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MCC

Materials Characterization Center

**Characterization of
Spent Fuel Approved
Testing Material—ATM-105**

December 1991

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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PNL-5109-105

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CHARACTERIZATION OF SPENT FUEL
APPROVED TESTING MATERIAL - ATM-105

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ABSTRACT

The characterization data obtained to date are described for Approved Testing Material 105 (ATM-105), which is spent fuel from Bundles CZ346 and CZ348 of the Cooper Nuclear Power Plant, a boiling-water reactor. This report is one in a series being prepared by the Materials Characterization Center at Pacific Northwest Laboratory (PNL) on spent fuel ATMs. The ATMs are receiving extensive examinations to provide a source of well-characterized spent fuel for testing in the U.S. Department of Energy Office of Civilian Radioactive Waste Management (OCRWM) Program. ATM-105 consists of 88 full-length irradiated fuel rods with rod-average burnups of about 2400 GJ/kgM (28 MWd/kgM) and expected fission gas release of about 1%. Characterization data include 1) descriptions of as-fabricated fuel design, irradiation history, and subsequent storage and handling; 2) isotopic gamma scans; 3) fission gas analyses; 4) ceramography of the fuel and metallography of the cladding; 5) special fuel studies involving analytical transmission electron microscopy (AEM); 6) calculated nuclide inventories and radioactivities in the fuel and cladding; and 7) radiochemical analyses of the fuel and cladding. Additional analyses of the fuel are being conducted and will be included in planned revisions of this report.

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F.6.d Actinide Inventory by Element at 25 MWd/kgM, g/gU	F.76
F.6.e Actinide Inventory by Element at 30 MWd/kgM, g/gU	F.77
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F.7.a Fuel Activation Product Inventory by Isotope at 10 MWd/kgM g/gU	F.78
F.7.b Fuel Activation Product Inventory by Isotope at 15 MWd/kgM, g/gU	F.81
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1.0 INTRODUCTION

The Materials Characterization Center (MCC) at Pacific Northwest Laboratory (PNL)(a) has the responsibility to provide spent fuel test material (samples) for laboratory investigations of nuclear waste forms by the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM) Program. This MCC reference report describes the characterization of Approved Testing Material 105 (ATM-105), one of six spent fuel ATMs that are being characterized. The first three reports in the series are on ATM-101 (Barner 1985), ATM-103 (Guenther et al. 1988a) and ATM-106 (Guenther et al. 1988b). General descriptions of the six spent fuel ATMs presently being characterized by the MCC are provided in Table 1.1. Additional spent fuel with burnable poisons, rods from newer high-burnup designs, and rods with stainless steel cladding are being considered as future ATMs.

ATM-105 has UO_2 -fueled rods with moderate burnup, estimated to average about 2400 GJ/kgM (28 MWd/kgM). These rods were expected to have low release of the fission gas from the UO_2 fuel during irradiation. The fuel rods were fabricated by General Electric (GE) and irradiated in the Cooper Nuclear Power Plant (Cooper) boiling-water reactor (BWR) operated by the Nebraska Public Power District.

The 88 full-length fuel rods from Bundles CZ346 and CZ348 that are loaded with urania only constitute ATM-105. An additional 10 fuel rods from these bundles are loaded with both urania and gadolinia, which is used as a burnable poison. The 10 $\text{UO}_2\text{-Gd}_2\text{O}_3$ fuel rods have been designated as ATM-108 and will be characterized in the future.

Characterization of the ATM-105 material was initiated because a significant portion of spent fuel in the U.S. will come from BWRs. The results of the characterization of ATM-105 will be compared with characterization data for pressurized-water reactor (PWR) spent fuel being obtained from ATM-101 (moderate burnup, low fission gas release), ATM-103 (moderate burnup, low fission gas release), ATM-104 (high burnup, low fission gas release), and

(a) Operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RL0 1830.

TABLE 1.1. Summary of Spent Fuel ATMs Being Characterized by the MCC

ATM	Fuel Type	Reactor	Burnup Range, MWd/kgM ^(a)	Range of Fission Gas Release, % ^(a)	No. of Rods
101	PWR	H. B. Robinson, No. 1	16-32	0.2-0.3	9 as 27 1.2-m (4-ft) segments
103	PWR	Calvert Cliffs, No. 1	13-33	0.25	176 full length
104	PWR	Calvert Cliffs, No. 1	26-44	1.1	128 full length
105	BWR	Cooper	18-34	0.6-7.9	88 full length
106	PWR	Calvert Cliffs, No. 1	29-47	7.8-18	20 full length
108	BWR	Cooper	~15-30 (expected)	~1-10 (expected)	10 full length

(a) Measured in the fuel rods examined to date. These ranges may expand as more rods are examined.

ATM-106 (high burnup, high fission gas release). These spent fuels were selected to represent the typical end-of-life (EOL) fuel conditions, potential extremes in EOL spent fuel conditions, or differences between PWR and BWR spent fuel from U.S. commercial nuclear reactors. The moderate burnup and expected low fission gas release of ATM-105 are representative of one type of spent fuel condition for BWR reactors operating in the United States. A portion of a characterized fuel rod has been made available to the Yucca Mountain Site Characterization Project (YMP) for spent fuel testing. Additional quantities of ATM-105 are available for distribution to experimenters.

The characterizations of ATM-105 spent fuel are based on a general characterization plan described by Barner (1984) and the specific characterization plan described in Section 3.0 of this report. All of the characterizations have been conducted at DOE's Hanford Site near Richland, Washington. The present report describes the characterizations completed to date for

Rods ADD2937, ADD2966, and ADD2974 of ATM-105. Additional characterization data for Rod ADD2966, Rod ADD2974, and other ATM-105 fuel rods will be included in subsequent revisions of this report.

2.0 SUMMARY AND CONCLUSIONS

Analyses completed to date on two BWR rods from ATM-105 indicate that this fuel achieved moderate peak burnups and a range of rod-average fission gas releases from the fuel. The peak burnups measured were 2930 GJ/kgM (33.9 MWd/kgM) in Rod ADD2966 and 2680 GJ/kgM (31.0 MWd/kgM) in Rod ADD2974. Rod ADD2974 had low fission gas release (0.6%) and only limited microstructural changes; these results are reasonably similar to those observed in MCC PWR rods that had moderate burnups and low fission gas release. Rod ADD2966 had slightly higher burnup than Rod ADD2974 but had significantly higher rod-average fission gas release (7.9%); there was much more grain growth in the fuel and much greater release of cesium and iodine to the cladding interior surface than in Rod ADD2974. The microstructural changes and distributions of cesium and iodine in high-release Rod ADD2966 are similar to those observed in an ATM-106 rod that also had high fission gas release.

These varied results for rods within the same fuel bundle underscore the need to adequately define the characteristics of samples used for testing purposes. An additional ATM-105 fuel rod will receive in-depth characterization to further establish the characteristics of the ATM-105 fuel rods. Information obtained during characterization of Rods ADD2966 and ADD2974 is summarized below.

Fission Gas Release and Gamma Scans

Analyses of the gas sampled from Rods ADD2966 and ADD2974 indicated rod-average fission gas releases of 7.9% and 0.59%, respectively. Gamma scans of the full-length rods indicated local variations in cesium release from the fuel pellets that were consistent with the differences in fission gas releases. In Rod ADD2966, which had about 13 times the fission gas release in Rod ADD2974, the gamma scan data indicated portions of the fuel had cesium release or movement; there were no indications of cesium release in Rod ADD2974. Such differences in fission gas release and cesium migration in adjacent rods were also observed in ATM-106 PWR rods.

Fuel Radiochemistry

Radiochemical analyses of fuel samples from nine locations in Rod ADD2966 and eight locations in Rod ADD2974 indicate that the ORIGEN2 computer code provides reasonable predictions of the inventory and radioactivity of the nuclides examined. Measured values for ^{243}Cm plus ^{244}Cm , ^{135}Cs , ^{137}Cs , ^{90}Sr , ^{99}Tc , ^{237}Np , ^{238}Pu , ^{239}Pu , ^{240}Pu , ^{242}Pu , ^{234}U , ^{235}U , ^{236}U , and ^{238}U agreed within about $\pm 10\%$ of the ORIGEN2 predictions. The average value of ^{129}I in the fuel agreed very well with the predicted values, but the measured values ranged from 25% below to 13% above the predicted levels. The ^{241}Pu and ^{241}Am contents in the fuel were consistently below the predicted values by an average of 17% and 22%, respectively. The ^{14}C in the fuel averaged 17% above the predicted value; however, measured values ranged from 38% below to 71% above the predicted levels. Similar variability in the ^{14}C contents has been observed in all of the ATMs examined. The measured values for ^{79}Se and ^{126}Sn were consistently lower than the predicted values by about 87% and 77%, respectively. Similar differences between the measured and predicted values for ^{79}Se and ^{126}Sn have been obtained for other ATMs characterized by the MCC; modifications may be required in the ORIGEN2 code for predicting amounts of ^{79}Se and ^{126}Sn . Results of the fuel radiochemistry are being provided to Oak Ridge National Laboratory for their use in validating ORIGEN2.

Cladding Radiochemistry

Analyses of the Zircaloy-2 cladding were conducted to determine the amount of ^{135}Cs and ^{137}Cs on the exterior and interior surfaces, the ^{129}I on the interior surface, and the ^{14}C in the cladding. The ^{135}Cs and ^{137}Cs did not show any particular trend along the exterior surface of the cladding. The levels of ^{137}Cs on the interior cladding surface followed the power/burnup profile of the rod and were 10 to 100 times higher than on the exterior surface. The ^{137}Cs activities on the cladding were about 100,000 times those measured for ^{135}Cs . Although the level of ^{129}I on the cladding interior surfaces was about 10% to 30% of that of ^{135}Cs , the results of these analyses indicate that the deposit of iodine parallels the pattern of ^{137}Cs .

The variations in ^{135}Cs , ^{137}Cs , and ^{129}I on the interior cladding surface also depend on local variations in fuel temperature that apparently occurred at different regions of the rod. Measured deposits of cesium and iodine on the cladding correlate with the apparent cesium release indicated by the gamma scans of the full-length rods and with the fuel grain growth. The relationship between deposits on the cladding and the fuel grain growth is also consistent with similar data for an ATM-106 rod that had a range of deposits and amounts of fuel grain growth.

The measured ^{14}C levels in the Zircaloy-2 cladding of the ATM-105 BWR fuel rods were comparable to those measured in the Zircaloy-4 cladding from an ATM-103 rod that also had moderate burnup. The ^{14}C values were lower than the predicted levels by an average of almost 50%; some values were less than half of the predicted amounts while one value was 32% higher than the predicted amount. The overall lower measured values may have resulted from the assumption of a higher-than-actual value for the as-fabricated nitrogen content used in the ORIGEN2 computer code. The variability in ^{14}C measured values has been observed in other ATMs and may partially result from carbon release from the fuel.

Analytical Transmission Electron Microscopy

Analytical transmission electron microscopy (AEM) was conducted on fuel from the outer edge, mid-radius, and center of a section of the fuel from the peak-power region of Rod ADD2974, which had low fission gas release. The AEM examination revealed wide variations in UO_2 grain sizes, local porosity, and subgrain structure; ceramography of the fuel also indicated a range in grain sizes, porosity, and the distribution of porosity.

At the outer edge and mid-radius of the fuel, bubbles and solid particles were uniformly distributed within the UO_2 grains. Regions near grain boundaries of the edge sample were locally denuded of bubbles. The grain boundaries in the fuel of the edge and mid-radius samples contained closely-spaced arrays of 2- to 10-nm-diameter gas bubbles and scattered 10- to 100-nm-diameter particles. The particles at the grain boundaries and within the fuel grains were identified by electron diffraction and energy-dispersive

X-ray spectrometry as the ϵ -ruthenium phase (ϵ -phase), which is composed of molybdenum, ruthenium, technetium, rhodium, and palladium. The ϵ -phase is the only fission product solid observed at all fuel locations.

At the center of the fuel rod, the ϵ -phase particles were up to 90 nm in diameter within the grains and up to 1000 nm along the grain boundaries. Few bubbles were observed within the grains and no bubbles were seen at the grain boundaries of the center sample of fuel, even though some gas bubbles appeared in ceramographic examinations of this low-release fuel. The particles within the grains were associated with xenon-rich regions that appeared to be a separate phase. ϵ -phase particles with high local concentrations of xenon were found previously near the mid-radius and center of ATM-103 fuel. The presence of xenon-enriched particles within the fuel grains near the center of the peak-power regions of fuel rods appears to be the general rule in commercial light-water fuels, and may be important for the interpretation of gas release behavior under fuel operating or storage conditions. The arrays of grain boundary bubbles revealed by AEM examination of both ATM-105 and ATM-103 may also be important to oxidation and leaching of the fuel.

Fuel Ceramography and Autoradiography

Ceramography and autoradiography conducted on the fuel samples indicated a wide range of fuel microstructure in the two ATM-105 rods examined. The as-fabricated grain sizes apparently varied from about 11.5 μm to 13.5 μm in Rod ADD2974 and from about 14.8 μm to 17.6 μm in Rod ADD2966. The as-fabricated porosity also varied substantially. Operating fuel temperatures in the ATM-105 rods were apparently different enough to cause a wide range of grain growth. Up to 14% grain growth occurred in Rod ADD2974, which had 0.6% fission gas release; in Rod ADD2966, which had 7.9% fission gas release, there was 62% or more grain growth. Only a few metallic ingots and fission gas bubbles were observed in the peak-power fuel samples from Rod ADD2974, but extensive metallic ingot and fission gas bubble formation was observed in Rod ADD2966.

Beta-gamma autoradiography also indicated major differences between the two ATM-105 fuel rods. While there were no indications of fission product redistribution in low-release Rod ADD2974, beta-gamma autoradiography of

high-release Rod ADD2966 indicated depletion of some volatile fission products from the center of the fuel and accumulations of fission products near the cladding interior surface. As noted above, the apparent deposits of fission products observed in the beta-gamma autoradiography are consistent with the observed grain growth and deposits of cesium and iodine measured during radiochemical analyses.

Cladding Metallography

Metallography was conducted on the Zircaloy-2 cladding from Rods ADD2966 and ADD2974 to evaluate the deposits on the interior and exterior cladding surfaces and the hydriding within the cladding. Cladding samples were taken from several locations representative of different combinations of fuel and cladding operating temperatures.

Examinations were conducted on interior and exterior cladding surfaces from low-power and peak-power locations. The interior cladding surfaces of samples from low-release Rod ADD2974 had nonuniform deposits up to about 10 μm thick on otherwise bare cladding; the high-release rod had more-uniform deposits that occasionally included small pieces of fuel. At least two unidentified phases are indicated in the deposits on the interior cladding surface of the peak-power sample examined from Rod ADD2974. Two kinds of oxide layers appeared on the exterior surface of the cladding: a thin (5- to 10- μm) layer and occasional nodular regions up to 64 μm thick. An additional layer, possibly crud, appears on the exterior surface of a few cladding samples; the crud may be lost from most of the samples during sample preparation.

Hydriding in the Zircaloy-2 cladding increased from the bottom towards the top of the fuel rod. Hydriding was almost nonexistent in the sample taken towards the bottom of the fuel rod. The hydrides in the Zircaloy-2 from ATM-105 are shorter and more randomly oriented than those observed in the Zircaloy-4 cladding of ATM-103 or ATM-106.

Measured vs. Anticipated Characteristics

Measured characteristics of ATM-105 spent fuel agree well with characteristics reported in the literature for early-vintage BWR fuel, the fuel classification to which ATM-105 belongs. In all instances where previously measured data could be found for a given characteristic, the ATM-105 data fit within the reported range of data for that characteristic. Details of the comparisons between ATM-105 as-measured and as-expected characteristics are given in Section 5.0.

3.0 CHARACTERIZATION PLAN FOR ATM-105

The characterization plan for ATM-105 was prepared by the MCC and approved by the repository project. The plan describes standard examinations that are performed on all rods and detailed examinations that are performed on three representative rods. Information is provided below on the types of analyses conducted on rods receiving standard or detailed examinations as well as the criteria for selecting rods for detailed characterization.

3.1 STANDARD EXAMINATIONS

As can be seen in Figure 3.1, the first step in the MCC's characterization of spent fuel ATMs is to perform a full-length gamma scan on each of the intact fuel rods. A correlation between cesium activity and burnup will be developed for each spent fuel ATM, which will make it possible to define the burnup of samples from any portion of a rod from a given ATM after the rod has been gamma scanned. The gamma scan data also provide valuable information on fission product movement in the rod (such as cesium migration) and on densification or shifts, if any, in the fuel column.

After gamma scanning, each rod (except for the rod used as a gamma scan reference) is punctured and a gas sample is taken. Analysis of the gas provides an estimate of the fission gas released from the fuel during irradiation. The magnitude of the fission gas release is an indication of the extent of the microstructural changes that have occurred in the fuel. These microstructural changes may be important to the dissolution of fuel in a potential repository. The magnitude of fission gas release is also indicative of the fraction of volatile fission products, such as cesium and iodine, which have migrated to the grain boundaries and the gap between the fuel and cladding. Quantifying the inventory of fission products in the gap and at the grain boundaries is important because fission product release in a potential repository after the waste package barriers are breached will occur from these locations first and will be independent of the dissolution rate of the matrix.

It is planned to gamma scan and fission gas sample a number of ATM-105 rods to 1) have a backlog ATM-105 material that can be made available

immediately upon request, 2) document the homogeneity of or differences between the ATM-105 rods, and 3) provide a means of correlating measured data for fully characterized fuel rods with the gamma scan and fission gas release data that will be obtained from other ATM-105 fuel rods.

3.2 DETAILED EXAMINATIONS

As shown in Figure 3.1, samples are taken from several locations along the length of a rod receiving detailed characterization. Three rods from each ATM are scheduled to receive detailed characterization. Samples are scheduled to be taken for radiochemical analysis of the fuel and cladding, metallography of the cladding, ceramography of the fuel, analysis of the assembly hardware, and special examinations involving spark-source mass spectrometry (SSMS), electron probe microanalyses (EPMA), and analytical transmission electron microscopy (AEM).^(a)

A principle purpose of sampling the fuel rod at different locations is to determine the bulk inventory of long-lived radionuclides in fuel with different burnups. The fission products, actinides, and activation products of interest in assessments of geologic disposal are analyzed. Samples are taken from the peak-power region of the rod that corresponds with the region of maximum gamma activity, and from additional locations of lower power near the rod ends. Generally, the radionuclide concentrations are obtained from radiometric measurements of dissolved or, in the case of ^{14}C , thermally decomposed samples. In addition to the radiometric measurements, thermal ionization and SSMS are being used to obtain the bulk concentration of selected isotopes to supplement the data obtained from radiochemical methods or as overchecks on the determined values.

One major type of examination involves measuring the bulk concentrations of the radionuclides of interest to geologic disposal and comparing the results with predictions made using the ORIGEN2 computer code. These calculations are based on measured and estimated burnups for samples from the rods

(a) The actual number and location of samples in a given rod or rods from an ATM may vary from the generic plan shown in Figure 3.1 depending on the results of the gamma scans, fission gas analyses, additional requests for samples, or other factors.

Report Sections	Type of Characterization	Description	
Sec. 4.3 & Append. B&D	Gamma Scan ^(a)	Selected isotopes, e.g., Cs-137, Cs-134, etc.	Bottom
Sec. 4.4 & Append C	Fission Gas ^(a)	H ₂ , Ar, Kr, Xe, N ₂ , O ₂ , CO ₂ (C-14), etc.
Sec. 4.8	Burnup	Nd-148 method, isotopes of U and Pu
Sec. 4.8	Specific Radionuclides	Se-79, Sr-90, Tc-99, Sn-126, Cs-135, Cs-137, Np-237, Am-241, and Cm-243 plus Cm-244	
	Spark Source Mass Spectroscopy (ORNL)	Radial distribution (six points on radius) of most fission products and actinides, plus bulk concentration of same radionuclides (adjacent sample)	
Sec. 4.5 & Append E	Fuel Ceramography	Amount and type of cracking, grain size and structure, porosity and noble metal fission product particles
Sec. 4.5 & Append E	Cladding Metallography	Hydride orientation, interior and exterior surface oxidation, crud on exterior surface, if present	
	Microprobe	Radial distribution of selected elements	
Sec. 4.5 & Append E	Autoradiography	Alpha and beta-gamma intensity maps
Sec. 4.8	I-129 Distribution	Bulk concentration in fuel and chemically stripped from interior cladding surface	
Sec. 4.8	Cs-135 and Cs-137 on Cladding	Chemically stripped from interior and exterior cladding surfaces	
Sec. 4.8	C-14 Distribution	Bulk concentration in fuel and cladding	
Sec. 4.6	Transmission Electron Microscopy	Fission product distribution within grains and at grain boundaries
	Activation Products in Assembly Hardware	C-14, Ni-59, Ni-63 and Nb-94	
	Crud Analyses ^(b)	C-14 and selected radionuclides	

- ^(a) Conducted on all rods
^(b) Conducted on one rod per ATM
^(c) Transverse and longitudinal examinations
^(d) Transverse section examinations only

FIGURE 3.1. Characterization of Spent Fuel ATMs

ted samples of grids, springs and subfittings

om cladding of boiling water reactor fuel only, eg , ATM 105

and the power history for the fuel rod. Comparison of the measured and predicted values serves to validate the ORIGEN2 code for use in predicting the radionuclide inventory in samples from other locations or other rods from the spent fuel ATMs at any decay time of interest.

In addition to determining the bulk concentrations of radionuclides in the fuel and cladding, characterization is also directed towards obtaining information on the radionuclide distribution in the fuel. Information on the nonuniform distribution of radionuclides will assist in providing an understanding of the preferential release of certain radionuclides that is observed in leach testing of spent fuel (Oversby and Wilson 1985). Special emphasis is being placed on determining the ^{14}C distribution in the fuel, cladding, crud, and assembly hardware because less is known about the actual concentrations of this radionuclide than most of the other radionuclides. Several mutually supportive techniques are being used to evaluate nonuniform distribution, including autoradiography, EPMA, AEM, SSMS of small radial samples from fuel pellets, and radiochemical analyses of material chemically stripped from the interior cladding surfaces.

Another major type of examination involves metallography and ceramography of samples from the peak-power and other lower-power regions of the fuel rod. Because cladding corrosion varies along the entire length of the rod, metallographic samples from the lower-power regions of the bottom and the top of the rod are examined. An understanding of cladding characteristics is needed because the cladding may serve as an important barrier during geologic disposal. Cladding corrosion on both the water side and fuel side is evaluated, along with hydriding and any crud deposition. Ceramography of the fuel is conducted to evaluate 1) the amount and location of fuel grain growth, 2) fission gas bubble formation and distribution, 3) the amount and distribution of fuel pellet cracking, 4) as-fabricated porosity and changes caused during irradiation, and 5) the formation of noble metal fission product agglomerates. Ceramography is important to interpreting differences in the behavior of fuel in leach tests and oxidation tests. Ceramography is also very important in establishing the characteristics of the individual spent fuel ATMs for comparison with the overall spent fuel population.

As indicated in Figure 3.1, selected samples from the spent fuel ATM assembly hardware will also be analyzed for specific activation products. To interpret this information, it will also be necessary to analyze for the precursor isotopes. The inventory of activation products in hardware is an important part of the evaluation of repository performance.

Special examinations consisting of SSMS, EPMA, and AEM are planned for selected samples from the rods that are receiving detailed characterization. As previously noted, SSMS is used to confirm the bulk measurements made by radiochemistry as well as to provide measurements of nuclides for which radiochemistry is not conducted. EPMA is used to determine the distribution of elements across the fuel radius and may prove useful in identifying secondary phases in the fuel and on the cladding. AEM provides a method for examining the fuel on a scale approaching the atomic level and can identify phases and structures that are not discernible in normal ceramography but are important to the understanding of the distribution of fission products in the fuel.

3.3 SELECTION OF RODS FOR DETAILED EXAMINATION

ATM-105 was selected for characterization because it contained BWR fuel rods with moderate burnup and expected fission gas releases from the fuel of about 1%. BWR fuel rods with a combination of moderate burnup and low to high fission gas release are one type of spent fuel that is expected to be emplaced in a geologic repository.

Because all of the ATM-105 rods had similar moderate burnups according to data provided by the vendor, it was desired to perform detailed examinations on ATM-105 rods with fission gas releases representative of ATM-105. Gamma scanning and fission gas sampling were used to select the rods that received detailed characterization.

Four ATM-105 rods from locations near the center of the fuel bundle were selected for the initial gamma scanning and fission gas sampling. Results of the gamma scanning and fission gas sampling indicated a range of fission gas release. Rod ADD2966 was selected for detailed characterization because it had distinct indications of cesium release and possible movement in the gamma scan as well as a measured fission gas release of ~8%. Although Rod ADD2974

had no indication of cesium release and had <1% fission gas release, it was also selected for detailed characterization because low release and moderate burnup were expected to be typical for ATM-105. Rod ADD2937 was preselected to be the reference rod for gamma scanning examinations; therefore, it was gamma scanned only. Additional ATM-105 fuel rods will be gamma scanned and fission gas sampled to establish the rod-to-rod variability among the ATM-105 fuel rods and to select the next rod to receive detailed characterization. The results of the detailed examinations of Rods ADD2966 and ADD2974 and the limited examinations conducted on Rod ADD2937 are discussed in Section 4.0.

4.0 CHARACTERIZATION OF ATM-105

The following detailed characterization of ATM-105 spent fuel consists of a description of the fuel rods and bundle design, the irradiation history, postirradiation handling and transportation, and a variety of destructive and nondestructive examinations conducted on Rods ADD2937 (the gamma scanning reference rod), ADD2966, and ADD2974 from ATM-105. Sections 4.1 and 4.2 include information on the as-fabricated fuel rod design, irradiation histories, and subsequent storage and handling of the 98 fuel rods in Bundles CZ346 and CZ348 that comprise ATM-105 and ATM-108. The remaining sections deal with the examinations conducted to date on Rods ADD2937, ADD2966, and ADD2974. This information includes 1) gamma scans (Section 4.3), 2) fission gas analyses (Section 4.4), 3) ceramography and metallography of the fuel and cladding (Section 4.5), 4) special fuel studies involving analytical transmission electron microscopy (AEM) (Section 4.6), 5) calculated nuclide inventories and radioactivities in the fuel and cladding (Section 4.7), and 6) radiochemical analyses of the fuel and cladding as well as a comparison with predicted values (Section 4.8).

4.1 BUNDLE AND FUEL ROD DESCRIPTIONS

ATM-105 consists of two spent fuel bundles (CZ346 and CZ348) from the Cooper Nuclear Power Plant located near Brownville, Nebraska, and operated by the Nebraska Public Power District. The bundles were manufactured in 1972, and are of the GE 7 x 7 design as shown in Figure 4.1. Available bundle and fuel rod design parameters are given in Table 4.1. The information in this and the next section (4.1 and 4.2) was provided primarily by GE.

The GE 7 x 7 fuel bundle has upper and lower end fittings that are fabricated from Type 304 stainless steel castings. Zircaloy-4 fuel rod spacers, equipped with Inconel^(a) X-750 springs, maintain rod-to-rod spacings within the bundle. There are also Inconel X-750 expansion springs located

(a) Inconel is a registered trademark of Huntington Alloys (INCO Alloys International), Huntington, West Virginia.

FIGURE 4.1. General Electric 7 x 7 Fuel Bundle

TABLE 4.1. ATM-105 Fuel Bundle and Rod Design Parameters

<u>Design Parameter</u>	<u>Description</u>	
Fuel rod array	7 x 7	
Overall bundle length	447.5 cm	(176.2 in.)
Nominal active fuel length	371 cm	(146 in.)
Fuel rod pitch	1.87 cm	(0.738 in.)
Outside rod diameter	1.43 cm	(0.563 in.)
Cladding thickness	0.094 cm	(0.037 in.)
Cladding material	Zircaloy-2	
Pellet outside diameter	1.21 cm	(0.477 in.)
Fuel pellet material	UO ₂ (a)	
Pellet immersion density	10.32 g/cm ³	(0.37 lb/in ³)
Fission gas plenum length	35.6 cm	(14 in.)
Helium fill gas pressure	1.0 atm	(14.7 psia)

(a) Five fuel rods that contain UO₂ and Gd₂O₃ have been redesignated as ATM-108; they will be removed from the bundles and characterized.

over the top end-plug pin of each fuel rod to keep the fuel rods seated in the lower tie plate and allow them to expand axially through holes in the upper tie plate to accommodate thermal expansion and irradiation growth.

Three types of fuel rods, all clad with Zircaloy-2, are in fuel Bundles CZ346 and CZ348: tie rods, one segmented rod (spacer capture rod), and standard rods. The location of the tie rods, segmented rod, and standard rods are shown in Figure 4.2.

The tie rods have threaded-end plugs that thread into the lower tie plate casting and extend through the upper tie plate casting. The upper ends of the tie rods are secured with lock nuts to hold the bundle together. The central fuel rod in each fuel bundle is segmented, consisting of eight individual tubes of fuel pellets separated by Zircaloy-2 connectors; this rod is one of the ATM-108 rods.

Wide-Wide Corner						
4	3	T 3	2	T 2	2	3
3	7	1	1	1	1	2
T 3	1	1	1	1	5	T 1
2	1	1	S 5	1	1	1
T 2	1	1	1	1	1	T 1
2	1	5	1	1	6	2
3	2	T 1	1	T 1	2	2

Fuel Bundle Map

Rod Type	Enrichment, Wt%, U-235	Wt% Gd ₂ O ₃	Number of Rods
1	2.93	0	26
2	1.94	0	11
3	1.69	0	6
4	1.33	0	1
5	2.93	3.0	3
6	2.93	4.0	1
7	1.94	4.0	1

Legend

S - Spacer Capture Rod

T - Tie Rods

FIGURE 4.2. Location of Different Type Fuel Rods in Bundles CZ346 and CZ348

Over half of the fuel rods had an initial ^{235}U enrichment of 2.94 wt%, as do the rods that are characterized in this report. (a) Rods with three lower initial ^{235}U enrichments are also present in the bundles. The segmented central fuel rod (also called a spacer capture rod) contains 3 wt% Gd_2O_3 . Four of the standard rods contain either 3 or 4 wt% Gd_2O_3 . All of the fuel rods with gadolinia have been redesignated as ATM-108 and are still in the BWR bundles pending characterization. The ^{235}U and Gd_2O_3 enrichments in the various types of rods are shown in the legend for Figure 4.2. Fuel rod loading diagrams for Bundles CZ346 and CZ348 are shown in Figures 4.3 and 4.4, respectively.

Only limited data are available for the material properties and design specifications for the fuel and Zircaloy-2 cladding of ATM-105 fuel rods. Most of the information, such as as-fabricated grain size and fuel or cladding as-fabricated impurities, are proprietary information. However, some information can be obtained related to the as-fabricated condition of the fuel from the examinations being conducted by the MCC. The pellets are flat-ended (not dished as in other ATMs) with chamfered edges. The pellets are about 1.3 cm (0.5 in.) long based on the gamma scan data; the regular dips in the gamma activity occur at pellet-pellet interfaces and are a means of confirming the pellet length. The longitudinal sections did not include any full-length pellets; however, the length estimated using the gamma scan data appears reasonable. Estimates for the as-fabricated fuel grain size are provided in Section 4.5.2. Assumptions for the impurities in the fuel and cladding, which are particularly important to ORIGEN2 predictions of activation products, are given in Section 4.7.

4.2 IRRADIATION AND HANDLING HISTORY

The two fuel bundles (CZ346 and CZ348) that contain the ATM-105 spent fuel rods were irradiated in the Cooper BWR, stored wet at the reactor site, and subsequently sent to the GE Morris Facility for use in a dry storage

(a) The enrichments listed in Figure 4.2 are the goal enrichments and may be slightly different than the actual enrichments; the 2.93 wt% enrichment for ^{235}U in the Type 1 rods was measured by GE as 2.939 wt%.

	a	b	c	d	e	f	g
1	ADH 0429	ADG 0646	ADC 0547	ADE 2270	ADB 0321	ADE 1575	ADG 0653
2	ADG 0621	ADP 0262	ADD 2965	ADD 2963	ADD 2967	ADD 2961	ADE 1553
3	ADC 0506	ADD 2966	ADD 2974	ADD 2937	ADD 2950	ADN 0206	ADA 0724
4	ADE 1507	ADD 2964	ADD 2945	ADZ 0472	ADD 2946	ADD 4319	ADD 2931
5	ADB 0309	ADD 4320	ADD 4352	ADD 4361	ADD 4326	ADD 4373	ADA 0714
6	ADE 1527	ADD 4368	ADN 1313	ADD 4353	ADD 4363	ADS 0134	ADE 1569
7	ADG 0662	ADE 1540	ADA 1715	ADD 4347	ADA 1771	ADE 1548	ADE 1537

FIGURE 4.3. Loading Diagram for Bundle CZ346 (characterized rods are denoted in highlighted boxes)

	a	b	c	d	e	f	g
1	ADH 0458	ADG 0635	ADC 0507	ADE 1526	ADB 0327	ADE 1529	ADG 0658
2	ADG 0633	ADP 0206	ADD 4351	ADD 4312	ADD 4357	ADD 4345	ADE 1573
3	ADC 0522	ADD 4310	ADD 4304	ADD 4301	ADD 4336	ADN 1364	ADA 0757
4	ADE 1551	ADD 4355	ADD 4359	ADZ 0426	ADD 4303	ADD 4330	ADD 4338
5	ADB 0341	ADD 4321	ADD 4305	ADD 4324	ADD 4340	ADD 4343	ADA 0708
6	ADE 1572	ADD 4332	ADN 1370	ADD 4354	ADD 4374	ADS 0113	ADE 1550
7	ADG 0650	ADE 1531	ADA 0761	ADD 4350	ADA 0769	ADE 1545	ADE 1560

FIGURE 4.4. Loading Diagram for Bundle CZ348

test. The two fuel bundles were then sent to PNL and stored at the Hanford Site for use by the MCC. A brief description of the irradiation history and subsequent handling is provided below.

4.2.1 Irradiation History

Cooper operates with 548 fuel bundles. Fuel bundle initial enrichments are an average of the rod-average enrichments such as shown in Figure 4.2. The two ATM-105 bundles were irradiated in Cycles 1, 2, 3, 6, and 7, as shown in Table 4.2. The initial bundle average enrichments for the two ATM-105 bundles were 2.5%. The bundles were removed for Cycles 4 and 5. The operating history for Cooper is depicted in Figure 4.5. The rod-average linear heat generation rate (LHGR) for Bundle CZ346 was based on the reactor operating history and end-of-cycle burnups for Bundle CZ346 given in Table 4.2 and is graphically displayed in Figure 4.6. The rod-average LHGR for Bundle CZ346 ranged from a high of about 28 kW/m (8.5 kW/ft) at the beginning of Cycle 1 to a low of about 11.5 kW/m (3.5 kW/ft) at the end of Cycle 7. Additional details on the operating history and determination of the power history for ATM-105 fuel rods are provided in Appendix A.

TABLE 4.2. Cooper Power History and Burnup Levels of Bundles CZ346 and CZ348 (McKinnon et al. 1986)

Cycle	Ave. Reactor Power (MW)	Startup	Shutdown	Bundle Burnup, MWd/kgM			
				CZ-346		CZ-348	
				<u>ΔBU</u>	<u>Total</u>	<u>ΔBU</u>	<u>Total</u>
1	1500	07/04/74	09/17/76	13.90	13.90	13.10	13.10
2	1750	11/16/76	09/17/77	5.24	19.14	5.93	19.03
3	1750	10/18/77	03/31/78	2.78	21.92	3.08	22.11
6	2150	06/08/80	04/20/81	3.28	25.20	2.66	24.77
7	1750	06/08/81	05/21/82	2.85	28.05	2.71	27.48

Cooper Station Operating History (Cycles 1 to 3)

Cooper Station Operating History (Cycles 4 to 7)

FIGURE 4.5. Cooper Nuclear Power Plant Operating History (McKinnon et al. 1986)

Cycle No.	1	2	3	6	7
Start/End of Cycle	07-04-74/ 09-17-76	11-16-76/ 09-17-77	10-18-77/ 03-31-78	06-08-80/ 04-20-81	06-08-81/ 05-21-82
Cycle Duration, months	~27	~10	~5.5	~10.5	~11.5
Cycle Burnup, GJ/kgM (MWd/kgM)	1201 (13.90)	453 (5.24)	240 (2.78)	283 (3.28)	246 (2.85)
Cumulative Burnup, GJ/kgM (MWd/kgM)	1201 (13.90)	1654 (19.14)	1894 (21.92)	2177 (25.20)	2424 (28.05)

FIGURE 4.6. Power History for Bundle CZ346 (based on data from McKinnon et al. 1986)

4.2.2 Handling History

The two bundles that make up ATM-105 were shipped from the Cooper storage pool to the pool at the GE Morris Facility, used in a dry storage cask test, and shipped to PNL. The bundles are stored at PNL dry for use by the MCC.

At the GE Morris Facility, the two bundles were among 52 BWR spent fuel bundles that were used in performance testing of the Ridihaugh, Eggers and Associates (REA) 2023 BWR spent fuel storage cask. The tests were conducted during the 1984/1985 winter (McKinnon et al. 1986). Bundles CZ346 and CZ348 were in the REA 2023 cask during 14 tests that were conducted. The tests were conducted primarily for the purpose of evaluating the effects of different backfill gases and cask orientations on the heat transfer characteristics of the cask. Cask temperatures were recorded hourly until steady-state was attained during each test run. The duration of most tests was less than a week.

As a result of being used in the REA 2023 storage cask tests, the ATM-105 spent fuel bundles have experienced more thermal cycling during post-irradiation storage than would normally occur. However, the maximum test temperatures during the cask tests were quite low, generally being in the 100 to 200°C range (McKinnon et al. 1986). The highest temperature reached was about 230°C. Thermal cycling at these low temperatures is not believed to have had any effect on the characteristics of ATM-105. Selected fuel bundles were inspected before and after the cask tests to determine if the cask tests had any effect on the fuel rod integrity; no effects were found. All of the fuel bundles were sipped at the GE Morris facility to determine if any of the fuel rods were leaking.

The two ATM-105 bundles were shipped dry from Morris, Illinois, to PNL at the Hanford Site in January 1986 and have been stored in air in B-cell of the 324 Building since then. There have been no unusual incidents associated with these fuel rods. Four rods (see Table 4.3) were removed from Bundle CZ346 in April 1987 and transferred to D-cell, 324 Building, where the intact fuel rods are stored in air at ambient temperature of ~25°C until they are sectioned to obtain samples for analysis or testing. The fuel rod sections

TABLE 4.3. Initial ATM-105 Fuel Rods to be Characterized and Used in Repository Project Testing Program

<u>Rod Number</u>	<u>Rod Location (a)</u>	<u>Comments</u>
ADD2937	3d	Gamma scan reference rod
ADD2963	2d	To be characterized
ADD2966	3b	Receiving in-depth characterization
ADD2974	3c	Receiving in-depth characterization

(a) Locations refer to Figure 4.3.

remaining after sectioning are stored in stainless steel tubes filled with argon and sealed with Swagelok fittings. The four rods removed from CZ346 are listed in Table 4.3 along with their bundle locations. These rods are being characterized by the MCC (see Section 4.3 through 4.8) and are available for use in the repository testing program.

4.3 GAMMA SCANNING RESULTS

Each fuel rod was gamma scanned axially using a germanium-lithium gamma-ray detector. Details on the gamma scanning equipment and procedure are provided in Appendix B. The same counting geometry, counting equipment, analyzing equipment, and data storage equipment were used for each measurement. This system is the same system used to measure the gamma activity in the ATM-103 and ATM-106 fuel rods. As in the gamma scans for other MCC spent fuel rods, the gamma scans for standard rods in ATM-105 are preceded and followed by gamma scans of short portions of a reference rod. The reference rod for ATM-105 is Rod ADD2937.

Initial spectral counting of the high-activity regions of the reference Rod ADD2937 showed significant gamma ray peaks at 605 KeV (^{134}Cs), 662 KeV (^{137}Cs), and 796 KeV (^{134}Cs), as was the case for all previous ATMs examined. The activity was sufficient to provide adequate counting statistics. The detailed results of the gamma scanning are provided in Appendix B for Rods ADD2937, ADD2966, and ADD2974.

The gamma scanning procedure requires the measurement of the as-irradiated fuel rod length from one end cap to the other. The as-measured fuel rod lengths are summarized in Table 4.4 for the three ATM-105 rods that have been gamma scanned.

The ^{137}Cs gamma activity along the fuel rod length is shown in Figures 4.7 and 4.8 for Rods ADD2974 and ADD2966, respectively. About 60 cm (2 ft) of the bottom end of each BWR fuel rod was not gamma scanned because of clearance limitations in the hot cell. These unscanned portions are contained in sections that have been cut from the rods and will be gamma scanned and reported later. A few centimeters of the top end of the fuel column also was not scanned.

The ^{137}Cs gamma scan for Rod ADD2974 is similar in nature to those seen for the PWR fuel rods from ATM-103. The regular dips in cesium activity in Figure 4.7 indicate interfaces between pellets. Measurement of several of these regular intervals indicates that the pellet length is about 1.3 cm (0.5 in.). The ^{137}Cs activity decreases about 5% at the location of each grid spacer. There is also a short region at about 330 cm (130 in.) from the bottom of the fuel rod where the gamma scan indicates part of the fuel has lower than normal activity: relocation of fuel fragments is indicated.

Rods ADD2974 and ADD2966 were irradiated next to each other in Bundle CZ346 (see Figure 4.3). However, the spikes of cesium activity in the bottom half of Rod ADD2966 are 5 to 10% higher than the nominal cesium levels. There were no spikes in cesium activity at comparable axial locations in Rod ADD2974 along the bottom half of the rods. Such variations between sibling rods in adjacent rod positions were also seen in ATM-106 fuel rods

TABLE 4.4. Fuel Rod Lengths Measured During Gamma Scanning

<u>Fuel Rod Number</u>	<u>As-Irradiated Fuel Rod Length, m (in.)</u>
ADD2937	4.160 $\pm$ 0.003 (163.8 $\pm$ 0.2)
ADD2966	4.155 $\pm$ 0.003 (163.6 $\pm$ 0.2)
ADD2974	4.163 $\pm$ 0.003 (163.9 $\pm$ 0.2)

FIGURE 4.7. Gamma Scan for ^{137}Cs Along Length of Rod ADD2974

FIGURE 4.8. Gamma Scan for ^{137}Cs Along Length of Rod ADD2966

(Guenther et al. 1988b). For the ATM-106 rods, it was noted that the cesium spikes were larger and more prevalent as the fission gas release increased from 1 to 11%. Although the correlation between fission gas release and cesium release may be different for the ATM-105 and ATM-106 rod designs, it is expected that greater lengths of the ATM-105 rods will exhibit spikes of cesium in the gamma scans when the level of fission gas release is greater.

