6846E - 03
124.00	5.6196E - 04	1.7039E - 04	7.5042E - 05	8.0739E - 04
134.00	1.4420E - 04	9.5613E - 05	4.5809E - 05	2.8562
144.00	3.8300E - 05	5.3462E - 05	2.7673E - 05	1.1944
154.00	1.0548	2.9790E - 05	1.6561E - 05	5.6899E - 05
164.00	3.0133E - 06	1.6544E - 05	9.8298E - 06	2.9387
174.00	8.9172E - 07	9.1592E - 06	5.7913E - 06	1.5842

Table A-8

Dose Rates in Salt from Buried 6-in. Waste Pots 100 Years After Fuel Reprocessing

Conditions: age upon burial - 1 year after reprocessing
initial heat rate - 7200 watts/pot

Distance from Pot Center Line (cm)	Dose Rate (rad/hr)			
	Fission Product Gamma	Neutrons	Capture Gamma	Total
0.70	5.2301E + 04	5.0673E - 02	6.9221E - 04	5.2301E + 04
2.10	5.1065	4.9232E - 02	6.8346E - 04	5.1065
3.50	4.8651	4.6614E - 02	6.6757E - 04	4.8651
4.90	4.4536	4.2669E - 02	6.4380E - 04	4.4536
7.00	3.0816	3.2995E - 02	5.7368E - 04	3.0816
8.05	1.6330	2.6698E - 02	5.2531E - 04	1.6330
8.40	1.1924	2.3719E - 02	5.5640E - 04	1.1924
11.20	7.2076E + 03	1.8766E - 02	5.7879E - 04	7.2076E + 03
14.00	4.1848	1.5145E - 02	5.7987E - 04	4.1848
24.00	6.7598E + 02	7.7775E - 03	5.1996E - 04	6.7598E + 02
34.00	1.2377	4.2815E - 03	4.2364E - 04	1.2377
44.00	2.4100E + 01	2.4185E - 03	3.2317E - 04	2.4103E + 01
54.00	4.8826E + 00	1.3803E - 03	2.3474E - 04	4.8842E + 00
64.00	1.0188	7.9039E - 04	1.6414E - 04	1.0198
74.00	2.1776E - 01	4.5255E - 04	1.1133E - 04	2.1832E - 01
84.00	4.7520E - 02	2.5860E - 04	7.3636E - 05	4.7852E - 02
94.00	1.0572	1.4732E - 04	4.7688E - 05	1.0767
104.00	2.3966E - 03	8.3633E - 05	3.0333E - 05	2.5106E - 03
114.00	5.5410E - 04	4.7294E - 05	1.8994E - 05	6.1313E - 04
124.00	1.3092	2.6642E - 05	1.1734E - 05	1.6930
134.00	3.1713E - 05	1.4951E - 05	7.1630E - 06	5.3827E - 05
144.00	7.9064E - 06	8.3595E - 06	4.3270E - 06	2.0593
154.00	2.0374E - 06	4.6580E - 06	2.5895E - 06	9.2849E - 06
164.00	5.4476E - 07	2.5869E - 06	1.5370E - 06	4.6687
174.00	1.5151	1.4322E - 06	9.0556E - 07	2.4893