4.4 FISSION GAS ANALYSES

The amount of fission gas release and the subsequent composition of the gas in the fuel rod void space can appreciably affect the fuel temperatures during reactor operation. This in turn can have an effect on the final characteristics of the spent fuel by increasing grain size, promoting additional fission gas release, and changing the distribution of some fission products within the fuel. The extent of this effect depends on the initial gas composition and pressure, initial fuel characteristics, power history, and final burnup. Fission gas analyses were made to determine the fission gas release from the fuel in Rods ADD2966 and ADD2974. The procedures for gas sampling, void volume measurement, and determination of the gas volume are described in Appendix C. Results are provided below for the elemental and isotopic gas analyses, measurement of ^{14}C in the gas, and calculated fission gas releases.

4.4.1 Elemental and Isotopic Gas Analyses

Analyses were conducted on gas samples from two ATM-105 rods to determine the components of the gas in the rods, the amount of the krypton and xenon isotopes, and the amount of ^{14}C in the gas.

Elemental Gas Analyses

The results of the elemental gas analyses for the ATM-105 rods are listed in Table 4.5. These data were obtained using a mass spectrometer. The primary components of the gas sample were helium, the fill gas used during fabrication, and xenon and krypton fission gas. There were no significant indications of air in the ATM-105 fuel rods. Unexpectedly, argon gas was also indicated in the analyses. Based on information provided by GE,

TABLE 4.5. Gas Composition for ATM-105 Fuel Rods, Vol%

<u>Rod No.</u>	<u>He</u>	<u>Xe</u>	<u>Kr</u>	<u>Ar</u>	<u>H₂</u>	<u>CO₂</u>	<u>CO</u>	<u>N₂</u>	<u>O₂</u>	<u>Organics</u>	<u>Xe-to-Kr Ratio</u>
ADD2966	25.5	66.0	7.67	0.73	<0.01	<0.01	<0.05	0.05	0.01	<0.01	8.60
ADD2974	74.5	19.9	2.37	3.16	<0.01	<0.01	<0.01	0.04	0.01	<0.01	8.40

the source of the argon has been attributed to residual argon left during fabrication of the rods. Evaluation of the gamma scans indicated higher fission gas release in Rod ADD2966 than in Rod ADD2974 and is confirmed by the higher xenon and krypton contents in Rod ADD2966 (see Table 4.5).

The BWR rods had a much higher percentage of fission products in the gas samples than observed for the ATM-103 and ATM-106 rods with comparable fission gas release levels because the BWR rods were initially filled with only 0.1 MPa (1 atm) of helium, as compared with >3 MPa (30 atm) for the PWR rods. Because of the lower initial fill gas pressure, comparable releases of fission gas dilute the fill gas more in the BWR fuel rods, although this is partially offset by a BWR plenum volume that is about twice as large as in the PWR rods.

The xenon-to-krypton ratio of approximately 8.5 (based on volume or mole %) for the two rods is slightly lower than the value of approximately 9.1 for the low-releasing PWR fuel with moderate burnup (ATM-101 and ATM-103) and about 9.2 for high-releasing PWR fuel with high burnup (ATM-106). However, these results are consistent with the xenon and krypton levels predicted using ORIGEN2. Assuming a 30 MWd/kgM average burnup and a 5.0-year discharge time, ORIGEN2 calculations described in Section 4.7 result in a xenon-to-krypton ratio of 9.0. The ratio of xenon and krypton in the gas sampled from the ATM-105 rods is about 5% lower than the predicted value.

Xenon and Krypton Isotopes in the Gas

The amounts of xenon and krypton gas recovered from each rod were evaluated in two ways. First, the volume percentages of the total rod gas were determined for xenon isotopes and krypton isotopes; the total rod gas includes the original fill gases plus any gases released to the rod void as

shown in Table 4.5. Second, the relative amounts of the various isotopes that make up the total xenon or krypton gas were determined and compared with the values predicted using ORIGEN2.

The isotopic gas analyses for xenon and krypton as a percentage of the total rod gas are given in Tables 4.6 and 4.7, respectively. As indicated in Tables 4.6 and 4.7, the volume percentage of both xenon and krypton increased as expected based on the gamma scanning results. The volume percentage of both xenon and krypton are about three times higher in Rod ADD2966 than in Rod ADD2974.

The relative amounts of the xenon or krypton isotopes measured in the rod gas are given in Tables 4.8 and 4.9, respectively. The relative amounts of the different isotopes of xenon and krypton estimated by using the ORIGEN2 code (see Section 4.7) assuming a discharge time of 5.0 years and 30 MWd/kgM burnup are also listed in Tables 4.8 and 4.9. The relative amounts predicted using ORIGEN2 are very close to the measured values. Even though Rod ADD2966 had substantially more xenon and krypton in the total gas, the relative amounts of xenon and krypton isotopes were about the same in both ATM-105 rods.

TABLE 4.6. Percentages of Xenon Isotopes in Total Rod Gas

<u>Rod No.</u>	<u>Volume Percentage</u>					
	<u>^{128}Xe</u>	<u>^{130}Xe</u>	<u>^{131}Xe</u>	<u>^{132}Xe</u>	<u>^{134}Xe</u>	<u>^{136}Xe</u>
ADD2966	0.03	0.15	5.61	13.5	19.3	27.4
ADD2974	0.006	0.03	1.69	4.04	5.83	8.33

TABLE 4.7. Percentages of Krypton Isotopes in Total Rod Gas

<u>Rod No.</u>	<u>Volume Percentage</u>				
	<u>^{82}Kr</u>	<u>^{83}Kr</u>	<u>^{84}Kr</u>	<u>^{85}Kr</u>	<u>^{86}Kr</u>
ADD2966	0.02	0.89	2.44	0.29	4.03
ADD2974	0.006	0.3	0.74	0.09	1.23

TABLE 4.8. Relative Amounts of Xenon Isotopes in Xenon Gas

Rod No.	Relative Volume Percentage					
	^{128}Xe	^{130}Xe	^{131}Xe	^{132}Xe	^{134}Xe	^{136}Xe
ADD2966	0.05	0.23	8.5	20.5	29.2	41.5
ADD2974	0.03	0.15	8.48	20.3	29.3	41.8
Predicted(a)	0.06	0.23	8.65	21.2	28.6	41.2

(a) Relative amount of xenon isotopes predicted by ORIGEN2 (see Section 4.7) assuming a burnup of 30 MWd/kgM and 5.0-year discharge.

TABLE 4.9. Relative Amounts of Krypton Isotopes in Krypton Gas

Rod No.	Relative Volume Percentage				
	^{82}Kr	^{83}Kr	^{84}Kr	^{85}Kr	^{86}Kr
ADD2966	0.26	11.6	31.8	3.8	52.5
ADD2974	0.25	12.7	31.3	3.8	52.0
Predicted(a)	0.26	11.9	31.7	3.8	52.3

(a) Relative amount of krypton isotopes predicted by ORIGEN2 (see Section 4.7) assuming a burnup of 30 MWd/kgM and 5.0-year discharge.

Carbon-14 in the Gas

The ^{14}C content in the gas removed from the two ATM-105 rods was determined by converting all forms of carbon in the gas to CO_2 , trapping the CO_2 in a caustic solution, and measuring it by beta-scintillation analysis. The ^{14}C content was about 0.012 nCi/cm³ for Rod ADD2966 and 0.0018 nCi/cm³ for Rod ADD2974 at standard temperature and pressure (STP). Based on void volume measurements of the irradiated Rods ADD2966 and ADD2974, the total ^{14}C in the plenums of these rods were 4.3 nCi and 0.2 nCi, respectively. This is comparable to the values measured in rods from ATM-103 and ATM-106. The ATM-101 fuel rods had values one to two orders of magnitude higher, apparently because of a small amount of residual nitrogen in the fill gas that activated to ^{14}C .

4.4.2 Fission Gas Release

Fission gas release was estimated to be 7.85% in Rod ADD2966 and 0.59% in Rod ADD2974. These values were obtained assuming 1) 31.0 cm³ of fission gas was generated for each MWd of burnup at standard temperature (0°C) and pressure (0.1 MPa, 1 atm) (SSA 1982), 2) data in Table 4.10, and 3) the calculated bundle-average burnup of 2424 GJ/KgM (28.05 MWd/kgM) provided by GE for the Type 1 rods.

Rod ADD2966 had about 13 times as much fission gas released as Rod ADD2974. Higher fission gas release was also indicated by the gamma scan data for Rod ADD2966 (see Figures 4.7 and 4.8). The measured fission gas releases are consistent with the different levels of apparent cesium release noted in Section 4.3 for the two ATM-105 fuel rods.

TABLE 4.10. Fission Gas Release Information for ATM-105 Fuel Rods^(a)

Rod No.	Total Recovered Gas at STP, cm ³	Xe + Kr, %	Volume of Xe + Kr at STP, cm ³	Bundle- Average Burnup, MWd/kgM	Estimated Fission Gas Produced, cm ³	Fission Gas Released, %
ADD2966	359	73.7	264.6	28.05	3370	7.85
ADD2974	89.7	22.3	20.0	28.05	3370	0.59

(a) Fuel weight in each rod was 3.875 kgM.

4.5 CERAMOGRAPHIC/METALLOGRAPHIC EXAMINATIONS

Selected samples were sectioned from ATM-105 Rods ADD2974 and ADD2966 for ceramographic examination of the irradiated fuel, metallographic examination of the irradiated cladding at the same location, and alpha and beta-gamma radiography of each sample. These samples were taken in coordination with several other samples taken for radiochemistry, analytical transmission electron microscopy, distribution to experimenters, and archiving. The sectioning was based on the results of the ^{137}Cs gamma scan and the desired number and types of examinations for this fuel. A brief summary of the sectioning process is provided below (Section 4.5.1) followed by analyses to date of the fuel ceramography (Section 4.5.2) and cladding metallography (Section 4.5.3) from Rods ADD2974 and ADD2966 of ATM-105.

4.5.1 Fuel Rod Sectioning and Sample Selection

After gamma scanning and fission gas sampling, a sectioning diagram was prepared for Rods ADD2974 and ADD2966. The sectioning was based on the characterization plan and the results of a ^{137}Cs gamma scan. The sections used for radiochemical, ceramographic, and metallographic analyses were 0.6 to 2.5 cm (0.25 to 1.0 in.) long. Each sample was designated with an alpha-numeric symbol in order of sectioning from the top of the fuel rod. During sectioning, care had to be taken to prevent fuel fragments from falling out of the fuel rod sections cut from the BWR fuel rods; however, some fuel fragments did relocate during sample preparation. Detailed descriptions of the fuel sections, their lengths, and locations in the fuel are given in Appendix D.

As indicated in Figure 4.9, a total of five samples were taken from Rod ADD2974 to provide detailed characterization across the fuel radius and at fuel axial locations with a variety of burnups. Similar sections from Rod ADD2966 that were or are currently being examined are shown in Figure 4.10 for comparison. (a) Transverse Sample 105-ADD2974-E, taken at the low-power

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- (a) Cladding metallography for Rod ADD2966 was changed slightly from that for Rod ADD2974. Only one photo location was photographed on each of the samples examined from Rod ADD2974. Photomicrographs were taken of the interior and exterior cladding surfaces at four symmetrical locations of transverse and longitudinal samples from Rod ADD2966.

FIGURE 4.9. Locations of Metallographic/Ceramographic Samples from Rod ADD2974

FIGURE 4.10. Locations of Metallographic/Ceramographic Samples from Rod ADD2966

region near the top of fuel Rod ADD2974, and transverse Sample 105-ADD2966-E from Rod ADD2966 also provide information on as-fabricated fuel data such as grain size and porosity.

4.5.2 Ceramography of ATM-105 Fuel

The fuel samples obtained from Rods ADD2974 and ADD2966 were taken to characterize porosity and microstructural variations as a function of radial position and axial location within the fuel rod. The general cracking pattern, porosity in the fuel, relocation of fuel (such as wedging of small fuel fragments in the gap) and as-irradiated gap width are of interest and can be observed in the as-polished transverse and longitudinal samples. The cracking pattern and gap width affect in-reactor temperatures. The number of fuel fragments/pieces and their sizes can be used to estimate the fuel surface area, a useful parameter for studies of fuel leaching. Fission gas bubble size and distribution, metallic ingots, and grain size variations are also of particular interest and can be observed after etching the fuel samples. Fission gas bubbles and metallic ingots are also seen in the as-polished condition when they are larger than about $1\mu\text{m}$. The formation of fission gas bubbles and grain growth will generally correlate with higher fuel operating temperatures and migration of fission products. The metallic ingots are usually seen during optical ceramography only near the fuel center, if at all, in fuel with normal operating temperatures. Details are given below for the macrophotography and microphotography of the fuel in the as-polished and as-etched conditions.

Both the transverse and longitudinal fuel samples were prepared for examination by placing them in prelabeled mounts followed by vacuum impregnation with polyester resin. The mounts included a reference notch so that photographs of the as-polished and etched samples could be taken along approximately the same radial line. After grinding the mounted fuel with up to 600 grit in a water lubricant, the samples were polished with $1\text{-}\mu\text{m}$ diamond paste using kerosene. A final polish was then made using $0.3\text{-}\mu\text{m}$ Al_2O_3 in an aqueous suspension.

As-Polished Fuel Condition

Several areas of interest were investigated using the as-polished fuel samples: 1) crack patterns, 2) variations in porosity of the fuel, and 3) metallic ingot formation. These topics are discussed below.

Crack Patterns. As-polished transverse and longitudinal samples of fuel sectioned from regions with approximately 65% and 100% of the peak power (peak burnup) of Rod ADD2974 were used to examine the crack patterns. Photomacrographs shown in Figures 4.11 and 4.12 are of samples lightly repolished following etching; a few stains from the etching are still present. Sample 105-ADD2974-E, a transverse fuel sample from a lower-power region, has six to seven radially-oriented cracks intersecting at, or near, the approximate center of the fuel and extending to the fuel pellet edge (Figure 4.11). Three to four randomly oriented shorter cracks intersect the longer cracks at various angles. Both wide-gapped ($>45\text{ }\mu\text{m}$) and fine-gapped ($\leq 45\text{ }\mu\text{m}$) cracks are observed; some of these cracks would close up or narrow at operating temperatures in the reactor. Cracks intersecting the outer fuel edge are approximately normal to this edge. The two dark regions near the cladding interior surface are areas where fuel was lost, probably during sectioning and preparation, and are not considered typical of most of the fuel.

Transverse Sample 105-ADD2974-T from the peak-power region (Figure 4.12) is more highly fragmented than lower-power Sample 105-ADD2974-E, as indicated by the higher concentration of randomly oriented interconnecting cracks. Higher fragmentation in this sample of fuel from the peak-power region probably resulted from the higher stresses that would be expected from the radial thermal gradients present during irradiation and power cycling. Many of the cracks in Sample 105-ADD2974-T are fine-gapped.

As-polished, longitudinal Sample 105-ADD2974-S is highly fragmented as shown in Figure 4.13. This fuel sample was taken at the peak-power region adjacent to transverse Sample 105-ADD2974-T. The cracks are generally shorter than the fuel diameter, and they interconnect. The majority of the relocated fuel shown in Figure 4.13 resulted from fuel sectioning and subsequent handling operations; BWR-type fuel is particularly susceptible to fuel fragment loss during handling of sectioned fuel because a significant portion of the gap between the fuel and cladding remains as a result of less

FIGURE 4.11. Photomicrograph of As-Polished Transverse Sample 105-ADD2974-E from Region at Approximately 65% of Peak Power (~10x) (Neg. No. 8707417-4) (Note: Photo taken at an oblique angle to fuel surface)

FIGURE 4.12. Photomicrograph of As-Polished Transverse Sample 105-ADD2974-T from the Peak-Power Region (~10x) (Neg. No. 8707417-3) (Note: Photo taken at an oblique angle to fuel surface)

FIGURE 4.13. Photomicrograph of As-Polished Longitudinal Sample 105-ADD2974-S from the Peak-Power Region (~10x) (Neg. No. 8707417-5) (Note: Photo taken at an oblique angle to fuel surface)

cladding creepdown during in-reactor operation of a BWR. Fuel fragment loss is primarily a problem at the ends of the fuel rods where the burnups are very low. The longitudinal fuel sample in Figure 4.13 is also a good example of the original fuel design that included flat-ended (nondished) pellets with chamfered edges.

To date, three samples from Rod ADD2966 have been examined: 105-ADD2966-E, 105-ADD2966-I, and 105-ADD2966-J. Examination of the as-polished photomicrographs of these samples indicated crack patterns similar to the samples from comparable regions in Rod ADD2974. Photomicrographs of the as-polished samples from ADD2966 are provided in Appendix E.

Porosity Variation. Photomicrographs were taken of transverse and longitudinal fuel samples at four radial positions to determine the variation in porosity from center to edge at a given axial location and as a function of axial position. Comparison of radial photomicrographs provides a means of detecting changes in fission gas bubble size, porosity concentration and distribution, and the agglomeration of fission products that are affected by operating fuel temperatures that increase from the edge towards the center of the fuel pellet. The as-polished condition of a transverse sample at approximately 65% peak power (Figure 4.14), a peak-power transverse sample (Figure 4.15), and a peak-power longitudinal sample (Figure 4.16) sectioned from Rod ADD2974 that had low fission gas release. These samples are compared with analogous samples cut from Rod ADD2966 that had high fission gas release: a transverse sample at approximately 65% peak power (Figure 4.17), a peak-power transverse sample (Figure 4.18), and a peak-power longitudinal sample (Figure 4.19).

Sample 105-ADD2974-E from the lower-power region of Rod ADD2974 has a relatively uniform concentration of rounded porosity (up to 5 μm in diameter) from the fuel center to 2/3 radius (Figure 4.14). These small pores at the fuel edge are partially obscured by angular porosity that is probably due primarily to grain pullout during preparation of this fine-grained sample.

There is a significantly lower concentration of the small round porosity in the peak-power transverse Sample 105-ADD2974-T (Figure 4.15) than in the low-power transverse sample; this may be due to possible differences in

a) Center (Neg. No. P-3887)

b) 1/3 Radius (Neg. No. P-3886)

c) 2/3 Radius (Neg. No. P-3885)

d) Edge (Neg. No. P-3884)

FIGURE 4.14. Photomicrographs of As-Polished Transverse Sample 105-ADD2974-E from a Region at Approximately 65% of Peak Power

a) Center (Neg. No. P-3847)

b) 1/3 Radius (Neg. No. P-3846)

c) 2/3 Radius (Neg. No. P-3845)

d) Edge (Neg. No. P-3844)

FIGURE 4.15. Photomicrographs of As-Polished Transverse Sample 105-ADD2974-T from the Peak-Power Region

a) Center (Neg. No. P-3858)

b) 1/3 Radius (Neg. No. P-3857)

c) 2/3 Radius (Neg. No. P-3856)

d) Edge (Neg. No. P-3855)

FIGURE 4.16. Photomicrographs of As-Polished Longitudinal Sample 105-ADD2974-S from the Peak-Power Region

a) Center (Neg. No. P-5121)

b) 1/3 Radius (Neg. No. P-5120)

c) 2/3 Radius (Neg. No. P-5119)

d) Edge (Neg. No. P-5118)

FIGURE 4.17. Photomicrographs of As-Polished Transverse Sample 105-ADD2966-E from a Region at Approximately 65% of Peak Power

a) Center (Neg. No. P5107)

b) 1/3 Radius (Neg. No. P-5106)

c) 2/3 Radius (Neg. No. P-5105)

d) Edge (Neg. No. P-5104)

FIGURE 4.18. Photomicrographs of As-Polished Transverse Sample 105-ADD2966-J from the Peak Power Region

a) Center (Neg. No. P-5135)

b) 1/3 Radius (Neg. No. P-5134)

c) 2/3 Radius (Neg. No. P-5133)

d) Edge (Neg. No. P-5132)

FIGURE 4.19. Photomicrographs of As-Polished Longitudinal Sample ADD2966-I from the Peak Power Region

the as-manufactured fuel in these two regions of the fuel rod, particularly where no significant grain growth occurred in the fuel. Fuel densification and grain growth are possible influences that would affect fuel porosity. Angular porosity, apparently due to grain pullout, was the predominate form of porosity at the sample edges. The as-polished condition of longitudinal Sample 105-ADD2974-S was similar to the adjacent transverse Sample 105-ADD2974-T (Figure 4.16).

Fission gas bubbles formed by xenon and krypton gases are expected to concentrate at the hotter fuel center at grain boundaries and/or within the grains if temperatures and burnup are sufficient for bubble formation. The porosity is relatively constant across the fuel radius of the Rod ADD2974 fuel from the center to the edge, where the structure is considered representative of as-manufactured porosity. The apparent lack of significant fission-gas-generated porosity near the fuel center is consistent with the low-fission gas release ($\sim 0.6\%$) for Rod ADD2974 (see Section 4.4).

Sample 105-ADD2966-E from the low-power region of Rod ADD2966 has a relatively uniform and high concentration of rounded and angular porosity (up to $5\text{ }\mu\text{m}$ in diameter or edge) extending from the center to approximately $1/3$ radius (Figure 4.17). Although Sample 105-ADD2966-E is from a low-power region of the rod, the fission gas release for Rod ADD2966 was high (approximately 8%) and the porosity may be partially due to fission gas migration to the grain boundaries in addition to the as-manufactured porosity. The larger rounded porosity ($10\text{ }\mu\text{m}$ in diameter and larger) is probably indicative of the larger as-manufactured porosity. The high concentration of angular porosity located near the edge is probably due to grain pullout during preparation. Compared with Sample 105-ADD2974-E from the low fission gas release Rod ADD2974, Sample 105-ADD2966-E appears to have a slightly higher concentration of larger size pores near the fuel center.

Sample 105-ADD2966-J (Figure 4.18) from the peak-power region of Rod ADD2966 has an as-fabricated porosity distribution across the fuel radius that is similar to low-power Sample 105-ADD2966-E near the center and $1/3$ radius locations, but the porosity concentration due to fission gas is slightly lower in the low-power sample. Because Rod ADD2966 has high fission gas release, the majority of the observed porosity at the center and

1/3 radius locations of the high-power sample is probably due to fission gas migration to the grain boundaries. This is indicated in the as-etched sample (see below). The porosity of Sample 105-ADD2966-J near the center and 1/3 radius locations is significantly higher than for the peak-power Samples 105-ADD2974-T (Figure 4.15) and 105-ADD2974-S (Figure 4.16) from Rod ADD2974, which is consistent with the higher fission gas release measured for Rod ADD2966.

Large elongated pores (up to 15 μm on edge) and a high concentration of smaller rounded pores are observed on peak-power Sample 105-ADD2966-I (Figure 4.19) at the center and 1/3 radius locations. In several regions the grain structure is delineated by the apparent fission-gas-generated porosity present at the grain boundaries. The porosity concentration of adjacent samples 105-ADD2966-I and 105-ADD2966-J are similar, although the average size of the elongated porosity near the fuel center is larger in Sample 105-ADD2966-I than in Sample 105-ADD2966-J. The difference may be due to variations in the fuel operating temperature or asymmetry of the peak temperature as indicated by grain growth (see below).

Metallic Ingot Formation. If sufficient burnup and fuel temperatures are attained, metallic ingots that are large enough for observation by optical microscopy can form in the fuel. The metallic ingots, also called five-metal particles, are made of the ϵ -ruthenium phase that contains molybdenum, ruthenium, technetium, palladium, and rhodium. When seen, the ingots appear as bright white spots as shown in Figure 4.20 for the central fuel region of Sample 105-ADD2966-I. The metallic ingots are observable in the as-polished peak-power Samples 105-ADD2966-I and 105-ADD2966-J out to about 2/3 radius. The concentration of metallic ingots in the peak-power Sample 105-ADD2974-T is lower than observed in the peak-power samples from Rod ADD2966 (Figure 4.21). Because higher fission gas release usually indicates higher operating fuel temperatures, it is not unexpected that the metallic ingots are more prevalent in the peak-power samples from Rod ADD2966 with about 7.9% fission gas release than in peak-power samples from Rod ADD2974 with about 0.6% fission gas release. The metallic ingots observed in Rods ADD2966 and ADD2974 of ATM-105 were much more visible than

FIGURE 4.20. Example of Metallic Ingots Near the Fuel Center of As-Polished Longitudinal Sample 105-ADD2966-I (Neg. No. P-5144)

FIGURE 4.21. Example of Metallic Ingots Near the Fuel Center of As-Polished Transverse Sample 105-ADD2974-T (Neg. No. P-3848)

they were in the low-release fuel (about 0.25%) examined in ATM-103 that had similar peak burnups (Guenther et al. 1988a).

As Etched Fuel Condition

Samples were etched using argon ions in a cathodic vacuum etcher to determine any grain size variation with radial position and to determine if porosity was located at selected sites, such as grain boundaries or within the grain interiors. Examples of the as-etched structures from low fission gas release Rod ADD2974 are provided for a transverse fuel sample from a region at about 65% of peak power (Figure 4.22), a transverse fuel sample from the peak-power region (Figure 4.23), and a longitudinal fuel sample from the peak-power region (Figure 4.24). Examples of the as-etched structures from high fission gas release Rod ADD2966 are provided for a transverse fuel sample from a region at about 65% of peak power (Figure 4.25), a transverse fuel sample from the peak-power region (Figure 4.26), and a longitudinal fuel sample from the peak-power region (Figure 4.27). These photomicrographs and similar ones for other fuel samples shown in Appendix E were used to evaluate the variation in grain size and porosity in the fuel of Rods ADD2974 and ADD2966.

Fuel Grain Size. Fuel grain size was determined using the intercept method (ASTM 1980) on the 250x photomicrographs; results are presented in Table 4.11. The true grain sizes listed in Table 4.11 are plotted in Figure 4.28 for Rod ADD2974 and Figure 4.29 for Rod ADD2966 as a function of fractional distance from the fuel center. These data are used to evaluate the as-fabricated grain size and the amount of grain growth that occurred during irradiation.

In Rod ADD2974, which had low fission gas release, there was no detectable grain growth in Sample 105-ADD2974-E from the low-power region where the true grain size was estimated to be 11 to 12 μm .^(a) The fuel grain sizes

(a) True grain size is determined by multiplying the grain size obtained using the intercept method by 1.57 (Mendelson 1969). This corrects for the grains that appear smaller in the ceramographic section than they really are because sectioning does not show the true grain size of all grains.

a) Center (Neg. No. P-3892)

b) 1/3 Radius (Neg. No. P-3891)

c) 2/3 Radius (Neg. No. P-3890)

d) Edge (Neg. No. P-3889)

FIGURE 4.22. Photomicrographs of Argon Ion-Etched Transverse Sample 105-ADD2974-E from a Region at Approximately 65% of Peak Power

a) Center (Neg. No. P-3852)

b) 1/3 Radius (Neg. No. P-3851)

c) 2/3 Radius (Neg. No. P-3850)

d) Edge (Neg. No. P-3849)

FIGURE 4.23. Photomicrographs of Argon Ion-Etched Transverse Sample 105-ADD2974-T from the Peak-Power Region

a) Center (Neg. No. P-3862)

b) 1/3 Radius (Neg. No. P-3861)

c) 2/3 Radius (Neg. No. P-3860)

d) Edge (Neg. No. P-3859)

FIGURE 4.24. Photomicrographs of Argon Ion-Etched Longitudinal Sample 105-ADD2974-S from the Peak-Power Region

a) Center (Neg. No. P-5155)

b) 1/3 Radius (Neg. No. P-5154)

c) 2/3 Radius (Neg. No. P-5153)

d) Edge (Neg. No. P-5152)

FIGURE 4.25. Photomicrographs of Argon Ion-Etched Transverse Sample 105-ADD2966-E from a Region at Approximately 65% of Peak Power

a) Center (Neg. No. P-5151)

b) 1/3 Radius (Neg. No. P-5150)

c) 2/3 Radius (Neg. No. P-5149)

d) Edge (Neg. No. P-5148)

FIGURE 4.26. Photomicrographs of Argon Ion-Etched Transverse Sample 105-ADD2966-J from the Peak-Power Region

a) Center (Neg. No. P-5159)

b) 1/3 Radius (Neg. No. P-5158)

c) 2/3 Radius (Neg. No. P-5157)

d) Edge (Neg. No. P-5156)

FIGURE 4.27. Photomicrographs of Argon Ion-Etched Longitudinal Sample ADD2966-I from the Peak-Power Region

TABLE 4.11. Results of ATM-105 Fuel Grain Size Measurements

Sample ID	Grain Size, μm							
	Center		1/3 Radius		2/3 Radius		Edge	
	Intercept	True ^a	Intercept	True ^a	Intercept	True ^a	Intercept	True ^a
105-ADD2974-E	7.6 $\pm$ 0.5	11.9 $\pm$ 0.8	7.9 $\pm$ 0.2	12.4 $\pm$ 0.4	7.2 $\pm$ 0.7	11.3 $\pm$ 1.0	7.3 $\pm$ 0.5	11.5 $\pm$ 0.7
105-ADD2974-H	7.7 $\pm$ 0.4	12.1 $\pm$ 0.7	7.4 $\pm$ 0.4	11.8 $\pm$ 0.6	7.2 $\pm$ 0.5	11.3 $\pm$ 0.8	7.4 $\pm$ 0.5	11.6 $\pm$ 0.8
105-ADD2974-I	8.5 $\pm$ 0.9	13.3 $\pm$ 1.4	7.4 $\pm$ 0.3	11.6 $\pm$ 0.5	7.5 $\pm$ 0.7	11.8 $\pm$ 1.0	7.5 $\pm$ 0.3	11.8 $\pm$ 0.4
105-ADD2974-S	9.4 $\pm$ 0.5	14.8 $\pm$ 0.8	9.7 $\pm$ 0.5	15.4 $\pm$ 0.8	8.8 $\pm$ 0.4	13.8 $\pm$ 0.6	8.6 $\pm$ 0.6	13.5 $\pm$ 1.0
105-ADD2974-T	9.3 $\pm$ 0.7	14.6 $\pm$ 1.1	9.1 $\pm$ 1.0	14.3 $\pm$ 1.6	8.4 $\pm$ 0.8	13.2 $\pm$ 1.3	8.4 $\pm$ 0.7	13.2 $\pm$ 1.1
105-ADD2988-E	11.3 $\pm$ 1.1	17.7 $\pm$ 1.8	9.8 $\pm$ 0.2	15.4 $\pm$ 0.2	9.6 $\pm$ 0.7	15.1 $\pm$ 1.1	9.4 $\pm$ 0.4	14.8 $\pm$ 0.6
105-ADD2988-I	17.5 $\pm$ 2.1	27.5 $\pm$ 3.4	14.2 $\pm$ 1.0	22.3 $\pm$ 1.5	10.1 $\pm$ 1.2	15.9 $\pm$ 1.9	10.8 $\pm$ 0.5	17.0 $\pm$ 0.8
105-ADD2988-J	14.1 $\pm$ 1.4	22.1 $\pm$ 2.3	17.1 $\pm$ 2.1	26.8 $\pm$ 3.2	10.9 $\pm$ 1.1	17.1 $\pm$ 1.7	11.2 $\pm$ 1.1	17.6 $\pm$ 1.8

(a) The true grain size equals the intercept grain size multiplied by 1.57.

FIGURE 4.28. Comparison of Radial Variation in True Grain Size of Fuel Samples from Rod ADD2974 of ATM-105

FIGURE 4.29. Comparison of Radial Variation in True Grain Size of Fuel Samples from Rod ADD2966 of ATM-105

near the fuel edge were similar for Samples 105-ADD2974-E, 105-ADD2974-H, and 105-ADD2974-I. However, the fuel grains near the edges of Samples 105-ADD2974-S and 105-ADD2974-T were approximately 16% larger than for the three fuel samples from the upper half of Rod ADD2974. The grain size near the edge of the fuel in peak-power Samples 105-ADD2974-S and 105-ADD2974-T is believed to be representative of the as-manufactured grain size for those fuel samples because grain growth at the pellet periphery is not expected. Variations in pellet fuel lots and/or processing conditions (such as sintering times) may account for the differences in estimated as-fabricated grain size. Thus, the as-fabricated fuel grain sizes ranged from about 11.5 to 13.5 μm depending on the fuel sample examined from Rod ADD2974.

Examination of fuel samples from Rod ADD2966 also revealed variations in the apparent as-fabricated grain sizes of different samples. Grain sizes for Samples 105-ADD2966-I and 105-ADD2966-J were 15% and 19% larger, respectively, than for Sample 105-ADD2966-E from the upper half of the rod. These

variations were similar to those observed in Rod ADD2974. Comparison between rods indicates that the apparent as-fabricated grain sizes of the samples examined from Rod ADD2974 ranged from 11.5 to 13.5 μm , whereas the size in samples from Rod ADD2966 ranged from 14.8 to 17.6 μm . The reasons for such variations in as-fabricated grain size between rods are probably similar to those mentioned previously, i.e., variabilities in fuel lots and/or processing conditions.

Examination of as-etched Samples 105-ADD2974-H and 105-ADD2974-I from a region at about 92% of the peak power in Rod ADD2974 indicated fuel grain growth of 4% and 13%, respectively, near the fuel centers. Grain growth at the center of Samples 105-ADD2974-S and 105-ADD2974-T were about 10% to 11%, although the as-fabricated grain sizes for these samples were apparently $\sim 13 \mu\text{m}$.

Maximum grain growth in Rod ADD2966 with 8% fission-gas release was much greater than in Rod ADD2974 with only 0.6% fission-gas release. The observed edge-to-center grain growth in Sample 105-ADD2966-E (taken from the low-power region of Rod ADD2966) was approximately 20%. Peak-power Samples 105-ADD2966-I and 105-ADD2966-J had maximum grain growths of 62% and 52%, respectively. The grain growth on Sample 105-ADD2966-J appears to have been asymmetric, with the maximum grain growth at approximately 1/3 the distance from the center. The asymmetric growth may have been due to the crack patterns causing an atypically low rate of heat transfer in the examined region that resulted in an off-center peak temperature. The as-polished photomicrographs (see Appendix E) appear to indicate more metallic ingots at the 1/3 radius than at the fuel center in Sample 105-ADD2966-J. A similar example of asymmetric heating was observed in an ATM-106 rod (Guenther et al. 1988b). Considering the apparent variability in as-fabricated grain size, part of the discrepancy in grain growths may be a result of variation in the initial grain size across the fuel radius. These observed grain growths in Rod ADD2966 are well above those observed for comparable samples from Rod ADD2974, which is consistent with the higher fission gas release measured for Rod ADD2966.

Fuel Porosity. The as-etched samples from Rod ADD2974 and Rod ADD2966 were evaluated to determine the location of fuel porosity. Results of these

examinations are consistent with the higher fission gas release in Rod ADD2966. In Rod ADD2974 fuel samples, pores with diameters up to about 5 μm appear to be principally located within the grains for low-power Sample 105-ADD2974-E; only a small fraction of the small round porosity is located at grain boundaries. A comparison of the as-etched Samples 105-ADD2974-E (~65% peak power) and 105-ADD2974-I (~92% peak power) is made in Figure 4.30. The concentration of porosity at the grain boundaries is lower for Sample 105-ADD2974-E from the lower-power region than for the higher-power sample. The increase in porosity at the grain boundaries in Sample 105-ADD2974-I is characteristic of fission gas bubbles that increase in concentration at grain boundaries and grain boundary intersections (or triple points) as burnup and fuel temperatures increase. Visual examination of the peak-power Samples 105-ADD2974-S and 105-ADD2974-T in general showed relatively low concentrations of porosity on grain boundaries near the fuel center.

FIGURE 4.30. Comparison of Argon Ion-Etched Fuel Samples from Rod ADD2974 Indicating Differences in Fission Gas Bubble Accumulation

Apparently, the center of Sample 105-ADD2974-I operated at a temperature sufficient to cause some fission gas accumulation at the grain boundaries. The grain growth observations noted in Table 4.11 also suggest that the fuel was at a higher temperature than in the adjacent Sample 105-ADD2974-H (see Table 4.11). The grain size increased 13% from edge to center for Sample 105-ADD2974-I compared with only 4% for adjacent Sample 105-ADD2974-H (see Table 4.11). A slightly higher fuel temperature may have resulted in Sample 105-ADD2974-I from random fragmentation, such as the cracks observed in Figure 4.30b, that would inhibit heat transfer to the outer pellet edge. The slightly higher burnup and a slightly higher operating LHGR in Sample 105-ADD2974-I may have contributed to the different amounts of porosity (fission gas bubbles) in these two adjacent fuel samples.

In Sample 105-ADD2966-E from Rod ADD2966, the porosity at the center of the sample was primarily located at the grain boundaries; the majority of these grain boundary bubbles had diameters (or edge lengths) of 5 μm or less (Figure 4.25a). The porosity decreased towards the fuel edge. In peak-power fuel Samples 105-ADD2966-I (Figures 4.27a and 4.27b) and 105-ADD2966-J (Figures 4.26a and 4.26b), most of the porosity was located at grain boundaries and triple points, indicating that the porosity was generated by fission gas. For each of these two peak-power samples, the porosity concentrations at the center and 1/3 radius positions were similar, and the majority of the pores were 5 μm or larger. This increase in the size of the grain boundary porosity corresponds to the increase in grain sizes noted in Table 4.11. Lower porosity concentrations were present at the 2/3 radius and edge positions in both Samples 105-ADD2966-I and 105-ADD2966-J. Samples from Rod ADD2966 had significantly higher concentrations of round and elongated porosity at the center and 1/3 radius positions than samples from Rod ADD2974, particularly for the peak-power samples as shown in Figure 4.31. The greater grain growth and larger fission-gas-generated porosity observed in Rod ADD2966 both indicate higher in-reactor operating temperatures than in Rod ADD2974, which had lower fission gas release. These results were also consistent with the gamma scan data that indicated regions of apparent cesium release in Rod ADD2966, but none in Rod ADD2974.

a) Fuel Center of Sample
105-ADD2974-S from the Peak-
Power Region (Neg. No. P-3862)

b) Fuel Center of Sample
105-ADD2966-I from the Peak-
Power Region (Neg. No. P-5159)

FIGURE 4.31. Argon Ion-Etched Fuel from Rod ADD2974 with Low Fission Gas Release and Rod ADD2966 with High Fission Gas Release

4.5.3 Metallography of ATM-105 Cladding

Oxide thickness on the interior and exterior surfaces of the Zircaloy-2 cladding and hydride orientation within the cladding were determined during the examinations on the same mounted samples as those used for the fuel examinations. Information on the exterior oxide and/or crud layers on the cladding is useful in determining the potential for airborne contamination during handling operations and potential interactions with the exterior environment during disposal. The interior oxide layer is of interest for correlating fission product deposits with structural observations in the fuel as possible clues to fission product distributions. Hydride orientations are important to the failure sensitivity of the cladding because of the brittle nature of zirconium hydrides. Selected data obtained to date on cladding oxide and hydride examinations are provided below. Photographic details of all samples examined are provided in Appendix E.

Cladding Oxide Examinations

The thicknesses of oxide and/or crud layers were measured on the interior and exterior surfaces of the cladding of as-polished samples from both Rods ADD2974 and ADD2966 and are listed in Table 4.12. A description is provided below for examinations conducted on the deposits on the interior and exterior surfaces of Rods ADD2974 and ADD2966.

Rod ADD2974 Examinations - The interior cladding surfaces of samples from Rod ADD2974 have nonuniform deposits of oxide or reaction products on otherwise bare cladding as shown in Figures 4.32b and 4.33b. The deposits on the interior surfaces average 6 to 7 μm (Table 4.12). Where the deposit is present, it appears that the Zircaloy-2 cladding is essentially unaffected, which suggests that the deposit is related to the fuel. The oxide or reaction product on the interior surface of Sample 105-ADD2974-S appears to be composed of at least two phases (Figure 4.33). Small localized patches of a lighter-colored solid are attached to the outer surface of the darker-colored deposit nearest the cladding wall. Future microprobe work may identify this second phase.

The oxide and/or crud layer on the exterior surface of the Zircaloy-2 cladding of Rod ADD2974 consisted of a thin layer over the entire surface and isolated regions where the cladding was measureably thinned (see Table 4.12). These isolated regions had a nodular appearance as shown in Figure 4.34 for Sample 105-ADD2974-T from the peak-power region. There also appeared to be a second layer, probably crud, over the entire nodular region and the adjacent cladding surface of Sample 105-ADD2974-S.

The apparent crud layer on the exterior cladding surface, such as shown in Figure 4.33a, does not appear on Sample 105-ADD2974-H (Figure 4.32a). The remaining thin layer on Sample 105-ADD2974-S was 5 to 10 μm thick. The nodular deposit shown for Sample 105-ADD2974-S had extensive layering parallel to the cladding surface and was about 40 μm thick at the deepest point. The exterior layer on the cladding of Sample 105-ADD2974-H, which was taken from a lower-power region closer to the top of the rod, was similar to the peak-power sample except that the deposit in the nodular region was over 30% thicker at the deepest point. It appears that 30 to 50% of the maximum

TABLE 4.12. Oxide Layer Thicknesses in ATM-105 Samples

Sample ID	Axial Location, cm (in.) from Top of Fuel Rod	Oxide Thickness, μm (mil)			
		Exterior Layer		Interior Layer	
		Average Measured Thickness	Two Standard Deviations	Average Measured Thickness	Two Standard Deviations
105-ADD2974-H	112.7 (44.4)	10.4 (0.4)	± 1.2 (0.05)	5.7 (0.2) ^(c)	± 4.2 (0.16)
		Observations		Observations	
		Nonuniform thickness Layered near cladding wall. Maximum depth in nodular region = 53.5 μm .		Nonuniform thickness, solid, some bare cladding.	
105-ADD2974-S	288.8 (113.7)	5-10 (0.2-0.4)	--	7.3 (0.29) ^(c)	± 3.6 (0.14)
		Observations		Observations	
		Nonuniform thickness Layered near cladding wall. Maximum depth in nodular region = 40.1 μm .		Nonuniform thickness, solid. Two phases present.	
105-ADD2966-E	59.8 (23.5)	5.2 (0.20)	± 0.5 (0.02)	No oxide observed	--
		Observations		Observations	
		Uniform thickness, solid. Maximum observed depth in nodular region = 58.0 μm .			
105-ADD2966-I	216.6 (85.3)	4.9 (0.20) 10.6 (0.42)	± 1.4 (0.06) ± 3.2 (0.12)	6.6 (0.26) ^(c)	± 1.2 (0.04)
		Observations		Observations	
		Uniform thickness, solid with some layering on thicker layers. Maximum observed depth in nodular region = 22.0 μm .		Uniform to nonuniform thickness, solid.	
105-ADD2966-J	218.2 (85.9)	9.5 (0.38)	± 1.8 (0.07)	6.5 (0.25) ^(c)	± 1.2 (0.04)
		Observations		Observations	
		Nonuniform thickness due to high concen- tration of nodular regions. Layered. Maximum nodular region depth = 64.4 μm .		Uniform thickness, solid. Fuel adhered to oxide in some locations.	

(a) For Rod ADD2974, oxide thicknesses were determined from a single location on each longitudinal sample. The reported typical values are a minimum of 8 measurements over the length of the area examined. For Rod ADD2966, oxide thicknesses are determined from four symmetrically oriented locations on each longitudinal or transverse sample. The reported typical values are a composite of a minimum of 12 measurements over the length of selected sample locations.

(b) Thick layer rapidly tapers to a thinner oxide layer.

(c) Typical where present.

a) Exterior Surface (Neg. No. P-3878)

b) Interior Surface (Neg. No. P-3879)

FIGURE 4.32. Exterior and Interior Cladding Surfaces of As-Polished Sample 105-ADD2974-H Taken from a Region at about 92% of the Peak Power

a) Exterior Surface (Neg. No. P-3853)

b) Interior Surface (Neg. No. P-3854)

FIGURE 4.33. Exterior and Interior Cladding Surfaces of As-Polished Sample 105-ADD2974-S from the Peak-Power Region

FIGURE 4.34. Example of Nodular Corrosion on Sample 105-ADD2974-T from the Peak-Power Region at the Upper End of Rod ADD2974 (Neg. 88A233-1)

depths of the regions are buildup of corrosion products. According to Marlowe et al. (1985), "nodular corrosion is a common feature of Zircaloy BWR fuel cladding and other fuel and core components, and is not detrimental in normal service conditions."

Rod ADD2966 Examinations - More detailed examinations were made of the interior and exterior cladding surfaces of samples from Rod ADD2966 than in Rod ADD2974 (see Table 4.12) to determine any variation in cladding conditions at different circumferential locations. Low-power Sample 105-ADD2966-E and peak-power Samples 105-ADD2974-I and 105-ADD2974-J were examined. The interior cladding surfaces of 105-ADD2966-E had no observable deposits (Figure 4.35). At the peak-power regions, some surfaces had deposits about 6.5 μm thick while other surfaces were bare (Figures 4.36 and 4.37). These thicknesses were similar to those on Rod ADD2974.

The exterior cladding oxide layer in the low-power region near the top of Rod ADD2966 was uniform and approximately 5 μm thick (Figure 4.35a).

Outer Oxide
Layer

Zircaloy-2

20 μ m

a) Exterior Surface (Neg. No. P-5122)

Zircaloy-2

Fuel

20 μ m

b) Interior Surface (Neg. No. P-5123)

FIGURE 4.35. Exterior and Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-E Taken from a Region at About 65% of the Peak Power

a) Exterior Surface (Neg. No. P-5136)

b) Interior Surface (Neg. No. P-5139)

FIGURE 4.36. Exterior and Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-I Taken from the Peak-Power Region

Zircaloy-2

20 μ m

a) Exterior Surface (Neg. No. P-5110)

Zircaloy-2

20 μ m

b) Interior Surface (Neg. No. P-5115)

FIGURE 4.37. Exterior and Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-J Taken from the Peak-Power Region

Nodular regions up to 64 μm deep and similar to those observed on Rod ADD2974 were also present. On the peak-power samples, the crud/oxide layer thickness ranged from 5 to 11 μm with only minor layering of the thicker deposits (Figure 4.36a). Nodular regions were layered parallel to the cladding and appeared to be more concentrated in the samples near the fuel rod center than near the top of the rod. Approximately 50% of the observed outer cladding edge of peak-power Sample 105-ADD2966-J was covered with nodular regions (Figure 4.38).

Cladding Hydride Examinations

The Zircaloy-2 cladding was etched with a 45% HNO_3 , 45% glycerin, and 10% HF solution to reveal the cladding grain structure. This step was followed by etching with a 45% HNO_3 , 45% H_2O_2 , 10% HF solution to reveal the hydrides. A comparison is made in Figure 4.39 of the hydriding in the three transverse samples taken from Rod ADD2974.

FIGURE 4.38. Exterior Cladding Surface of Peak-Power Sample 105-ADD2966-J with Nodular Deposits on the Outer Surface (Neg. No. P-5117)

Transverse Sample 105-ADD2974-E, taken from near the top of the fuel rod, has randomly oriented hydrides as shown in Figure 4.39. These hydrides are shorter in length but more randomly oriented than those observed in the Zircaloy-4 cladding of ATM-103. Sample 105-ADD2974-T from the bottom half of the rod has almost no hydriding at all. Sample 105-ADD2974-I, taken from the upper half of the fuel rod between these two samples, had an intermediate amount of hydriding. An increase in hydride level towards the top of the rod was also observed in Rod ADD2966 (Figure 4.40). Additional photographs were taken of the cladding in Rod ADD2966 to determine whether there was a circumferential variation in cladding hydriding. For each sample examined from Rod ADD2966, the levels of hydriding were uniform from the cladding exterior to interior surface. The low-power Sample 105-ADD2966-E, sectioned from the upper end of Rod ADD2966 had randomly oriented hydrides similar to the low-power sample taken from approximately the same axial location on Rod ADD2974.

The hydriding level in cladding is known to increase with increasing corrosion, but also depends on neutron fluence, cladding prefilms, and other factors (Lanning et al. 1984; Johnson and Lanning 1985). Additional analyses of the oxide layers and hydriding are planned to determine if there is a correlation between exterior oxide thickness and hydride levels in the cladding from these rods.

4.5.4 Autoradiography of ATM-105 Samples

Alpha and beta-gamma autoradiographs of ion-etched samples from Rods ADD2974 and ADD2966 were obtained to evaluate the distributions of alpha emitting isotopes and other fission products. Kodak LR115 (Type II) film and Kodak SO-343 film were used for the alpha and beta-gamma autoradiographs, respectively. The photographs were obtained by direct contact of the fuel samples on the film. A summary of the results from these examinations are provided below for low-release Rod ADD2974 and high-release Rod ADD2966.

Autoradiography of Low-Release Rod - The alpha and beta-gamma autoradiographs for longitudinal Sample 105-ADD2974-S and transverse Sample 105-ADD2974-T are shown in Figures 4.41 through 4.44. These two samples were taken from the peak-power region in the lower half of the fuel rod. The darker regions of the photographs indicate higher relative activity. The high activity in the alpha autoradiographs at the pellet outer edges

FIGURE 4.39. Comparison of Hydriding in Etched Cladding from Rod ADD2974

FIGURE 4.40. Comparison of Hydriding in Etched Cladding from Rod ADD2966

1 (referenced from notch on metallographic mount)

Sample Identification
(Distance from
Top of Rod, cm)

0° Clockwise

180° Clockwise

270° Clockwise

Water Side

Water Side

Water Side

E
(59.2)

Water Side

Water Side

Water Side

J
(217.6)

100 μ m

100 μ m

100 μ m

Water Side

S
(273.5)

100 μ m

FIGURE 4.41. Alpha Autoradiograph of Longitudinal Sample 105-ADD2974-S from Peak-Power Region (Neg. No. 5468)

FIGURE 4.42. Beta-Gamma Autoradiograph of Longitudinal Sample 105-ADD2974-S from Peak-Power Region (Neg. No. 5469)

FIGURE 4.43. Alpha Autoradiograph of Transverse Sample 105-ADD2974-T from Peak-Power Region (Neg. No. 5470)

FIGURE 4.44. Beta-Gamma Autoradiograph of Transverse Sample 105-ADD2974-T from Peak-Power Region (Neg. No. 5471)

indicates the preferential generation of alpha emitting isotopes such as plutonium, americium, and curium. The neutron flux peaks at the outer edge of the fuel during irradiation, thus producing a relatively higher amount of alpha-emitting isotopes. Comparison of the Rod ADD2974 fuel samples with those from the moderate burnup ATM-103 fuel indicates similar relative radial distributions of alpha-emitting isotopes.

The beta-gamma autoradiographs (Figures 4.42 and 4.44) do not indicate any radial variations in activity. Slightly higher production of the fission products occurs near the fuel edge, as is the case for plutonium, but the higher production of fission products at the edge is not noticeable in the

beta-gamma radiographs because of range and geometric effects of gamma radiation in the fuel. The gamma radiation does shine down the cracks, causing axially oriented cracks to appear dark in the beta-gamma radiographs. However, this does not necessarily indicate substantial fission product movement, particularly if the degree of darkness is uniform along all the cracks.

Examination of the other beta-gamma autoradiographs shown in Appendix E for samples from Rod ADD2974 indicates no variations occurred in the radial distribution of beta-gamma emitting material. The lack of any radial variation across the fuel indicates that there has been no significant migration of fission products to the fuel edge or cracks; some fission product migration is expected for fuel operated at sufficiently high temperatures. The lack of fission product migration correlates with the low level of grain growth, low concentration of fission gas bubbles at the grain boundaries, and low fission gas release of this rod. These observations are similar to samples from ATM-103 peak-power samples with comparable burnups.

Autoradiography of High-Release Rod - Autoradiographs of the peak-power Samples 105-ADD2966-I and 105-ADD2966-J from the high fission gas release Rod ADD2966 are shown in Figures 4.45 to 4.48. The high activity of the alpha radiographs at the outer edge indicates an increased concentration of alpha emitters and is similar to samples examined from Rod ADD2974.

In contrast to peak-power samples removed from Rod ADD2974, examination of beta-gamma autoradiographs from Rod ADD2966 samples indicate variations in the radial distribution of beta-gamma emitting material. A symmetrical region located at the center and out to approximately 40 to 45% of the radius of Samples 105-ADD2966-I (Figure 4.46) and 105-ADD2966-J (Figure 4.48) has a lower beta-gamma activity than the remainder of the pellet peripheral region. In addition, highly localized regions of beta-gamma activity are observable for both peak-power samples between the outer pellet surface and the interior of the cladding. The partially depleted central region and the local accumulations of β/γ emitters indicate that fission products have migrated from the fuel center towards the outer edge. The greater grain growth (~60% or more), higher concentration of fission gas bubbles at the grain boundaries, and 8% fission gas release for this rod are consistent with the apparent fission product migration. The beta-gamma radiographs for Rod ADD2966 are similar to

FIGURE 4.45. Alpha Autoradiograph of Longitudinal Sample 105-ADD2966-I from Peak-Power Region (Neg. No. 5558)

FIGURE 4.46. Beta-Gamma Autoradiograph of Longitudinal Sample 105-ADD2966-I from Peak-Power Region (Neg. No. 5559)

FIGURE 4.47. Alpha Autoradiograph of Transverse Sample 105-ADD2966-J from Peak-Power Region (Neg. No. 5560)

FIGURE 4.48. Beta-Gamma Autoradiograph of Transverse Sample 105-ADD2966-J from Peak-Power Region (Neg. No. 5561)

those observed for peak-power samples from ATM-106 Rod NBD107 that had 11.2% fission gas releasing rod (Guenther et al. 1988b). There was no evidence of fission product migration in Sample 105-ADD2966-E from the low-power region (See Appendix E). Microprobe analyses on selected samples of ATM-105 are planned to further investigate fission product migration in this fuel.

4.6 SPECIAL FUEL STUDIES

Special studies are being conducted on the spent fuel ATMs to enhance characterization of microstructural features that could affect the rate of release of radionuclides from spent fuel in a geologic repository. One technique being used to carry out such characterization is analytical transmission electron microscopy (AEM). Although most fission product aggregates (gas bubbles and solid particles) in LWR spent fuel are too small to be observed by optical microscopy, large numbers of these small aggregates are present at grain boundaries and within UO_2 grains. Few metallic inclusions 1000 nm or larger were visible by optical microscopy of the center region of Rod ADD2974 (see Figure 4.21); however, the optically visible particles represent only the extreme upper size fraction of particles actually present in the fuel. AEM allows the observation of fuel microstructures at resolutions approaching the atomic level and provides compositional analyses and phase identification of particles as small as about 20 nm in diameter. Such analyses may afford a means of understanding differences between various fuel samples that might otherwise seem similar based on radiochemical or ceramic evidence alone.

The remainder of this section contains information on 1) the preparation techniques, equipment, and analytical techniques used to perform these analyses; 2) analytical results for AEM conducted on three samples (small fuel particles) taken from locations along the radius of the fuel in Sample 105-ADD2974-X; 3) discussion of the implications of these results. AEM has been conducted on only the low-release Rod ADD2974.

4.6.1 Experimental Details of Special Studies by AEM

Sample 105-ADD2974-X was taken from the peak-power region of Rod ADD2974 (see Appendix D) to provide samples for characterization by AEM. The AEM samples were particles approximately 200 μm in diameter that were selected from three radial locations (the outer edge, mid-radius, and fuel pellet center) on the as-cut fuel surface of Sample 105-ADD2974-X. Sample preparation involved potting a single particle of fuel into a 3-mm-diameter molybdenum or copper washer with epoxy resin, grinding the embedded particle to about 15- μm thickness, and ion micromilling to produce "electron-transparent" regions (50 to 150 nm thick) for AEM. Details of the preparation method are given by McCarthy and Thomas (1985). No water was used in preparing the samples; however, acetone, ethanol, and Freon TF solvents were used for necessary sample cleaning. Finished samples contained only about 10 μg of fuel held in epoxy; consequently they could be handled and analyzed without special shielding.

Microstructural, compositional, and crystallographic analyses were performed in a 200 KV transmission/scanning transmission electron microscope (TEM/STEM) equipped with a Si(Li) detector for energy-dispersive X-ray spectrometry (EDS). Analysis methods included brightfield TEM microstructural imaging, selected-area and microbeam electron diffraction for phase identification, and EDS for qualitative and semi-quantitative elemental analyses of sample micro-areas. The X-ray (EDS) detector used in this work was sensitive to all elements heavier than neon ($Z = 10$), and gave minimum detection limits of 0.3 to 0.5 wt%. The accuracy of semi-quantitative elemental analyses performed with the commercial analysis program SMTF in the Tracor Northern TN-5500 multichannel analyzer was not verified.

4.6.2 Results of AEM Special Studies

AEM examinations and analyses were conducted on fuel samples from the outer edge, mid-radius and center of Section 105-ADD2974-X. The microstructures are similar at the edge and mid-radius of the fuel rod section, but change significantly between the mid-radius and center. Results are given below by sample location.

AEM of Material From Near Fuel Edge

In the sample from the outer edge of the fuel rod, high densities of very small particles and gas bubbles are present throughout the UO_2 grains and along grain boundaries. In most areas the structures are uniform, with UO_2 grain sizes ranging from 10 to 20 μm and low densities of dislocation lines. For comparison, ceramography indicated an average as-measured grain size of $\sim 8 \mu\text{m}$ (see Section 4.5.2). The region shown in Figure 4.49a contains some UO_2 grains smaller than 1 μm that are associated with local porosity and 100-nm particles containing the fission products molybdenum, ruthenium, technetium, rhodium, and palladium. This region may be atypical of the fuel as a whole. It is assumed that local variations in microstructures, such as in Figure 4.49a, resulted from fuel fabrication. The EDS spectrum for one of the particles is shown in Figure 4.49b and is characteristic of the ϵ -ruthenium phase (ϵ -phase) in a UO_2 matrix. EDS and electron diffraction analyses also indicated that the grains are α - UO_2 .

Grain boundaries near the edge of the fuel in Sample 105-ADD2974-X contain closely-spaced 2- to 8-nm-diameter bubbles and scattered particles up to 200 nm in size. In Figure 4.50a, the bubbles on a grain boundary are viewed edge-on. Enlarged particles on and near the boundary were identified by EDS and electron diffraction as the ϵ -phase. The grain boundary region shown in Figure 4.50b also contains several enlarged ϵ -phase particles. The curvature of the grain boundary near the ~ 100 -nm particle in the center of Figure 4.50b, the displacement of some of the particles from the boundary, and denuding of the smaller particles over a distance of about 50 nm from the boundary all indicate that the grain boundary moved during irradiation. Minor grain growth may have occurred at the fuel edge even though the temperatures at the fuel pellet edges were relatively low during irradiation. Bubbles are present along the grain boundary, but they are not visible in Figure 4.50b due to the choice of electron microscopic imaging conditions.

Within the interior of the UO_2 grains, spheroidal particles and bubbles about 4 to 5 nm in diameter are distributed uniformly. Because of the small size of the bubbles and particles, and the low density of the bubbles, EDS microanalysis could not be used to detect fission products in the bubbles or particles. These small bubble-particle pairs in the interior of a UO_2 grain

a) micrograph of grains at edge

b) spectra of ε-phase particle

FIGURE 4.49. General Structure and EDS Analysis of Fuel from the Edge of Sample 105-ADD2974-X Used for AEM (Neg. No. LT 1450)

a) Grain Boundary Bubbles and ϵ -Phase Particles
(Neg. No. LT 1455)

b) Nonequilibrium Grain Boundary Near ϵ -Phase Particle
(Neg. No. LT 1464)

FIGURE 4.50. Examples of Grain Boundaries in Fuel Taken from Edge of Sample 105-ADD2974-X Used for AEM

are shown in Figure 4.51. An unidentified planar defect within the grain (not a grain boundary) appears edge-on in this micrograph. These defects were occasionally found in the ATM-105 (and other) fuels, but are not numerous and can be easily overlooked. These planar defects have the following characteristics: a) length of about 1000 nm; b) {111} habit planes in the UO_2 grains; c) local strains in surrounding UO_2 ; d) termination within UO_2 grains with no change in orientation across defect; e) no diffraction characteristic of second-phase inclusion; f) association with ϵ -phase particles, but no other detectable fission products; and g) UO_2 matrix adjacent to defects is denuded of gas bubbles for a distance of about 150 nm. Although the origin of these defects is unknown, they may start as internal cracks in the fuel and become preferred sites for precipitation of fission products during irradiation. They were not noticed the ATM-103 fuel.

Within the UO_2 grains, 50- to 100-nm particles containing iron, chromium, and nickel were also occasionally observed. Fabrication-induced impurities, such as steel particles picked up during ball-milling of the UO_2 powder, may be the origin of these impurities.

AEM of Material From Fuel Mid-Radius

Microstructures observed in the fuel mid-radius region are similar to those described at the fuel rod edges. The 5- to 10-nm bubbles and larger ϵ -phase particles on grain boundaries are concentrated especially at grain boundary triple-points as shown in Figure 4.52. The only fission products detected by EDS analysis of the grain boundaries were the constituents of ϵ -phase (molybdenum, ruthenium, technetium, rhodium and palladium in ratios corresponding approximately to the fission yields of these elements). The grain interiors contain uniformly dispersed, 2- to 8-nm associated particles and bubbles similar to those shown in Figure 4.51 at the fuel rod edge.

AEM of Material From Fuel Center

Microstructures at the center of Section 105-ADD2974-X include greatly coarsened ϵ -phase particles (up to about 90 nm in diameter) at the interior of UO_2 grains and larger particles (up to about 1000 nm) at the grain boundaries. The 50- to 90-nm diameter particles within UO_2 grains are also associated with local strains in the surrounding UO_2 and with high concentrations

FIGURE 4.51. Plate-Shaped Defect with Associated Bubbles and Particles in Fuel from Edge of Sample 105-ADD2974-X Used for AEM (Neg. No. LT 1452)

FIGURE 4.52. Structure of Fuel at Mid-Radius of Sample 105-ADD2974-X
Used for AEM (Neg. No. LT 1498)

of xenon detected by EDS. The fuel center sample contains few bubbles within the grains and none were detected at the grain boundaries.

EDS analyses were conducted on ϵ -phase particles in the center sample such as those shown in Figure 4.53a. High concentrations of xenon, and traces of krypton, were detected in localized regions at the edges of the particles (Figure 4.52b). EDS analysis of the xenon-containing particles from the center of Sample 105-ADD2974-X gave xenon concentrations as high as 20 wt%. However, these analyses inevitably included contributions from the adjacent ϵ -phase particles, and it appears that the xenon (together with small concentrations of krypton) occurs in a phase separate from the ϵ -phase. Adjacent ϵ -phase and xenon/krypton-containing particles are indicated in Figure 4.53a. Whether the xenon/krypton particles are crystalline or noncrystalline is still undetermined.

The only fission products detected by EDS analyses in the center sample were xenon, minor amounts of krypton, and the constituents of the ϵ -phase. Analyses of grain boundary, particle, and matrix regions showed no other fission products above the detection limits of EDS (about 0.3 wt%).

4.6.3 Implications of AEM Analyses

The results of AEM for Rod ADD2974 provide information on microscopic changes in the fuel that are not visible by ceramography. Optical examination of the ceramographic samples from Rod ADD2974 indicated little grain growth and very limited formation of fission product phases (metallic ingots and fission gas bubbles) within the fuel grains or at grain boundaries (see Section 4.5.2). AEM indicated extensive fine-scale precipitation of fission gas bubbles and solids throughout the peak-power fuel from low-release Rod ADD2974, but only ϵ -phase particles and noble gases (xenon and krypton) were significantly precipitated or concentrated within the fuel.

There are several important observations from AEM of Rod ADD2974:

- 1) most of the fission products are evenly distributed throughout this fuel with moderate burnup and low fission gas release; 2) the existence of grain boundary bubbles in the outer regions of the fuel pellet may be important to fission product release from the fuel; and 3) fission gas release in

a) ϵ -Phase Particles with High Xenon Concentrations
(Neg. No. LT 1395)

b) Spectra of ϵ -Phase Particle

FIGURE 4.53. AEM Examination of ϵ -Phase Particles in UO_2 Grain Interior
Interior of Fuel from Center of Section 105-ADD2974-X

moderate-burnup fuels may be affected by the apparent formation of a condensed phase of xenon and krypton. These points are discussed below.

The low fission gas release from the fuel and the limited concentrations of fission products detected by EDS indicate that most of the fission products are finely dispersed in the UO_2 grains. Xenon and krypton precipitated as an apparent condensed phase in association with ϵ -phase particles near the fuel center. Gas bubbles that formed along grain boundaries or associated with small ϵ -phase particles within the UO_2 grains at the edge and mid-radius of the fuel rod presumably also contain xenon and krypton. However, the gas in these bubbles was below EDS detection limits; the possibility that the bubbles contain volatile fission products such as cesium or iodine (in addition to or instead of xenon and krypton) cannot be excluded based on these analyses. The important radionuclide ^{99}Tc is concentrated in the relatively insoluble ϵ -phase particles that are distributed throughout the fuel. Grain boundary inventories of radionuclides other than those in the ϵ -phase particles were undetectable by EDS and should contribute limited releases during leach testing.

The microstructure of the fuel may also affect the behavior of the test material. Grain boundary structures near the outer edge and mid-radius of the fuel from the peak-power region of Rod ADD2974 include densely packed arrays of small (<10 -nm diameter) gas bubbles and solid particles. Similar arrays of bubbles were observed near the edge of the ATM-103 moderate-burnup and low fission gas release PWR fuel (Guenther et al. 1988a). Bubble arrays have been found at grain boundaries in other PWR fuels (Thomas, McCarthy, Gilbert 1986) and appear to be a common feature near the outer edges of LWR fuel rods. These structures may locally promote internal oxidation, dissolution, and radionuclide release from the fuel. Depending on the extent of these grain boundary bubbles near the outer regions of the fuel, dissolution and oxidation may affect the fuel more rapidly at the fuel rod edges than at the centers.

Xenon and krypton were previously found to exist as a condensed phase near the center (and mid-radius) of PWR fuel ATM-103 (Guenther et al. 1988a). More details of the analyses of these noble gas particles are given in the ATM-103 report. Formation of condensed-phase fission gases has been observed

near the center of fuel pellets examined from the peak-power region of both BWR and PWR fuels and appears to be a general phenomenon of irradiated LWR fuels. As was suggested in the evaluations of the ATM-103 fuel, the presence of xenon under high pressures as a liquid or solid is likely to be important to evaluations of fission gas release from the fuel during in-reactor operation as well as oxidation and leach testing of fuel under storage or disposal conditions.

4.7 NUCLIDE INVENTORY AND RADIOACTIVITY CALCULATIONS

Burnup and decay calculations were made with the ORIGEN2 computer code (Croff 1980a, Croff 1980b) to estimate the nuclide inventories in the fuel and the cladding as a function of exposure and decay times (see Appendix F). This information is useful for comparison with the measured values obtained by radiochemical methods. The comparison of measured to predicted values of radionuclides in the fuel and cladding provides a means of cross checking the validity of the predictions as well as the measurements.

The VAX version of the ORIGEN2 code and the decay, photon, and BWR cross-section libraries (Croff, Haese, and Gore 1979; Croff et al. 1978) were obtained from the Radiation Shielding Information Center in July 1986. The cross-section library was generated for a void fraction of 31.6% (Croff et al. 1978). A summary of the input data for making these calculations is provided below, including fuel composition, cladding composition, and power history.

The fuel composition given in Table 4.13 was used as a basis for ORIGEN2 input. The ^{235}U enrichment information was provided by GE. The ^{234}U content was estimated by interpolating between published values for fuels of various enrichments. The oxygen content was estimated assuming two oxygen atoms per uranium atom. Because the fuel impurity compositions were not available from GE, it was assumed that the impurities are the same as for ATM-104, which had a similar ^{235}U enrichment.

The cladding composition given in Table 4.14 was also used as a basis for ORIGEN2 input. It is based on nominal values assumed for the Zircaloy-2 cladding. There are 4.583 g of uranium for each gram of cladding over the UO_2 -bearing length of the rod.

TABLE 4.13. Fuel Composition of ATM-105 Assumed for ORIGEN2 Calculations

<u>Parameter</u>	<u>Value^(a)</u>
Enrichment, wt%	2.939 ^(b)
²³⁴ U, ppm	238.2 ^(c)
Total uranium, wt%	88.147
Oxygen, wt%	11.853
Carbon, ppm	18
Nitrogen, ppm	23
Fluorine, ppm	5
Chlorine, ppm	5
Chromium, ppm	0 ^(d)
Iron, ppm	45
Silver, ppm	1
Calcium, ppm	32
Aluminum, ppm	32
Silicon, ppm	32
Nickel, ppm	25

- (a) Based on nominal values for low-enriched fuel used in other ATMs; measured data not available.
 (b) Provided by GE.
 (c) Interpolated value based on ²³⁵U fuel enrichments.
 (d) Although assumed to be absent for the ORIGEN2 calculations, chromium and a few other elements were detected by AEM as minor impurities (see Section 4.6.2).

The irradiation history shown in Figure 4.6 and tabulated in Appendix A was used as a basis for ORIGEN2 input. The power densities were normalized to give burnup exposures of 10, 15, 20, 25, 30, and 35 MWd/kgM. Nuclide inventories were calculated for decay times of 4, 6, 8, 10, 15, 20, and 1000 years after discharge from the reactor. These times bracket the period during which experimenters may be evaluating this fuel and approximates a common time at which long-term repository calculations are made. Sample inputs for irradiation and decay calculations for the fuel and cladding are provided in Appendix F. Appendix F contains extensive tables of ORIGEN2 output for fuel and cladding.

TABLE 4.14. Cladding Composition of ATM-105 Assumed
for ORIGEN2 Calculations

<u>Parameter</u>	<u>Value</u>
Zirconium, wt%	98.05
Tin, wt%	1.5
Iron, wt%	0.13
Chromium, wt%	0.11
Nickel, ppm	500
Aluminum, ppm	40
Hafnium, ppm	55
Silicon, ppm	80
Oxygen, ppm	1200
Carbon, ppm	175
Nitrogen, ppm	35
Hydrogen, ppm	12

4.8 RADIOCHEMICAL ANALYSES

Results of the radiochemical analyses of the fuel and cladding from Rods ADD2966 and ADD2974 of ATM-105 are provided in this section. The analyses were conducted primarily to determine how well measured concentrations compared with those predicted by the ORIGEN2 code. Secondary reasons for radiochemical analyses were to 1) characterize radionuclide migration (which ORIGEN2 cannot predict) and 2) characterize inventories of radionuclides for which input information is unknown or uncertain, such as ^{14}C or various activation products. Thus, analytical samples were taken at locations representative of various burnups and fuel and cladding operating temperature levels.

A general view of the locations of the samples used for radiochemical analyses of the ATM-105 fuel rods is provided in Figures 4.54 and 4.55. Three sets of three samples were taken from each of the rods. Samples were taken from the peak-power region, the lower-power region near the top of the rods, and in regions indicating possible cesium release. Additional fuel samples are scheduled to be taken from these rods once the bottom ends of the rods are gamma scanned (see Section 4.3). These additional samples will be

FIGURE 4.54. General Locations of Samples Used for Radiochemical Analyses of Rod ADD2966

FIGURE 4.55. General Locations of Samples Used for Radiochemical Analyses of Rod ADD2974

used to evaluate ^{14}C in the cladding and fuel, ^{129}I on the interior cladding surface, and ^{137}Cs and ^{135}Cs on the interior and exterior cladding surfaces.

The analyses performed on the fuel and cladding samples are indicated in Figures 4.54 and 4.55. Three fuel samples were included to measure the fuel burnup, the isotopes of uranium and plutonium, and specific nuclides: ^{79}Se , ^{90}Sr , ^{99}Tc , ^{126}Sn , ^{135}Cs , ^{137}Cs , ^{237}Np , ^{241}Am , and ^{243}Cm plus ^{244}Cm . (a) Additional samples were taken and analyzed for ^{14}C in the fuel and cladding and ^{129}I in the fuel. Further details about these fuel sections, as they relate to other samples cut from Rods ADD2966 and ADD2974, are provided in Appendix D. The procedures used in performing the radiochemistry analyses are described in Table 4.15. An estimate of the uncertainty, expressed as the relative standard deviation, is included for each analysis listed in Table 4.15. Results from the fuel burnup analyses are given in Section 4.8.1. Radiochemistry of the fuel and cladding are discussed in Sections 4.8.2 and 4.8.3, respectively.

4.8.1 Fuel Burnup Measurements

Burnup analyses were completed on samples from both Rod ADD2966 and Rod ADD2974 at positions representative of three burnup levels as indicated by the amount of ^{137}Cs activity (see Figures 4.54 and 4.55). The measured burnups for these samples have been correlated to the ^{137}Cs gamma scan results in order to estimate the burnup and radionuclide content of any particular sample from ATM-105 that might be provided to a repository experimenter.

The results of the burnup analyses are listed in Table 4.16. Values are presented for burnups based on the measured amounts of ^{148}Nd indicated in the burnup measurements. The gamma activity for ^{137}Cs obtained during the full-length scans of Rods ADD2966 and ADD2974 are also presented in Table 4.16. The measured burnup values, in units of MWd/kgM for ease of interpolating the tables in Appendix F, are plotted in Figure 4.56 against the ^{137}Cs activity

(a) Note: The MCC has also been requested to analyze ^{93}Zr , ^{226}Ra , ^{243}Am , and ^{245}Cm in the ATM fuels. These analyses have not been performed on ATM-105 because procedures were not in place in the analytical laboratory and funding limitations prevented installing the procedures.

TABLE 4.15. Description of Radiochemical Analysis Procedures

Analysis	Description
<u>Fuel</u>	
Sample Preparation	Weighed sample is dissolved in heated 12N HNO ₃ (+trace HF). Solution is separated from cladding and made up to 100 mL. Aliquots are taken for subsequent analyses. Uncertainty: $\pm 1.0\%$. ^(a)
Burnup (including U and Pu isotopes)	Fission product neodymium is chemically separated from irradiated fuel and determined by isotopic dilution mass spectrometry. Enriched ¹⁵⁰ Nd is used as the Nd isotope diluent, and mass 142 is used to determine natural Nd contamination. Uranium and plutonium are also determined by mass spectrometry. The method uses a calibrated triple spike of ¹⁵⁰ Nd, ²³³ U, and ²⁴² Pu per ANSI/ASTM Standard Test Method E321-79. Uncertainty: Atom % burnup, $\pm 2.5\%$; Pu, $\pm 1.6\%$; U, $\pm 1.6\%$.
¹⁴ C	The carbon in a specially-crushed sample of the fuel is evolved by combustion in pure oxygen. The CO ₂ is collected and ¹⁴ C is measured by liquid scintillation counting. Uncertainty: $\pm 5.6\%$.
⁷⁹ Se	Selenium-79 is separated from other radioactive species by passing the chemically-adjusted solution through a cation plus anion exchange resin column. The selenium in the column effluent is distilled from hydrobromic acid and precipitated as metal by reducing it with hydroxylamine hydrochloride. The reduced metal is dissolved in nitric acid, and the ⁷⁹ Se is measured using liquid scintillation counting. Uncertainty: $\pm 4.9\%$.
⁹⁰ Sr	The ⁹⁰ Sr is separated from other radioactive species by selective elution from a cation exchange resin using 2-methylactic acid. Following separation, the growth of ⁹⁰ Y is measured by beta counting. The ⁹⁰ Sr is then calculated, based on the growth of the ⁹⁰ Y daughter over a measured period of time. Uncertainty: $\pm 5.7\%$.

(a) Uncertainties are one relative standard deviation that is based on experience in the PNL laboratory.

TABLE 4.15. (contd)

Analysis	Description
<u>Fuel</u> (contd)	
^{99}Tc	Technetium is separated from other radioactive species by a process that absorbs most of the other species onto a cation exchange resin. The technetium is extracted from the effluent into hexone as tetraphenylarsonium pertechnetate. The technetium activity is then measured by beta counting. Uncertainty: $\pm 3.5\%$.
^{129}I	Iodine is separated by distillation and precipitation as AgI. Iodine-129 is determined in a GeLi well detector. Uncertainty: $\pm 2.2\%$.
^{126}Sn	Tin is separated by a combination of cation and anion exchange resins. Tin is finally eluted with dilute nitric acid and measured using a GeLi gamma spectrometer. Uncertainty: $\pm 10.2\%$.
^{135}Cs	Cesium is separated from other elements by chromatographic elution from a cation exchange column. Isotopic abundance of the cesium isotope is determined by mass spectrometry. Uncertainty: $\pm 14\%$.
^{137}Cs	The cesium is determined by gamma ray spectrometry on an aliquot of the aqueous solution. Uncertainty: $\pm 3.5\%$.
^{237}Np	Neptunium-237 is separated from other radionuclides species by extraction into a mixture of tri-iso-octylamine (TiOA) in xylene, stripped from the TiOA phase with HCl and re-extraction into a mixture of thenoyl-trifluoroacetone (TTA) in xylene for additional separation. Neptunium-237 is measured by alpha counting. A ^{239}Np tracer is added to the sample and gamma-counted to determine a recovery factor. Uncertainty: $\pm 1.9\%$.
^{241}Am , ^{243}Cm plus ^{244}Cm	Americium and curium are separated using cation and anion exchange and determined by alpha spectrometry. Uncertainty: ^{241}Am , $\pm 4.9\%$; ^{243}Cm plus ^{244}Cm , $\pm 4.1\%$.
<u>Cladding</u>	
^{14}C	The carbon in the cladding is evolved by total combustion in pure oxygen, the CO_2 collected, and the ^{14}C measured by liquid scintillation counting. Uncertainty: $\pm 5.6\%$.

TABLE 4.15. (contd)

Analysis	Description
<u>Cladding (contd)</u>	
^{135}Cs Interior and Exterior Surfaces	The cesium is leached from (interior or exterior) surface and separated from other elements by chromatographic elution from a cation exchange column. Isotope abundance of cesium isotopes is determined by mass spectrometry. Uncertainty: $\pm 14\%$.
^{137}Cs Interior and Exterior Surfaces	The cesium is leached from interior or exterior surface and determined by gamma ray spectrometry on an aliquot of the leachate. Uncertainty: $\pm 3.7\%$.
^{129}I Interior Surface	The cladding interior surface is leached in nitric acid. The iodine is separated from the nitric acid leachate by distillation and precipitation as AgI. Iodine-129 is determined in a GeLi well detector. Uncertainty: $\pm 2.8\%$.

measured during gamma scanning of the full-length rods. The location of the fuel samples and detailed gamma scanning data are provided in Appendices D and B, respectively.

Because the ^{137}Cs activity and the measured burnup form a very linear relationship in the burnup range measured, an equation can be derived for estimating the burnup in other fuel samples from Rods ADD2966 and ADD2974. Using the measured ^{137}Cs activity and burnup values shown in Table 4.16, the relationship between burnup and ^{137}Cs activity for both rods is:

$$\text{BU} = 0.01744 \cdot \bar{A} - 0.9723$$

where BU = the burnup of the Rod ADD2966 or ADD2974 fuel samples in question, MWd/kgM

$\bar{A}$ = the activity measured over the length of the fuel samples in question (see the as-cut sectioning diagram in Appendix D), counts/s.

This equation is valid for determining the burnup in fuel samples from both Rods ADD2966 and ADD2974 as long as the appropriate ^{137}Cs activities given in Appendix D are used. One other fuel rod from ATM-105 will be gamma scanned and

TABLE 4.16. Burnup Results for ATM-105 Fuel Samples(a)

Rod and Sample Numbers	Burnup Based on ¹⁴⁸ Nd		Measured Gamma Activity, Counts/s	Sample Location
	Atom %	GJ/kgM (MWd/kgM)		
<u>Rod ADD2966</u>				
105-ADD2966-B	1.992	1638 (18.96)	1142	Representative of approximately 56% of peak ¹³⁷ Cs activity in top portion of Rod ADD2966.
105-ADD2966-K	3.469	2857 (33.07)	1972	Representative of approximately 97% of peak ¹³⁷ Cs activity in mid portion of Rod ADD2966.
105-ADD2966-T	3.561	2932 (33.94)	1991	Typical peak burnup in lower portion of Rod ADD2966.
<u>Rod ADD2974</u>				
105-ADD2974-B	1.874	1541 (17.84)	1086	Representative of approximately 57% of peak ¹³⁷ Cs activity in top portion of Rod ADD2974.
105-ADD2974-J	3.064	2525 (29.23)	1705	Representative of approximately 94% of peak ¹³⁷ Cs activity in upper portion of Rod ADD2974.
105-ADD2974-U	3.257	2682 (31.04)	1848	Typical peak burnup in lower portion of Rod ADD2974.

(a) See sectioning diagrams in Appendix D for sample locations with respect to gamma activity.

FIGURE 4.56. Correlation Between ^{137}Cs Gamma Counting and ^{148}Nd Burnup Analyses

burnup analyses will be conducted to determine how well the relationship between burnup and ^{137}Cs activity will estimate the burnup in other ATM-105 fuel rods based solely on the gamma scan data. The present burnup and gamma scan data for the two BWR fuel rods indicate a very good linear relationship.

When ATM-105 fuel rods are gamma scanned in the future, a correction for the decay of ^{137}Cs will be incorporated in comparisons of gamma scan data. The rate of decrease in ^{137}Cs activity is indicated by the plot of calculated ^{137}Cs activity shown in Figure 4.57. At the time of gamma scanning, Rods ADD2966 and ADD2974 had been discharged from the reactor for 5.13 years and 5.07 years, respectively. At the time of burnup analyses, Rod ADD2966 had been discharged 5.35 years and Rod ADD2974 had been discharged 5.28 years.

The correlation between ^{137}Cs activity and burnup values can be used in conjunction with the inventory calculations in Appendix F and the gamma scans in Appendix D to estimate the radioisotope inventory for a particular sample that might be used by an experimenter.

FIGURE 4.57. Fractional ^{137}Cs Activity as a Function of Decay Period

4.8.2 Fuel Radiochemical Analyses and Comparisons with ORIGEN2 Predictions

A total of 17 samples (nine for Rod ADD2966 and eight for Rod ADD2974) were analyzed for fuel radiochemistry as indicated in Figures 4.54 and 4.55 and Appendix D. Sample 105-ADD2974-D was contaminated with epoxy after sectioning and was never used. The results of the radiochemical analyses for the fuel are provided in Table 4.17 and are compared with the ORIGEN2 predictions. For the fuel samples being analyzed for ^{14}C and ^{129}I , the burnup was estimated using the gamma scan sectioning diagram in Appendix D and the equation relating ^{137}Cs activity and fuel burnup in Section 4.8.1.