Table A-9. Total Integrated Dose in Salt as Function of Time and Distance

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	TØTAL SALT DØSE (RADS) AFTER TIME (YEARS) SINCE PRØCESSING				
	11.0	12.0	15.0	20.0	30.0
0.70	2.5097E+10	4.8439E+10	1.1140E+11	2.0128E+11	3.4725E+11
2.10	2.4390E+10	4.7076E+10	1.0827E+11	1.9561E+11	3.3749E+11
3.50	2.3239E+10	4.4853E+10	1.0316E+11	1.8638E+11	3.2156E+11
4.90	2.1276E+10	4.1066E+10	9.4447E+10	1.7065E+11	2.9442E+11
7.00	1.4731E+10	2.8431E+10	6.5386E+10	1.1813E+11	2.0380E+11
8.05	7.8308E+09	1.5112E+10	3.4744E+10	6.2750E+10	1.0818E+11
8.40	5.7121E+09	1.1023E+10	2.5342E+10	4.5769E+10	7.8926E+10
11.20	3.4572E+09	6.6714E+09	1.5336E+10	2.7694E+10	4.7748E+10
14.00	2.0111E+09	3.8805E+09	8.9196E+09	1.6105E+10	2.7757E+10
24.00	3.3025E+08	6.3695E+08	1.4625E+09	2.6373E+09	4.5378E+09
34.00	6.2033E+07	1.1957E+08	2.7417E+08	4.9356E+08	8.4717E+08
44.00	1.2510E+07	2.4090E+07	5.5129E+07	9.9012E+07	1.6942E+08
54.00	2.6529E+06	5.1019E+06	1.1644E+07	2.0846E+07	3.5526E+07
64.00	5.8687E+05	1.1266E+06	2.5613E+06	4.5666E+06	7.7424E+06
74.00	1.3511E+05	2.5872E+05	5.8525E+05	1.0378E+06	1.7483E+06
84.00	3.2421E+04	6.1894E+04	1.3912E+05	2.4502E+05	4.0952E+05
94.00	8.1584E+03	1.5519E+04	3.4620E+04	6.0496E+04	1.0018E+05
104.00	2.1774E+03	4.1267E+03	9.1371E+03	1.5838E+04	2.5969E+04
114.00	6.2749E+02	1.1862E+03	2.6121E+03	4.4996E+03	7.3138E+03
124.00	1.9981E+02	3.7762E+02	8.3125E+02	1.4300E+03	2.3131E+03
134.00	7.1709E+01	1.3595E+02	3.0123E+02	5.2097E+02	8.4368E+02
144.00	2.9150E+01	5.5591E+01	1.2467E+02	2.1792E+02	3.5513E+02
154.00	1.3216E+01	2.5378E+01	5.7701E+01	1.0207E+02	1.6770E+02
164.00	6.4996E+00	1.2558E+01	2.8896E+01	5.1645E+01	8.5478E+01
174.00	3.3714E+00	6.5449E+00	1.5197E+01	2.7368E+01	4.5546E+01

Table A-9 (continued)

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	TØTAL SALT DØSE (RADS) AFTER TIME (YEARS) SINCE PRØCESSING			
	40.0	50.0	75.0	100.0
0.70	4.6063E+11	5.4956E+11	6.9756E+11	7.7906E+11
2.10	4.4768E+11	5.3411E+11	6.7796E+11	7.5717E+11
3.50	4.2655E+11	5.0891E+11	6.4598E+11	7.2146E+11
4.90	3.9055E+11	4.6596E+11	5.9146E+11	6.6057E+11
7.00	2.7032E+11	2.7537E+11	2.7537E+11	3.2318E+11
8.05	1.4341E+11	1.7103E+11	2.1696E+11	2.4223E+11
8.40	1.0466E+11	1.2483E+11	1.5838E+11	1.7683E+11
11.20	6.3308E+10	7.5503E+10	9.5771E+10	1.0692E+11
14.00	3.6793E+10	4.3872E+10	5.5634E+10	6.2100E+10
24.00	6.0076E+09	7.1562E+09	9.0593E+09	1.0102E+10
34.00	1.1196E+09	1.3318E+09	1.6820E+09	1.8730E+09
44.00	2.2340E+08	2.6528E+08	3.3403E+08	3.7131E+08
54.00	4.6716E+07	5.5353E+07	6.9447E+07	7.7035E+07
64.00	1.0146E+07	1.1991E+07	1.4978E+07	1.6573E+07
74.00	2.2816E+06	2.6879E+06	3.3399E+06	3.6841E+06
84.00	5.3178E+05	6.2414E+05	7.7065E+05	8.4691E+05
94.00	1.2933E+05	1.5111E+05	1.8516E+05	2.0257E+05
104.00	3.3304E+04	3.8714E+04	4.7008E+04	5.1140E+04
114.00	9.3176E+03	1.0771E+04	1.2943E+04	1.3987E+04
124.00	2.9312E+03	3.3713E+03	4.0081E+03	4.2996E+03
134.00	1.0663E+03	1.2221E+03	1.4401E+03	1.5344E+03
144.00	4.4895E+02	5.1372E+02	6.0196E+02	6.3827E+02
154.00	2.1239E+02	2.4302E+02	2.8405E+02	3.0036E+02
164.00	1.0849E+02	1.2421E+02	1.4507E+02	1.5322E+02
174.00	5.7909E+01	6.6342E+01	7.7493E+01	8.1806E+01