As seen in Table 4.17, most of the radiochemical results agree with ORIGEN2 predictions within about 10%. Only five isotopes had measured values significantly beyond this range: ^{79}Se , ^{126}Sn , ^{241}Pu , ^{241}Am , and ^{14}C . The biggest exceptions are ^{79}Se and ^{126}Sn , for which the measured values are about 13% and 24% of their respective ORIGEN2 predictions. Previous results for fuel from ATM-101, ATM-103, and ATM-106 were similar for ^{79}Se and ^{126}Sn . All of these data are being provided to Oak Ridge National Laboratory for

TABLE 4.17. Fuel Radiochemical Analyses Results and Comparisons with ORIGEN2-Calculated Radionuclide Inventory

Sample ID and Radionuclide	Burnup, (a) MWD/kgM	Analytical Value	ORIGEN2 Value (b)	Ratio, Analytical to ORIGEN2
<u>105-ADD2966-B</u>				
U-234	18.96	1.7×10^{-4} g/g fuel	1.607×10^{-4} g/g fuel	1.06
U-235		1.191×10^{-2} "	1.151×10^{-2} "	1.03
U-236		2.63×10^{-3} "	2.494×10^{-3} "	1.05
U-238		8.437×10^{-1} "	8.439×10^{-1} "	1.00
Pu-238		5.35×10^{-5} "	4.825×10^{-5} "	1.11
Pu-239		3.738×10^{-3} "	3.896×10^{-3} "	0.96
Pu-240		1.220×10^{-4} "	1.239×10^{-4} "	0.98
Pu-241		3.403×10^{-5} "	4.125×10^{-5} "	0.82
Pu-242		9.892×10^{-7} "	1.128×10^{-7} "	0.88
Np-237		1.11×10^{-4} Ci/g fuel	1.248×10^{-4} Ci/g fuel	0.89
Am-241		5.18×10^{-4} "	6.714×10^{-4} "	0.77
Cm-243 & 244		1.10×10^{-8} "	1.147×10^{-7} "	0.96
Se-79		2.77×10^{-2} "	2.109×10^{-2} "	0.13
Sr-90		3.21×10^{-6} "	3.250×10^{-6} "	0.99
Tc-99		6.26×10^{-8} "	7.013×10^{-7} "	0.89
Sn-126		7.79×10^{-7} "	3.463×10^{-7} "	0.22
Cs-135		3.74×10^{-2} "	3.710×10^{-2} "	1.01
Cs-137		4.27×10^{-2} "	4.274×10^{-2} "	1.00
<u>105-ADD2966-C</u>				
I-129	19.89	1.71×10^{-8} Ci/g fuel	1.618×10^{-8} Ci/g fuel	1.06
<u>105-ADD2966-D</u>				
C-14	21.18	6.01×10^{-7} Ci/g fuel (c)	3.505×10^{-7} Ci/g fuel	1.71
<u>105-ADD2966-K</u>				
U-234	33.07	1.35×10^{-4} g/g fuel	1.330×10^{-4} g/g fuel	1.02
U-235		5.34×10^{-3} "	5.533×10^{-3} "	0.97
U-236		3.53×10^{-3} "	3.300×10^{-3} "	1.07
U-238		8.346×10^{-1} "	8.339×10^{-1} "	1.00
Pu-238		1.743×10^{-4} "	1.778×10^{-4} "	0.98
Pu-239		3.579×10^{-3} "	4.324×10^{-3} "	0.83
Pu-240		2.216×10^{-4} "	2.064×10^{-4} "	1.07
Pu-241		6.390×10^{-4} "	8.208×10^{-4} "	0.78
Pu-242		4.407×10^{-7} "	4.421×10^{-7} "	1.00
Np-237		2.54×10^{-4} Ci/g fuel	2.789×10^{-3} Ci/g fuel	0.91
Am-241		8.78×10^{-4} "	1.219×10^{-3} "	0.72
Cm-243 & 244		1.45×10^{-8} "	1.765×10^{-7} "	0.82
Se-79		4.59×10^{-2} "	3.545×10^{-2} "	0.13
Sr-90		4.86×10^{-2} "	5.045×10^{-2} "	0.96

TABLE 4.17. (contd)

Sample ID and Radionuclide	Burnup, (a) MWd/kgM	Analytical Value	ORIGEN2 Value ^(b)	Ratio, Analytical to ORIGEN2
<u>105-ADD2966-K (contd)</u>				
Tc-99		1.03×10^{-5} Ci/g fuel	1.157×10^{-5} Ci/g fuel	0.89
Sn-126		1.52×10^{-7} "	6.669×10^{-7} "	0.23
Cs-135		4.46×10^{-7} "	4.617×10^{-7} "	0.97
Cs-137		7.48×10^{-2} "	7.468×10^{-2} "	1.00
<u>105-ADD2966-N</u>				
I-129	31.75	2.01×10^{-8} Ci/g fuel	2.670×10^{-8} Ci/g fuel	0.75
<u>105-ADD2966-O</u>				
C-14	31.81	5.21×10^{-7} Ci/g fuel ^(c)	5.587×10^{-7} Ci/g fuel	0.93
<u>105-ADD2966-T</u>				
U-234	33.94	1.44×10^{-4} g/g fuel	1.315×10^{-4} g/g fuel	1.10
U-235		4.83×10^{-3} "	5.269×10^{-3} "	0.92
U-236		3.62×10^{-3} "	3.328×10^{-3} "	1.09
U-238		8.391×10^{-1} "	8.332×10^{-1} "	1.01
Pu-238		1.706×10^{-4} "	1.880×10^{-4} "	0.91
Pu-239		3.336×10^{-3} "	4.333×10^{-3} "	0.77
Pu-240		2.190×10^{-3} "	2.097×10^{-3} "	1.04
Pu-241		6.201×10^{-4} "	8.440×10^{-4} "	0.73
Pu-242		4.737×10^{-4} "	4.682×10^{-4} "	1.01
Np-237		2.46×10^{-7} Ci/g fuel	2.886×10^{-7} Ci/g fuel	0.85
Am-241		8.38×10^{-4} "	1.246×10^{-3} "	0.67
Cm-243 & 244		1.50×10^{-3} "	1.994×10^{-3} "	0.75
Se-79		4.96×10^{-2} "	3.630×10^{-2} "	0.14
Sr-90		5.09×10^{-5} "	5.141×10^{-5} "	0.99
Tc-99		1.06×10^{-7} "	1.182×10^{-7} "	0.90
Sn-126		1.60×10^{-7} "	6.878×10^{-7} "	0.23
Cs-135		4.29×10^{-2} "	4.658×10^{-2} "	0.92
Cs-137		7.70×10^{-2} "	7.666×10^{-2} "	1.00
<u>105-ADD2966-X</u>				
I-129	34.45	2.40×10^{-8} Ci/g fuel	2.911×10^{-8} Ci/g fuel	0.82
<u>105-ADD2966-Y</u>				
C-14	34.33	3.80×10^{-7} Ci/g fuel ^(c)	6.12×10^{-7} Ci/g fuel	0.62

TABLE 4.17. (contd)

Sample ID and Radionuclide	Burnup, (a) MWd/kgM	Analytical Value	ORIGEN2 Value (b)	Ratio, Analytical to ORIGIN2
<u>105-ADD2974-B</u>				
U-234	17.84	1.74×10^{-4} g/g fuel	1.632×10^{-4} g/g fuel	1.07
U-235		1.30×10^{-2} "	1.214×10^{-2} "	1.07
U-236		2.48×10^{-3} "	2.397×10^{-3} "	1.03
U-238		8.545×10^{-1} "	8.447×10^{-1} "	1.01
Pu-238		5.21×10^{-5} "	4.132×10^{-5} "	1.26
Pu-239		4.056×10^{-3} "	3.825×10^{-3} "	1.06
Pu-240		1.184×10^{-3} "	1.158×10^{-3} "	1.02
Pu-241		3.415×10^{-4} "	3.771×10^{-4} "	0.91
Pu-242		8.742×10^{-5} "	9.573×10^{-5} "	0.91
Np-237		1.09×10^{-7} Ci/g fuel	1.137×10^{-7} Ci/g fuel	0.96
Am-241		5.23×10^{-4} "	6.111×10^{-4} "	0.86
Cm-243 & 244		1.14×10^{-4} "	8.433×10^{-5} "	1.35
Se-79		2.70×10^{-8} "	1.990×10^{-7} "	0.14
Sr-90		2.92×10^{-2} "	3.092×10^{-2} "	0.94
Tc-99		6.17×10^{-6} "	6.626×10^{-6} "	0.93
Sn-126		7.34×10^{-8} "	3.227×10^{-7} "	0.23
Cs-135		3.83×10^{-7} "	3.604×10^{-7} "	1.06
Cs-137		4.05×10^{-2} "	4.028×10^{-2} "	1.01
<u>105-ADD2974-C</u>				
I-129	18.39	1.40×10^{-8} Ci/g fuel	1.488×10^{-8} Ci/g fuel	0.94
<u>105-ADD2974-J</u>				
U-234	29.23	1.46×10^{-4} g/g fuel	1.397×10^{-4} g/gu fuel	1.05
U-235		7.76×10^{-3} "	6.836×10^{-3} "	1.14
U-236		3.36×10^{-3} "	3.154×10^{-3} "	1.07
U-238		8.490×10^{-1} "	8.368×10^{-1} "	1.01
Pu-238		1.64×10^{-4} "	1.357×10^{-4} "	1.21
Pu-239		4.526×10^{-3} "	4.263×10^{-3} "	1.06
Pu-240		2.164×10^{-3} "	1.893×10^{-3} "	1.14
Pu-241		6.649×10^{-4} "	7.157×10^{-4} "	0.93
Pu-242		3.247×10^{-4} "	3.341×10^{-4} "	0.97
Np-237		2.35×10^{-7} Ci/g fuel	2.354×10^{-7} Ci/g fuel	1.00
Am-241		9.46×10^{-4} "	1.082×10^{-3} "	0.87
Cm-243 & 244		1.10×10^{-3} "	9.822×10^{-4} "	1.12
Se-79		4.26×10^{-8} "	3.165×10^{-7} "	0.13
Sr-90		4.38×10^{-2} "	4.608×10^{-2} "	0.95
Tc-99		9.86×10^{-6} "	1.039×10^{-5} "	0.95
Sn-126		1.41×10^{-7} "	5.756×10^{-7} "	0.24
Cs-135		5.23×10^{-7} "	4.427×10^{-7} "	1.18
Cs-137		7.25×10^{-2} "	6.609×10^{-2} "	1.10

TABLE 4.17. (contd)

Sample ID and Radionuclide	Burnup, (a) MWd/kgM	Analytical Value	ORIGEN2 Value ^(b)	Ratio, Analytical to ORIGEN2
<u>105-ADD2974-M</u>				
I-129	29.37	2.75×10^{-8} Ci/g fuel	2.457×10^{-8} Ci/g fuel	1.12
<u>105-ADD2974-N</u>				
C-14	29.55	4.06×10^{-7} Ci/g fuel ^(c)	5.117×10^{-7} Ci/g fuel	0.79
<u>105-ADD2974-U</u>				
U-234	31.04	1.54×10^{-4} g/g fuel	1.364×10^{-4} g/g fuel	1.13
U-235		6.28×10^{-3} "	6.193×10^{-3} "	1.01
U-236		3.48×10^{-3} "	3.229×10^{-3} "	1.08
U-238		8.455×10^{-1} "	8.354×10^{-1} "	1.01
Pu-238		1.389×10^{-4} "	1.550×10^{-4} "	0.90
Pu-239		3.668×10^{-3} "	4.297×10^{-3} "	0.85
Pu-240		2.082×10^{-3} "	1.981×10^{-3} "	1.05
Pu-241		6.139×10^{-4} "	7.669×10^{-4} "	0.80
Pu-242		3.823×10^{-4} "	3.835×10^{-4} "	1.00
Np-237		2.36×10^{-7} Ci/g fuel	2.560×10^{-7} Ci/g fuel	0.92
Am-241		8.69×10^{-4} "	1.143×10^{-3} "	0.76
Cm-243 & 244		1.07×10^{-3} "	1.310×10^{-3} "	0.82
Se-79		4.50×10^{-8} "	3.345×10^{-7} "	0.13
Sr-90		4.82×10^{-2} "	4.822×10^{-2} "	1.00
Tc-99		1.00×10^{-5} "	1.095×10^{-5} "	0.91
Sn-126		1.46×10^{-7} "	6.183×10^{-7} "	0.24
Cs-135		4.31×10^{-7} "	4.519×10^{-7} "	0.95
Cs-137		6.85×10^{-2} "	7.020×10^{-2} "	0.98
<u>105-ADD2974-Y</u>				
I-129	31.20	3.05×10^{-8} Ci/g fuel	2.710×10^{-8} Ci/g fuel	1.13
<u>105-ADD2974-Z</u>				
C-14	31.29	7.00×10^{-7} Ci/g fuel ^(c)	5.478×10^{-7} Ci/g fuel	1.28

- (a) Burnup values were measured for Samples 105-ADD2966-B, 105-ADD2966-K, 105-ADD2966-T, 105-ADD-2974-B, 105-ADD2974-J, and 105-ADD2974-U. All other burnups are estimated using the equation in Section 4.8.1 and ^{137}Cs activity in Appendix D for specific samples. These estimated burnups are probably accurate to about ± 0.5 MWd/kgM.
- (b) ORIGEN2 values obtained from Appendix F using burnup derived with equation in Section 4.8 and ^{137}Cs activity in Appendix D, except for Samples 105-ADD2966-B, 105-ADD2966-K, 105-ADD2966-T, 105-ADD-2974-B, 105-ADD2974-J, and 105-ADD2974-U, for which these values were directly calculated using ORIGEN2 and the measured sample burnup. Values in Appendix F were converted from g/gU to g/g UO_2 . One gram of unirradiated UO_2 is equivalent to 1 g of as-irradiated fuel with all fission products.
- (c) Average of two measurements that varied within less than 10%.

validation work being conducted on ORIGEN2. In Rod ADD2966, the ^{241}Pu and ^{241}Am measurements were about 25% lower than the ORIGEN2 predictions. In Rod ADD2974 the ^{241}Am measurements averaged about 17% below the ORIGEN2 predictions. The measured values for ^{14}C in the fuel ranged from 38% below to 71% above ORIGEN2 predictions in Rod ADD2966; in Rod ADD2974, the values varied by about 25%.

The variation in the analytical-to-predicted ratios for all of the samples from both ATM-105 rods are compared graphically in Figure 4.58. The diamonds represent the mean values of the ratios and the bars represent one standard deviation. As indicated previously, the smallest deviation in the ratios were observed for ^{238}U , ^{79}Se , and ^{126}Sn . The largest deviations occurred for ^{243}Cm plus ^{244}Cm and ^{14}C .

4.8.3 Cladding Radiochemical Analyses

A total of 12 cladding samples were taken from ATM-105 fuel rods, six samples from each of Rods ADD2966 and ADD2974. One sample, 105-ADD2974-D, was not used because it was contaminated by plastic resin. These analyses included determination of the amount of ^{135}Cs and ^{137}Cs on both the interior and exterior cladding surfaces, the ^{129}I on the interior cladding surface, and the ^{14}C in the cladding. Six additional ^{14}C analyses were later conducted on the unused cladding that was sectioned along with the burnup samples. The analyses of these isotopes on the interior cladding surface can provide useful information on the relationship between fission product release, possible migration and their relationship to fuel and/or cladding temperatures. The levels of ^{135}Cs and ^{137}Cs on the exterior cladding surface are of interest to handling operations where large quantities of dispersible radioactivity could be an issue. The ^{14}C in the cladding, which results from the activation of ^{14}N and ^{17}O , is of interest because ^{14}C has a relatively long half life (>5000 yr) (Van Konynenburg et al. 1985; Van Konynenburg et al. 1987). The ^{14}C in the cladding contributes about 10 to 20% of the total ^{14}C in the fuel rod.

Cesium and Iodine Analyses

Radiochemical analyses for cesium and iodine were obtained from 2.5-cm (1.0-in.) cladding sections taken from locations along the length of the rod

FIGURE 4.58. Ratios of Measured-to-Predicted Values for Nuclides in ATM-105 Fuel

as indicated in Figures 4.54 and 4.55. The fuel was removed from the cladding with a specially constructed punch, and the interior cladding surface was wiped four to five times with fresh, dry Q-tips to remove loose particles. The first Q-tip swabs were black-streaked; thus, it may be inferred that some "loose" cesium and iodine may have been removed by the swabs. After stoppering the open ends, the cladding was immersed in 8N HNO₃, and the resulting solution was analyzed for ¹³⁷Cs and ¹³⁵Cs to obtain the exterior surface values for cesium and iodine. Then the stoppers were removed before another 8N HNO₃ treatment was made to obtain the interior surface values for cesium and iodine.

The results of the cladding radiochemical analyses for cesium and iodine are provided in Table 4.18. The cesium concentration on the exterior

TABLE 4.18. Radiochemical Analyses of Cesium and Iodine on Cladding

Sample No.	Exterior Surface		Interior Surface		
	Activity, $\mu\text{Ci}/\text{cm}^2$		Activity, $\mu\text{Ci}/\text{cm}^2$		
	^{137}Cs	^{135}Cs	^{137}Cs	^{135}Cs	^{129}I
<u>Rod ADD2966:</u>					
105-ADD2966-C	4.39	3.2×10^{-5}	145	118×10^{-5}	30.9×10^{-5}
105-ADD2966-N	3.47	2.2×10^{-5}	1405	887×10^{-5}	81.5×10^{-5}
105-ADD2966-X	18.3	10.9×10^{-5}	5090	3040×10^{-5}	445×10^{-5}
<u>Rod ADD2974:</u>					
105-ADD2974-C	2.33	1.8×10^{-5}	5.09	4.77×10^{-5}	0.36×10^{-5}
105-ADD2974-M	2.00	1.4×10^{-5}	205	148×10^{-5}	13.4×10^{-5}
105-ADD2974-Y	2.92	1.8×10^{-5}	38.3	23.6×10^{-5}	3.6×10^{-5}

cladding surface was generally one to two orders of magnitude lower than the concentration on the interior surface and was uniform over the rod length. The ratio of ^{135}Cs and ^{137}Cs activities are approximately as expected from the data in Appendix F. The amounts of these isotopes are somewhat similar in terms of grams, but the shorter half life for ^{137}Cs results in a much greater activity. The trend in cesium and iodine concentrations on the interior surfaces tended to follow the burnup profile; that is, the concentrations were lower towards the top ends of the rods. However, there was also an apparent effect of fuel temperatures and fission gas release on the level of deposits on the interior cladding surface.

Cesium deposits on the interior cladding surface also correlate with the ^{137}Cs activity measured during gamma scanning of the full-length rod. Such a correlation was also observed for an ATM-106 fuel rod with fission gas release of about 11% (Guenther et al. 1988b). For Rod ADD2966, which had 7.9% fission gas release, the ^{137}Cs deposited on the interior cladding surface of Sample 105-ADD2966-X was more than 25 times that measured on the cladding from Sample 105-ADD2966-C in the low-power region. However, the cesium deposits at even the low-power region in Rod ADD2966 were higher than most of the deposits on the cladding in Rod ADD2974, which had only 0.6% fission gas release.

The cesium deposits on the cladding interior surface for Sample 105-ADD2974-M from Rod ADD2974 were higher than those measured at other locations in the same rod. Sample 105-ADD2974-M was taken from within 2.5 cm (1 in.) of Sample 105-ADD2974-I. Sample 105-ADD2974-I had about 30% higher grain growth than Samples 105-ADD2974-S or 105-ADD2974-T, which were taken from a region with higher burnup (see Table 4.11). Thus, the cesium deposited on the interior cladding surface at Sample 105-ADD2974-M is further evidence suggesting that the fuel operating temperatures in the peak-power region at the top of Rod ADD2974 were higher than in the peak-power region near the bottom of rod.

Although the levels of ^{129}I on the cladding interior surfaces were about 10% to 30% of those for ^{135}Cs , the results of these analyses indicate that the iodine follows the same pattern of deposition as the cesium. This pattern of deposition of iodine for the BWR fuel rods is comparable to that observed for the ATM-106 fuel rods.

It was observed for the high-release ATM-106 Rod NBD107 that deposits of cesium and iodine on the interior cladding surfaces correlated with the maximum fuel grain growth, a measure of fuel operating temperatures. The cesium and iodine deposits and grain growth measurements for Rods ADD2974 and ADD2966 are plotted in Figures 4.59 and 4.60 to show how the deposits increase with increasing grain growth. Data for the ATM-106 rod are also included and show that all of these data follow a similar trend.

Carbon-14 Analyses

Analyses were also performed to determine the ^{14}C content in cladding sections taken from locations along the length of the rod. Additional samples are scheduled to be taken once the bottoms of the fuel rods are gamma scanned. The fuel was removed from these 1-cm (0.5-in.) samples, and the cladding was broken into two portions that were analyzed separately. The analytical results are compared with ORIGEN2 predictions in Table 4.19.

The analyzed concentrations of ^{14}C in the cladding averaged about 47% of the predicted concentrations, but there is wide scatter in the as-analyzed values. Because there was such a large range in measured values, cladding sectioned along with fuel used for burnup analyses was also analyzed for ^{14}C .

FIGURE 4.59. Trend in ^{129}I Deposits on Interior Cladding Surfaces of ATM-105 and ATM-106 Rods

FIGURE 4.60. Trend in ^{137}Cs Deposits on Interior Cladding Surfaces of ATM-105 and ATM-106

TABLE 4.19. Radiochemical Analyses of Carbon-14 in Cladding and Comparison with ORIGEN2 Predictions

<u>Sample No.</u>	<u>Analyzed Activities, $\mu\text{Ci/g}$ Cladding(a)</u>	<u>Average of Analyzed Activities, $\mu\text{Ci/g}$ Cladding</u>	<u>Interpolated ORIGEN2 Activity, $\mu\text{Ci/g}$ Cladding(b)</u>	<u>Ratio, Average Analytical Activity to ORIGEN2</u>
105-ADD2966-B	0.301,0.197	0.249	0.391	0.64
105-ADD2966-D	0.631,0.530	0.581	0.441	1.32
105-ADD2966-K	0.248,0.361	0.304	0.737	0.41
105-ADD2966-O	0.272,0.331	0.302	0.704	0.43
105-ADD2966-T	0.200,0.421	0.311	0.761	0.41
105-ADD2966-Y	0.494,0.494	0.494	0.771	0.64
105-ADD2974-B	0.102,0.169	0.136	0.366	0.37
105-ADD2974-J	0.111,0.175	0.143	0.637	0.22
105-ADD2974-N	0.373,0.283	0.328	0.645	0.51
105-ADD2974-U	0.088,0.231	0.160	0.684	0.23
105-ADD2974-Z	0.214,0.249	0.232	0.691	0.34

(a) Each cladding sample was separated for duplicate analyses.

(b) Interpolated ORIGEN2 values obtained from Appendix F using estimated burnup from equation in Section 4.7 and ^{137}Cs activity in Appendix D.

These values are also listed in Table 4.19. These results indicate that the assumed values for nitrogen in the cladding (Table 4.14) may be slightly high; however, in previous analyses for other ATMs the measured values for ^{14}C in the cladding also varied substantially about the predicted values. A comparison of the ATM-105 data is made in Figure 4.61 which also includes data for one ATM-103 rod and one ATM-106 rod. Predicted data are indicated by lines for each rod. Even though there is fairly wide scatter in the measured values, the data for the Zircaloy-2 from the BWR rods follow the same general trend as for the two PWR rods. There is an apparent and expected increase with burnup and initial nitrogen content. It is not clear why there is so much scatter, particularly at higher burnups. Some of these differences may result from uncertainties in the assumed values for the as-fabricated nitrogen content or uncertainties in the measurement of the

FIGURE 4.61. Comparison of ^{14}C Content in Cladding of ATM-103, ATM-105, and ATM-106 Rods

small quantities rather than from errors in the computer code. Preliminary data for a second ATM-106 rod indicate even greater disparity between measured and predicted values suggesting that some of the ^{14}C in the hot fuel may be migrating to the cladding. Further evaluation of this situation is scheduled.

5.0 RELATIONSHIP OF ATM-105 TO BWR SPENT FUEL POPULATION

The manufacture, irradiation, and handling of nuclear fuel is carefully controlled, and numerous examinations of irradiated fuel have been made; therefore, it may be expected that the characteristics of spent fuel are understood and predictable. In addition to providing pre-test characterization data to the experimenters who will be using the ATMs, the data described in the ATM characterization reports are also being used to confirm the pre-examination expectations for the ATMs, based on the fuel classification to which each ATM belongs. This section is included to define the pre-examination expectations for ATM-105 and compare those expectations with the actual observations.

Broadly speaking, the characteristics of spent fuel are determined by fuel design, fabrication, and irradiation history. The two spent fuel assemblies that comprise ATM-105 are representative of early-vintage General Electric BWR fuel; General Electric is the dominant supplier of BWRs and BWR fuel in the United States. The ATM-105 fuel was fabricated in 1972 prior to a number of improvements that have been introduced by General Electric. One fabrication problem that had arisen prior to 1972, and which was corrected in the ATM-105 fuel, was the presence of excess moisture introduced during fabrication, which led to localized internal cladding hydriding and occasional in-reactor fuel rod failures (Baily et al. 1979). This problem was solved by the inclusion of a hydrogen getter within the plenum region of the fuel rods and improved fuel rod drying techniques. Subsequent to the ATM-105 fuel rod design, General Electric introduced numerous other design changes. Those changes include: a) beginning in 1973, shorter, chamfered fuel pellets were introduced to reduce local cladding stresses and alleviate pellet-cladding interaction (PCI); b) during 1973 through 1975, the bundle configuration was changed from 7x7 to 8x8 to reduce individual rod power levels; c) in 1978, higher initial helium pressurization levels (three atmospheres) were introduced to improve the thermal performance of the fuel rods during irradiation; and d) in 1979, barrier cladding fuel rods were introduced that allowed loosening of operating restrictions that had been in place to reduce PCI-related fuel rod failures (Baily et al. 1988). It is apparent that because

of these design changes, and associated changes in the operation of the fuel, spent fuel of the ATM-105 vintage may have different characteristics than BWR spent fuel originating from the current fuel design.

Several sources of information exist to define the expected characteristics of spent fuel. These sources include technical papers discussing fuel performance, models of fuel performance, and data bases compiling information on spent fuel inventories and performance. The primary source of information on the spent fuel inventory is the Characteristics Data Base (CDB) compiled for DOE by the Oak Ridge National Laboratory (DOE 1987). The CDB contains information on the inventory, including fuel and assembly design and irradiation history, of fuel from each reactor in the United States. The as-observed/measured characteristics of the ATM-105 fuel rods will be compared with the data in the CDB and with data obtained from literature sources.

5.1 COMPARISON OF AS-MEASURED ATM-105 CHARACTERISTICS WITH CDB-PREDICTED CHARACTERISTICS

The CDB was queried to obtain the data stored within it for assemblies CZ346 and CZ348 from the Cooper Nuclear Power Plant, which constitute ATM-105. The stored data were of two types: 1) physical description, and 2) irradiation/storage history.

5.1.1 Physical Description of ATM-105 Fuel

The CDB identifies the assembly type for ATM-105 as 7x7 BWR/4-6. The data on the physical description in the CDB on this type of assembly are limited to the following:

Assembly width = 5.518 in.
Assembly length = 176 in.
Rod pitch = 0.738 in.
Rod diameter = 0.563 in.
Active length = 144-146 in.
Clad material = Zircaloy-2
Plenum length = 14-16 in.

The information that was provided by GE when assemblies CZ346 and CZ348 were obtained to become ATM-105 is described in Section 4.1. This information is more complete than the physical description information in the CDB. For

example, the CDB data does not include initial fill gas composition and pressure nor dimensions for the pellet-cladding gap. These kinds of information, if available, can be used to help estimate the ultimate pressure in the fuel rods.

5.1.2 Irradiation/Storage History of ATM-105 Fuel

The irradiation/storage history for ATM-105 fuel, as retrieved from the CDB, agrees very well with the information obtained by the MCC from GE and the Nebraska Public Power District when it obtained the fuel. The CDB contains the following data, which may be compared with that in Section 4.2:

<u>Cycle Number</u>	<u>Shutdown Date</u>	<u>Effective Full Power Days</u>	<u>EOC Burnup, Mwd/MTM</u>	
			<u>CZ346</u>	<u>CZ348</u>
1	9/1976	510	13603	13046
2	9/1977	235	18735	18910
3	4/1978	121	21736	22098
6	4/1981	287	25107	24974
7	5/1982	268	28048	27480

The burnup values in the CDB are assembly average values, which are calculated by the reactor operators using thermal data from the overall core and neutron flux measurements for energy distribution within the core. The burnup levels that were measured by the MCC on samples of ATM-105 fuel (see Table 4.16) are for specific points along the lengths of two individual fuel rods from assembly CZ346. The rod average burnup for these two rods was calculated by calibrating the axial ^{137}Cs gamma scan data to measured burnup as described in Section 4.8.1 and averaging over the full length of the fuel column. When this was done, the rod-average burnup value was 29,010 Mwd/MTM for Rod ADD2966. Although not calculated because a small portion of the gamma scan is missing, the rod-average burnup value for Rod ADD2974 can be seen to be very similar. Thus, the rod-average burnup value determined by destructive measurement agrees within 3.4% of the utility-reported assembly-average burnup value for the assembly from which the rods were taken.

For the purposes of the information provided in the CDB, the fuel discharged from each reactor is divided into batches with similar irradiation histories. The two ATM-105 fuel assemblies are part of Batch IIIJ in the

CDB, which consisted of 28 assemblies. The CDB contains assembly-average burnup values for each individual assembly. These burnup values for Batch IIIJ vary from a high of 28,048 MWd/MTM (assembly CZ346, which is now part of ATM-105) to a low of 25,419 MWd/MTM, a range of 9.4%. It should be noted that the ATM-105 fuel rods whose characterization is described in this report are from the assembly with the highest burnup, and therefore highest power level, in the batch.

5.2 COMPARISON OF AS-MEASURED ATM-105 CHARACTERISTICS WITH OTHER EXPECTED CHARACTERISTICS

Many characteristics that may affect the behavior of spent fuel in a geologic repository are not available in the CDB, thus other sources must be used to obtain an understanding of what characteristics would be expected to be in spent fuel of the ATM-105 classification. Fortunately, there is a large volume of literature on the examination of irradiated LWR fuel. A review of this literature was made, and the as-measured ATM-105 characteristics are compared with literature values for BWR fuel rods in the following subsections. In some cases comparisons are not possible because directly comparable literature data are not available, for example, on ^{14}C concentrations and most aspects of fission product redistribution. It will also be readily apparent that most of the characteristics for which data exists exhibit a fairly large range in actual fuel. Nevertheless, it is of value to make the comparisons 1) to show where the ATM-105 characteristics lie within the expected range, and 2) to document how broad the expected range is. Brief explanations are also given for some of the variations that are observed in the characteristics.

5.2.1 Irradiation-induced Changes in Fuel Rod Dimensions

Measurements of the dimensions of irradiated fuel rods show an increase in rod length that is approximately proportional to burnup. This growth in rod length is well understood and compensated for in fuel assembly design. If it were not, rod bowing could result. The lengths of the ATM-105 rods given in Table 4.4 amount to increases in rod length of 0.24, 0.11, and 0.30% for Rods ADD2937, ADD2966, and ADD2974, respectively, based on an initial rod

length of 163.4 in. These increases in length are on the low side of the range typical for BWR fuel rods of similar burnup, as shown through comparison with literature values in Figure 5.1.

5.2.2 Corrosion of Fuel Cladding

The in-reactor corrosion of the external surface of the Zircaloy-2 cladding of BWR fuel is considerably different from the corrosion of the external surface of the Zircaloy-4 cladding of PWR fuel. The corrosion rate in BWRs is mainly a function of neutron flux and thus tends to be highest in the central portions of the fuel rods, whereas the rate in PWRs is controlled more by temperature and thus tends to increase uniformly from the bottom to the top of the fueled portion of the rods (Holzer 1981). In addition, the corrosion of BWR fuel is usually nonuniform, i.e., nodular, whereas the oxide corrosion layer on PWR fuel is uniform. The nodular corrosion has in general not been deleterious to BWR performance (Garzarolli and Stehle 1987). The magnitude of the corrosion of BWR cladding is usually reported as maximum thickness of the nodular deposits. The oxide thicknesses on BWR cladding that should be similar to ATM-105, as found in the literature, are shown in Figure 5.2. The maximum oxide thickness that was observed on any of the ATM-105 specimens was $\sim 65 \mu\text{m}$ (See Figure 4.37), well within the expected range shown in Figure 5.2. The data plotted in Figure 5.2 illustrate the large differences in the extent of cladding corrosion that are observed in BWRs. The reasons for the reactor-to-reactor variations are still not well known; however, a new patented heat treatment process is expected to produce a generally lower, more uniform corrosion of the cladding of General Electric-produced fuel (Baily, Marlowe, and Proebstle 1985).

5.2.3 Hydriding

A secondary effect of cladding corrosion is the absorption into the Zircaloy cladding of part of the hydrogen produced by the oxidation reaction. The solubility limit of hydrogen in Zircaloy is approximately 200 ppm at normal reactor operating temperatures (Slattery 1967). When in solution, the absorbed hydrogen does not affect the mechanical properties of the cladding. Above the solubility limit, which decreases with temperature, the hydrogen

FIGURE 5.1. BWR Fuel Rod Relative Length Increase Versus Rod Average Burnup (Grapengiesser et al. 1988)

FIGURE 5.2. Corrosion of BWR Fuel Rods (Produced 1965-1980) (Garzarolli and Stehle 1987)

precipitates in the form of zirconium hydride platelets. The effect of the precipitated hydrides on cladding mechanical properties is dependent on their orientation; platelets with a radial orientation may significantly degrade cladding hoop ductility whereas circumferentially oriented platelets do not (Pickman 1972). The hydride orientation depends upon the crystallographic texture of the cladding. The crystallographic orientation of the Zircaloy-4 used for PWR cladding produces a predominance of circumferentially-oriented hydrides. Apparently there is less emphasis on controlling hydride orientation in BWR cladding. The random hydride orientation observed in ATM-105 cladding is similar to that reported by Baumgartner (1984) for other General Electric fuel.

5.2.4 Crud on Fuel Cladding

Crud is a term used to describe activated corrosion products from the reactor coolant water that deposit on the outside of the oxide coating on fuel rods. The crud on BWR fuel is generally a flocculent red Fe_2O_3 , with Fe being about 87 wt% of the metal content (Hazelton 1987). Cobalt-60 is the primary source of radiation from crud, but it may also contain ^{14}C and other radionuclides. Because crud is somewhat nonadherent, it is a potential source of radioactive contamination during the handling, shipment and disposal of spent fuel.

The amount of crud found on BWR fuel varies widely from reactor to reactor, and is a function of water chemistry and plant design. In a few instances, crud-induced localized corrosion (CILC) has led to fuel failure. In General Electric fueled BWR plants the failures have been limited to high power density plants with copper bearing condenser tubing and filter demineralizer cleanup system (Bailey, Marlowe, and Proebstle 1985). The crud on CILC-failed fuel is denser than the normal fluffy iron oxide crud, which has excellent heat transfer characteristics. Formation of the denser, less heat conductive crud is believed to be due to the presence of corrosion-product copper in the coolant water. The Cooper Nuclear Power Plant, from which the ATM-105 fuel was obtained, does not have copper bearing condenser tubing, has a history of maintaining excellent water quality, and has never experienced CILC fuel failures.

The ATM-105 fuel should be representative of BWR fuel from a well-run plant with a powdered resin coolout cleanup system and have less than 150 mg/dm² crud on the fuel surfaces. The ATM-105 cladding is an overall red-rust color (as opposed to the gray to black color of ATM-103, -104, and -106 cladding) indicating the presence of a uniform crud layer. The amount of crud has not been measured, but crud can be seen in some of the metalurgical mounts (see, for example, Figure 4.33). There is a definite tendency for some of the crud to come off as fine particulates when the ATM-105 fuel rods are handled. This also is normal, expected behavior for the crud on BWR fuel.

5.2.5 Fuel Pellet Fracturing

Irradiated LWR fuel pellets usually exhibit four to six radial cracks extending from the center to the edge plus a few subsidiary cracks extending from the edge to locations along the axis. In pellets with a length/diameter (L/D) ratio considerably more than one, such as the ATM-105 fuel pellets, there is usually one major transverse crack at mid-length of the pellet. Most of the cracking occurs in the first cycle, when the fuel pellets are usually subjected to the highest changes in temperature; however, some additional cracking may occur in later cycles. Fuel pellets that have been subjected to ramping, that is, rapid excursions to powers/temperatures well in excess of normal, exhibit enhanced cracking, usually of a characteristic pattern. Characteristically, a circumferential crack appears at about mid-radius in ramped fuel, in addition to a proliferation of other cracks. The cracking documented in the photomicrographs of ATM-105 fuel is very similar to that reported elsewhere for unramped reactor fuel (see, for example, Atabek et al. 1982; Mogard, Howl, and Grounes 1988).

5.2.6 Fission Gas Release and Rod Pressurization

What might seem to be a significant disparity in fission gas release (FGR) was found in the two ATM-105 rods in which FGR has been measured to date; however, such disparities in FGR have been reported for other early vintage BWR fuel (Junkrans, Varnild, and Vesterlund 1982). Similarly, Tsuchie and Iwamoto (1982) found that the FGR from BWR rods manufactured in

1972 and irradiated to 22,000 MWd/MTM fell into two groups, "high and low". Indeed, the disparity is reported as the rule, rather than the exception, for unpressurized fuel (Ocken 1982).

Fission gas release from nuclear fuel is a complex, principally thermally-driven phenomenon. The threshold temperature for significant release is $1100 \pm 100^\circ\text{C}$ (Kauffmann et al. 1982). Below that temperature the fission gases xenon and krypton are locked in the fuel matrix; above that temperature the release of xenon and krypton increases. "Thermal feedback" may account for the division of the rods into high and low FGR categories. Thermal feedback occurs when enough fission gas is released to decrease the thermal conductivity of the pellet-cladding gap. This causes the centerline temperature of the pellet to rise, resulting in more fission gas release; the additional fission gas release further reduces gap thermal conductance, resulting in a feedback effect. If the ATM-105 fuel was operated near the temperature for significant FGR, normal small power level differences from rod to rod may have triggered thermal feedback in some rods and not in others. (a) Thermal feedback probably occurred in ATM-105 Rod ADD2966, but not in Rod ADD2974. The FGR from the two ATM-105 rods is compared with the FGR measured in other early vintage BWR fuel rods in Figure 5.3. Fuel microstructures and radionuclide redistribution are related to fission gas release. As would be expected, the microstructural changes and amount of radionuclide redistribution observed in Rod ADD2966 were much larger than in Rod ADD2974 (see for example Tables 4.11 and 4.18).

As was described earlier, shortly after the ATM-105 fuel was manufactured it became standard practice to backfill BWR fuel rods with three atmospheres of helium. The greater quantity of helium in the rods increases the dilution of released fission gases, reduces their thermal effect, and diminishes the thermal feedback effect. The increased helium pressure, plus improved control of fuel pellet densification and a general improvement in understanding the causes underlying the FGR phenomenon, are expected to reduce the disparity in FGR between fuel rods of more modern design.

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- (a) The location of rods in a BWR assembly has a much higher impact on burnup than in a PWR rod due to the water and position of poison rods or control blades in a BWR.

FIGURE 5.3. Fission Gas Release Versus BWR Fuel Rod Average Burnup (Junkrans, Varnild, and Vesterlund 1982)

The helium generated from ternary fission and actinide decay is released from spent fuel in a manner similar to the fission gases but at a higher rate (Yang and Rowland 1982; Ohuchi and Sakurai 1988). Using the information in Tables 4.5 and 4.10, the amount of helium released in the ATM-105 rods can be calculated to be about 49 and 24 cm³ for Rods ADD2966 and ADD2974, respectively. The relation of helium release to fission gas release observed for the ATM-105 rods (assuming a void volume of 44 cm³ and an initial fill pressure of 1 atmosphere helium for the ATM-105 rods) agrees very well with that reported for Monticello BWR fuel rods with a burnup level of 30,000 to 40,000 MWd/MTM (see Figure 5.4).

5.3 THE REPRESENTATIVENESS OF ATM-105

Based on the agreement between as-measured and expected characteristics described above, it may be concluded that ATM-105 is representative of early-vintage BWR fuel. But the documentation above also demonstrates that

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APPENDIX A

POWER HISTORY FOR BUNDLES CZ346 AND CZ348

APPENDIX A

POWER HISTORY FOR BUNDLES CZ346 AND CZ348

Fuel Bundles CZ346 and CZ348 were irradiated in the Cooper Nuclear Power Plant during Cycles 1, 2, 3, 6, and 7. Cycle 1 started on July 4, 1974, and Cycle 7 ended on May 21, 1982. Fuel Bundles CZ346 and CZ348 were not in the reactor during Cycles 4 and 5. The power history for the ATM-105 fuel is based on the history associated with Bundle CZ346. The average burnup for Bundle CZ346 at the end of each cycle was supplied by General Electric (GE) and is given in Table A.1.

TABLE A.1. Burnup of Bundle CZ346

<u>Cycle No.</u>	<u>Bundle-Average Burnup, MWd/kgM</u>	
	<u>Incremental</u>	<u>Cumulative</u>
1	13.90	13.90
2	5.24	19.14
3	2.78	21.92
6	3.28	25.20
7	2.85	28.05

The irradiation history of the reactor was supplied by GE and is given in Columns 2 and 4 of Table A.2. Column 3 is interpreted as follows: the core power density was 12.15 MW/MTU for the first 19 days of Cycle 1. The reactor was down for the next 8 days; i.e., day 20 through day 27. Cycle 1 ended with day 807 and Cycle 2 started with day 867. Thus, the reactor was down for 59 days between Cycle 1 and Cycle 2. Likewise, the reactor was down for 31 days between Cycle 2 and Cycle 3. Since Bundle CZ346 was out of the reactor for Cycles 4 and 5, the data in Table A.2 shows a downtime of 799 days between Cycle 3 and Cycle 6. Finally, the downtime between Cycles 6 and 7 is 48 days. The within-cycle and between-cycle down times were retained in Table A.2 because the ORIGEN2 code can model these decay periods accurately.

TABLE A.2. Power History for Cooper BWR and Bundle CZ346
During Cycles 1, 2, 3, 6, and 7

Cycle	Elapsed Time, Days	Time Interval, Days	Core Power Density, MW/MTU	Bundle CZ346		
				Power Density, MW/MTU	Cumulative Burnup, MWd/kgM	Average LHGR, kW/m
1	19	19	12.15	15.63	0.297	16.34
	27	8	0	0	0.297	0
	90	63	11.04	14.21	1.192	14.84
	157	67	17.67	22.74	2.715	23.76
	174	17	0	0	2.715	0
	182	8	11.04	14.21	2.829	14.84
	215	33	19.88	25.58	3.673	26.73
	225	10	0	0	3.673	0
	296	71	20.99	27.01	5.591	28.22
	451	155	11.04	14.21	7.793	14.84
	486	35	0	0	7.793	0
	505	19	11.04	14.21	8.062	14.84
	525	20	19.88	25.58	8.574	26.73
	532	7	0	0	8.574	0
	554	22	17.67	22.74	9.074	23.76
	566	12	0	0	9.074	0
	621	55	17.67	22.74	10.325	23.76
	674	53	15.46	19.89	11.379	20.79
	693	19	0	0	11.379	0
	718	25	15.46	19.89	11.876	20.79
	807	89	17.67	22.74	13.900	23.76
2	866	59	0	0	13.900	0
	880	14	15.46	15.46	14.116	16.15
	904	24	20.98	20.98	14.620	21.92
	919	15	11.04	11.04	14.785	11.53
	945	26	20.99	20.99	15.331	21.93
	953	8	0	0	15.331	0
	996	43	20.99	20.99	16.234	21.93
	1001	5	8.84	8.84	16.278	9.24
	1017	16	20.99	20.99	16.614	21.93
	1022	5	0	0	16.614	0
	1044	22	19.88	19.88	17.051	20.77
	1083	39	13.25	13.25	17.568	13.84
	1172	89	17.67	17.67	19.140	18.46
3	1203	31	0	0	19.140	0
	1367	164	15.46	16.95	21.920	17.71

Table A.2. Power History for Cooper BWR and Bundle CZ346
During Cycles 1, 2, 3, 6, and 7 (contd)

Cycle	Elapsed Time, Days	Time Interval, Days	Core Power Density, MW/MTU	Bundle CZ346		
				Power Density, MW/MTU	Cumulative Burnup, MWd/kgM	Average LHGR, kW/m
6	2166	799	0	0	21.920	0
	2189	23	19.88	10.33	22.158	10.80
	2214	25	22.09	11.48	22.445	12.00
	2228	14	11.04	5.74	23.525	6.00
	2326	98	20.99	10.91	23.594	11.40
	2335	9	0	0	23.594	0
	2377	42	20.99	10.91	24.052	11.40
	2393	16	22.09	11.48	24.236	12.00
	2452	59	20.99	10.91	24.880	11.40
	2483	31	19.88	10.33	25.200	10.80
7	2531	48	0	0	25.200	0
	2539	8	8.84	4.38	25.235	4.57
	2548	9	17.67	8.75	25.314	9.14
	2627	79	21.64	10.71	26.160	11.19
	2688	61	0	0	26.160	0
	2743	55	21.64	10.71	26.749	11.19
	2817	74	20.99	10.39	27.518	10.86
	2822	5	0	0	27.518	0
	2853	31	19.88	9.84	27.823	10.28
	2879	26	17.67	8.75	28.050	9.14

The power history for Bundle CZ346 was determined by normalizing the core power history for each cycle to yield the burnups given in Table A.1. The core power history is given in Column 4 of Table A.2. Specifically, this was accomplished by multiplying each time interval by the core power density, then summing the product over each cycle. A normalization factor was calculated for each cycle by dividing the incremental burnup (Table A.1) by the sum described above. The bundle power density is the product of the core power density and the normalization factor for the appropriate cycle. The bundle power density values are given in Column 5 of Table A.2 and the bundle cumulative burnup values are given in Column 6 of Table A.2.

The average linear heat generation rate (LHGR) was calculated by multiplying the bundle power density by a second normalization factor (1.045) which is a composite of the terms:

30.11 g UO₂/in. of fuel rod,

0.88147 g U/g UO₂,

100 cm/m,

2.54 cm/in.

1000 kgM/MTU; the first three values are in the numerator, the last two are in the denominator. The average LHGR values are given in Column 7 of Table A.2.

APPENDIX B

GAMMA SCANNING FOR ATM-105

APPENDIX B

GAMMA SCANNING FOR ATM-105

The Materials Characterization Center (MCC) gamma scan system consists of three major components: 1) the Data Acquisition (DA) System, 2) the in-cell hardware, and 3) an IBM host computer that supervises and controls the gamma scan process and logs all pertinent data. The DA system and the IBM host system are illustrated in the schematic representation shown in Figure B.1. The in-cell hardware is shown in Figure B.2. The fuel rod is drawn by a motor-driven chuck past the germanium-lithium gamma ray detector, which is located in a wall plug in the front face of the hot cell. The wall plug contains a collimator and normally a 0.254-cm (0.1-in) slit, although a 0.0254-cm (0.01-in) slit may be installed. A stepping motor controls the position of the fuel rod relative to the detector and controls the rate at which the fuel rod is stepped past the detector. The available hot cell space was insufficient for gamma scanning full-length PWR and BWR fuel rods from top to bottom. Thus, this system is designed to scan from the center of the fuel rod to one end. The rod is then rotated 180° (end-over-end), and the process is repeated to scan the other half. The stepping motors determine the center of the fuel rod from an overall fuel rod length measurement made before scanning is started.

The software used to complete gamma scanning operations was written to use a variable counting time at each position. The counting time is set to maintain a fixed statistical uncertainty (set at 1%) until the counting time reaches a maximum preset value. Typically, the counting time is 40 to 60 s in the center of the fuel rod (area of maximum activity) and gradually increases to 5 min (preset maximum value) as the activity decreases near the end of a fuel rod. With this approach, gamma scan results have been obtained for the following isotopes: ^{134}Cs (0.6 MeV), ^{137}Cs , and ^{134}Cs (0.8 MeV). A ^{60}Co signal was also detected during gamma scanning because a sample of this material is placed in the detection system to identify whether the multi-channel analyzer (MCA) is functioning correctly. These are the only isotopes

FIGURE B.1. Data Acquisition System and IBM Host System for Gamma Scanning Spent Fuel Rods

Figure B.2. Plan View of In-Cell Hardware for Gamma Scanning of MCC Spent Fuel Rods

present that meet the predetermined statistical requirements. Other isotopes can be selected and counted, but the error associated with them will force the use of maximum counting times.

The following procedure is used for each ATM.(a) One rod is designated as the reference rod for that ATM (ADD2937 for ATM-105). A full-length gamma scan is completed. The data is plotted and the scan is accepted or rejected on the basis of the "reasonableness" of the data plot. For example, there should be no sudden shifts in activity; and the activity is normally highest near the middle, decreasing rapidly toward the ends. Subsequent scans of fuel rods are accepted or rejected on the basis of a 5-cm (2-in.) scan of the reference rod taken before and after the full-length gamma scan. The variability in the average activity for those 5-cm (2-in.) sections must be less than 5% for ^{137}Cs for the rod being scanned to be accepted.

Spectral gamma scan results are presented in this appendix in alphanumeric order for the two rods of ATM-105 that have been examined. A summary of the figures is provided below:

^{137}Cs spectral gamma scans - Figures B.3 to B.5

^{134}Cs spectral gamma scans for 0.6 MeV gamma rays - Figures B.6 to B.8

^{134}Cs spectral gamma scans for 0.8 MeV gamma rays - Figures B.9 to B.11.

(a) "Fuel Rod Scanning Procedure," MCC-TP-9, Rev. 0, 1987, Materials Characterization Center, Pacific Northwest Laboratory, Richland, Washington.

Log 027 6/4/87

FIGURE B.3. Spectral Gamma Scan for ¹³⁷Cs - Rod ADD2937

Log 032 7/7/87

FIGURE B.4. Spectral Gamma Scan for ¹³⁷Cs - Rod ADD2966

Log 029 6/17/87

FIGURE B.5. Spectral Gamma Scan for ^{137}Cs - Rod ADD2974

Log 027 6/4/87

FIGURE B.6. Spectral Gamma Scan for ^{134}Cs (0.6 MeV) - Rod ADD2937

Log 032 7/7/87

FIGURE B.7. Spectral Gamma Scan for ^{134}Cs (0.6 MeV) - Rod ADD2966

Log 029 6/17/87

FIGURE B.8. Spectral Gamma Scan for ^{134}Cs (0.6 MeV) - Rod ADD2974

Log 027 6/4/87

FIGURE B.9. Spectral Gamma Scan for ^{134}Cs (0.8 MeV) - Rod ADD2937

Log 032 7/7/87

FIGURE B.10. Spectral Gamma Scan for ^{134}Cs (0.8 MeV) - Rod ADD2966

Log 029 6/17/87

FIGURE B.11. Spectral Gamma Scan for ^{134}Cs (0.8 MeV) - Rod ADD2974

APPENDIX C

FISSION GAS SAMPLING

APPENDIX C

FISSION GAS SAMPLING

OPERATING PROCEDURE

There are three objectives for fission gas sampling operations. The first objective is to collect the fission gas from the fuel rods for analysis without contaminating the sample. The other two objectives are to determine the volume of fission gas present in the fuel rod and to determine the fuel rod void volume. To accomplish these objectives a system of leak-tight piping, valves, and calibrated flasks connected to vacuum pumps was fabricated. This system (referred to as the fission gas sample cart) is located in the operating gallery or the "cold" side of the hot cell facility. Piping runs from this cart to a wall plug that extends through the wall of the hot cell. All operations of the system are carried out with a partial vacuum using the current procedure. The top of the fuel rod is inserted into the machined "head" with a flange which, when clamped to the other end of the wall plug, makes a leak-tight connection between the fuel rod and the fission gas sample cart (Figure C.1).

The entire system is evacuated by vacuum pumps to the lowest pressure obtainable, as indicated by a Baratron® gauge. This pressure is usually less than 10^{-1} mm Hg. The system is purged with argon and re-evacuated to remove residual air or other contaminants. The valve to the vacuum pumps is closed, and the readout on the pressure gauge is observed for at least 1 min to determine whether there are any leaks in the system. If no leaks are indicated, the valves to all of the calibrated flasks are closed and fission gas sampling can be conducted. A laser is used to make a small hole in the fuel rod by focusing the laser to a pinhole-sized beam to breach the cladding. The fission gas flows into the evacuated sample cart system. Valves to the calibrated flasks are opened until the Baratron gauge is on scale. This

® Manufactured by MKS Instruments, Inc., Burlington, Massachusetts.

FIGURE C.1. Schematic of Fission Gas Sampling System

pressure, referred to as the system pressure P_s , is recorded. Valves are then opened to the evacuated analytical sample flasks (to obtain the samples for analysis). Two samples are taken in case the fission gas analysis needs to be repeated. The valves to these flasks are closed and the entire system is again evacuated to remove residual fission gas in the rod. The sample flasks are removed from the cart and transferred to the analytical lab.

FUEL ROD VOID VOLUME

After the fuel rod gas is collected, the fuel rod void volume is determined. The entire piping system is evacuated. Then, the valves to the evacuated calibrated flasks are closed, and the fission gas system piping and the fuel rod are pressurized with argon. The argon is permitted to flow into

the fuel rod until equilibrium is reached (as indicated by no change in pressure on the Baratron gauge). This pressure is recorded, and the valve to one of the calibrated flasks is opened. When a second equilibrium is reached, the void volume calculation can be completed. The fuel rod void volume is calculated from Boyles' law

$$V_p = \frac{(P_2) (V_s) + P_2 (V_x) - P_1 (V_s)}{P_1 - P_2}$$

where: P_1 = first pressure reading, mm Hg
 P_2 = second pressure reading, mm Hg
 V_s = volume of fission gas system piping, cm^3
 V_x = volume of selected calibrated flask, cm^3
 V_p = fuel rod void volume, cm^3 .

QUANTITY OF GAS COLLECTED

Once V_p has been determined, the number of moles of gas collected from the fuel rod can be determined according to the ideal gas law.

$$n = \frac{(P_s) (\Sigma V)_i}{(62360) (273 + T)}$$

where: P_s = system pressure recorded after fuel rod puncture, mm Hg
 T = system temperature, $^{\circ}\text{C}$
 ΣV_i = volume of system piping (V_s plus V_p plus volume of all calibrated flasks opened to obtain P_s)
 n = moles of gas
62360 = gas law constant in appropriate units.

Because V_p is a very small value compared with the other volumes used to determine ΣV_i , normal errors in V_p have only a minor effect on the values reported for n .

APPENDIX D

SECTIONING DIAGRAMS

APPENDIX D

SECTIONING DIAGRAMS

The sectioning diagrams for Rods ADD2966 and ADD2974 are shown in Figures D.1 and D.2, respectively. Each figure consists of a continuous four-part graph of the appropriate ^{137}Cs gamma scan with notations indicating the section location and designation. The gamma scan data for both plots are dashed near the lower end of the fuel rods because the gamma scans have not been obtained for the last 0.6 m (2 ft.) of either fuel rod (see Section 4.3). Each letter along the top of the graph identifies a specific section of the rod. The letters are keyed to the detailed section assignment and location description in Tables D.1 and D.2 that follow the figures for Rods ADD2966 and ADD2974, respectively. The vertical dashed line separating sections Q and R in Figure D.2 for Rod ADD2974 indicates an intended cut that has not yet been made.

Sections were cut from the rods using a circular saw with an aluminum oxide blade; the saw is operated without coolant. Each cut required about 1 min to complete. After cutting, the small fuel samples were placed in glass vials for transfer to the analytical facilities. The remaining longer segments (for repository testing or MCC spare material) were marked at the top end for orientation purposes and were placed in individual stainless steel storage tubes that were filled with argon before being capped with a Swagelok fitting. Two operators were used during sectioning operations to verify that the sections were cut correctly and placed in the proper prelabelled transfer or storage containers. As the sections longer than 2.5 cm (1.0 in.) were cut, as-cut measurements were made. These as-cut measurements were used to prepare an as-cut sectioning diagram as shown in this appendix.

FIGURE D.1. As-Cut Sectioning Diagram for Rod ADD2966

FIGURE D.1. As-Cut Sectioning Diagram for Rod ADD2966 (contd)

FIGURE D.1. As-Cut Sectioning Diagram for Rod ADD2966 (contd)

FIGURE D.1. As-Cut Sectioning Diagram for Rod ADD2966 (contd)

FIGURE D.2. As-Cut Sectioning Diagram for Rod ADD2974

FIGURE D.2. As-Cut Sectioning Diagram for Rod ADD2974 (contd)

FIGURE D.2. As-Cut Sectioning Diagram for Rod ADD2974 (contd)

FIGURE D.2. As-Cut Sectioning Diagram for Rod ADD2974 (contd)

TABLE D.1. Description of As-Cut Sections of ATM-105, Spent Fuel Rod ADD2966 (Keyed to Figure D.1)

Section Identification	Section Assignment	Distance From Top, (a) cm (in.)	Length, (b) cm (in.)	Notes
A.	MCC Spare Material	0-54.044 (0-21.277)	54.04 (21.28)	c,d,h
B.	MCC Burnup, Isotopes and Radionuclides	54.107-55.314 (21.302-21.777)	1.21 (0.48)	d
C.	MCC I-129 in Fuel and on Cladding ID; MCC Cs-135 and Cs-137 on Cladding ID and OD	55.377-57.854 (21.802-22.777)	2.48 (0.98)	d
D.	MCC C-14 in Fuel and Cladding	57.917-59.124 (22.802-23.277)	1.21 (0.48)	d
E.	MCC Transverse Metallography-Ceramography	59.187-60.394 (23.302-23.777)	1.21 (0.48)	d,i
F.	MCC Spare and Archive Material	60.457-101.803 (23.802-40.080)	41.35 (16.28)	c,h
G.	MCC Spare and Archive Material	101.867-155.278 (40.105-61.133)	53.41 (21.03)	c,h
H.	MCC Spare and Archive Material	155.341-215.595 (61.158-84.880)	60.25 (23.72)	c,e,h
I.	MCC Longitudinal Metallography-Ceramography	215.659-217.518 (84.905-85.637)	1.86 (0.73)	e
J.	MCC Transverse Metallography-Ceramography	217.581-218.806 (85.662-86.144)	1.23 (0.48)	e
K.	MCC Burnup, Isotopes, and Radionuclides	218.869-220.094 (86.169-86.651)	1.23 (0.48)	e
L.	ORNL Spark Source	220.157-221.381 (86.676-87.158)	1.22 (0.48)	e
M.	ORNL Spark Source	221.445-222.669 (87.183-87.665)	1.22 (0.48)	e
N.	MCC I-129 in Fuel and on Cladding ID; MCC Cs-135 and Cs-137 on Cladding ID and OD	222.733-225.227 (87.690-88.672)	2.49 (0.98)	e

TABLE D.1. Description of As-Cut Sections of ATM-105, Spent Fuel Rod ADD2966 (Keyed to Figure D.1) (contd)

<u>Section Identification</u>	<u>Section Assignment</u>	<u>Distance From Top, (a) cm (in.)</u>	<u>Length, (b) cm (in.)</u>	<u>Notes</u>
O.	MCC C-14 in Fuel and Cladding	225.290-226.515 (88.697-89.179)	1.23 (0.48)	e
P.	MCC Crud Sample	226.578-229.072 (89.204-90.186)	2.49 (0.98)	e, j
Q.	NNWSI	229.136-271.478 (90.211-106.881)	42.34 (16.67)	c, f, h
R.	MCC Longitudinal Metallography-Ceramography	271.541-273.413 (106.906-107.643)	1.87 (0.74)	f
S.	MCC Transverse Metallography-Ceramography	273.477-274.714 (107.668-108.155)	1.24 (0.49)	f
T.	MCC Burnup, Isotopes and Radionuclides	274.777-276.014 (108.180-108.667)	1.24 (0.49)	f
U.	ORNL Spark Source	276.078-277.315 (108.692-109.179)	1.24 (0.49)	f
V.	ORNL Spark Source	277.378-278.615 (109.204-109.691)	1.24 (0.49)	f
W.	MCC Transmission Electron Microscopy	278.679-279.916 (109.716-110.203)	1.24 (0.49)	f
X.	MCC I-129 in Fuel and on Cladding ID; MCC Cs-135 and Cs-137 on Cladding ID and OD	279.979-282.486 (110.228-111.215)	2.51 (0.99)	f
Y.	MCC C-14 in Fuel and Cladding	282.550-283.787 (111.240-111.727)	1.24 (0.49)	f
Z.	MCC Crud Sample	283.850-286.357 (111.752-112.739)	2.51 (0.99)	f, j
AA.	MCC Spare Material	286.421-330.942 (112.764-130.292)	44.52 (17.53)	c, h

TABLE D.1. Description of As-Cut Sections of ATM-105, Spent Fuel Rod ADD2966 (Keyed to Figure D.1) (contd)

Section Identification	Section Assignment	Distance From Top, (a) cm (in.)	Length, (b) cm (in.)	Notes
BB.	MCC Spare Material	331.005-415.595 (130.317-163.620)	84.59 (33.30)	c,g,h

- (a) Distance from top reported to three decimal places to keep account of saw loss between sections. Section lengths reported to two decimal places.
- (b) Length does not include 0.064 cm (0.025 in.) saw loss. (This loss is accounted for between sections.) Measured lengths are within ± 0.16 cm (0.063 in.).
- (c) Within ± 0.16 cm (0.063 in.) of as-measured length.
- (d) Subtracted 0.063 cm (0.025 in.) from each of the five sections (A-E) to compensate for 0.318-cm (0.125-in.) difference between as-cut length measurements and "theoretical" summation of sections B through E after accounting for saw loss.
- (e) Subtracted 0.046 cm (0.018 in.) from each of the nine sections (H-P) to compensate for 0.414 cm (0.163 in.) difference between as-cut length measurements and "theoretical" summation of sections I through P after accounting for saw loss.
- (f) Subtracted 0.033 cm (0.013 in.) from each of the 10 sections (Q-Z) to compensate for 0.318 cm (0.125 in.) difference between as-cut length measurements and "theoretical" summation of sections R through Z after accounting for saw loss.
- (g) Due to space limitations and length of the BWR fuel rod, section BB was only partially gamma scanned. This section will be completely scanned and cut into additional characterization sections at a later date.
- (h) Added 0.033 cm (0.053 in.) to each of these seven sections to compensate for 0.940 cm (0.370 in.) difference between as-cut length measurement of section BB and length of section based on total rod length determined from the gamma scan equipment. This correction was made following all other corrections to segment lengths noted above. All 7 sections are still within ± 0.16 cm (0.063 in.) of as-measured lengths.
- (i) Approximately 0.318 cm (0.125 in.) of fuel was lost from the bottom of section E.
- (j) Top end of outer cladding surface of section P marked with tech pen (for orientation purposes) but was wiped off before it could dry. Crud section Z was not marked.

TABLE D.2. Description of As-Cut Sections of ATM-105, Spent Fuel Rod ADD2974 (Keyed to Figure D.2)

Section Identification	Section Assignment	Distance From Top, (a) cm (in.)	Length, (b) cm (in.)	Notes
A.	MCC Spare Material	0-55.659 (0-21.913)	55.66 (21.91)	c, d
B.	MCC Burnup, Isotopes and Radionuclides	55.723-56.929 (21.938-22.413)	1.21 (0.48)	d
C.	MCC I-129 in Fuel and on Cladding ID; MCC Cs-135 and Cs-137 on Cladding ID and OD	56.993-59.469 (22.438-23.413)	2.48 (0.98)	d
D.	MCC C-14 in Fuel and Cladding	59.533-60.739 (23.438-23.913)	1.21 (0.48)	d, i
E.	MCC Transverse Metallography-Ceramography	60.803-62.009 (23.938-24.413)	1.21 (0.48)	d, j
F.	ONWI Material	62.073-64.549 (24.438-25.413)	2.48 (0.98)	d, k
G.	MCC Spare and Archive Material	64.613-111.732 (25.438-43.989)	47.12 (18.55)	c, e, l
H.	MCC Longitudinal Metallography-Ceramography	111.796-113.673 (44.014-44.753)	1.88 (0.74)	e
I.	MCC Transverse Metallography-Ceramography	113.736-114.978 (44.778-45.267)	1.24 (0.49)	e, m
J.	MCC Burnup, Isotopes, and Radionuclides	115.042-116.284 (45.292-45.781)	1.24 (0.49)	e
K.	ORNL Spark Source	116.347-116.954 (45.806-46.045)	0.61 (0.24)	e
L.	ORNL Spark Source	117.018-117.625 (46.070-46.309)	0.61 (0.24)	e
M.	MCC I-129 in Fuel and on Cladding ID; MCC Cs-135 and Cs-137 on Cladding ID and OD	117.688-120.200 (46.334-47.323)	2.51 (0.99)	e

TABLE D.2. Description of As-Cut Sections of ATM-105, Spent Fuel Rod ADD2974 (Keyed to Figure D.2) (contd)

Section Identifi- cation	Section Assignment	Distance From Top, (a) cm (in.)	Length, (b) cm (in.)	Notes
N.	MCC C-14 in Fuel and Cladding	120.264-121.506 (47.348-47.837)	1.24 (0.49)	e
O.	ONWI Material	121.570-124.082 (47.862-48.851)	2.51 (0.99)	e
P.	MCC Spare and Archive Material	124.145-208.062 (48.876-81.914)	83.92 (33.04)	c
Q.	MCC Spare and Archive Material	208.125-264.099 (81.939-103.976)	55.97 (22.04)	c, f, g
R.	MCC Spare and Archive Material	264.163-287.792 (104.001-113.304)	23.63 (9.30)	c, f, g
S.	MCC Longitudinal Metallography- Ceramography	287.856-289.725 (113.329-114.065)	1.87 (0.74)	f
T.	MCC Transverse Metallog- raphy-Ceramography	289.789-291.023 (114.090-114.576)	1.23 (0.49)	f
U.	MCC Burnup, Isotopes and Radionuclides	291.087-292.321 (114.601-115.087)	1.23 (0.49)	f
V.	ORNL Spark Source	292.385-292.984 (115.112-115.348)	0.60 (0.24)	f
V. (lost)	Lost Specimen	293.047-293.647 (115.373-115.609)	0.60 (0.24)	f, g
W.	ORNL Spark Source	293.710-294.310 (115.634-115.870)	0.60 (0.24)	f
X.	MCC Transmission Electron Microscopy	294.373-295.608 (115.895-116.381)	1.23 (0.49)	f
Y.	MCC I-129 in Fuel and on Cladding ID; MCC Cs-135 and Cs-137 on Cladding ID and OD	295.671-298.176 (116.406-117.392)	2.50 (0.99)	f
Z.	MCC C-14 in Fuel and Cladding	298.239-299.474 (117.417-117.903)	1.23 (0.49)	f

TABLE D.2. Description of As-Cut Sections of ATM-105, Spent Fuel Rod ADD2974 (Keyed to Figure D.2) (contd)

Section Identification	Section Assignment	Distance From Top, ^(a) cm (in.)	Length, ^(b) cm (in.)	Notes
AA.	ONWI Material	299.537-302.042 (117.928-118.914)	2.50 (0.99)	f
BB.	MCC Spare Material	302.105-329.982 (118.939-129.914)	27.88 (10.98)	c
CC.	MCC Spare Material	330.045-416.20 (129.939-163.86)	86.16 (33.92)	h

- (a) Distance from top reported to three decimal places to keep account of saw loss between sections. Section lengths reported to two decimal places.
- (b) Length does not include 0.064-cm (0.025-in.) saw loss. (This loss is accounted for between sections.) Measured lengths are within ± 0.16 cm (1/16 in.).
- (c) Within ± 0.16 cm (1/16 in.) of as-measured length.
- (d) Subtracted 0.064 cm (0.025 in.) from each of the six sections (A-F) to compensate for 0.381-cm (0.150-in.) difference between as-cut length measurements and "theoretical" summation of sections B through F after accounting for saw loss.
- (e) Subtracted 0.028 cm (0.011 in.) from each of the nine sections (G-O) to compensate for 0.254-cm (0.100-in.) difference between as-cut length measurements and "theoretical" summation of sections H through O after accounting for saw loss.
- (f) Subtracted 0.036 cm (0.014 in.) from each of 11 sections (Q/R-AA) to compensate for 0.381-cm (0.150-in.) difference between as-cut length measurements and "theoretical" summation of sections S through AA after accounting for saw loss.
- (g) Fuel from section V lost after saw blade fractured during cutting. A second 0.635-cm (0.25-in.), nominal length was cut to generate section V, which shifted sections V, U, T, and S 0.635 cm (0.25 in.) closer to the top of the fuel rod than specified in the pre-cut plan. Section Q-R was 0.635 cm (0.25 in.) shorter than specified.
- (h) Due to space limitations and length of the BWR fuel rod, section CC was only partially gamma scanned. This section will be completely scanned and cut into additional characterization sections at a later date.
- (i) Approximately 0.318 cm (0.125 in.) of fuel was lost from the bottom of section D.
- (j) Approximately 0.635 cm (0.25 in.) of fuel fragments vibrated loose from the bottom of section E. The fragments were placed in vial along with section E.
- (k) Several fragments fell out of section F during handling. Fragments were placed in vial along with Section F.

TABLE D.2. Description of As-Cut Sections of ATM-105, Spent Fuel
Rod ADD2974 (Keyed to Figure D.2) (contd)

- (l) Approximately 0.318 cm (0.125 in.) of fuel was lost from the top end of section G during cutting.
- (m) Approximately 0.318 cm (0.125 in.) of fuel was lost from the bottom of section I.

APPENDIX E

DETAILS OF CERAMOGRAPHY/METALLOGRAPHY

APPENDIX E

DETAILS OF CERAMOGRAPHY/METALLOGRAPHY

This appendix includes the results of all ceramographic and metallographic examinations conducted to date on ATM-105 fuel. Fuel sections have been taken from both Rods ADD2974 and ADD2966. Photographs presented in the text are also presented here for completeness. A summary of the sample locations is given in Table E.1. Refer to Figures 4.9 and 4.10 and Appendix D (Sectioning Diagram) for further details.

The organization of the Figures in Appendix E is given below:

- Figure E.1.a - E.1.c Photomacrographs of As-Polished Transverse Samples from Rod ADD2974
- Figure E.1.d - E.1.e Photomacrographs of As-Polished Longitudinal Samples from Rod ADD2974
- Figure E.1.f - E.1.g Photomacrographs of As-Polished Transverse Samples from Rod ADD2966
- Figure E.1.h Photomacrograph of As-Polished Longitudinal Sample from Rod ADD2966
- Figure E.2.a - E.2.c Photomicrographs of As-Polished Transverse Samples for Rod ADD2974
- Figure E.2.d - E.2.e Photomicrographs of As-Polished Longitudinal Samples from Rod ADD2974
- Figure E.2.f - E.2.g Photomicrographs of As-Polished Transverse Samples for Rod ADD2966
- Figure E.2.h Photomicrographs of As-Polished Longitudinal Sample from Rod ADD2966
- Figure E.3.a - E.3.c Photomicrographs of Argon Ion-etched Transverse Samples from Rod ADD2974
- Figure E.3.d - E.3.e Photomicrographs of Argon Ion-etched Longitudinal Samples from Rod ADD2974
- Figure E.3.f - E.3.g Photomicrographs of Argon Ion-etched Transverse Samples from Rod ADD2966

- Figure E.3.h Photomicrographs of Argon Ion-etched Longitudinal Samples from Rod ADD2966
- Figure E.4.a - E.4.b Exterior/Interior Cladding Surfaces of As-Polished Longitudinal Samples from Rod ADD2974
- Figure E.4.c - E.4.j Exterior/Interior Cladding Surfaces of As-Polished Transverse Samples from Rod ADD2966
- Figure E.4.k - E.4.n Exterior/Interior Cladding Surfaces of As-Polished Longitudinal Samples from Rod ADD2966
- Figure E.5.a - E.5.c Etched Cladding of Transverse Samples from Rod ADD2974
- Figure E.5.d - E.5.e Etched Cladding of Longitudinal Samples from Rod ADD2974
- Figure E.5.f - E.5.j Etched Cladding of Transverse Samples from Rod ADD2966
- Figure E.5.k Etched Cladding of Longitudinal Sample from Rod ADD2966
- Figure E.6.a - E.6.f Alpha and Beta-Gamma Autoradiographs of Transverse Samples from Rod ADD2974
- Figure E.6.g - E.6.j Alpha and Beta-Gamma Autoradiographs of Longitudinal Samples from Rod ADD2974
- Figure E.6.k - E.6.n Alpha and Beta-Gamma Autoradiographs of Transverse Samples from Rod ADD2966
- Figure E.6.o - E.6.p Alpha and Beta-Gamma Autoradiographs of Longitudinal Samples from Rod ADD2966

TABLE E.1. Summary of Ceramographic/Metallographic Samples

<u>Sample ID</u>	<u>Distance from Top, (a) cm (in.)</u>	<u>Type</u>
105-ADD2974-E	60.80-62.01 (23.94-24.41)	Transverse Sample
105-ADD2974-H	111.80-113.67 (44.01-44.75)	Longitudinal Sample
105-ADD2974-I	113.74-114.98 (44.78-45.27)	Transverse Sample
105-ADD2974-S	287.86-289.73 (113.33-114.06)	Longitudinal Sample
105-ADD2974-T	289.79-291.02 (114.09-114.58)	Transverse Sample
105-ADD2966-E	59.19-60.39 (23.30-23.78)	Transverse Sample
105-ADD2966-I	215.66-217.52 (84.91-85.64)	Longitudinal Sample
105-ADD2966-J	217.58-218.81 (85.66-86.14)	Transverse Sample
105-ADD2966-R	217.54-273.41 (106.91-107.64)	Longitudinal Sample (exam in progress)
105-ADD2966-S	273.48-274.71 (107.67-108.16)	Transverse Sample (exam in progress)

(a) Rod distance referenced from the top end of the rod.

FIGURE E.1.a. Photomicrograph of As-Polished Transverse Sample
105-ADD2974-E (~10x) (Neg. No. 8707417-4)

FIGURE E.1.b. Photomicrograph of As-Polished Transverse Sample
105-ADD2974-I (~10x) (Neg. No. 8707417-2)

FIGURE E.1.c. Photomicrograph of As-Polished Transverse Sample
105-ADD2974-T (~10x) (Neg. No. 8707417-3)

FIGURE E.1.d. Photomicrograph of As-Polished Longitudinal Sample
105-ADD2974-H (~10x) (Neg. No. 8707417-1)

FIGURE E.1.e. Photomicrograph of As-Polished Longitudinal Sample
105-ADD2974-S (~10x) (Neg. No. 8707417-5)

FIGURE E.1.f. Photomicrograph of As-Polished Transverse Sample
105-ADD2966-E (~10x) (Neg. No. 8803473-4)

FIGURE E.1.g. Photomicrograph of As-Polished Transverse Sample
105-ADD2966-J (~10x) (Neg. No. 8802836-1)

FIGURE E.1.h. Photomicrograph of As-Polished Transverse Sample
105-ADD2966-I (~10x) (Neg. No. 8803473-6)

a) Center (Neg. No. P-3887)

b) 1/3 Radius (Neg. No. P-3886)

c) 2/3 Radius (Neg. No. P-3885)

d) Edge (Neg. No. P-3884)

FIGURE E.2.a. Photomicrographs of As-Polished Transverse Fuel Sample 105-ADD2974-E

a) Center (Neg. No. P-3866)

b) 1/3 Radius (Neg. No. P-3865)

c) 2/3 Radius (Neg. No. P-3864)

d) Edge (Neg. No. P-3863)

FIGURE E.2.b. Photomicrographs of As-Polished Transverse Fuel Sample 105-ADD2974-I

a) Center (Neg. No. P-3847)

b) 1/3 Radius (Neg. No. P-3846)

c) 2/3 Radius (Neg. No. P-3845)

d) Edge (Neg. No. P-3844)

FIGURE E.2.c. Photomicrographs of As-Polished Transverse Fuel Sample 105-ADD2974-T

a) Center (Neg. No. P-3877)

b) 1/3 Radius (Neg. No. P-3876)

c) 2/3 Radius (Neg. No. P-3875)

d) Edge (Neg. No. P-3874)

FIGURE E.2.d. Photomicrographs of As-Polished Longitudinal Fuel
Sample 105-ADD2974-H

a) Center (Neg. No. P-3858)

b) 1/3 Radius (Neg. No. P-3857)

c) 2/3 Radius (Neg. No. P-3856)

d) Edge (Neg. No. P-3855)

FIGURE E.2.e. Photomicrographs of As-Polished Longitudinal Fuel Sample 105-ADD2974-S

a) Center (Neg. No. P-5121)

b) 1/3 Radius (Neg. No. P-5120)

c) 2/3 Radius (Neg. No. P-5119)

d) Edge (Neg. No. P-5118)

FIGURE E.2.f. Photomicrographs of As-Polished Transverse
Sample 105-ADD2966-E

a) Center (Neg. No. P-5107)

b) 1/3 Radius (Neg. No. P-5106)

c) 2/3 Radius (Neg. No. P-5105)

d) Edge (Neg. No. P-5104)

FIGURE E.2.g. Photomicrographs of As-Polished Transverse
Sample 105-ADD2966-J

a) Center (Neg. No. P-5135)

b) 1/3 Radius (Neg. No. P-5134)

c) 2/3 Radius (Neg. No. P-5133)

d) Edge (Neg. No. P-5132)

FIGURE E.2.h. Photomicrographs of As-Polished Longitudinal
Sample 105-ADD2966-I

a) Center (Neg. No. P-3892)

b) 1/3 Radius (Neg. No. P-3891)

c) 2/3 Radius (Neg. No. P-3890)

d) Edge (Neg. No. P-3889)

FIGURE E.3.a. Photomicrographs of Argon Ion-Etched Transverse Fuel Sample 105-ADD2974-E

a) Center (Neg. No. P-3871)

b) 1/3 Radius (Neg. No. P-3870)

c) 2/3 Radius (Neg. No. P-3869)

d) Edge (Neg. No. P-3868)

FIGURE E.3.b. Photomicrographs of Argon Ion-Etched Transverse Fuel Sample 105-ADD2974-I

a) Center (Neg. No. P-3852)

b) 1/3 Radius (Neg. No. P-3851)

c) 2/3 Radius (Neg. No. P-3850)

d) Edge (Neg. No. P-3849)

FIGURE E.3.c. Photomicrographs of Argon Ion-Etched Transverse Fuel Sample 105-ADD2974-T

a) Center (Neg. No. P-3883)

b) 1/3 Radius (Neg. No. P-3882)

c) 2/3 Radius (Neg. No. P-3881)

d) Edge (Neg. No. P-3880)

FIGURE E.3.d. Photomicrographs of Argon Ion-Etched Longitudinal Fuel Sample 105-ADD2974-H

a) Center (Neg. No. P-3862)

b) 1/3 Radius (Neg. No. P-3861)

c) 2/3 Radius (Neg. No. P-3860)

d) Edge (Neg. No. P-3859)

FIGURE E.3.e. Photomicrographs of Argon Ion-etched Longitudinal Fuel Sample 105-ADD2974-S

a) Center (Neg. No. P-5155)

b) 1/3 Radius (Neg. No. P-5154)

c) 2/3 Radius (Neg. No. P-5153)

d) Edge (Neg. No. P-5152)

FIGURE E.3.f. Photomicrographs of Argon Ion-Etched Transverse
Sample 105-ADD2966-E

a) Center (Neg. No. P-5151)

b) 1/3 Radius (Neg. No. P-5150)

c) 2/3 Radius (Neg. No. P-5149)

d) Edge (Neg. No. P-5148)

FIGURE E.3.g. Photomicrographs of Argon Ion-Etched Transverse
Sample 105-ADD2966-J

a) Center (Neg. No. P-5159)

b) 1/3 Radius (Neg. No. P-5158)

c) 2/3 Radius (Neg. No. P-5157)

d) Edge (Neg. No. P-5156)

FIGURE E.3.h. Photomicrographs of Argon Ion-Etched Longitudinal Sample 105-ADD2966-I

Zircaloy-2

20 μm

a) Exterior Surface (Neg. No. P-3878)

b) Interior Surface (Neg. No. P-3879)

FIGURE E.4.a. Exterior/Interior Cladding Surfaces of As-Polished Fuel Sample 105-ADD2974-H

Zircaloy-2

20 μ m

a) Exterior Surface (Neg. No. P-3853)

Zircaloy-2

20 μ m

b) Interior Surface (Neg. No. P-3854)

FIGURE E.4.b. Exterior/Interior Cladding Surfaces of As-Polished Fuel Sample 105-ADD2974-S

a) Exterior Surface (Neg. No. P-5122)

b) Interior Surface (Neg. No. P-5123)

FIGURE E.4.c. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-E at 0 Degrees from Mounting Notch (location measured clockwise from notch in Figure E.1.f)

Zircaloy-2

20 μm

a) Exterior Surface (Neg. No. P-5124)

Zircaloy-2

b) Interior Surface (Neg. No. P-5125)

FIGURE E.4.d. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-E at 90 Degrees Clockwise from Mounting Notch (location measured clockwise from notch in Figure E.1.f)

a) Exterior Surface (Neg. No. P-5126)

b) Interior Surface (Neg. No. P-5127)

FIGURE E.4.e. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-E at 180 Degrees Clockwise from Mounting Notch (location measured clockwise from notch in Figure E.1.f)

Outer Oxide
Layer

Zircaloy-2

20 μm

a) Exterior Surface (Neg. No. P-5128)

Zircaloy-2

Fuel

20 μm

b) Interior Surface (Neg. No. P-5129)

FIGURE E.4.f. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-E at 270 Degrees Clockwise from Mounting Notch (location measured clockwise from notch in Figure E.1.f)

a) Exterior Surface (Neg. No. P-5108)

b) Interior Surface (Neg. No. P-5109)

FIGURE E.4.g. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-J at 0 Degrees from Mounting Notch (location measured clockwise from notch in Figure E.1.g)

Zircaloy-2

20 μ m

a) Exterior Surface (Neg. No. P-5110)

Zircaloy-2

b) Interior Surface (Neg. No. P-5111)

FIGURE E.4.h. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-J at 90 Degrees Clockwise from Mounting Notch (location measured clockwise from notch in Figure E.1.g)

Zircaloy-2

20 μ m

a) Exterior Surface (Neg. No. P-5112)

Zircaloy-2

b) Interior Surface (Neg. No. P-5113)

FIGURE E.4.i. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-J at 180 Degrees Clockwise from Mounting Notch (location measured clockwise from notch in Figure E.1.g)

Isolated
Nodular
Deposit

Zircaloy-2

20 μ m

a) Exterior Surface (Neg. No. P-5114)

Zircaloy-2

b) Interior Surface (Neg. No. P-5115)

FIGURE E.4.i. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-J at 270 Degrees Clockwise from Mounting Notch (location measured clockwise from notch in Figure E.1.g)

a) Exterior Surface (Neg. No. P-5136)

b) Interior Surface (Neg. No. P-5137)

FIGURE E.4.k. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-I at Lower Left Corner of Cladding (Note: Position is relative and does not necessarily correspond to Figure E.1.h)

a) Exterior Surface (Neg. No. P-5138)

b) Interior Surface (Neg. No. P-5139)

FIGURE E.4.1. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-I at Lower Right Corner of Cladding
(Note: Position is relative and does not necessarily correspond to Figure E.1.h)

a) Exterior Surface (Neg. No. P-5140)

b) Interior Surface (Neg. No. P-5141)

FIGURE E.4.m. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-I at Upper Right Corner of Cladding (Note: Position is relative and does not necessarily correspond to Figure E.1.h)

a) Exterior Surface (Neg. No. P-5142)

b) Interior Surface (Neg. No. P-5143)

FIGURE E.4.n. Exterior/Interior Cladding Surfaces of As-Polished Sample 105-ADD2966-I at Upper Left Corner of Cladding
(Note: Position is relative and does not necessarily correspond to Figure E.1.h)

FIGURE E.5.a. Etched Cladding of Transverse Sample 105-ADD2974-E
(Neg. No. P-3893)

FIGURE E.5.b. Etched Cladding of Transverse Sample 105-ADD2974-I
(Neg. No. P-3896)

FIGURE E.5.c. Etched Cladding of Transverse Sample 105-ADD2974-T
(Neg. No. P-3897)

FIGURE E.5.d. Etched Cladding of Longitudinal Sample 105-ADD2974-H
(Neg. No. P-3895)

FIGURE E.5.e. Etched Cladding of Longitudinal Sample 105-ADD2974-S (Neg. No. P-3894)

FIGURE E.5.f. Typical Etched Cladding of Transverse Sample 105-ADD2966-E (0° from mounting notch, See Figure E.1.f). Note: photos are available for 90°, 180°, and 270° locations; Neg. Nos. 5179-5184.

a) Exterior Surface
(Neg. No. P-5170)

b) Interior Surface
(Neg. No. P-5169)

FIGURE E.5.g. Etched Cladding of Transverse Sample 105-ADD2966-J
(0° from mounting notch, see Figure E.1.g)

a) Exterior Surface
(Neg. No. P-5172)

b) Interior Surface
(Neg. No. P-5171)

FIGURE E.5.h. Etched Cladding of Transverse Sample 105-ADD2966-J
(90° clockwise from mounting notch, see Figure E.4.g)

a) Exterior Surface
(Neg. No. P-5174)

b) Interior Surface
(Neg. No. P-5173)

FIGURE E.5.i. Etched Cladding of Transverse Sample 105-ADD2966-J
(180° clockwise from mounting notch, see Figure E.1.g)

a) Exterior Surface
(Neg. No. P-5176)

b) Interior Surface
(Neg. No. P-5175)

FIGURE E.5.j. Etched Cladding of Transverse Sample 105-ADD2966-J
(270° clockwise from mounting notch, see Figure E.1.g)

FIGURE E.5.k. Typical Etched Cladding of Longitudinal Sample 105-ADD2966-I (Lower Right Corner from reference point). Note: photos are available for three other locations on this sample, Negs. 5161-5164 and 5167-5168.