Table A-10. Dose Rates in Salt from Waste Pots After 10 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	DØSE RATE (RAD/HR) F. P. GAMMA	NEUTRØNS	CAPTURE GAMMA	TØTAL
0.70	2.97736E+06	7.42877E+00	1.01480E-01	2.97737E+06
2.10	2.89354E+06	7.21756E+00	1.00197E-01	2.89355E+06
3.50	2.75688E+06	6.83368E+00	9.78679E-02	2.75689E+06
4.90	2.52408E+06	6.25543E+00	9.43822E-02	2.52409E+06
7.00	1.74759E+06	4.83719E+00	8.41034E-02	1.74759E+06
8.05	9.29147E+05	3.91394E+00	7.70121E-02	9.29151E+05
8.40	6.77766E+05	3.47726E+00	8.15701E-02	6.77770E+05
11.20	4.10239E+05	2.75116E+00	8.48517E-02	4.10242E+05
14.00	2.38658E+05	2.22031E+00	8.50104E-02	2.38660E+05
24.00	3.92083E+04	1.14020E+00	7.62282E-02	3.92095E+04
34.00	7.36955E+03	6.27682E-01	6.21073E-02	7.37024E+03
44.00	1.48742E+03	3.54561E-01	4.73774E-02	1.48782E+03
54.00	3.15734E+02	2.02354E-01	3.44130E-02	3.15971E+02
64.00	6.99016E+01	1.15873E-01	2.40632E-02	7.00415E+01
74.00	1.60852E+01	6.63445E-02	1.63208E-02	1.61679E+01
84.00	3.84436E+00	3.79116E-02	1.07952E-02	3.89307E+00
94.00	9.54936E-01	2.15979E-02	6.99112E-03	9.83525E-01
104.00	2.46831E-01	1.22608E-02	4.44683E-03	2.63539E-01
114.00	6.64481E-02	6.93346E-03	2.78459E-03	7.61661E-02
124.00	1.86332E-02	3.90584E-03	1.72023E-03	2.42593E-02
134.00	5.43460E-03	2.19180E-03	1.05011E-03	8.67651E-03
144.00	1.64425E-03	1.22553E-03	6.34355E-04	3.50413E-03
154.00	5.14093E-04	6.82882E-04	3.79635E-04	1.57661E-03
164.00	1.65408E-04	3.79246E-04	2.25335E-04	7.69989E-04
174.00	5.45366E-05	2.09960E-04	1.32757E-04	3.97254E-04

Table A-11. Dose Rates in Salt from Waste Pots After 12 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	DØSE RATE (RAD/HR) F. P. GAMMA	NEUTRØNS	CAPTURE GAMMA	TØTAL
0.70	2.57599E+06	6.85733E+00	9.36738E-02	2.57600E+06
2.10	2.50350E+06	6.66236E+00	9.24896E-02	2.50351E+06
3.50	2.38531E+06	6.30801E+00	9.03396E-02	2.38532E+06
4.90	2.18392E+06	5.77425E+00	8.71221E-02	2.18393E+06
7.00	1.51194E+06	4.46510E+00	7.76339E-02	1.51194E+06
8.05	8.03417E+05	3.61287E+00	7.10881E-02	8.03421E+05
8.40	5.86008E+05	3.20978E+00	7.52955E-02	5.86011E+05
11.20	3.54628E+05	2.53953E+00	7.83246E-02	3.54631E+05
14.00	2.06247E+05	2.04951E+00	7.84712E-02	2.06249E+05
24.00	3.38210E+04	1.05249E+00	7.03645E-02	3.38221E+04
34.00	6.34022E+03	5.79398E-01	5.73298E-02	6.34086E+03
44.00	1.27470E+03	3.27287E-01	4.37330E-02	1.27507E+03
54.00	2.69101E+02	1.86788E-01	3.17658E-02	2.69320E+02
64.00	5.91175E+01	1.06960E-01	2.22122E-02	5.92467E+01
74.00	1.34615E+01	6.12411E-02	1.50654E-02	1.35378E+01
84.00	3.17297E+00	3.49953E-02	9.96484E-03	3.21793E+00
94.00	7.74335E-01	1.99366E-02	6.45334E-03	8.00725E-01
104.00	1.95884E-01	1.13176E-02	4.10477E-03	2.11306E-01
114.00	5.14289E-02	6.40011E-03	2.57039E-03	6.03994E-02
124.00	1.40259E-02	3.60539E-03	1.58790E-03	1.92192E-02
134.00	3.97276E-03	2.02320E-03	9.69332E-04	6.96529E-03
144.00	1.16693E-03	1.13126E-03	5.85558E-04	2.88374E-03
154.00	3.54478E-04	6.30353E-04	3.50432E-04	1.33526E-03
164.00	1.10960E-04	3.50073E-04	2.08001E-04	6.69035E-04
174.00	3.56486E-05	1.93810E-04	1.22545E-04	3.52003E-04

Table A-12. Dose Rates in Salt from Waste Pots After 15 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	DØSE RATE (RAD/HR) F. P. GAMMA	NEUTRØNS	CAPTURE GAMMA	TØTAL
0.70	2.22118E+06	6.13348E+00	8.37857E-02	2.22119E+06
2.10	2.15871E+06	5.95909E+00	8.27266E-02	2.15872E+06
3.50	2.05682E+06	5.64215E+00	8.08035E-02	2.05683E+06
4.90	1.88319E+06	5.16473E+00	7.79256E-02	1.88320E+06
7.00	1.30364E+06	3.99377E+00	6.94390E-02	1.30364E+06
8.05	6.92404E+05	3.23150E+00	6.35842E-02	6.92407E+05
8.40	5.05001E+05	2.87096E+00	6.73474E-02	5.05004E+05
11.20	3.05555E+05	2.27146E+00	7.00568E-02	3.05557E+05
14.00	1.77687E+05	1.83317E+00	7.01879E-02	1.77689E+05
24.00	2.90843E+04	9.41392E-01	6.29369E-02	2.90853E+04
34.00	5.43951E+03	5.18238E-01	5.12782E-02	5.44008E+03
44.00	1.09002E+03	2.92739E-01	3.91166E-02	1.09035E+03
54.00	2.29061E+02	1.67071E-01	2.84127E-02	2.29256E+02
64.00	5.00055E+01	9.56691E-02	1.98675E-02	5.01210E+01
74.00	1.12904E+01	5.47766E-02	1.34751E-02	1.13587E+01
84.00	2.63159E+00	3.13013E-02	8.91296E-03	2.67180E+00
94.00	6.33132E-01	1.78321E-02	5.77214E-03	6.56736E-01
104.00	1.57357E-01	1.01230E-02	3.67148E-03	1.71151E-01
114.00	4.04567E-02	5.72453E-03	2.29907E-03	4.84803E-02
124.00	1.07737E-02	3.22481E-03	1.42029E-03	1.54188E-02
134.00	2.97356E-03	1.80963E-03	8.67011E-04	5.65020E-03
144.00	8.50302E-04	1.01184E-03	5.23748E-04	2.38589E-03
154.00	2.51470E-04	5.63814E-04	3.13441E-04	1.12872E-03
164.00	7.66981E-05	3.13120E-04	1.86045E-04	5.75863E-04
174.00	2.40397E-05	1.73351E-04	1.09609E-04	3.07000E-04

Table A-13. Dose Rates in Salt from Waste Pots After 20 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FROM CL (CM)	DOSE RATE (RAD/HR) F. P. GAMMA	NEUTRONS	CAPTURE GAMMA	TOTAL
0.70	1.88880E+06	5.06679E+00	6.92144E-02	1.88881E+06
2.10	1.83570E+06	4.92274E+00	6.83394E-02	1.83570E+06
3.50	1.74909E+06	4.66091E+00	6.67508E-02	1.74909E+06
4.90	1.60146E+06	4.26652E+00	6.43734E-02	1.60146E+06
7.00	1.10849E+06	3.29921E+00	5.73627E-02	1.10849E+06
8.05	5.88312E+05	2.66950E+00	5.25261E-02	5.88315E+05
8.40	4.29115E+05	2.37166E+00	5.56349E-02	4.29117E+05
11.20	2.59582E+05	1.87643E+00	5.78731E-02	2.59584E+05
14.00	1.50894E+05	1.51436E+00	5.79813E-02	1.50896E+05
24.00	2.46413E+04	7.77673E-01	5.19914E-02	2.46421E+04
34.00	4.59396E+03	4.28110E-01	4.23603E-02	4.59443E+03
44.00	9.16783E+02	2.41828E-01	3.23137E-02	9.17057E+02
54.00	1.91632E+02	1.38016E-01	2.34714E-02	1.91793E+02
64.00	4.15488E+01	7.90311E-02	1.64123E-02	4.16442E+01
74.00	9.30040E+00	4.52503E-02	1.11316E-02	9.35678E+00
84.00	2.14451E+00	2.58576E-02	7.36289E-03	2.17773E+00
94.00	5.09140E-01	1.47309E-02	4.76829E-03	5.28639E-01
104.00	1.24549E-01	8.36247E-03	3.03296E-03	1.35944E-01
114.00	3.14392E-02	4.72896E-03	1.89923E-03	3.80674E-02
124.00	8.20280E-03	2.66398E-03	1.17328E-03	1.20401E-02
134.00	2.21528E-03	1.49492E-03	7.16227E-04	4.42642E-03
144.00	6.19675E-04	8.35871E-04	4.32662E-04	1.88821E-03
154.00	1.79441E-04	4.65760E-04	2.58930E-04	9.04131E-04
164.00	5.36881E-05	2.58665E-04	1.53690E-04	4.66042E-04
174.00	1.65491E-05	1.43203E-04	9.05470E-05	2.50300E-04