FIGURE E.6.a. Alpha Autoradiograph of Transverse Fuel Sample 105-ADD2974-E (Neg. No. 5462)

FIGURE E.6.b. Beta-Gamma Autoradiograph of Transverse Fuel
Sample 105-ADD2974-E (Neg. No. 5463)

FIGURE E.6.c. Alpha Autoradiograph of Transverse Fuel Sample 105-ADD2974-I
(Neg. No. 5466)

FIGURE E.6.d. Beta-Gamma Autoradiograph of Transverse Fuel
Sample 105-ADD2974-I (Neg. No. 5467)

FIGURE E.6.e. Alpha Autoradiograph of Transverse Fuel Sample 105-ADD2974-T
(Neg. No. 5470)

FIGURE E.6.f. Beta-Gamma Autoradiograph of Transverse Fuel Sample
105-ADD2974-T (Neg. No. 5471)

FIGURE E.6.g. Alpha Autoradiograph of Longitudinal Fuel Sample 105-ADD2974-H
(Neg. No. 5464)

FIGURE E.6.h. Beta-Gamma Autoradiograph of Longitudinal Fuel Sample
105-ADD2974-H (Neg. No. 5465)

FIGURE E.6.i. Alpha Autoradiograph of Longitudinal Fuel Sample 105-ADD2974-S
(Neg. No. 5468)

FIGURE E.6.j. Beta-Gamma Autoradiograph of Longitudinal Fuel Sample
105-ADD2974-S (Neg. No. 5469)

FIGURE E.6.k. Alpha Autoradiograph of Transverse Sample 105-ADD2966-E
(Neg. No. 5556)

FIGURE E.6.1. Beta-Gamma Autoradiograph of Transverse Sample 105-ADD2966-E
(Neg. No. 5557)

FIGURE E.6.m. Alpha Autoradiograph of Transverse Sample 105-ADD2966-J
(Neg. No. 5560)

FIGURE E.6.n. Beta-Gamma Autoradiograph of Transverse Sample 105-ADD2966-J
(Neg. No. 5561)

FIGURE E.6.o. Alpha Autoradiograph of Longitudinal Fuel Sample 105-ADD2966-I (Neg. No. 5558)

1000 μm

FIGURE E.6.p. Beta-Gamma Autoradiograph of Longitudinal Fuel Sample
105-ADD2966-I (Neg. No. 5559)

APPENDIX F

RESULTS OF ORIGEN2 RADIONUCLIDE INVENTORY CALCULATIONS

APPENDIX F

RESULTS OF ORIGEN2 RADIONUCLIDE INVENTORY CALCULATIONS

Appendix F contains input and output from the ORIGEN2 calculations for ATM-105 spent fuel based on data described in Section 4.7 and Appendix A. An example of the ORIGEN2 input for fuel irradiation/decay is shown in Figure F.1. The power densities used in ORIGEN2 are the bundle power densities from Table A.2 times a normalization factor of desired exposure in units of MWd/kgM divided by 28.05 MWd/kgM and by 10^6 to convert the mass from MTU to grams U. An example of the ORIGEN2 input for cladding irradiation/decay is shown in Figure F.2. The power densities used in ORIGEN2 are the values as described above times a factor of 4.040. This factor is the number of grams of uranium metal per gram of cladding. The composition values were also increased by this factor of 4.040. The power densities given in Appendix A were normalized to give burnup exposures of 10, 15, 20, 25, 30, and 35 MWd/kgM. Eight tables of output at each of these exposures are given in Appendix F. Their contents are as follows:

Table F.1.a - F.1.f Fission Product Radioactivity by Isotope, Ci/gU

Table F.2.a - F.2.f Actinide Radioactivity by Isotope, Ci/gU

Table F.3.a - F.3.f Fission Product Inventory by Isotope, g/gU

Table F.4.a - F.4.f Actinide Inventory by Isotope, g/gU

Table F.5.a - F.5.f Fission Product Inventory by Element, g/gU

Table F.6.a - F.6.f Actinide Inventory by Element, g/gU

Table F.7.a - F.7.f Fuel Activation Product Inventory by Isotope, g/gU

Table F.8.a - F.8.f Cladding Activation Product Inventory by Isotope,
g/gZr

ORIGEN2 output includes a variety of additional tables, a few of which were used in preparing the comparisons of measured and predicted activities given in Table 4.17.

```

-1
-1
-1
TIT    ATM-105 FUEL  BWR  E=2.939  10 GWD/MTU
BAS    GRAM
LIB    0 1 2 3 251 252 253 9 3 0 1 4
PHO    101 102 103 10
LIP    0 0 0
INP    1 1 -1 -1 1 1
RDA    BURNUP TO 10,000 MWD/MTU
BUP
IRP    19.      5.5736-6  1 2 4 2
DEC    27.      2 3 4 0
IRP    90.      5.0644-6  3 4 4 0
IRP    157.     8.1058-6  4 5 4 0
DEC    174.     5 6 4 0
IRP    182.     5.0644-6  6 7 4 0
IRP    215.     9.1196-6  7 8 4 0
DEC    225.     8 9 4 0
IRP    296.     9.6287-6  9 1 4 0
IRP    451.     5.0644-6  1 2 4 0
DEC    486.     2 3 4 0
IRP    505.     5.0644-6  3 4 4 0
IRP    525.     9.1196-6  4 5 4 0
DEC    532.     5 6 4 0
IRP    554.     8.1058-6  6 7 4 0
DEC    566.     7 8 4 0
IRP    621.     8.1058-6  8 9 4 0
IRP    674.     7.0920-6  9 1 4 0
DEC    693.     1 2 4 0
IRP    718.     7.0920-6  2 3 4 0
IRP    807.     8.1058-6  3 4 4 0
DEC    866.     4 5 4 0
IRP    880.     5.5109-6  5 6 4 0
IRP    904.     7.4785-6  6 7 4 0
IRP    919.     3.9353-6  7 8 4 0
IRP    945.     7.4821-6  8 9 4 0
DEC    953.     9 1 4 0
IRP    996.     7.4821-6  1 2 4 0
IRP    1001.    3.1511-6  2 3 4 0
IRP    1017.    7.4821-6  3 4 4 0
DEC    1022.    4 5 4 0
IRP    1044.    7.0864-6  5 6 4 0
IRP    1083.    4.7231-6  6 7 4 0
IRP    1172.    6.2986-6  7 8 4 0
DEC    1203.    8 9 4 0
IRP    1367.    6.0432-6  9 1 4 0
DEC    2166.    1 2 4 0
IRP    2189.    3.6836-6  2 3 4 0
IRP    2214.    4.0931-6  3 4 4 0

```

FIGURE F.1. Sample ORIGEN2 Input for ATM-105 Fuel


```

-1
-1
-1
TIT    ATM-105 CLAD BWR  E=2.939  10 GWD/MTU
BAS    GRAM
LIB    0 1 2 3 251 252 253 9 3 0 1 4
PHO    101 102 103 10
LIP    0 0 0
INP    1 1 -1 -1 1 1
RDA    BURNUP TO 10,000 MWD/MTU
BUP
IRP    19.      22.5164-6    1 2 4 2
DEC    27.      20.4593-6    2 3 4 0
IRP    90.      20.4593-6    3 4 4 0
IRP    157.     32.7460-6    4 5 4 0
DEC    174.     20.4593-6    5 6 4 0
IRP    182.     20.4593-6    6 7 4 0
IRP    215.     36.8416-6    7 8 4 0
DEC    225.     8 9 4 0
IRP    296.     38.8987-6    9 1 4 0
IRP    451.     20.4593-6    1 2 4 0
DEC    486.     2 3 4 0
IRP    505.     20.4593-6    3 4 4 0
IRP    525.     36.8416-6    4 5 4 0
DEC    532.     5 6 4 0
IRP    554.     32.7460-6    6 7 4 0
DEC    566.     7 8 4 0
IRP    621.     32.7460-6    8 9 4 0
IRP    674.     28.6505-6    9 1 4 0
DEC    693.     1 2 4 0
IRP    718.     28.6505-6    2 3 4 0
IRP    807.     32.7460-6    3 4 4 0
DEC    866.     4 5 4 0
IRP    880.     22.2624-6    5 6 4 0
IRP    904.     30.2112-6    6 7 4 0
IRP    919.     15.8976-6    7 8 4 0
IRP    945.     30.2256-6    8 9 4 0
DEC    953.     9 1 4 0
IRP    996.     30.2256-6    1 2 4 0
IRP    1001.    12.7296-6    2 3 4 0
IRP    1017.    30.2256-6    3 4 4 0
DEC    1022.    4 5 4 0
IRP    1044.    28.6272-6    5 6 4 0
IRP    1083.    19.0800-6    6 7 4 0
IRP    1172.    25.4448-6    7 8 4 0
DEC    1203.    8 9 4 0
IRP    1367.    24.4129-6    9 1 4 0
DEC    2166.    1 2 4 0
IRP    2189.    14.8802-6    2 3 4 0
IRP    2214.    16.5344-6    3 4 4 0

```

FIGURE F.2. Sample ORIGEN2 Input for ATM-105 Cladding

TABLE F.1.a. Fission Product Radioactivity by Isotope at
10 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	9.937E-05	8.882E-05	7.939E-05	7.096E-05	5.359E-05	4.048E-05	0.00
Be-10	8.862E-13	8.862E-13	8.862E-13	8.862E-13	8.862E-13	8.862E-13	8.858E-13
C-14	3.571E-11	3.570E-11	3.569E-11	3.568E-11	3.566E-11	3.564E-11	3.165E-11
Se-79	1.292E-07	1.292E-07	1.292E-07	1.292E-07	1.292E-07	1.292E-07	1.278E-07
Kr-81	5.300E-14	5.300E-14	5.300E-14	5.300E-14	5.300E-14	5.300E-14	5.282E-14
Kr-85	2.006E-03	1.763E-03	1.549E-03	1.361E-03	9.850E-04	7.129E-04	0.00
Rb-87	7.584E-12	7.584E-12	7.584E-12	7.584E-12	7.584E-12	7.584E-12	7.584E-12
Sr-89	1.974E-10	8.724E-15	3.855E-19	1.703E-23	0.00	0.00	0.00
Sr-90	2.180E-02	2.078E-02	1.982E-02	1.890E-02	1.678E-02	1.489E-02	1.103E-12
Y-90	2.180E-02	2.079E-02	1.982E-02	1.890E-02	1.678E-02	1.490E-02	1.104E-12
Y-91	3.836E-09	6.688E-13	1.166E-16	2.033E-20	0.00	0.00	0.00
Zr-93	6.110E-07	6.110E-07	6.110E-07	6.110E-07	6.110E-07	6.110E-07	6.107E-07
Nb-93m	2.121E-07	2.478E-07	2.800E-07	3.091E-07	3.701E-07	4.175E-07	5.802E-07
Nb-94	2.663E-11	2.663E-11	2.663E-11	2.663E-11	2.662E-11	2.662E-11	2.574E-11
Zr-95	2.063E-08	7.542E-12	2.758E-15	1.008E-18	0.00	0.00	0.00
Nb-95	4.580E-08	1.674E-11	6.122E-15	2.238E-18	0.00	0.00	0.00
Nb-95m	1.530E-10	5.595E-14	2.046E-17	7.479E-21	0.00	0.00	0.00
Tc-98	3.600E-13	3.600E-13	3.600E-13	3.600E-13	3.600E-13	3.600E-13	3.599E-13
Tc-99	4.329E-06	4.329E-06	4.329E-06	4.329E-06	4.329E-06	4.329E-06	4.315E-06
Rh-102	1.982E-08	1.229E-08	7.620E-09	4.724E-09	1.430E-09	4.328E-10	0.00
Ru-103	7.394E-13	1.866E-18	4.709E-24	0.00	0.00	0.00	0.00
Rh-103m	6.666E-13	1.682E-18	4.245E-24	0.00	0.00	0.00	0.00
Ru-106	2.081E-03	5.260E-04	1.330E-04	3.361E-05	1.080E-06	3.468E-08	0.00
Rh-106	2.081E-03	5.260E-04	1.330E-04	3.361E-05	1.080E-06	3.468E-08	0.00
Pd-107	1.859E-08	1.859E-08	1.859E-08	1.859E-08	1.859E-08	1.859E-08	1.859E-08
Ag-108	3.927E-13	3.884E-13	3.842E-13	3.801E-13	3.698E-13	3.599E-13	1.711E-15
Ag-108m	4.412E-12	4.365E-12	4.317E-12	4.270E-12	4.155E-12	4.043E-12	1.923E-14
Ag-109m	8.802E-13	2.956E-13	9.925E-14	3.333E-14	2.178E-15	1.423E-16	0.00
Cd-109	8.802E-13	2.956E-13	9.925E-14	3.333E-14	2.178E-15	1.423E-16	0.00
Ag-110	1.985E-08	2.616E-09	3.449E-10	4.546E-11	2.868E-13	1.810E-15	0.00
Ag-110m	1.492E-06	1.967E-07	2.593E-08	3.418E-09	2.156E-11	1.361E-13	0.00
Cd-113m	7.036E-06	6.398E-06	5.818E-06	5.291E-06	4.172E-06	3.290E-06	0.00
In-114	2.263E-16	8.194E-21	2.967E-25	0.00	0.00	0.00	0.00
In-114m	2.365E-16	8.562E-21	3.100E-25	0.00	0.00	0.00	0.00
Cd-115m	1.564E-14	1.833E-19	2.148E-24	0.00	0.00	0.00	0.00
Sn-119m	2.187E-07	2.770E-08	3.507E-09	4.441E-10	2.533E-12	1.446E-14	0.00
Sn-121m	4.068E-08	3.956E-08	3.848E-08	3.743E-08	3.492E-08	3.258E-08	4.069E-14
Sn-123	1.001E-07	1.987E-09	3.942E-11	7.820E-13	4.336E-17	2.404E-21	0.00
Te-123m	2.153E-11	3.130E-13	4.550E-15	6.617E-17	1.686E-21	0.00	0.00
Sb-124	1.462E-12	3.250E-16	7.224E-20	1.606E-23	0.00	0.00	0.00
Sb-125	6.177E-04	3.745E-04	2.270E-04	1.376E-04	3.938E-05	1.127E-05	0.00
Te-125m	1.507E-04	9.139E-05	5.541E-05	3.359E-05	9.609E-06	2.750E-06	0.00
Sn-126	1.892E-07	1.892E-07	1.892E-07	1.891E-07	1.891E-07	1.891E-07	1.879E-07
Sb-126	2.648E-08	2.648E-08	2.648E-08	2.648E-08	2.648E-08	2.648E-08	2.630E-08
Sb-126m	1.892E-07	1.892E-07	1.892E-07	1.891E-07	1.891E-07	1.891E-07	1.879E-07
Te-127	9.264E-08	8.901E-10	8.551E-12	8.216E-14	7.434E-19	6.727E-24	0.00
Te-127m	9.458E-08	9.086E-10	8.730E-12	8.387E-14	7.589E-19	6.867E-24	0.00

Table F.1.a. Fission Product Radioactivity by Isotope at
10 MWd/kgM, Ci/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Te-129	1.977E-16	5.640E-23	0.00	0.00	0.00	0.00	0.00
Te-129m	3.038E-16	8.664E-23	0.00	0.00	0.00	0.00	0.00
I-129	8.740E-09	8.740E-09	8.740E-09	8.740E-09	8.740E-09	8.740E-09	8.740E-09
Cs-134	2.063E-03	1.053E-03	5.378E-04	2.746E-04	5.113E-05	9.522E-06	0.00
Cs-135	2.934E-07	2.934E-07	2.934E-07	2.934E-07	2.934E-07	2.934E-07	2.933E-07
Cs-137	2.634E-02	2.515E-02	2.401E-02	2.293E-02	2.043E-02	1.820E-02	2.667E-12
Ba-137m	2.491E-02	2.379E-02	2.272E-02	2.169E-02	1.932E-02	1.721E-02	2.523E-12
Ce-141	4.543E-15	7.826E-22	0.00	0.00	0.00	0.00	0.00
Ce-142	8.517E-12	8.517E-12	8.517E-12	8.517E-12	8.517E-12	8.517E-12	8.517E-12
Ce-144	3.005E-03	5.062E-04	8.525E-05	1.436E-05	1.672E-07	1.946E-09	0.00
Pr-144	3.005E-03	5.062E-04	8.525E-05	1.436E-05	1.672E-07	1.946E-09	0.00
Pr-144m	3.606E-05	6.074E-06	1.023E-06	1.723E-07	2.006E-09	2.335E-11	0.00
Nd-144	4.199E-16	4.208E-16	4.209E-16	4.210E-16	4.210E-16	4.210E-16	4.210E-16
Pm-146	9.208E-08	7.157E-08	5.562E-08	4.323E-08	2.302E-08	1.226E-08	0.00
Sm-146	3.742E-14	3.802E-14	3.848E-14	3.884E-14	3.943E-14	3.974E-14	4.010E-14
Pm-147	1.298E-02	7.650E-03	4.510E-03	2.659E-03	7.095E-04	1.893E-04	0.00
Sm-147	2.356E-12	2.486E-12	2.563E-12	2.609E-12	2.656E-12	2.669E-12	2.674E-12
Pm-148	3.464E-15	1.639E-20	7.755E-26	0.00	0.00	0.00	0.00
Pm-148m	6.150E-14	2.910E-19	1.377E-24	0.00	0.00	0.00	0.00
Eu-150	1.525E-11	1.467E-11	1.412E-11	1.358E-11	1.274E-11	1.120E-11	7.165E-20
Sm-151	2.092E-04	2.060E-04	2.029E-04	1.998E-04	1.922E-04	1.850E-04	9.751E-08
Eu-152	2.043E-05	1.845E-05	1.666E-05	1.505E-05	1.166E-05	9.039E-06	0.00
Gd-153	2.679E-07	3.306E-08	4.080E-09	5.035E-10	2.694E-12	1.442E-14	0.00
Eu-154	5.522E-04	4.700E-04	4.000E-04	3.405E-04	2.275E-04	1.521E-04	0.00
Eu-155	4.357E-04	3.295E-04	2.491E-04	1.884E-04	9.365E-05	4.656E-05	0.00
Tb-160	1.285E-11	1.168E-14	1.062E-17	9.657E-21	0.00	0.00	0.00
Ho-166m	7.352E-11	7.343E-11	7.335E-11	7.326E-11	7.305E-11	7.284E-11	4.136E-11
Tm-170	5.918E-14	1.154E-15	2.252E-17	3.950E-19	2.096E-23	0.00	0.00
Tm-171	1.091E-13	5.298E-14	2.573E-14	1.250E-14	2.056E-15	3.381E-16	0.00
Total	1.242E-01	1.046E-01	9.464E-02	8.780E-02	7.569E-02	6.657E-02	6.454E-06

TABLE F.1.b. Fission Product Radioactivity by Isotope at
15 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	1.534E-04	1.371E-04	1.225E-04	1.095E-04	8.273E-05	6.249E-05	0.00
Be-10	1.326E-12	1.326E-12	1.326E-12	1.326E-12	1.326E-12	1.326E-12	1.325E-12
C-14	5.342E-11	5.340E-11	5.339E-11	5.338E-11	5.335E-11	5.331E-11	4.735E-11
Se-79	1.913E-07	1.913E-07	1.913E-07	1.912E-07	1.912E-07	1.912E-07	1.892E-07
Kr-81	1.120E-13	1.120E-13	1.120E-13	1.120E-13	1.120E-13	1.120E-13	1.116E-13
Kr-85	2.888E-03	2.538E-03	2.230E-03	1.959E-03	1.418E-03	1.026E-03	0.00
Rb-87	1.087E-11	1.087E-11	1.087E-11	1.087E-11	1.087E-11	1.087E-11	1.087E-11
Sr-89	2.710E-10	1.198E-14	5.292E-19	2.338E-23	0.00	0.00	0.00
Sr-90	3.118E-02	2.973E-02	2.834E-02	2.703E-02	2.399E-02	2.130E-02	1.578E-12
Y-90	3.118E-02	2.973E-02	2.835E-02	2.703E-02	2.400E-02	2.131E-02	1.578E-12
Y-91	5.327E-09	9.288E-13	1.619E-16	2.823E-20	0.00	0.00	0.00
Zr-93	8.889E-07	8.888E-07	8.888E-07	8.888E-07	8.888E-07	8.888E-07	8.884E-07
Nb-93m	3.096E-07	3.614E-07	4.082E-07	4.505E-07	5.391E-07	6.078E-07	8.440E-07
Nb-94	4.880E-11	4.880E-11	4.880E-11	4.879E-11	4.879E-11	4.878E-11	4.717E-11
Zr-95	2.995E-08	1.095E-11	4.003E-15	1.464E-18	0.00	0.00	0.00
Nb-95	6.648E-08	2.431E-11	8.887E-15	3.249E-18	0.00	0.00	0.00
Nb-95m	2.222E-10	8.122E-14	2.970E-17	1.086E-20	0.00	0.00	0.00
Tc-98	8.264E-13	8.264E-13	8.264E-13	8.264E-13	8.264E-13	8.264E-13	8.263E-13
Tc-99	6.383E-06	6.383E-06	6.383E-06	6.383E-06	6.383E-06	6.383E-06	6.362E-06
Rh-102	4.635E-08	2.874E-08	1.782E-08	1.105E-08	3.343E-09	1.012E-09	0.00
Ru-103	1.198E-12	3.024E-18	7.631E-24	0.00	0.00	0.00	0.00
Rh-103m	1.080E-12	2.726E-18	6.879E-24	0.00	0.00	0.00	0.00
Ru-106	3.853E-03	9.740E-04	2.462E-04	6.223E-05	1.999E-06	6.420E-08	0.00
Rh-106	3.853E-03	9.740E-04	2.462E-04	6.223E-05	1.999E-06	6.420E-08	0.00
Pd-107	3.452E-08	3.452E-08	3.452E-08	3.452E-08	3.452E-08	3.452E-08	3.452E-08
Ag-108	7.957E-13	7.870E-13	7.785E-13	7.700E-13	7.493E-13	7.291E-13	3.467E-15
Ag-108m	8.940E-12	8.843E-12	8.747E-12	8.652E-12	8.419E-12	8.192E-12	3.896E-14
Ag-109m	3.833E-12	1.287E-12	4.322E-13	1.451E-13	9.484E-15	6.197E-16	0.00
Cd-109	3.833E-12	1.287E-12	4.322E-13	1.451E-13	9.484E-15	6.197E-16	0.00
Ag-110	5.761E-08	7.594E-09	1.001E-09	1.320E-10	8.326E-13	5.253E-15	0.00
Ag-110m	4.331E-06	5.710E-07	7.527E-08	9.922E-09	6.260E-11	3.949E-13	0.00
Cd-113m	1.194E-05	1.086E-05	9.872E-06	8.977E-06	7.079E-06	5.582E-06	0.00
In-114	5.867E-16	2.124E-20	7.691E-25	0.00	0.00	0.00	0.00
In-114m	6.130E-16	2.220E-20	8.036E-25	0.00	0.00	0.00	0.00
Cd-115m	2.577E-14	3.020E-19	3.539E-24	0.00	0.00	0.00	0.00
Sn-119m	3.644E-07	4.615E-08	5.843E-09	7.399E-10	4.222E-12	2.409E-14	0.00
Sn-121m	6.894E-08	6.705E-08	6.522E-08	6.344E-08	5.919E-08	5.522E-08	6.896E-14
Sn-123	1.588E-07	3.150E-09	6.250E-11	1.240E-12	6.874E-17	3.811E-21	0.00
Te-123m	8.054E-11	1.171E-12	1.702E-14	2.475E-16	6.308E-21	1.608E-25	0.00
Sb-124	3.566E-12	7.928E-16	1.762E-19	3.918E-23	0.00	0.00	0.00
Sb-125	9.963E-04	6.040E-04	3.662E-04	2.220E-04	6.352E-05	1.818E-05	0.00
Te-125m	2.431E-04	1.474E-04	8.937E-05	5.418E-05	1.550E-05	4.435E-06	0.00
Sn-126	3.001E-07	3.000E-07	3.000E-07	3.000E-07	3.000E-07	3.000E-07	2.980E-07
Sb-126	4.201E-08	4.201E-08	4.201E-08	4.201E-08	4.200E-08	4.200E-08	4.172E-08
Sb-126m	3.001E-07	3.000E-07	3.000E-07	3.000E-07	3.000E-07	3.000E-07	2.980E-07
Te-127	1.523E-07	1.464E-09	1.406E-11	1.351E-13	1.223E-18	1.106E-23	0.00
Te-127m	1.555E-07	1.494E-09	1.436E-11	1.379E-13	1.248E-18	1.129E-23	0.00

Table F.1.b. Fission Product Radioactivity by Isotope at
15 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Te-129	3.144E-16	8.967E-23	0.00	0.00	0.00	0.00	0.00
Te-129m	4.830E-16	1.378E-22	0.00	0.00	0.00	0.00	0.00
I-129	1.354E-08	1.354E-08	1.354E-08	1.354E-08	1.354E-08	1.354E-08	1.354E-08
Cs-134	4.703E-03	2.401E-03	1.226E-03	6.257E-04	1.165E-04	2.170E-05	0.00
Cs-135	3.736E-07	3.736E-07	3.736E-07	3.736E-07	3.736E-07	3.736E-07	3.735E-07
Cs-137	3.955E-02	3.777E-02	3.606E-02	3.443E-02	3.068E-02	2.733E-02	4.006E-12
Ba-137m	3.742E-02	3.573E-02	3.411E-02	3.257E-02	2.902E-02	2.585E-02	3.789E-12
Ce-141	6.708E-15	1.155E-21	0.00	0.00	0.00	0.00	0.00
Ce-142	1.262E-11	1.262E-11	1.262E-11	1.262E-11	1.262E-11	1.262E-11	1.262E-11
Ce-144	4.360E-03	7.343E-04	1.237E-04	2.083E-05	2.425E-07	2.823E-09	0.00
Pr-144	4.360E-03	7.344E-04	1.237E-04	2.083E-05	2.425E-07	2.823E-09	0.00
Pr-144m	5.232E-05	8.812E-06	1.484E-06	2.500E-07	2.910E-09	3.388E-11	0.00
Nd-144	6.456E-16	6.470E-16	6.472E-16	6.472E-16	6.473E-16	6.473E-16	6.473E-16
Pm-146	1.957E-07	1.521E-07	1.182E-07	9.189E-08	4.893E-08	2.606E-08	0.00
Sm-146	7.960E-14	8.087E-14	8.185E-14	8.262E-14	8.387E-14	8.453E-14	8.529E-14
Pm-147	1.751E-02	1.032E-02	6.087E-03	3.588E-03	9.576E-04	2.555E-04	0.00
Sm-147	3.142E-12	3.318E-12	3.422E-12	3.483E-12	3.548E-12	3.565E-12	3.571E-12
Pm-148	6.374E-15	3.016E-20	1.427E-25	0.00	0.00	0.00	0.00
Pm-148m	1.132E-13	5.354E-19	2.533E-24	0.00	0.00	0.00	0.00
Eu-150	1.979E-11	1.904E-11	1.832E-11	1.763E-11	1.601E-11	1.454E-11	9.293E-20
Sm-151	2.349E-04	2.313E-04	2.278E-04	2.243E-04	2.158E-04	2.077E-04	1.095E-07
Eu-152	2.251E-05	2.033E-05	1.836E-05	1.658E-05	1.285E-05	9.959E-06	0.00
Gd-153	4.925E-07	6.078E-08	7.501E-09	9.257E-10	4.956E-12	2.652E-14	0.00
Eu-154	1.357E-03	1.155E-03	9.828E-04	8.365E-04	5.591E-04	3.736E-04	0.00
Eu-155	7.735E-04	5.849E-04	4.423E-04	3.344E-04	1.662E-04	8.265E-05	0.00
Tb-160	3.769E-11	3.426E-14	3.115E-17	2.832E-20	0.00	0.00	0.00
Ho-166m	2.290E-10	2.288E-10	2.285E-10	2.282E-10	2.276E-10	2.269E-10	1.288E-10
Tm-170	3.182E-13	6.202E-15	1.208E-16	2.418E-18	1.283E-22	0.00	0.00
Tm-171	9.137E-13	4.438E-13	2.156E-13	1.047E-13	1.722E-14	2.833E-15	0.00
Total	1.847E-01	1.545E-01	1.394E-01	1.292E-01	1.113E-01	9.787E-02	9.453E-06

TABLE F.1.c. Fission Product Radioactivity by Isotope at
20 MWd/kgM, Ci/gU

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
H-3	2.095E-04	1.873E-04	1.674E-04	1.496E-04	1.130E-04	8.534E-05	0.00
Be-10	1.763E-12	1.763E-12	1.763E-12	1.763E-12	1.763E-12	1.763E-12	1.763E-12
C-14	7.105E-11	7.103E-11	7.102E-11	7.100E-11	7.096E-11	7.091E-11	6.298E-11
Se-79	2.517E-07	2.517E-07	2.517E-07	2.517E-07	2.517E-07	2.517E-07	2.491E-07
Kr-81	1.917E-13	1.917E-13	1.917E-13	1.917E-13	1.916E-13	1.916E-13	1.910E-13
Kr-85	3.710E-03	3.260E-03	2.864E-03	2.517E-03	1.822E-03	1.318E-03	0.00
Rb-87	1.392E-11	1.392E-11	1.392E-11	1.392E-11	1.392E-11	1.392E-11	1.392E-11
Sr-89	3.340E-10	1.476E-14	6.522E-19	2.882E-23	0.00	0.00	0.00
Sr-90	3.980E-02	3.795E-02	3.619E-02	3.450E-02	3.063E-02	2.719E-02	2.014E-12
Y-90	3.981E-02	3.796E-02	3.619E-02	3.451E-02	3.064E-02	2.720E-02	2.015E-12
Y-91	6.637E-09	1.157E-12	2.018E-16	3.518E-20	0.00	0.00	0.00
Zr-93	1.152E-06	1.152E-06	1.152E-06	1.152E-06	1.152E-06	1.152E-06	1.152E-06
Nb-93m	4.025E-07	4.696E-07	5.302E-07	5.849E-07	6.996E-07	7.884E-07	1.094E-06
Nb-94	7.417E-11	7.417E-11	7.416E-11	7.416E-11	7.414E-11	7.413E-11	7.169E-11
Zr-95	3.882E-08	1.419E-11	5.190E-15	1.897E-18	0.00	0.00	0.00
Nb-95	8.619E-08	3.151E-11	1.152E-14	4.213E-18	0.00	0.00	0.00
Nb-95m	2.880E-10	1.053E-13	3.850E-17	1.408E-20	0.00	0.00	0.00
Tc-98	1.500E-12	1.500E-12	1.500E-12	1.500E-12	1.500E-12	1.500E-12	1.500E-12
Tc-99	8.361E-06	8.361E-06	8.361E-06	8.361E-06	8.360E-06	8.360E-06	8.334E-06
Rh-102	8.450E-08	5.239E-08	3.248E-08	2.014E-08	6.095E-09	1.845E-09	0.00
Ru-103	1.681E-12	4.242E-18	1.071E-23	0.00	0.00	0.00	0.00
Rh-103m	1.516E-12	3.825E-18	9.651E-24	0.00	0.00	0.00	0.00
Ru-106	5.961E-03	1.507E-03	3.809E-04	9.627E-05	3.092E-06	9.933E-08	0.00
Rh-106	5.961E-03	1.507E-03	3.809E-04	9.627E-05	3.092E-06	9.933E-08	0.00
Pd-107	5.386E-08	5.386E-08	5.386E-08	5.386E-08	5.386E-08	5.386E-08	5.386E-08
Ag-108	1.306E-12	1.292E-12	1.278E-12	1.264E-12	1.230E-12	1.197E-12	5.692E-15
Ag-108m	1.468E-11	1.452E-11	1.436E-11	1.420E-11	1.382E-11	1.345E-11	6.395E-14
Ag-109m	1.101E-11	3.698E-12	1.242E-12	4.170E-13	2.725E-14	1.781E-15	0.00
Cd-109	1.101E-11	3.698E-12	1.242E-12	4.170E-13	2.725E-14	1.781E-15	0.00
Ag-110	1.228E-07	1.618E-08	2.133E-09	2.812E-10	1.774E-12	1.119E-14	0.00
Ag-110m	9.231E-06	1.217E-06	1.604E-07	2.114E-08	1.334E-10	8.416E-13	0.00
Cd-113m	1.785E-05	1.623E-05	1.476E-05	1.342E-05	1.059E-05	8.347E-06	5.017E-26
In-114	1.188E-15	4.302E-20	1.558E-24	0.00	0.00	0.00	0.00
In-114m	1.242E-15	4.496E-20	1.628E-24	0.00	0.00	0.00	0.00
Cd-115m	3.716E-14	4.354E-19	5.103E-24	0.00	0.00	0.00	0.00
Sn-119m	5.320E-07	6.737E-08	8.531E-09	1.080E-09	6.164E-12	3.518E-14	0.00
Sn-121m	1.002E-07	9.751E-08	9.484E-08	9.224E-08	8.606E-08	8.030E-08	1.003E-13
Sn-123	2.208E-07	4.381E-09	8.692E-11	1.724E-12	9.560E-17	5.300E-21	0.00
Te-123m	2.099E-10	3.052E-12	4.438E-14	6.451E-16	1.644E-20	4.190E-25	0.00
Sb-124	6.817E-12	1.515E-15	3.369E-19	7.489E-23	0.00	0.00	0.00
Sb-125	1.403E-03	8.504E-04	5.155E-04	3.125E-04	8.943E-05	2.559E-05	0.00
Te-125m	3.422E-04	2.075E-04	1.258E-04	7.627E-05	2.182E-05	6.244E-06	0.00
Sn-126	4.181E-07	4.181E-07	4.181E-07	4.181E-07	4.181E-07	4.181E-07	4.152E-07
Sb-126	5.854E-08	5.853E-08	5.853E-08	5.853E-08	5.853E-08	5.853E-08	5.813E-08
Sb-126m	4.181E-07	4.181E-07	4.181E-07	4.181E-07	4.181E-07	4.181E-07	4.152E-07
Te-127	2.167E-07	2.082E-09	2.000E-11	1.921E-13	1.739E-18	1.573E-23	0.00
Te-127m	2.212E-07	2.125E-09	2.042E-11	1.962E-13	1.775E-18	1.606E-23	0.00

Table F.1.c. Fission Product Radioactivity by Isotope at
20 MWd/kgM, Ci/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Te-129	4.365E-16	1.245E-22	0.00	0.00	0.00	0.00	0.00
Te-129m	6.706E-16	1.913E-22	0.00	0.00	0.00	0.00	0.00
I-129	1.847E-08	1.847E-08	1.847E-08	1.847E-08	1.847E-08	1.847E-08	1.847E-08
Cs-134	8.403E-03	4.290E-03	2.190E-03	1.118E-03	2.082E-04	3.878E-05	0.00
Cs-135	4.315E-07	4.315E-07	4.315E-07	4.315E-07	4.315E-07	4.315E-07	4.313E-07
Cs-137	5.278E-02	5.040E-02	4.812E-02	4.595E-02	4.094E-02	3.647E-02	5.346E-12
Ba-137m	4.993E-02	4.768E-02	4.552E-02	4.347E-02	3.873E-02	3.450E-02	5.057E-12
Ce-141	8.825E-15	1.520E-21	0.00	0.00	0.00	0.00	0.00
Ce-142	1.665E-11	1.665E-11	1.665E-11	1.665E-11	1.665E-11	1.665E-11	1.665E-11
Ce-144	5.655E-03	9.524E-04	1.604E-04	2.702E-05	3.145E-07	3.661E-09	0.00
Pr-144	5.655E-03	9.525E-04	1.604E-04	2.702E-05	3.145E-07	3.662E-09	0.00
Pr-144m	6.785E-05	1.143E-05	1.925E-06	3.242E-07	3.774E-09	4.394E-11	0.00
Nd-144	8.831E-16	8.848E-16	8.851E-16	8.852E-16	8.852E-16	8.852E-16	8.852E-16
Pm-146	3.297E-07	2.562E-07	1.991E-07	1.548E-07	8.242E-08	4.389E-08	0.00
Sm-146	1.334E-13	1.356E-13	1.372E-13	1.385E-13	1.406E-13	1.417E-13	1.430E-13
Pm-147	2.107E-02	1.242E-02	7.324E-03	4.318E-03	1.152E-03	3.075E-04	0.00
Sm-147	3.724E-12	3.936E-12	4.061E-12	4.135E-12	4.212E-12	4.233E-12	4.241E-12
Pm-148	9.329E-15	4.414E-20	2.089E-25	0.00	0.00	0.00	0.00
Pm-148m	1.656E-13	7.837E-19	3.708E-24	0.00	0.00	0.00	0.00
Eu-150	2.294E-11	2.207E-11	2.124E-11	2.043E-11	1.856E-11	1.685E-11	1.078E-19
Sm-151	2.567E-04	2.528E-04	2.489E-04	2.451E-04	2.358E-04	2.269E-04	1.196E-07
Eu-152	2.211E-05	1.997E-05	1.803E-05	1.629E-05	1.262E-05	9.783E-06	0.00
Gd-153	7.077E-07	8.735E-08	1.078E-08	1.330E-09	7.118E-12	3.810E-14	0.00
Eu-154	2.543E-03	2.164E-03	1.842E-03	1.568E-03	1.048E-03	7.002E-04	0.00
Eu-155	1.258E-03	9.509E-04	7.190E-04	5.436E-04	2.703E-04	1.344E-04	0.00
Tb-160	8.231E-11	7.483E-14	6.802E-17	6.184E-20	0.00	0.00	0.00
Ho-166m	5.391E-10	5.384E-10	5.378E-10	5.372E-10	5.357E-10	5.341E-10	3.032E-10
Tm-170	1.056E-12	2.058E-14	4.012E-16	7.769E-18	4.121E-22	0.00	0.00
Tm-171	4.188E-12	2.035E-12	9.883E-13	4.801E-13	7.895E-14	1.298E-14	0.00
Total	2.449E-01	2.036E-01	1.832E-01	1.696E-01	1.459E-01	1.282E-01	1.234E-05

TABLE F.1.d. Fission Product Radioactivity by Isotope at
25 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	2.676E-04	2.392E-04	2.138E-04	1.911E-04	1.443E-04	1.090E-04	0.00
Be-10	2.199E-12	2.199E-12	2.199E-12	2.199E-12	2.199E-12	2.199E-12	2.198E-12
C-14	8.862E-11	8.859E-11	8.857E-11	8.855E-11	8.850E-11	8.844E-11	7.856E-11
Se-79	3.106E-07	3.106E-07	3.105E-07	3.105E-07	3.105E-07	3.105E-07	3.073E-07
Kr-81	2.941E-13	2.941E-13	2.941E-13	2.941E-13	2.941E-13	2.941E-13	2.932E-13
Kr-85	4.475E-03	3.932E-03	3.455E-03	3.036E-03	2.197E-03	1.590E-03	0.00
Rb-87	1.673E-11	1.673E-11	1.673E-11	1.673E-11	1.673E-11	1.673E-11	1.673E-11
Sr-89	3.859E-10	1.705E-14	7.535E-19	3.329E-23	0.00	0.00	0.00
Sr-90	4.772E-02	4.550E-02	4.338E-02	4.137E-02	3.672E-02	3.260E-02	2.415E-12
Y-90	4.773E-02	4.551E-02	4.339E-02	4.138E-02	3.673E-02	3.261E-02	2.416E-12
Y-91	7.757E-09	1.352E-12	2.358E-16	4.111E-20	0.00	0.00	0.00
Zr-93	1.402E-06	1.402E-06	1.402E-06	1.402E-06	1.402E-06	1.402E-06	1.401E-06
Nb-93m	4.913E-07	5.727E-07	6.463E-07	7.128E-07	8.520E-07	9.600E-07	1.331E-06
Nb-94	1.020E-10	1.019E-10	1.019E-10	1.019E-10	1.019E-10	1.019E-10	9.854E-11
Zr-95	4.722E-08	1.727E-11	6.313E-15	2.308E-18	0.00	0.00	0.00
Nb-95	1.048E-07	3.833E-11	1.401E-14	5.124E-18	0.00	0.00	0.00
Nb-95m	3.503E-10	1.281E-13	4.683E-17	1.712E-20	0.00	0.00	0.00
Tc-98	2.402E-12	2.402E-12	2.402E-12	2.402E-12	2.402E-12	2.402E-12	2.401E-12
Tc-99	1.026E-05	1.026E-05	1.026E-05	1.026E-05	1.026E-05	1.026E-05	1.022E-05
Rh-102	1.350E-07	8.372E-08	5.190E-08	3.218E-08	9.740E-09	2.948E-09	0.00
Ru-103	2.210E-12	5.576E-18	1.407E-23	0.00	0.00	0.00	0.00
Rh-103m	1.992E-12	5.027E-18	1.269E-23	0.00	0.00	0.00	0.00
Ru-106	8.438E-03	2.133E-03	5.391E-04	1.363E-04	4.377E-06	1.406E-07	0.00
Rh-106	8.438E-03	2.133E-03	5.391E-04	1.363E-04	4.377E-06	1.406E-07	0.00
Pd-107	7.644E-08	7.644E-08	7.644E-08	7.644E-08	7.644E-08	7.644E-08	7.644E-08
Ag-108	1.925E-12	1.904E-12	1.884E-12	1.863E-12	1.813E-12	1.764E-12	8.390E-15
Ag-108m	2.163E-11	2.140E-11	2.117E-11	2.094E-11	2.037E-11	1.982E-11	9.427E-14
Ag-109m	2.538E-11	8.524E-12	2.862E-12	9.612E-13	6.281E-14	4.104E-15	0.00
Cd-109	2.538E-11	8.524E-12	2.862E-12	9.612E-13	6.280E-14	4.104E-15	0.00
Ag-110	2.220E-07	2.926E-08	3.857E-09	5.084E-10	3.209E-12	2.025E-14	0.00
Ag-110m	1.669E-05	2.200E-06	2.900E-07	3.823E-08	2.413E-10	1.522E-12	0.00
Cd-113m	2.496E-05	2.270E-05	2.064E-05	1.877E-05	1.480E-05	1.167E-05	7.015E-26
In-114	2.103E-15	7.615E-20	2.757E-24	0.00	0.00	0.00	0.00
In-114m	2.198E-15	7.957E-20	2.881E-24	0.00	0.00	0.00	0.00
Cd-115m	4.979E-14	5.834E-19	6.837E-24	0.00	0.00	0.00	0.00
Sn-119m	7.267E-07	9.202E-08	1.165E-08	1.475E-09	8.422E-12	4.807E-14	0.00
Sn-121m	1.340E-07	1.304E-07	1.268E-07	1.233E-07	1.151E-07	1.074E-07	1.341E-13
Sn-123	2.866E-07	5.686E-09	1.128E-10	2.238E-12	1.241E-16	6.880E-21	0.00
Te-123m	4.518E-10	6.568E-12	9.550E-14	1.388E-15	3.538E-20	9.017E-25	0.00
Sb-124	1.142E-11	2.539E-15	5.645E-19	1.255E-22	0.00	0.00	0.00
Sb-125	1.837E-03	1.114E-03	6.753E-04	4.094E-04	1.171E-04	3.352E-05	0.00
Te-125m	4.483E-04	2.719E-04	1.648E-04	9.991E-05	2.858E-05	8.179E-06	0.00
Sn-126	5.427E-07	5.427E-07	5.427E-07	5.427E-07	5.427E-07	5.426E-07	5.390E-07
Sb-126	7.598E-08	7.598E-08	7.598E-08	7.597E-08	7.597E-08	7.597E-08	7.545E-08
Sb-126m	5.427E-07	5.427E-07	5.427E-07	5.427E-07	5.427E-07	5.426E-07	5.390E-07
Te-127	2.858E-07	2.746E-09	2.638E-11	2.535E-13	2.294E-18	2.075E-23	0.00
Te-127m	2.918E-07	2.803E-09	2.693E-11	2.588E-13	2.342E-18	2.119E-23	0.00