Table A-14. Dose Rates in Salt from Waste Pots After 30 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	DØSE RATE (RAD/HR) F. P. GAMMA	NEUTRØNS	CAPTURE GAMMA	TØTAL
0.70	1.46008E+06	3.44397E+00	4.70459E-02	1.46008E+06
2.10	1.41906E+06	3.34605E+00	4.64512E-02	1.41906E+06
3.50	1.35212E+06	3.16808E+00	4.53714E-02	1.35212E+06
4.90	1.23800E+06	2.90001E+00	4.37554E-02	1.23800E+06
7.00	8.56775E+05	2.24251E+00	3.89902E-02	8.56777E+05
8.05	4.53898E+05	1.81449E+00	3.57027E-02	4.53900E+05
8.40	3.31572E+05	1.61205E+00	3.78157E-02	3.31574E+05
11.20	2.00496E+05	1.27543E+00	3.93371E-02	2.00497E+05
14.00	1.16448E+05	1.02933E+00	3.94107E-02	1.16449E+05
24.00	1.89647E+04	5.28594E-01	3.53392E-02	1.89653E+04
34.00	3.52070E+03	2.90992E-01	2.87928E-02	3.52102E+03
44.00	6.98928E+02	1.64374E-01	2.19641E-02	6.99114E+02
54.00	1.45169E+02	9.38110E-02	1.59538E-02	1.45279E+02
64.00	3.12388E+01	5.37185E-02	1.11556E-02	3.13037E+01
74.00	6.93097E+00	3.07572E-02	7.56630E-03	6.96929E+00
84.00	1.58185E+00	1.75758E-02	5.00465E-03	1.60443E+00
94.00	3.71165E-01	1.00128E-02	3.24107E-03	3.84419E-01
104.00	8.96128E-02	5.68408E-03	2.06154E-03	9.73584E-02
114.00	2.22915E-02	3.21434E-03	1.29093E-03	2.67968E-02
124.00	5.72648E-03	1.81074E-03	7.97495E-04	8.33472E-03
134.00	1.52211E-03	1.01611E-03	4.86829E-04	3.02505E-03
144.00	4.19186E-04	5.68152E-04	2.94086E-04	1.28142E-03
154.00	1.19635E-04	3.16583E-04	1.75998E-04	6.12216E-04
164.00	3.53375E-05	1.75818E-04	1.04465E-04	3.15620E-04
174.00	1.07759E-05	9.73372E-05	6.15460E-05	1.69659E-04