TABLE F.1.d. Fission Product Radioactivity by Isotope at
25 MWd/kgM, Ci/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Te-129	5.642E-16	1.609E-22	0.00	0.00	0.00	0.00	0.00
Te-129m	8.667E-16	2.472E-22	0.00	0.00	0.00	0.00	0.00
I-129	2.348E-08	2.348E-08	2.348E-08	2.348E-08	2.348E-08	2.348E-08	2.348E-08
Cs-134	1.322E-02	6.750E-03	3.446E-03	1.759E-03	3.276E-04	6.101E-05	0.00
Cs-135	4.743E-07	4.743E-07	4.743E-07	4.743E-07	4.743E-07	4.743E-07	4.741E-07
Cs-137	6.603E-02	6.304E-02	6.020E-02	5.748E-02	5.121E-02	4.562E-02	6.687E-12
Ba-137m	6.246E-02	5.964E-02	5.695E-02	5.438E-02	4.844E-02	4.316E-02	6.326E-12
Ce-141	1.089E-14	1.876E-21	0.00	0.00	0.00	0.00	0.00
Ce-142	2.060E-11	2.060E-11	2.060E-11	2.060E-11	2.060E-11	2.060E-11	2.060E-11
Ce-144	6.888E-03	1.160E-03	1.954E-04	3.291E-05	3.831E-07	4.460E-09	0.00
Pr-144	6.888E-03	1.160E-03	1.954E-04	3.291E-05	3.831E-07	4.460E-09	0.00
Pr-144m	8.265E-05	1.392E-05	2.345E-06	3.949E-07	4.597E-09	5.352E-11	0.00
Nd-144	1.133E-15	1.135E-15	1.135E-15	1.135E-15	1.135E-15	1.135E-15	1.135E-15
Pm-146	4.898E-07	3.807E-07	2.959E-07	2.300E-07	1.225E-07	6.521E-08	0.00
Sm-146	1.972E-13	2.004E-13	2.029E-13	2.048E-13	2.079E-13	2.096E-13	2.115E-13
Pm-147	2.379E-02	1.402E-02	8.267E-03	4.874E-03	1.301E-03	3.471E-04	0.00
Sm-147	4.130E-12	4.369E-12	4.510E-12	4.593E-12	4.681E-12	4.704E-12	4.713E-12
Pm-148	1.204E-14	5.696E-20	2.695E-25	0.00	0.00	0.00	0.00
Pm-148m	2.137E-13	1.011E-18	4.785E-24	0.00	0.00	0.00	0.00
Eu-150	2.537E-11	2.441E-11	2.349E-11	2.260E-11	2.053E-11	1.865E-11	1.190E-19
Sm-151	2.767E-04	2.725E-04	2.683E-04	2.642E-04	2.543E-04	2.446E-04	1.290E-07
Eu-152	2.060E-05	1.860E-05	1.680E-05	1.517E-05	1.176E-05	9.113E-06	0.00
Gd-153	9.066E-07	1.119E-07	1.381E-08	1.704E-09	9.117E-12	4.879E-14	0.00
Eu-154	4.088E-03	3.479E-03	2.961E-03	2.520E-03	1.684E-03	1.126E-03	0.00
Eu-155	1.912E-03	1.446E-03	1.093E-03	8.267E-04	4.110E-04	2.043E-04	0.00
Tb-160	1.531E-10	1.392E-13	1.265E-16	1.150E-19	0.00	0.00	0.00
Ho-166m	1.094E-09	1.092E-09	1.091E-09	1.090E-09	1.087E-09	1.084E-09	6.152E-10
Tm-170	2.732E-12	5.325E-14	1.038E-15	2.026E-17	1.075E-21	5.703E-26	0.00
Tm-171	1.408E-11	6.840E-12	3.323E-12	1.614E-12	2.654E-13	4.365E-14	0.00
Total	3.051E-01	2.519E-01	2.260E-01	2.090E-01	1.796E-01	1.578E-01	1.512E-05

TABLE F.1.e. Fission Product Radioactivity by Isotope at
30 MWd/kgM, Ci/gU

Isotopes	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	3.276E-04	2.928E-04	2.617E-04	2.339E-04	1.767E-04	1.334E-04	0.00
Be-10	2.633E-12	2.633E-12	2.633E-12	2.633E-12	2.633E-12	2.633E-12	2.632E-12
C-14	1.061E-10	1.061E-10	1.061E-10	1.060E-10	1.060E-10	1.059E-10	9.406E-11
Se-79	3.678E-07	3.678E-07	3.678E-07	3.678E-07	3.678E-07	3.678E-07	3.639E-07
Kr-81	4.229E-13	4.229E-13	4.229E-13	4.229E-13	4.229E-13	4.229E-13	4.215E-13
Kr-85	5.187E-03	4.558E-03	4.005E-03	3.519E-03	2.547E-03	1.843E-03	0.00
Rb-87	1.932E-11	1.932E-11	1.932E-11	1.932E-11	1.932E-11	1.932E-11	1.932E-11
Sr-89	4.249E-10	1.878E-14	8.297E-19	3.666E-23	0.00	0.00	0.00
Sr-90	5.496E-02	5.241E-02	4.997E-02	4.765E-02	4.230E-02	3.755E-02	2.782E-12
Y-90	5.498E-02	5.242E-02	4.998E-02	4.766E-02	4.231E-02	3.756E-02	2.782E-12
Y-91	8.661E-09	1.510E-12	2.633E-16	4.591E-20	0.00	0.00	0.00
Zr-93	1.638E-06	1.638E-06	1.638E-06	1.638E-06	1.638E-06	1.638E-06	1.638E-06
Nb-93m	5.760E-07	6.710E-07	7.568E-07	8.343E-07	9.968E-07	1.123E-06	1.556E-06
Nb-94	1.316E-10	1.316E-10	1.316E-10	1.316E-10	1.316E-10	1.316E-10	1.272E-10
Zr-95	5.508E-08	2.014E-11	7.363E-15	2.692E-18	0.00	0.00	0.00
Nb-95	1.223E-07	4.471E-11	1.635E-14	5.977E-18	0.00	0.00	0.00
Nb-95m	4.086E-10	1.494E-13	5.462E-17	1.997E-20	0.00	0.00	0.00
Tc-98	3.563E-12	3.563E-12	3.563E-12	3.563E-12	3.563E-12	3.563E-12	3.562E-12
Tc-99	1.206E-05	1.206E-05	1.206E-05	1.206E-05	1.206E-05	1.206E-05	1.202E-05
Rh-102	1.995E-07	1.237E-07	7.669E-08	4.754E-08	1.439E-08	4.356E-09	0.00
Ru-103	2.777E-12	7.007E-18	1.768E-23	0.00	0.00	0.00	0.00
Rh-103m	2.503E-12	6.317E-18	1.594E-23	0.00	0.00	0.00	0.00
Ru-106	1.127E-02	2.849E-03	7.201E-04	1.820E-04	5.847E-06	1.878E-07	0.00
Rh-106	1.127E-02	2.849E-03	7.201E-04	1.820E-04	5.847E-06	1.878E-07	0.00
Pd-107	1.020E-07	1.020E-07	1.020E-07	1.020E-07	1.020E-07	1.020E-07	1.020E-07
Ag-108	2.663E-12	2.634E-12	2.605E-12	2.577E-12	2.508E-12	2.440E-12	1.160E-14
Ag-108m	2.992E-11	2.960E-11	2.927E-11	2.896E-11	2.818E-11	2.742E-11	1.304E-13
Ag-109m	5.142E-11	1.727E-11	5.798E-12	1.947E-12	1.272E-13	8.313E-15	0.00
Cd-109	5.142E-11	1.727E-11	5.798E-12	1.947E-12	1.272E-13	8.313E-15	0.00
Ag-110	3.665E-07	4.831E-08	6.368E-09	8.395E-10	5.296E-12	3.341E-14	0.00
Ag-110m	2.755E-05	3.632E-06	4.788E-07	6.312E-08	3.982E-10	2.512E-12	0.00
Cd-113m	3.347E-05	3.044E-05	2.768E-05	2.517E-05	1.985E-05	1.565E-05	9.407E-26
In-114	3.483E-15	1.261E-19	4.565E-24	0.00	0.00	0.00	0.00
In-114m	3.639E-15	1.318E-19	4.770E-24	0.00	0.00	0.00	0.00
Cd-115m	6.463E-14	7.574E-19	8.876E-24	0.00	0.00	0.00	0.00
Sn-119m	9.603E-07	1.216E-07	1.539E-08	1.949E-09	1.112E-11	6.346E-14	0.00
Sn-121m	1.700E-07	1.653E-07	1.608E-07	1.564E-07	1.459E-07	1.362E-07	1.700E-13
Sn-123	3.584E-07	7.111E-09	1.411E-10	2.799E-12	1.552E-16	8.602E-21	0.00
Te-123m	8.810E-10	1.281E-11	1.862E-13	2.707E-15	6.899E-20	1.758E-24	0.00
Sb-124	1.796E-11	3.993E-15	8.876E-19	1.973E-22	0.00	0.00	0.00
Sb-125	2.303E-03	1.396E-03	8.463E-04	5.130E-04	1.468E-04	4.201E-05	0.00
Te-125m	5.618E-04	3.407E-04	2.065E-04	1.252E-04	3.582E-05	1.025E-05	0.00
Sn-126	6.735E-07	6.735E-07	6.735E-07	6.735E-07	6.735E-07	6.735E-07	6.689E-07
Sb-126	9.430E-08	9.429E-08	9.429E-08	9.429E-08	9.429E-08	9.428E-08	9.365E-08
Sb-126m	6.735E-07	6.735E-07	6.735E-07	6.735E-07	6.735E-07	6.735E-07	6.689E-07
Te-127	3.608E-07	3.467E-09	3.331E-11	3.200E-13	2.896E-18	2.620E-23	0.00
Te-127m	3.684E-07	3.540E-09	3.400E-11	3.267E-13	2.956E-18	2.675E-23	0.00

TABLE F.1.e. Fission Product Radioactivity by Isotope at
30 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Te-129	6.981E-16	1.991E-22	0.00	0.00	0.00	0.00	0.00
Te-129m	1.072E-15	3.059E-22	0.00	0.00	0.00	0.00	0.00
I-129	2.853E-08	2.853E-08	2.853E-08	2.853E-08	2.853E-08	2.853E-08	2.853E-08
Cs-134	1.932E-02	9.862E-03	5.035E-03	2.570E-03	4.787E-04	8.914E-05	0.00
Cs-135	5.067E-07	5.067E-07	5.067E-07	5.067E-07	5.067E-07	5.067E-07	5.066E-07
Cs-137	7.927E-02	7.569E-02	7.228E-02	6.901E-02	6.148E-02	5.477E-02	8.029E-12
Ba-137m	7.499E-02	7.161E-02	6.837E-02	6.528E-02	5.816E-02	5.182E-02	7.595E-12
Ce-141	1.289E-14	2.220E-21	0.00	0.00	0.00	0.00	0.00
Ce-142	2.448E-11	2.448E-11	2.448E-11	2.448E-11	2.448E-11	2.448E-11	2.448E-11
Ce-144	8.054E-03	1.356E-03	2.285E-04	3.848E-05	4.479E-07	5.214E-09	0.00
Pr-144	8.054E-03	1.357E-03	2.285E-04	3.848E-05	4.480E-07	5.215E-09	0.00
Pr-144m	9.665E-05	1.628E-05	2.742E-06	4.617E-07	5.375E-09	6.258E-11	0.00
Nd-144	1.395E-15	1.397E-15	1.398E-15	1.398E-15	1.398E-15	1.398E-15	1.398E-15
Pm-146	6.742E-07	5.240E-07	4.072E-07	3.165E-07	1.685E-07	8.976E-08	0.00
Sm-146	2.702E-13	2.745E-13	2.779E-13	2.806E-13	2.849E-13	2.871E-13	2.898E-13
Pm-147	2.569E-02	1.514E-02	8.928E-03	5.263E-03	1.404E-03	3.748E-04	0.00
Sm-147	4.378E-12	4.636E-12	4.789E-12	4.878E-12	4.973E-12	4.998E-12	5.007E-12
Pm-148	1.448E-14	6.852E-20	3.242E-25	0.00	0.00	0.00	0.00
Pm-148m	2.571E-13	1.216E-18	5.756E-24	0.00	0.00	0.00	0.00
Eu-150	2.747E-11	2.643E-11	2.543E-11	2.447E-11	2.223E-11	2.019E-11	1.289E-19
Sm-151	2.929E-04	2.885E-04	2.840E-04	2.797E-04	2.691E-04	2.590E-04	1.365E-07
Eu-152	1.857E-05	1.677E-05	1.514E-05	1.368E-05	1.060E-05	8.215E-06	0.00
Gd-153	1.103E-06	1.361E-07	1.679E-08	2.073E-09	1.109E-11	5.935E-14	0.00
Eu-154	5.951E-03	5.065E-03	4.311E-03	3.669E-03	2.452E-03	1.639E-03	0.00
Eu-155	2.737E-03	2.069E-03	1.565E-03	1.183E-03	5.881E-04	2.924E-04	0.00
Tb-160	2.617E-10	2.380E-13	2.163E-16	1.967E-19	0.00	0.00	0.00
Ho-166m	2.032E-09	2.030E-09	2.027E-09	2.025E-09	2.019E-09	2.013E-09	1.143E-09
Tm-170	6.145E-12	1.198E-13	2.335E-15	4.558E-17	2.418E-21	1.283E-25	0.00
Tm-171	3.977E-11	1.932E-11	9.385E-12	4.559E-12	7.497E-13	1.233E-13	0.00
Total	3.654E-01	2.996E-01	2.680E-01	2.475E-01	2.124E-01	1.864E-01	1.778E-05

TABLE F.1.f. Fission Product Radioactivity by Isotope at
35 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	3.892E-04	3.479E-04	3.109E-04	2.779E-04	2.099E-04	1.585E-04	0.00
Be-10	3.066E-12	3.066E-12	3.066E-12	3.066E-12	3.066E-12	3.066E-12	3.064E-12
C-14	1.235E-10	1.235E-10	1.235E-10	1.234E-10	1.234E-10	1.233E-10	1.095E-10
Se-79	4.234E-07	4.234E-07	4.234E-07	4.234E-07	4.234E-07	4.234E-07	4.189E-07
Kr-81	5.794E-13	5.794E-13	5.794E-13	5.794E-13	5.794E-13	5.794E-13	5.775E-13
Kr-85	5.849E-03	5.140E-03	4.516E-03	3.968E-03	2.872E-03	2.079E-03	0.00
Rb-87	2.171E-11	2.171E-11	2.171E-11	2.171E-11	2.171E-11	2.171E-11	2.171E-11
Sr-89	4.556E-10	2.013E-14	8.896E-19	3.931E-23	0.00	0.00	0.00
Sr-90	6.158E-02	5.872E-02	5.599E-02	5.339E-02	4.740E-02	4.208E-02	3.117E-12
Y-90	6.160E-02	5.873E-02	5.600E-02	5.340E-02	4.741E-02	4.209E-02	3.118E-12
Y-91	9.420E-09	1.642E-12	2.864E-16	4.993E-20	0.00	0.00	0.00
Zr-93	1.862E-06	1.862E-06	1.862E-06	1.862E-06	1.862E-06	1.862E-06	1.861E-06
Nb-93m	6.567E-07	7.645E-07	8.619E-07	9.498E-07	1.134E-06	1.277E-06	1.768E-06
Nb-94	1.627E-10	1.627E-10	1.627E-10	1.627E-10	1.626E-10	1.626E-10	1.572E-10
Zr-95	6.255E-08	2.287E-11	8.361E-15	3.057E-18	0.00	0.00	0.00
Nb-95	1.389E-07	5.077E-11	1.856E-14	6.787E-18	0.00	0.00	0.00
Nb-95m	4.640E-10	1.697E-13	6.203E-17	2.268E-20	0.00	0.00	0.00
Tc-98	4.980E-12	4.980E-12	4.980E-12	4.980E-12	4.980E-12	4.980E-12	4.979E-12
Tc-99	1.377E-05	1.377E-05	1.377E-05	1.377E-05	1.377E-05	1.377E-05	1.372E-05
Rh-102	2.753E-07	1.707E-07	1.058E-07	6.561E-08	1.936E-08	6.010E-09	0.00
Ru-103	3.366E-12	8.494E-18	2.143E-23	0.00	0.00	0.00	0.00
Rh-103m	3.034E-12	7.657E-18	1.932E-23	0.00	0.00	0.00	0.00
Ru-106	1.442E-02	3.644E-03	9.210E-04	2.328E-04	7.478E-06	2.402E-07	0.00
Rh-106	1.442E-02	3.644E-03	9.210E-04	2.328E-04	7.478E-06	2.402E-07	0.00
Pd-107	1.303E-07	1.303E-07	1.303E-07	1.303E-07	1.303E-07	1.303E-07	1.303E-07
Ag-108	3.519E-12	3.480E-12	3.443E-12	3.405E-12	3.314E-12	3.224E-12	1.533E-14
Ag-108m	3.953E-11	3.911E-11	3.868E-11	3.826E-11	3.723E-11	3.623E-11	1.723E-13
Ag-109m	9.281E-11	3.116E-11	1.046E-11	3.514E-12	2.296E-13	1.500E-14	0.00
Cd-109	9.281E-11	3.116E-11	1.046E-11	3.514E-12	2.296E-13	1.500E-14	0.00
Ag-110	5.529E-07	7.289E-08	9.608E-09	1.267E-09	7.991E-12	5.042E-14	0.00
Ag-110m	4.157E-05	5.480E-06	7.224E-07	9.523E-08	6.009E-10	3.791E-12	0.00
Cd-113m	4.349E-05	3.955E-05	3.596E-05	3.270E-05	2.579E-05	2.033E-05	1.222E-25
In-114	5.327E-15	1.929E-19	6.983E-24	0.00	0.00	0.00	0.00
In-114m	5.567E-15	2.015E-19	7.297E-24	0.00	0.00	0.00	0.00
Cd-115m	8.028E-14	9.408E-19	1.103E-23	0.00	0.00	0.00	0.00
Sn-119m	1.220E-06	1.545E-07	1.957E-08	2.477E-09	1.414E-11	8.066E-14	0.00
Sn-121m	2.077E-07	2.020E-07	1.965E-07	1.911E-07	1.783E-07	1.664E-07	2.078E-13
Sn-123	4.325E-07	8.582E-09	1.703E-10	3.378E-12	1.873E-16	1.038E-20	0.00
Te-123m	1.539E-09	2.238E-11	3.253E-13	4.730E-15	1.205E-19	3.072E-24	0.00
Sb-124	2.611E-11	5.804E-15	1.290E-18	2.868E-22	0.00	0.00	0.00
Sb-125	2.788E-03	1.690E-03	1.025E-03	6.212E-04	1.778E-04	5.087E-05	0.00
Te-125m	6.803E-04	4.125E-04	2.501E-04	1.516E-04	4.337E-05	1.241E-05	0.00
Sn-126	8.095E-07	8.095E-07	8.095E-07	8.095E-07	8.095E-07	8.095E-07	8.040E-07
Sb-126	1.133E-07	1.133E-07	1.133E-07	1.133E-07	1.133E-07	1.133E-07	1.126E-07
Sb-126m	8.095E-07	8.095E-07	8.095E-07	8.095E-07	8.095E-07	8.095E-07	8.040E-07
Te-127	4.385E-07	4.213E-09	4.049E-11	3.890E-13	3.520E-13	3.185E-23	0.00
Te-127m	4.476E-07	4.302E-09	4.133E-11	3.971E-13	3.594E-18	3.252E-23	0.00

TABLE F.1.f. Fission Product Radioactivity by Isotope at
35 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Te-129	8.342E-16	2.379E-22	0.00	0.00	0.00	0.00	0.00
Te-129m	1.282E-15	3.655E-22	0.00	0.00	0.00	0.00	0.00
I-129	3.357E-08	3.357E-08	3.357E-08	3.357E-08	3.357E-08	3.357E-08	3.357E-08
Cs-134	2.638E-02	1.347E-02	6.875E-03	3.510E-03	6.536E-04	1.217E-04	0.00
Cs-135	5.339E-07	5.339E-07	5.339E-07	5.339E-07	5.339E-07	5.339E-07	5.339E-07
Cs-137	9.252E-02	8.834E-02	8.435E-02	8.054E-02	7.176E-02	6.393E-02	9.370E-12
Ba-137m	8.752E-02	8.357E-02	7.980E-02	7.619E-02	6.788E-02	6.047E-02	8.864E-12
Ce-141	1.485E-14	2.558E-21	0.00	0.00	0.00	0.00	0.00
Ce-142	2.829E-11	2.829E-11	2.829E-11	2.829E-11	2.829E-11	2.829E-11	2.829E-11
Ce-144	9.169E-03	1.544E-03	2.601E-04	4.380E-05	5.100E-07	5.938E-09	0.00
Pr-144	9.169E-03	1.544E-03	2.601E-04	4.381E-05	5.100E-07	5.938E-09	0.00
Pr-144m	1.100E-04	1.853E-05	3.121E-06	5.257E-07	6.120E-09	7.125E-11	0.00
Nd-144	1.667E-15	1.670E-15	1.670E-15	1.671E-15	1.671E-15	1.671E-15	1.671E-15
Pm-146	8.753E-07	6.802E-07	5.287E-07	4.109E-07	2.188E-07	1.165E-07	0.00
Sm-146	3.477E-13	3.534E-13	3.578E-13	3.612E-13	3.668E-13	3.698E-13	3.731E-13
Pm-147	2.709E-02	1.597E-02	9.414E-03	5.550E-03	1.481E-03	3.952E-04	0.00
Sm-147	4.509E-12	4.781E-12	4.942E-12	5.037E-12	5.137E-12	5.163E-12	5.173E-12
Pm-148	1.647E-14	7.793E-20	3.687E-25	0.00	0.00	0.00	0.00
Pm-148m	2.924E-13	1.384E-18	6.546E-24	0.00	0.00	0.00	0.00
Eu-150	2.923E-11	2.813E-11	2.706E-11	2.604E-11	2.365E-11	2.148E-11	1.373E-19
Sm-151	3.107E-04	3.060E-04	3.013E-04	2.967E-04	2.855E-04	2.747E-04	1.448E-07
Eu-152	1.652E-05	1.492E-05	1.347E-05	1.217E-05	9.432E-06	7.310E-06	0.00
Gd-153	1.258E-06	1.552E-07	1.915E-08	2.364E-09	1.265E-11	6.767E-14	0.00
Eu-154	7.990E-03	6.800E-03	5.788E-03	4.926E-03	3.292E-03	2.200E-03	0.00
Eu-155	3.688E-03	2.789E-03	2.109E-03	1.594E-03	7.926E-04	3.941E-04	0.00
Tb-160	4.088E-10	3.716E-13	3.378E-16	3.071E-19	0.00	0.00	0.00
Ho-166m	3.519E-09	3.515E-09	3.511E-09	3.507E-09	3.497E-09	3.486E-09	1.979E-09
Tm-170	1.222E-11	2.383E-13	4.644E-15	9.049E-17	4.801E-21	2.547E-25	0.00
Tm-171	9.616E-11	4.671E-11	2.269E-11	1.102E-11	1.813E-12	2.981E-13	0.00
Total	4.258E-01	3.468E-01	3.092E-01	2.850E-01	2.443E-01	2.143E-01	2.034E-05

TABLE F.2.a. Actinide Radioactivity by isotope at 10 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Tl-207	4.176E-12	5.373E-12	5.605E-12	7.872E-12	1.117E-11	1.464E-11	9.013E-10
Tl-208	7.574E-10	8.293E-10	8.679E-10	8.857E-10	8.815E-10	8.520E-10	8.258E-14
Tl-209	6.746E-16	7.023E-16	7.320E-16	7.637E-16	8.515E-16	9.513E-16	4.879E-13
Pb-209	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Pb-210	4.042E-14	6.315E-14	9.286E-14	1.303E-13	2.627E-13	4.584E-13	2.298E-09
Pb-211	4.188E-12	5.388E-12	6.624E-12	7.894E-12	1.120E-11	1.468E-11	9.038E-10
Pb-212	2.108E-09	2.308E-09	2.416E-09	2.465E-09	2.453E-09	2.371E-09	2.298E-13
Pb-214	3.550E-13	4.835E-13	6.319E-13	8.004E-13	1.309E-12	1.943E-12	2.298E-09
Bi-210	4.043E-14	6.318E-14	9.290E-14	1.304E-13	2.627E-13	4.585E-13	2.298E-09
Bi-211	4.188E-12	5.388E-12	6.624E-12	7.894E-12	1.120E-11	1.468E-11	9.038E-10
Bi-212	2.108E-09	2.308E-09	2.416E-09	2.465E-09	2.453E-09	2.371E-09	2.298E-13
Bi-213	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Bi-214	3.550E-13	4.835E-13	6.319E-13	8.004E-13	1.309E-12	1.943E-12	2.298E-09
Po-210	3.532E-14	5.607E-14	8.359E-14	1.186E-13	2.628E-13	4.585E-13	2.298E-09
Po-211	1.173E-14	1.509E-14	1.855E-14	2.210E-14	3.136E-14	4.110E-14	2.531E-12
Po-212	1.351E-09	1.479E-09	1.548E-09	1.579E-09	1.572E-09	1.519E-09	1.473E-13
Po-213	3.056E-14	3.181E-14	3.316E-14	3.459E-14	3.857E-14	4.309E-14	2.210E-11
Po-214	3.550E-13	4.834E-13	6.318E-13	8.002E-13	1.309E-12	1.943E-12	2.298E-09
Po-215	4.188E-12	5.388E-12	6.624E-12	7.894E-12	1.120E-11	1.468E-11	9.038E-10
Po-216	2.108E-09	2.308E-09	2.416E-09	2.465E-09	2.453E-09	2.371E-09	2.298E-13
Po-218	3.551E-13	4.836E-13	6.320E-13	8.005E-13	1.309E-12	1.943E-12	2.299E-09
At-217	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Rn-219	4.188E-12	5.388E-12	6.624E-12	7.894E-12	1.120E-11	1.468E-11	9.038E-10
Rn-220	2.108E-09	2.308E-09	2.416E-09	2.465E-09	2.453E-09	2.371E-09	2.298E-13
Rn-222	3.551E-13	4.836E-13	6.320E-13	8.005E-13	1.309E-12	1.943E-12	2.299E-09
Fr-221	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Fr-223	5.772E-14	7.423E-14	9.125E-14	1.087E-13	1.543E-13	2.023E-13	1.247E-11
Ra-223	4.188E-12	5.388E-12	6.624E-12	7.894E-12	1.120E-11	1.468E-11	9.038E-10
Ra-224	2.108E-09	2.308E-09	2.416E-09	2.465E-09	2.453E-09	2.371E-09	2.298E-13
Ra-225	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Ra-226	3.551E-13	4.836E-13	6.320E-13	8.005E-13	1.309E-12	1.943E-12	2.299E-09
Ra-228	1.903E-17	2.628E-17	3.429E-17	4.292E-17	6.650E-17	9.198E-17	5.787E-15
Ac-225	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Ac-227	4.182E-12	5.379E-12	6.612E-12	7.880E-12	1.118E-11	1.466E-11	9.038E-10
Ac-228	1.903E-17	2.628E-17	3.430E-17	4.293E-17	6.650E-17	9.198E-17	5.787E-15
Th-227	4.130E-12	5.314E-12	6.533E-12	7.785E-12	1.104E-11	1.448E-11	8.913E-10
Th-228	2.105E-09	2.303E-09	2.410E-09	2.459E-09	2.451E-09	2.369E-09	2.298E-13
Th-229	3.123E-14	3.251E-14	3.389E-14	3.536E-14	3.942E-14	4.404E-14	2.259E-11
Th-230	1.370E-10	1.603E-10	1.835E-10	2.068E-10	2.651E-10	3.235E-10	1.215E-08
Th-231	4.216E-08	4.216E-08	4.216E-08	4.217E-08	4.217E-08	4.217E-08	4.237E-08
Th-232	5.199E-17	6.330E-17	7.462E-17	8.593E-17	1.142E-16	1.425E-16	5.787E-15
Th-234	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07
Pa-231	1.268E-11	2.446E-11	2.625E-11	2.804E-11	3.250E-11	3.696E-11	9.035E-10
Pa-233	5.306E-08	5.322E-08	5.342E-08	5.364E-08	5.430E-08	5.509E-08	1.797E-07
Pa-234m	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07
Pa-234	4.214E-10	4.214E-10	4.214E-10	4.214E-10	4.214E-10	4.214E-10	4.214E-10
U-232	2.460E-09	2.504E-09	2.512E-09	2.498E-09	2.418E-09	2.316E-09	2.190E-13

TABLE F.2.a. Actinide Radioactivity by Isotope at 10 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
U-233	6.567E-12	7.057E-12	7.548E-12	8.041E-12	9.220E-12	1.042E-11	5.770E-10
U-234	1.291E-06	1.292E-06	1.293E-06	1.294E-06	1.296E-06	1.298E-06	1.353E-06
U-235	4.216E-08	4.216E-08	4.216E-08	4.217E-08	4.217E-08	4.217E-08	4.237E-08
U-236	1.147E-07	1.147E-07	1.147E-07	1.147E-07	1.147E-07	1.147E-07	1.187E-07
U-237	4.166E-07	3.784E-07	3.437E-07	3.171E-07	2.454E-07	1.929E-07	3.286E-15
U-238	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07	3.242E-07
U-240	7.564E-16	7.564E-16	7.564E-16	7.564E-16	7.564E-16	7.564E-16	7.563E-16
Np-235	1.298E-11	3.613E-12	1.006E-12	2.802E-13	1.147E-14	4.692E-16	0.00
Np-236	3.783E-13	3.783E-13	3.783E-13	3.783E-13	3.783E-13	3.782E-13	3.760E-13
Np-237	5.306E-08	5.322E-08	5.342E-08	5.364E-08	5.430E-08	5.509E-08	1.797E-07
Np-238	1.900E-08	1.883E-08	1.866E-08	1.849E-08	1.807E-08	1.766E-08	2.025E-10
Np-239	2.067E-07	2.067E-07	2.066E-07	2.066E-07	2.065E-07	2.064E-07	1.882E-07
Np-240m	7.564E-16	7.564E-16	7.564E-16	7.564E-16	7.564E-16	7.564E-16	7.563E-16
Pu-236	5.992E-09	3.685E-09	2.266E-09	1.393E-09	4.132E-10	1.225E-10	3.384E-14
Pu-238	1.763E-04	1.736E-04	1.710E-04	1.683E-04	1.619E-04	1.558E-04	1.440E-07
Pu-239	2.118E-04	2.118E-04	2.118E-04	2.117E-04	2.117E-04	2.117E-04	2.058E-04
Pu-240	1.451E-04	1.450E-04	1.450E-04	1.450E-04	1.449E-04	1.448E-04	1.305E-04
Pu-241	1.698E-02	1.543E-02	1.401E-02	1.272E-02	1.000E-02	7.862E-03	1.341E-10
Pu-242	7.576E-08	7.576E-08	7.577E-08	7.577E-08	7.577E-08	7.578E-08	7.588E-08
Pu-244	7.573E-16	7.573E-16	7.573E-16	7.573E-16	7.573E-16	7.573E-16	7.573E-16
Am-241	2.256E-04	2.768E-04	3.230E-04	3.647E-04	4.521E-04	5.194E-04	1.642E-04
Am-242m	3.800E-06	3.766E-06	3.732E-06	3.698E-06	3.614E-06	3.533E-06	4.049E-08
Am-242	3.781E-06	3.747E-06	3.713E-06	3.679E-06	3.596E-06	3.515E-06	4.029E-08
Am-243	2.067E-07	2.067E-07	2.066E-07	2.066E-07	2.065E-07	2.064E-07	1.882E-07
Cm-242	1.137E-05	3.474E-06	3.093E-06	3.049E-06	2.975E-06	2.908E-06	3.332E-08
Cm-243	3.715E-07	3.539E-07	3.371E-07	3.211E-07	2.843E-07	2.518E-07	1.122E-17
Cm-244	4.549E-06	4.214E-06	3.903E-06	3.616E-06	2.986E-06	2.466E-06	1.264E-22
Cm-245	1.452E-10	1.452E-10	1.452E-10	1.452E-10	1.451E-10	1.450E-10	1.339E-10
Cm-246	7.340E-12	7.338E-12	7.336E-12	7.334E-12	7.328E-12	7.323E-12	6.344E-12
Bk-249	1.229E-16	2.527E-17	5.173E-18	1.084E-18	0.00	0.00	0.00
Total	1.777E-02	1.625E-02	1.488E-02	1.363E-02	1.099E-02	8.910E-03	5.042E-04

TABLE F.2.b. Actinide Radioactivity by Isotope at 15 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Tl-207	4.675E-12	5.978E-12	7.287E-12	8.605E-12	1.192E-11	1.528E-11	7.327E-10
Tl-208	1.517E-09	1.697E-09	1.802E-09	1.857E-09	1.870E-09	1.815E-09	1.777E-13
Tl-209	1.463E-15	1.503E-15	1.546E-15	1.594E-15	1.729E-15	1.886E-15	9.813E-13
Pb-209	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Pb-210	3.792E-14	5.900E-14	8.652E-14	1.212E-13	2.439E-13	4.255E-13	2.308E-09
Pb-211	4.688E-12	5.995E-12	7.308E-12	8.629E-12	1.196E-11	1.533E-11	7.347E-10
Pb-212	4.222E-09	4.724E-09	5.016E-09	5.168E-09	5.205E-09	5.051E-09	4.945E-13
Pb-214	3.297E-13	4.484E-13	5.859E-13	7.421E-13	1.214E-12	1.804E-12	2.309E-09
Bi-210	3.793E-14	5.902E-14	8.655E-14	1.213E-13	2.440E-13	4.257E-13	2.308E-09
Bi-211	4.688E-12	5.995E-12	7.308E-12	8.629E-12	1.196E-11	1.533E-11	7.347E-10
Bi-212	4.222E-09	4.724E-09	5.016E-09	5.168E-09	5.205E-09	5.051E-09	4.945E-13
Bi-213	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Bi-214	3.297E-13	4.484E-13	5.859E-13	7.421E-13	1.214E-12	1.804E-12	2.309E-09
Po-210	3.319E-14	5.243E-14	7.793E-14	1.104E-13	2.440E-13	4.257E-13	2.308E-09
Po-211	1.313E-14	1.679E-14	2.046E-14	2.416E-14	3.348E-14	4.292E-14	2.057E-12
Po-212	2.705E-09	3.027E-09	3.214E-09	3.311E-09	3.335E-09	3.236E-09	3.168E-13
Po-213	6.625E-14	6.806E-14	7.005E-14	7.220E-14	7.830E-14	8.543E-14	4.445E-11
Po-214	3.296E-13	4.484E-13	5.858E-13	7.419E-13	1.214E-12	1.804E-12	2.308E-09
Po-215	4.688E-12	5.995E-12	7.308E-12	8.629E-12	1.196E-11	1.533E-11	7.347E-10
Po-216	4.222E-09	4.724E-09	5.016E-09	5.168E-09	5.205E-09	5.051E-09	4.945E-13
Po-218	3.297E-13	4.485E-13	5.860E-13	7.422E-13	1.215E-12	1.805E-12	2.309E-09
At-217	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Rn-219	4.688E-12	5.995E-12	7.308E-12	8.629E-12	1.196E-11	1.533E-11	7.347E-10
Rn-220	4.222E-09	4.724E-09	5.016E-09	5.168E-09	5.205E-09	5.051E-09	4.945E-13
Rn-222	3.297E-13	4.485E-13	5.860E-13	7.422E-13	1.215E-12	1.805E-12	2.309E-09
Fr-221	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Fr-223	6.462E-14	8.259E-14	1.007E-13	1.189E-13	1.648E-13	2.112E-13	1.014E-11
Ra-223	4.688E-12	5.995E-12	7.308E-12	8.629E-12	1.196E-11	1.533E-11	7.347E-10
Ra-224	4.222E-09	4.724E-09	5.016E-09	5.168E-09	5.205E-09	5.051E-09	4.945E-13
Ra-225	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Ra-226	3.297E-13	4.485E-13	5.860E-13	7.422E-13	1.215E-12	1.805E-12	2.309E-09
Ac-225	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Ac-227	4.683E-12	5.985E-12	7.295E-12	8.613E-12	1.194E-11	1.530E-11	7.347E-10
Th-227	4.624E-12	5.912E-12	7.207E-12	8.510E-12	1.179E-11	1.512E-11	7.246E-10
Th-228	4.217E-09	4.713E-09	5.004E-09	5.155E-09	5.201E-09	5.047E-09	4.945E-13
Th-229	6.771E-14	6.957E-14	7.159E-14	7.379E-14	8.003E-14	8.732E-14	4.543E-11
Th-230	1.267E-10	1.483E-10	1.700E-10	1.918E-10	2.464E-10	3.013E-10	1.231E-08
Th-231	3.393E-08	3.393E-08	3.393E-08	3.393E-08	3.393E-08	3.393E-08	3.417E-08
Th-232	7.156E-17	8.696E-17	1.024E-16	1.178E-16	1.563E-16	1.948E-16	7.908E-15
Th-234	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07
Pa-231	2.506E-11	2.650E-11	2.794E-11	2.937E-11	3.296E-11	3.655E-11	7.345E-10
Pa-233	9.923E-08	9.957E-08	9.999E-08	1.005E-07	1.019E-07	1.036E-07	3.742E-07
Pa-234m	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07
Pa-234	4.199E-10	4.199E-10	4.199E-10	4.199E-10	4.199E-10	4.199E-10	4.199E-10
U-232	5.080E-09	5.239E-09	5.296E-09	5.292E-09	5.150E-09	4.939E-09	4.757E-13
U-233	9.403E-12	1.032E-11	1.124E-11	1.216E-11	1.437E-11	1.662E-11	1.178E-09
U-234	1.202E-06	1.204E-06	1.207E-06	1.210E-06	1.217E-06	1.224E-06	1.389E-06
U-235	3.393E-08	3.393E-08	3.393E-08	3.393E-08	3.393E-08	3.393E-08	3.417E-08