Table A-15. Dose Rates in Salt from Waste Pots After 50 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	DØSE RATE (RAD/HR) F. P. GAMMA	NEUTRØNS	CAPTURE GAMMA	TØTAL
0.70	8.98760E+05	1.60010E+00	2.18580E-02	8.98762E+05
2.10	8.73534E+05	1.55461E+00	2.15817E-02	8.73536E+05
3.50	8.32351E+05	1.47193E+00	2.10800E-02	8.32352E+05
4.90	7.62104E+05	1.34738E+00	2.03293E-02	7.62105E+05
7.00	5.00000E+00	1.04190E+00	1.81153E-02	6.06001E+00
8.05	2.79038E+05	8.43034E-01	1.65879E-02	2.79039E+05
8.40	2.03796E+05	7.48976E-01	1.75696E-02	2.03797E+05
11.20	1.23183E+05	5.92580E-01	1.82764E-02	1.23184E+05
14.00	7.14926E+04	4.78238E-01	1.83106E-02	7.14931E+04
24.00	1.15876E+04	2.45591E-01	1.64190E-02	1.15879E+04
34.00	2.13738E+03	1.35198E-01	1.33775E-02	2.13753E+03
44.00	4.20877E+02	7.63699E-02	1.02047E-02	4.20964E+02
54.00	8.65667E+01	4.35856E-02	7.41231E-03	8.66177E+01
64.00	1.84141E+01	2.49582E-02	5.18303E-03	1.84442E+01
74.00	4.03056E+00	1.42901E-02	3.51539E-03	4.04837E+00
84.00	9.05636E-01	8.16589E-03	2.32522E-03	9.16127E-01
94.00	2.08743E-01	4.65204E-03	1.50584E-03	2.14901E-01
104.00	4.93891E-02	2.64088E-03	9.57816E-04	5.29878E-02
114.00	1.20179E-02	1.49342E-03	5.99781E-04	1.41111E-02
124.00	3.01510E-03	8.41290E-04	3.70525E-04	4.22691E-03
134.00	7.82149E-04	4.72098E-04	2.26186E-04	1.48043E-03
144.00	2.10304E-04	2.63970E-04	1.36635E-04	6.10909E-04
154.00	5.86952E-05	1.47088E-04	8.17705E-05	2.87554E-04
164.00	1.70010E-05	8.16868E-05	4.85355E-05	1.47223E-04
174.00	5.10086E-06	4.52239E-05	2.85949E-05	7.89197E-05

Table A-16. Dose Rates in Salt from Waste Pots After 100 Years Following Processing

(Initial Heat Rate: 5000 W)

DISTANCE FRØM CL (CM)	DØSE RATE (RAD/HR) F. P. GAMMA	NEUTRØNS	CAPTURE GAMMA	TØTAL
0.70	2.72825E+05	2.35819E-01	3.22138E-03	2.72825E+05
2.10	2.65176E+05	2.29114E-01	3.18066E-03	2.65176E+05
3.50	2.52682E+05	2.16929E-01	3.10672E-03	2.52682E+05
4.90	2.31359E+05	1.98573E-01	2.99607E-03	2.31359E+05
7.00	1.60033E+05	1.53552E-01	2.66978E-03	1.60033E+05
8.05	8.45628E+04	1.24244E-01	2.44468E-03	8.45629E+04
8.40	6.17419E+04	1.10382E-01	2.58936E-03	6.17420E+04
11.20	3.72894E+04	8.73329E-02	2.69353E-03	3.72895E+04
14.00	2.16291E+04	7.04815E-02	2.69857E-03	2.16292E+04
24.00	3.48300E+03	3.61945E-02	2.41979E-03	3.48304E+03
34.00	6.36792E+02	1.99251E-02	1.97154E-03	6.36814E+02
44.00	1.23996E+02	1.12552E-02	1.50395E-03	1.24009E+02
54.00	2.51540E+01	6.42353E-03	1.09241E-03	2.51615E+01
64.00	5.26186E+00	3.67827E-03	7.63862E-04	5.26630E+00
74.00	1.12877E+00	2.10604E-03	5.18089E-04	1.13139E+00
84.00	2.47583E-01	1.20347E-03	3.42684E-04	2.49129E-01
94.00	5.54549E-02	6.85605E-04	2.21926E-04	5.63624E-02
104.00	1.26856E-02	3.89207E-04	1.41160E-04	1.32160E-02
114.00	2.96800E-03	2.20096E-04	8.83941E-05	3.27649E-03
124.00	7.12167E-04	1.23987E-04	5.46070E-05	8.90761E-04
134.00	1.75906E-04	6.95765E-05	3.33347E-05	2.78817E-04
144.00	4.49197E-05	3.89032E-05	2.01370E-05	1.03960E-04
154.00	1.19075E-05	2.16774E-05	1.20511E-05	4.56361E-05
164.00	3.28637E-06	1.20388E-05	7.15304E-06	2.24782E-05
174.00	9.45296E-07	6.66499E-06	4.21424E-06	1.18245E-05

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