TABLE F.2.b. Actinide Radioactivity by Isotope at 15 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
U-236	1.561E-07	1.561E-07	1.561E-07	1.561E-07	1.561E-07	1.562E-07	1.628E-07
U-237	9.164E-07	8.323E-07	7.559E-07	6.865E-07	5.397E-07	4.242E-07	4.223E-14
U-238	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07	3.230E-07
U-240	6.628E-15	6.628E-15	6.628E-15	6.628E-15	6.628E-15	6.628E-15	6.628E-15
Np-235	3.606E-11	1.004E-11	2.796E-12	7.787E-13	3.186E-14	1.304E-15	0.00
Np-236	9.017E-13	9.017E-13	9.017E-13	9.017E-13	9.016E-13	9.016E-13	8.963E-13
Np-237	9.923E-08	9.957E-08	9.999E-08	1.005E-07	1.019E-07	1.036E-07	3.742E-07
Np-238	4.855E-08	4.811E-08	4.767E-08	4.724E-08	4.618E-08	4.514E-08	5.173E-10
Np-239	1.109E-06	1.108E-06	1.108E-06	1.108E-06	1.108E-06	1.107E-06	1.010E-06
Np-240m	6.628E-15	6.628E-15	6.628E-15	6.628E-15	6.628E-15	6.628E-15	6.628E-15
Pu-236	1.694E-08	1.042E-08	6.406E-09	3.939E-09	1.168E-09	3.464E-10	8.067E-14
Pu-238	5.166E-04	5.088E-04	5.009E-04	4.932E-04	4.744E-04	4.563E-04	3.932E-07
Pu-239	2.547E-04	2.547E-04	2.546E-04	2.546E-04	2.546E-04	2.546E-04	2.475E-04
Pu-240	2.407E-04	2.407E-04	2.406E-04	2.406E-04	2.405E-04	2.404E-04	2.167E-04
Pu-241	3.736E-02	3.393E-02	3.081E-02	2.799E-02	2.200E-02	1.729E-02	1.724E-09
Pu-242	2.558E-07	2.558E-07	2.558E-07	2.558E-07	2.558E-07	2.558E-07	2.560E-07
Pu-243	1.794E-16	1.794E-16	1.794E-16	1.794E-16	1.794E-16	1.794E-16	1.794E-16
Pu-244	6.637E-15	6.637E-15	6.637E-15	6.637E-15	6.637E-15	6.637E-15	6.637E-15
Am-241	4.739E-04	5.865E-04	6.882E-04	7.800E-04	9.724E-04	1.121E-03	3.566E-04
Am-242m	9.710E-06	9.622E-06	9.535E-06	9.448E-06	9.235E-06	9.027E-06	1.035E-07
Am-242	9.662E-06	9.574E-06	9.487E-06	9.401E-06	9.189E-06	8.982E-06	1.029E-07
Am-243	1.109E-06	1.108E-06	1.108E-06	1.108E-06	1.108E-06	1.107E-06	1.010E-06
Cm-242	3.407E-05	9.103E-06	7.913E-06	7.791E-06	7.603E-06	7.431E-06	8.514E-08
Cm-243	1.862E-06	1.773E-06	1.689E-06	1.609E-06	1.425E-06	1.262E-06	5.621E-17
Cm-244	3.935E-05	3.645E-05	3.376E-05	3.128E-05	2.583E-05	2.133E-05	1.094E-21
Cm-245	1.866E-09	1.866E-09	1.866E-09	1.865E-09	1.865E-09	1.864E-09	1.721E-09
Cm-246	1.538E-10	1.537E-10	1.537E-10	1.536E-10	1.535E-10	1.534E-10	1.329E-10
Cm-247	1.794E-16	1.794E-16	1.794E-16	1.794E-16	1.794E-16	1.794E-16	1.794E-16
Cm-248	1.637E-16	1.637E-16	1.637E-16	1.637E-16	1.637E-16	1.637E-16	1.633E-16
Bk-249	9.669E-15	1.987E-15	4.084E-16	8.393E-17	1.595E-18	4.210E-20	0.00
Cf-249	8.513E-16	8.671E-16	8.676E-16	8.650E-16	8.567E-16	8.483E-16	1.221E-16
Cf-250	1.776E-15	1.598E-15	1.437E-15	1.292E-15	9.916E-16	7.608E-16	0.00
Cf-252	1.767E-16	1.045E-16	6.177E-17	3.652E-17	9.809E-18	2.648E-18	0.00
Total	3.894E-02	3.559E-02	3.257E-02	2.982E-02	2.400E-02	1.942E-02	8.271E-04

TABLE F.2.c. Actinide Radioactivity by Isotope at 20 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Tl-207	5.024E-12	6.401E-12	7.763E-12	9.110E-12	1.242E-11	1.566E-11	5.882E-10
Tl-208	2.578E-09	2.932E-09	3.147E-09	3.266E-09	3.318E-09	3.229E-09	3.155E-13
Tl-209	2.749E-15	2.801E-15	2.858E-15	2.920E-15	3.102E-15	3.319E-15	1.484E-12
Pb-209	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Pb-210	3.565E-14	5.511E-14	8.053E-14	1.126E-13	2.261E-13	3.946E-13	2.438E-09
Pb-211	5.038E-12	6.419E-12	7.784E-12	9.136E-12	1.245E-11	1.571E-11	5.899E-10
Pb-212	7.175E-09	8.161E-09	8.759E-09	9.089E-09	9.233E-09	8.986E-09	8.781E-13
Pb-214	3.052E-13	4.148E-13	5.419E-13	6.865E-13	1.125E-12	1.675E-12	2.438E-09
Bi-210	3.566E-14	5.513E-14	8.057E-14	1.127E-13	2.262E-13	3.947E-13	2.438E-09
Bi-211	5.038E-12	6.419E-12	7.784E-12	9.136E-12	1.245E-11	1.571E-11	5.899E-10
Bi-212	7.175E-09	8.161E-09	8.759E-09	9.089E-09	9.233E-09	8.986E-09	8.781E-13
Bi-213	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Bi-214	3.052E-13	4.148E-13	5.419E-13	6.865E-13	1.125E-12	1.675E-12	2.438E-09
Po-210	3.127E-14	4.904E-14	7.259E-14	1.026E-13	2.262E-13	3.947E-13	2.438E-09
Po-211	1.411E-14	1.797E-14	2.180E-14	2.558E-14	3.487E-14	4.397E-14	1.652E-12
Po-212	4.597E-09	5.229E-09	5.612E-09	5.823E-09	5.916E-09	5.757E-09	5.626E-13
Po-213	1.245E-13	1.269E-13	1.294E-13	1.323E-13	1.405E-13	1.503E-13	6.724E-11
Po-214	3.051E-13	4.147E-13	5.418E-13	6.863E-13	1.125E-12	1.674E-12	2.438E-09
Po-215	5.038E-12	6.419E-12	7.784E-12	9.136E-12	1.245E-11	1.571E-11	5.899E-10
Po-216	7.175E-09	8.161E-09	8.759E-09	9.089E-09	9.233E-09	8.986E-09	8.781E-13
Po-218	3.053E-13	4.149E-13	5.420E-13	6.866E-13	1.125E-12	1.675E-12	2.439E-09
At-217	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Rn-219	5.038E-12	6.419E-12	7.784E-12	9.136E-12	1.245E-11	1.571E-11	5.899E-10
Rn-220	7.175E-09	8.161E-09	8.759E-09	9.089E-09	9.233E-09	8.986E-09	8.781E-13
Rn-222	3.053E-13	4.149E-13	5.420E-13	6.866E-13	1.125E-12	1.675E-12	2.439E-09
Fr-221	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Fr-223	6.944E-14	8.844E-14	1.072E-13	1.258E-13	1.716E-13	2.164E-13	8.140E-12
Ra-223	5.038E-12	6.419E-12	7.784E-12	9.136E-12	1.245E-11	1.571E-11	5.899E-10
Ra-224	7.175E-09	8.161E-09	8.759E-09	9.089E-09	9.233E-09	8.986E-09	8.781E-13
Ra-225	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Ra-226	3.053E-13	4.149E-13	5.420E-13	6.866E-13	1.125E-12	1.675E-12	2.439E-09
Ac-225	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Ac-227	5.032E-12	6.408E-12	7.771E-12	9.119E-12	1.243E-11	1.568E-11	5.899E-10
Th-227	4.969E-12	6.331E-12	7.677E-12	9.010E-12	1.228E-11	1.549E-11	5.817E-10
Th-228	7.166E-09	8.143E-09	8.739E-09	9.066E-09	9.226E-09	8.978E-09	8.781E-13
Th-229	1.273E-13	1.297E-13	1.323E-13	1.352E-13	1.436E-13	1.536E-13	6.872E-11
Th-230	1.168E-10	1.370E-10	1.573E-10	1.777E-10	2.292E-10	2.813E-10	1.317E-08
Th-231	2.689E-08	2.689E-08	2.689E-08	2.689E-08	2.689E-08	2.689E-08	2.716E-08
Th-232	8.781E-17	1.065E-16	1.252E-16	1.439E-16	1.906E-16	2.373E-16	9.629E-15
Th-234	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07
Pa-231	2.677E-11	2.791E-11	2.905E-11	3.019E-11	3.303E-11	3.588E-11	5.897E-10
Pa-233	1.532E-07	1.537E-07	1.543E-07	1.551E-07	1.572E-07	1.597E-07	5.644E-07
Pa-234m	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07
Pa-234	4.183E-10	4.183E-10	4.183E-10	4.183E-10	4.183E-10	4.183E-10	4.183E-10
U-232	8.833E-09	9.199E-09	9.353E-09	9.377E-09	9.159E-09	8.795E-09	8.492E-13
U-233	1.195E-11	1.337E-11	1.479E-11	1.621E-11	1.962E-11	2.309E-11	1.781E-09
U-234	1.119E-06	1.125E-06	1.131E-06	1.137E-06	1.151E-06	1.165E-06	1.512E-06
U-235	2.689E-08	2.689E-08	2.689E-08	2.689E-08	2.689E-08	2.689E-08	2.716E-08

TABLE F.2.c. Actinide Radioactivity by Isotope at 20 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
U-236	1.894E-07	1.894E-07	1.894E-07	1.894E-07	1.895E-07	1.895E-07	1.988E-07
U-237	1.373E-06	1.247E-06	1.133E-06	1.029E-06	8.085E-07	6.356E-07	2.411E-13
U-238	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07	3.218E-07
U-240	2.961E-14	2.961E-14	2.961E-14	2.961E-14	2.961E-14	2.961E-14	2.961E-14
Np-235	7.341E-11	2.044E-11	5.693E-12	1.585E-12	6.487E-14	2.655E-15	0.00
Np-236	1.625E-12	1.625E-12	1.625E-12	1.625E-12	1.625E-12	1.625E-12	1.615E-12
Np-237	1.532E-07	1.537E-07	1.543E-07	1.551E-07	1.572E-07	1.597E-07	5.644E-07
Np-238	8.357E-08	8.281E-08	8.206E-08	8.131E-08	7.948E-08	7.769E-08	8.904E-10
Np-239	3.394E-06	3.393E-06	3.393E-06	3.392E-06	3.390E-06	3.389E-06	3.091E-06
Np-240m	2.961E-14	2.961E-14	2.961E-14	2.961E-14	2.961E-14	2.961E-14	2.961E-14
Pu-236	3.544E-08	2.180E-08	1.340E-08	8.242E-09	2.444E-09	7.248E-10	1.454E-13
Pu-238	1.081E-03	1.065E-03	1.048E-03	1.032E-03	9.924E-04	9.545E-04	7.502E-07
Pu-239	2.790E-04	2.789E-04	2.789E-04	2.789E-04	2.789E-04	2.788E-04	2.712E-04
Pu-240	3.386E-04	3.386E-04	3.385E-04	3.385E-04	3.384E-04	3.382E-04	3.051E-04
Pu-241	5.597E-02	5.083E-02	4.617E-02	4.193E-02	3.296E-02	2.591E-02	9.842E-09
Pu-242	5.640E-07	5.640E-07	5.640E-07	5.640E-07	5.640E-07	5.640E-07	5.641E-07
Pu-243	2.032E-15	2.032E-15	2.032E-15	2.032E-15	2.032E-15	2.032E-15	2.032E-15
Pu-244	2.965E-14	2.965E-14	2.965E-14	2.965E-14	2.965E-14	2.965E-14	2.965E-14
Am-241	7.047E-04	8.733E-04	1.026E-03	1.163E-03	1.452E-03	1.674E-03	5.332E-04
Am-242m	1.671E-05	1.656E-05	1.641E-05	1.626E-05	1.589E-05	1.554E-05	1.781E-07
Am-242	1.663E-05	1.648E-05	1.633E-05	1.618E-05	1.582E-05	1.546E-05	1.772E-07
Am-243	3.394E-06	3.393E-06	3.393E-06	3.392E-06	3.390E-06	3.389E-06	3.091E-06
Cm-242	6.868E-05	1.612E-05	1.364E-05	1.341E-05	1.309E-05	1.279E-05	1.465E-07
Cm-243	5.465E-06	5.206E-06	4.959E-06	4.723E-06	4.182E-06	3.703E-06	1.650E-16
Cm-244	1.739E-04	1.611E-04	1.492E-04	1.382E-04	1.141E-04	9.425E-05	4.833E-21
Cm-245	1.066E-08	1.066E-08	1.065E-08	1.065E-08	1.065E-08	1.064E-08	9.825E-09
Cm-246	1.251E-09	1.251E-09	1.251E-09	1.250E-09	1.249E-09	1.249E-09	1.082E-09
Cm-247	2.032E-15	2.032E-15	2.032E-15	2.032E-15	2.032E-15	2.032E-15	2.032E-15
Cm-248	2.614E-15	2.614E-15	2.614E-15	2.614E-15	2.614E-15	2.614E-15	2.609E-15
Bk-249	2.060E-13	4.233E-14	8.699E-15	1.788E-15	3.422E-17	6.743E-19	0.00
Cf-249	1.773E-14	1.806E-14	1.808E-14	1.802E-14	1.785E-14	1.767E-14	2.544E-15
Cf-250	4.554E-14	4.096E-14	3.684E-14	3.314E-14	2.543E-14	1.951E-14	2.063E-24
Cf-251	2.400E-16	2.397E-16	2.393E-16	2.389E-16	2.380E-16	2.371E-16	1.113E-16
Cf-252	7.704E-15	4.555E-15	2.693E-15	1.592E-15	4.280E-16	1.151E-16	0.00
Total	5.866E-02	5.361E-02	4.907E-02	4.494E-02	3.619E-02	2.931E-02	1.121E-03

TABLE F.2.d. Actinide Radioactivity by Isotope at 25 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Tl-207	5.244E-12	6.672E-12	8.064E-12	9.426E-12	1.270E-11	1.582E-11	4.663E-10
Tl-208	3.963E-09	4.569E-09	4.946E-09	5.160E-09	5.277E-09	5.147E-09	4.992E-13
Tl-209	4.718E-15	4.779E-15	4.848E-15	4.926E-15	5.154E-15	5.430E-15	1.989E-12
Pb-209	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Pb-210	3.363E-14	5.152E-14	7.491E-14	1.044E-13	2.092E-13	3.652E-13	2.675E-09
Pb-211	5.258E-12	6.690E-12	8.087E-12	9.453E-12	1.274E-11	1.587E-11	4.676E-10
Pb-212	1.103E-08	1.272E-08	1.377E-08	1.436E-08	1.469E-08	1.433E-08	1.389E-12
Pb-214	2.815E-13	3.823E-13	4.994E-13	6.331E-13	1.040E-12	1.553E-12	2.676E-09
Bi-210	3.363E-14	5.154E-14	7.494E-14	1.045E-13	2.092E-13	3.653E-13	2.675E-09
Bi-211	5.258E-12	6.690E-12	8.087E-12	9.453E-12	1.274E-11	1.587E-11	4.676E-10
Bi-212	1.103E-08	1.272E-08	1.377E-08	1.436E-08	1.469E-08	1.433E-08	1.389E-12
Bi-213	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Bi-214	2.815E-13	3.823E-13	4.994E-13	6.331E-13	1.040E-12	1.553E-12	2.676E-09
Po-210	2.960E-14	4.593E-14	6.759E-14	9.517E-14	2.093E-13	3.653E-13	2.675E-09
Po-211	1.472E-14	1.873E-14	2.264E-14	2.647E-14	3.566E-14	4.443E-14	1.309E-12
Po-212	7.068E-09	8.147E-09	8.820E-09	9.202E-09	9.411E-09	9.179E-09	8.902E-13
Po-213	2.137E-13	2.165E-13	2.196E-13	2.231E-13	2.334E-13	2.459E-13	9.009E-11
Po-214	2.814E-13	3.822E-13	4.993E-13	6.329E-13	1.040E-12	1.553E-12	2.675E-09
Po-215	5.258E-12	6.690E-12	8.087E-12	9.453E-12	1.274E-11	1.587E-11	4.676E-10
Po-216	1.103E-08	1.272E-08	1.377E-08	1.436E-08	1.469E-08	1.433E-08	1.389E-12
Po-218	2.815E-13	3.824E-13	4.995E-13	6.332E-13	1.040E-12	1.553E-12	2.676E-09
At-217	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Rn-219	5.258E-12	6.690E-12	8.087E-12	9.453E-12	1.274E-11	1.587E-11	4.676E-10
Rn-220	1.103E-08	1.272E-08	1.377E-08	1.436E-08	1.469E-08	1.433E-08	1.389E-12
Rn-222	2.815E-13	3.824E-13	4.995E-13	6.332E-13	1.040E-12	1.553E-12	2.676E-09
Fr-221	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Fr-223	7.248E-14	9.217E-14	1.114E-13	1.302E-13	1.755E-13	2.186E-13	6.453E-12
Ra-223	5.258E-12	6.690E-12	8.087E-12	9.453E-12	1.274E-11	1.587E-11	4.676E-10
Ra-224	1.103E-08	1.272E-08	1.377E-08	1.436E-08	1.469E-08	1.433E-08	1.389E-12
Ra-225	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Ra-226	2.815E-13	3.824E-13	4.995E-13	6.332E-13	1.040E-12	1.553E-12	2.676E-09
Ac-225	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Ac-227	5.252E-12	6.679E-12	8.073E-12	9.435E-12	1.272E-11	1.584E-11	4.676E-10
Th-227	5.186E-12	6.598E-12	7.976E-12	9.322E-12	1.256E-11	1.565E-11	4.612E-10
Th-228	1.102E-08	1.269E-08	1.373E-08	1.433E-08	1.468E-08	1.431E-08	1.389E-12
Th-229	2.184E-13	2.212E-13	2.245E-13	2.280E-13	2.386E-13	2.514E-13	9.208E-11
Th-230	1.073E-10	1.262E-10	1.452E-10	1.644E-10	2.133E-10	2.632E-10	1.465E-08
Th-231	2.096E-08	2.096E-08	2.097E-08	2.097E-08	2.097E-08	2.097E-08	2.125E-08
Th-232	1.010E-16	1.223E-16	1.435E-16	1.647E-16	2.178E-16	2.710E-16	1.097E-14
Th-234	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07
Pa-231	2.794E-11	2.882E-11	2.971E-11	3.060E-11	3.281E-11	3.503E-11	4.674E-10
Pa-233	2.128E-07	2.135E-07	2.142E-07	2.152E-07	2.179E-07	2.212E-07	7.486E-07
Pa-234m	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07
Pa-234	4.166E-10	4.166E-10	4.166E-10	4.166E-10	4.166E-10	4.166E-10	4.166E-10
U-232	1.383E-08	1.452E-08	1.483E-08	1.490E-08	1.460E-08	1.403E-08	1.348E-12
U-233	1.424E-11	1.620E-11	1.817E-11	2.015E-11	2.488E-11	2.968E-11	2.376E-09
U-234	1.042E-06	1.053E-06	1.063E-06	1.073E-06	1.098E-06	1.121E-06	1.715E-06
U-235	2.096E-08	2.096E-08	2.097E-08	2.097E-08	2.097E-08	2.097E-08	2.125E-08

TABLE F.2.d. Actinide Radioactivity by Isotope at 25 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
U-236	2.152E-07	2.152E-07	2.152E-07	2.153E-07	2.153E-07	2.154E-07	2.272E-07
U-237	1.802E-06	1.636E-06	1.486E-06	1.350E-06	1.061E-06	8.341E-07	8.980E-13
U-238	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07	3.204E-07
U-240	9.240E-14	9.240E-14	9.240E-14	9.240E-14	9.240E-14	9.240E-14	9.240E-14
Np-235	1.263E-10	3.517E-11	9.794E-12	2.727E-12	1.116E-13	4.567E-15	0.00
Np-236	2.510E-12	2.510E-12	2.510E-12	2.510E-12	2.510E-12	2.510E-12	2.495E-12
Np-237	2.128E-07	2.135E-07	2.142E-07	2.152E-07	2.179E-07	2.212E-07	7.486E-07
Np-238	1.137E-07	1.126E-07	1.116E-07	1.106E-07	1.081E-07	1.057E-07	1.211E-09
Np-239	7.735E-06	7.733E-06	7.732E-06	7.730E-06	7.727E-06	7.723E-06	7.044E-06
Np-240m	9.240E-14	9.240E-14	9.240E-14	9.240E-14	9.240E-14	9.240E-14	9.240E-14
Pu-236	6.294E-08	3.871E-08	2.380E-08	1.464E-08	4.340E-09	1.287E-09	2.245E-13
Pu-238	1.854E-03	1.826E-03	1.797E-03	1.770E-03	1.702E-03	1.636E-03	1.167E-06
Pu-239	2.927E-04	2.926E-04	2.926E-04	2.926E-04	2.926E-04	2.925E-04	2.846E-04
Pu-240	4.279E-04	4.280E-04	4.280E-04	4.280E-04	4.280E-04	4.279E-04	3.864E-04
Pu-241	7.345E-02	6.671E-02	6.058E-02	5.502E-02	4.325E-02	3.400E-02	3.665E-08
Pu-242	9.987E-07	9.987E-07	9.987E-07	9.987E-07	9.988E-07	9.988E-07	9.984E-07
Pu-243	1.319E-14	1.319E-14	1.319E-14	1.319E-14	1.319E-14	1.319E-14	1.319E-14
Pu-244	9.252E-14	9.252E-14	9.252E-14	9.252E-14	9.252E-14	9.252E-14	9.252E-14
Am-241	9.016E-04	1.123E-03	1.323E-03	1.504E-03	1.882E-03	2.174E-03	6.950E-04
Am-242m	2.273E-05	2.253E-05	2.232E-05	2.212E-05	2.162E-05	2.113E-05	2.422E-07
Am-242	2.262E-05	2.241E-05	2.221E-05	2.201E-05	2.151E-05	2.103E-05	2.410E-07
Am-243	7.735E-06	7.733E-06	7.732E-06	7.730E-06	7.727E-06	7.723E-06	7.044E-06
Cm-242	1.098E-04	2.266E-05	1.859E-05	1.824E-05	1.780E-05	1.740E-05	1.993E-07
Cm-243	1.183E-05	1.127E-05	1.073E-05	1.022E-05	9.053E-06	8.017E-06	3.572E-16
Cm-244	5.343E-04	4.949E-04	4.584E-04	4.246E-04	3.507E-04	2.896E-04	1.485E-20
Cm-245	3.969E-08	3.968E-08	3.968E-08	3.967E-08	3.965E-08	3.964E-08	3.659E-08
Cm-246	6.239E-09	6.237E-09	6.236E-09	6.234E-09	6.229E-09	6.225E-09	5.392E-09
Cm-247	1.319E-14	1.319E-14	1.319E-14	1.319E-14	1.319E-14	1.319E-14	1.319E-14
Cm-248	2.244E-14	2.244E-14	2.244E-14	2.244E-14	2.244E-14	2.244E-14	2.240E-14
Bk-249	2.205E-12	4.531E-13	9.313E-14	1.914E-14	3.665E-16	7.030E-18	0.00
Cf-249	1.856E-13	1.892E-13	1.893E-13	1.888E-13	1.870E-13	1.851E-13	2.665E-14
Cf-250	5.541E-13	4.984E-13	4.483E-13	4.032E-13	3.094E-13	2.374E-13	5.632E-23
Cf-251	3.331E-15	3.326E-15	3.321E-15	3.316E-15	3.303E-15	3.290E-15	1.544E-15
Cf-252	1.418E-13	8.384E-14	4.957E-14	2.931E-14	7.879E-15	2.118E-15	0.00
Total	7.765E-02	7.097E-02	6.498E-02	5.953E-02	4.800E-02	3.891E-02	1.387E-03

TABLE F.2.e. Actinide Radioactivity by Isotope at 30 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Tl-207	5.346E-12	6.805E-12	8.213E-12	9.577E-12	1.280E-11	1.581E-11	3.656E-10
Tl-208	5.684E-09	6.630E-09	7.231E-09	7.579E-09	7.795E-09	7.616E-09	7.315E-13
Tl-209	7.583E-15	7.653E-15	7.734E-15	7.825E-15	8.097E-15	8.433E-15	2.513E-12
Pb-209	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Pb-210	3.193E-14	4.829E-14	6.968E-14	9.674E-14	1.930E-13	3.372E-13	3.012E-09
Pb-211	5.361E-12	6.824E-12	8.236E-12	9.604E-12	1.284E-11	1.585E-11	3.666E-10
Pb-212	1.582E-08	1.845E-08	2.012E-08	2.109E-08	2.169E-08	2.120E-08	2.036E-12
Pb-214	2.584E-13	3.507E-13	4.583E-13	5.815E-13	9.588E-13	1.438E-12	3.013E-09
Bi-210	3.194E-14	4.831E-14	6.971E-14	9.678E-14	1.931E-13	3.373E-13	3.012E-09
Bi-211	5.361E-12	6.824E-12	8.236E-12	9.604E-12	1.284E-11	1.585E-11	3.666E-10
Bi-212	1.582E-08	1.845E-08	2.012E-08	2.109E-08	2.169E-08	2.120E-08	2.036E-12
Bi-213	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Bi-214	2.584E-13	3.507E-13	4.583E-13	5.815E-13	9.588E-13	1.438E-12	3.013E-09
Po-210	2.824E-14	4.317E-14	6.298E-14	8.824E-14	1.931E-13	3.374E-13	3.012E-09
Po-211	1.501E-14	1.911E-14	2.306E-14	2.689E-14	3.594E-14	4.438E-14	1.026E-12
Po-212	1.013E-08	1.182E-08	1.289E-08	1.352E-08	1.390E-08	1.358E-08	1.304E-12
Po-213	3.435E-13	3.466E-13	3.503E-13	3.544E-13	3.668E-13	3.820E-13	1.138E-10
Po-214	2.583E-13	3.506E-13	4.582E-13	5.814E-13	9.586E-13	1.438E-12	3.012E-09
Po-215	5.361E-12	6.824E-12	8.236E-12	9.604E-12	1.284E-11	1.585E-11	3.666E-10
Po-216	1.582E-08	1.845E-08	2.012E-08	2.109E-08	2.169E-08	2.120E-08	2.036E-12
Po-218	2.584E-13	3.508E-13	4.584E-13	5.816E-13	9.590E-13	1.438E-12	3.013E-09
At-217	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Rn-219	5.361E-12	6.824E-12	8.236E-12	9.604E-12	1.284E-11	1.585E-11	3.666E-10
Rn-220	1.582E-08	1.845E-08	2.012E-08	2.109E-08	2.169E-08	2.120E-08	2.036E-12
Rn-222	2.584E-13	3.508E-13	4.584E-13	5.816E-13	9.590E-13	1.438E-12	3.013E-09
Fr-221	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Fr-223	7.390E-14	9.401E-14	1.135E-13	1.323E-13	1.769E-13	2.184E-13	5.059E-12
Ra-223	5.361E-12	6.824E-12	8.236E-12	9.604E-12	1.284E-11	1.585E-11	3.666E-10
Ra-224	1.582E-08	1.845E-08	2.012E-08	2.109E-08	2.169E-08	2.120E-08	2.036E-12
Ra-225	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Ra-226	2.584E-13	3.508E-13	4.584E-13	5.816E-13	9.590E-13	1.438E-12	3.013E-09
Ac-225	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Ac-227	5.355E-12	6.812E-12	8.222E-12	9.586E-12	1.282E-11	1.582E-11	3.666E-10
Th-227	5.288E-12	6.730E-12	8.123E-12	9.472E-12	1.266E-11	1.563E-11	3.615E-10
Th-228	1.580E-08	1.841E-08	2.008E-08	2.104E-08	2.168E-08	2.118E-08	2.036E-12
Th-229	3.510E-13	3.543E-13	3.580E-13	3.623E-13	3.749E-13	3.904E-13	1.163E-10
Th-230	9.809E-11	1.157E-10	1.336E-10	1.518E-10	1.984E-10	2.467E-10	1.672E-08
Th-231	1.608E-08	1.608E-08	1.608E-08	1.608E-08	1.609E-08	1.609E-08	1.638E-08
Th-232	1.114E-16	1.345E-16	1.576E-16	1.807E-16	2.384E-16	2.962E-16	1.196E-14
Th-234	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07
Pa-231	2.863E-11	2.931E-11	3.000E-11	3.068E-11	3.238E-11	3.407E-11	3.664E-10
Pa-233	2.766E-07	2.774E-07	2.784E-07	2.795E-07	2.828E-07	2.869E-07	9.376E-07
Pa-234m	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07
Pa-234	4.148E-10	4.148E-10	4.148E-10	4.148E-10	4.148E-10	4.148E-10	4.148E-10
U-232	2.017E-08	2.131E-08	2.184E-08	2.200E-08	2.160E-08	2.077E-08	1.978E-12
U-233	1.626E-11	1.881E-11	2.137E-11	2.394E-11	3.008E-11	3.631E-11	2.991E-09
U-234	9.708E-07	9.866E-07	1.002E-06	1.018E-06	1.055E-06	1.091E-06	1.992E-06
U-235	1.608E-08	1.608E-08	1.608E-08	1.608E-08	1.609E-08	1.609E-08	1.638E-08

TABLE F.2.e. Actinide Radioactivity by Isotope at 30 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
U-236	2.340E-07	2.340E-07	2.341E-07	2.341E-07	2.342E-07	2.342E-07	2.481E-07
U-237	2.249E-06	2.043E-06	1.855E-06	1.685E-06	1.324E-06	1.041E-06	2.556E-12
U-238	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07
U-240	2.312E-13	2.312E-13	2.312E-13	2.312E-13	2.312E-13	2.312E-13	2.312E-13
Np-235	1.966E-10	5.474E-11	1.524E-11	4.245E-12	1.737E-13	7.108E-15	0.00
Np-236	3.519E-12	3.519E-12	3.519E-12	3.519E-12	3.518E-12	3.518E-12	3.498E-12
Np-237	2.766E-07	2.774E-07	2.784E-07	2.795E-07	2.828E-07	2.869E-07	9.376E-07
Np-238	1.339E-07	1.327E-07	1.315E-07	1.303E-07	1.274E-07	1.245E-07	1.427E-09
Np-239	1.485E-05	1.485E-05	1.484E-05	1.484E-05	1.483E-05	1.483E-05	1.352E-05
Np-240m	2.312E-13	2.312E-13	2.312E-13	2.312E-13	2.312E-13	2.312E-13	2.312E-13
Pu-236	1.011E-07	6.214E-08	3.821E-08	2.350E-08	6.968E-09	2.066E-09	3.148E-13
Pu-238	2.820E-03	2.777E-03	2.734E-03	2.691E-03	2.588E-03	2.489E-03	1.619E-06
Pu-239	3.020E-04	3.020E-04	3.019E-04	3.019E-04	3.019E-04	3.018E-04	2.939E-04
Pu-240	4.995E-04	4.996E-04	4.998E-04	4.999E-04	5.001E-04	5.003E-04	4.527E-04
Pu-241	9.168E-02	8.326E-02	7.562E-02	6.868E-02	5.399E-02	4.244E-02	1.043E-07
Pu-242	1.537E-06	1.537E-06	1.537E-06	1.537E-06	1.537E-06	1.537E-06	1.536E-06
Pu-243	6.105E-14	6.105E-14	6.105E-14	6.105E-14	6.105E-14	6.105E-14	6.105E-14
Pu-244	2.315E-13	2.315E-13	2.315E-13	2.315E-13	2.315E-13	2.315E-13	2.315E-13
Am-241	1.077E-03	1.353E-03	1.603E-03	1.829E-03	2.302E-03	2.666E-03	8.577E-04
Am-242m	2.678E-05	2.654E-05	2.630E-05	2.606E-05	2.547E-05	2.490E-05	2.854E-07
Am-242	2.665E-05	2.641E-05	2.617E-05	2.593E-05	2.534E-05	2.477E-05	2.839E-07
Am-243	1.485E-05	1.485E-05	1.484E-05	1.484E-05	1.483E-05	1.483E-05	1.352E-05
Am-245	2.265E-16	4.656E-17	9.569E-18	1.967E-18	3.766E-20	7.211E-22	0.00
Cm-242	1.541E-04	2.781E-05	2.194E-05	2.149E-05	2.097E-05	2.050E-05	2.348E-07
Cm-243	2.150E-05	2.048E-05	1.951E-05	1.858E-05	1.645E-05	1.457E-05	6.492E-16
Cm-244	1.304E-03	1.208E-03	1.119E-03	1.036E-03	8.559E-04	7.068E-04	3.624E-20
Cm-245	1.130E-07	1.129E-07	1.129E-07	1.129E-07	1.129E-07	1.128E-07	1.041E-07
Cm-246	2.303E-08	2.302E-08	2.302E-08	2.301E-08	2.299E-08	2.298E-08	1.990E-08
Cm-247	6.105E-14	6.105E-14	6.105E-14	6.105E-14	6.105E-14	6.105E-14	6.105E-14
Cm-248	1.322E-13	1.322E-13	1.322E-13	1.322E-13	1.322E-13	1.322E-13	1.320E-13
Bk-249	1.562E-11	3.210E-12	6.597E-13	1.356E-13	2.596E-15	4.970E-17	0.00
Cf-249	1.278E-12	1.304E-12	1.305E-12	1.301E-12	1.289E-12	1.276E-12	1.837E-13
Cf-250	4.307E-12	3.874E-12	3.484E-12	3.134E-12	2.404E-12	1.845E-12	5.628E-22
Cf-251	2.852E-14	2.848E-14	2.843E-14	2.839E-14	2.828E-14	2.817E-14	1.322E-14
Cf-252	1.555E-12	9.182E-13	5.429E-13	3.210E-13	8.628E-14	2.319E-14	0.00
Total	9.794E-02	8.954E-02	8.201E-02	7.516E-02	6.066E-02	4.922E-02	1.641E-03

TABLE F.2.f. Actinide Radioactivity by Isotope at 35 MWd/kgM, Ci/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Tl-207	5.330E-12	6.790E-12	8.190E-12	9.534E-12	1.267E-11	1.554E-11	2.843E-10
Tl-208	7.684E-09	9.050E-09	9.928E-09	1.044E-08	1.079E-08	1.056E-08	1.004E-12
Tl-209	1.140E-14	1.148E-14	1.157E-14	1.167E-14	1.199E-14	1.238E-14	3.014E-12
Pb-209	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Pb-210	3.065E-14	4.552E-14	6.500E-14	8.970E-14	1.781E-13	3.113E-13	3.433E-09
Pb-211	5.345E-12	6.809E-12	8.213E-12	9.561E-12	1.271E-11	1.559E-11	2.850E-10
Pb-212	2.139E-08	2.519E-08	2.763E-08	2.907E-08	3.003E-08	2.938E-08	2.793E-12
Pb-214	2.363E-13	3.206E-13	4.194E-13	5.328E-13	8.829E-13	1.332E-12	3.433E-09
Bi-210	3.066E-14	4.553E-14	6.503E-14	8.974E-14	1.781E-13	3.114E-13	3.433E-09
Bi-211	5.345E-12	6.809E-12	8.213E-12	9.561E-12	1.271E-11	1.559E-11	2.850E-10
Bi-212	2.139E-08	2.519E-08	2.763E-08	2.907E-08	3.003E-08	2.938E-08	2.793E-12
Bi-213	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Bi-214	2.363E-13	3.206E-13	4.194E-13	5.328E-13	8.829E-13	1.332E-12	3.433E-09
Po-210	2.729E-14	4.085E-14	5.888E-14	8.193E-14	1.781E-13	3.114E-13	3.433E-09
Po-211	1.497E-14	1.907E-14	2.299E-14	2.677E-14	3.558E-14	4.365E-14	7.981E-13
Po-212	1.370E-08	1.614E-08	1.770E-08	1.862E-08	1.924E-08	1.883E-08	1.790E-12
Po-213	5.164E-13	5.199E-13	5.241E-13	5.288E-13	5.430E-13	5.607E-13	1.365E-10
Po-214	2.362E-13	3.206E-13	4.193E-13	5.327E-13	8.827E-13	1.332E-12	3.433E-09
Po-215	5.345E-12	6.809E-12	8.213E-12	9.561E-12	1.271E-11	1.559E-11	2.850E-10
Po-216	2.139E-08	2.519E-08	2.763E-08	2.907E-08	3.003E-08	2.938E-08	2.793E-12
Po-218	2.363E-13	3.207E-13	4.194E-13	5.329E-13	8.831E-13	1.332E-12	3.434E-09
At-217	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Rn-219	5.345E-12	6.809E-12	8.213E-12	9.561E-12	1.271E-11	1.559E-11	2.850E-10
Rn-220	2.139E-08	2.519E-08	2.763E-08	2.907E-08	3.003E-08	2.938E-08	2.793E-12
Rn-222	2.363E-13	3.207E-13	4.194E-13	5.329E-13	8.831E-13	1.332E-12	3.434E-09
Fr-221	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Fr-223	7.368E-14	9.380E-14	1.131E-13	1.317E-13	1.751E-13	2.148E-13	3.934E-12
Ra-223	5.345E-12	6.809E-12	8.213E-12	9.561E-12	1.271E-11	1.559E-11	2.850E-10
Ra-224	2.139E-08	2.519E-08	2.763E-08	2.907E-08	3.003E-08	2.938E-08	2.793E-12
Ra-225	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Ra-226	2.363E-13	3.207E-13	4.194E-13	5.329E-13	8.831E-13	1.332E-12	3.434E-09
Ac-225	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Ac-227	5.339E-12	6.797E-12	8.198E-12	9.543E-12	1.269E-11	1.556E-11	2.850E-10
Th-227	5.272E-12	6.715E-12	8.099E-12	9.430E-12	1.253E-11	1.537E-11	2.811E-10
Th-228	2.136E-08	2.513E-08	2.757E-08	2.900E-08	3.000E-08	2.936E-08	2.793E-12
Th-229	5.278E-13	5.314E-13	5.356E-13	5.404E-13	5.549E-13	5.730E-13	1.395E-10
Th-230	8.942E-11	1.059E-10	1.228E-10	1.401E-10	1.850E-10	2.322E-10	1.927E-08
Th-231	1.217E-08	1.217E-08	1.217E-08	1.217E-08	1.217E-08	1.217E-08	1.246E-08
Th-232	1.191E-16	1.435E-16	1.678E-16	1.921E-16	2.529E-16	3.138E-16	1.262E-14
Th-234	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07
Pa-231	2.872E-11	2.924E-11	2.975E-11	3.027E-11	3.155E-11	3.284E-11	2.849E-10
Pa-233	3.400E-07	3.409E-07	3.420E-07	3.433E-07	3.472E-07	3.519E-07	1.115E-06
Pa-234m	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07
Pa-234	4.129E-10	4.129E-10	4.129E-10	4.129E-10	4.129E-10	4.129E-10	4.129E-10
U-232	2.762E-08	2.934E-08	3.016E-08	3.043E-08	2.994E-08	2.881E-08	2.717E-12
U-233	1.801E-11	2.114E-11	2.429E-11	2.744E-11	3.499E-11	4.263E-11	3.574E-09
U-234	9.057E-07	9.278E-07	9.497E-07	9.711E-07	1.023E-06	1.074E-06	2.329E-06
U-235	1.217E-08	1.217E-08	1.217E-08	1.217E-08	1.217E-08	1.217E-08	1.246E-08

TABLE F.2.f. Actinide Radioactivity by Isotope at 35 MWd/kgM, Ci/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
U-236	2.464E-07	2.465E-07	2.465E-07	2.465E-07	2.466E-07	2.467E-07	2.621E-07
U-237	2.667E-06	2.423E-06	2.200E-06	1.998E-06	1.571E-06	1.235E-06	5.969E-12
U-238	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07	3.176E-07
U-240	4.937E-13	4.937E-13	4.937E-13	4.937E-13	4.937E-13	4.937E-13	4.937E-13
Np-235	2.785E-10	7.755E-11	2.160E-11	6.014E-12	2.461E-13	1.007E-14	0.00
Np-236	4.581E-12	4.581E-12	4.581E-12	4.581E-12	4.581E-12	4.581E-12	4.554E-12
Np-237	3.400E-07	3.409E-07	3.420E-07	3.433E-07	3.472E-07	3.519E-07	1.115E-06
Np-238	1.473E-07	1.460E-07	1.446E-07	1.433E-07	1.401E-07	1.369E-07	1.570E-09
Np-239	2.500E-05	2.499E-05	2.499E-05	2.498E-05	2.497E-05	2.496E-05	2.277E-05
Np-240m	4.937E-13	4.937E-13	4.937E-13	4.937E-13	4.937E-13	4.937E-13	4.937E-13
Pu-236	1.486E-07	9.140E-08	5.621E-08	3.456E-08	1.025E-08	3.039E-09	4.098E-13
Pu-238	3.941E-03	3.880E-03	3.820E-03	3.760E-03	3.616E-03	3.477E-03	2.102E-06
Pu-239	3.063E-04	3.063E-04	3.063E-04	3.063E-04	3.062E-04	3.062E-04	2.984E-04
Pu-240	5.516E-04	5.521E-04	5.525E-04	5.528E-04	5.536E-04	5.541E-04	5.031E-04
Pu-241	1.087E-01	9.875E-02	8.969E-02	8.146E-02	6.403E-02	5.033E-02	2.436E-07
Pu-242	2.169E-06	2.169E-06	2.169E-06	2.169E-06	2.169E-06	2.169E-06	2.167E-06
Pu-243	2.176E-13	2.176E-13	2.176E-13	2.176E-13	2.176E-13	2.176E-13	2.176E-13
Pu-244	4.944E-13	4.944E-13	4.944E-13	4.944E-13	4.944E-13	4.944E-13	4.944E-13
Am-241	1.224E-03	1.552E-03	1.848E-03	2.116E-03	2.677E-03	3.110E-03	1.007E-03
Am-242m	2.946E-05	2.919E-05	2.893E-05	2.866E-05	2.802E-05	2.739E-05	3.139E-07
Am-242	2.931E-05	2.905E-05	2.878E-05	2.852E-05	2.788E-05	2.725E-05	3.123E-07
Am-243	2.500E-05	2.499E-05	2.499E-05	2.498E-05	2.497E-05	2.496E-05	2.277E-05
Am-245	1.158E-15	2.381E-16	4.893E-17	1.006E-17	1.926E-19	3.687E-21	0.00
Cm-242	1.993E-04	3.193E-05	2.420E-05	2.365E-05	2.307E-05	2.255E-05	2.583E-07
Cm-243	3.410E-05	3.248E-05	3.094E-05	2.947E-05	2.610E-05	2.311E-05	1.030E-15
Cm-244	2.715E-03	2.515E-03	2.329E-03	2.158E-03	1.782E-03	1.472E-03	7.545E-20
Cm-245	2.638E-07	2.638E-07	2.637E-07	2.637E-07	2.636E-07	2.635E-07	2.432E-07
Cm-246	6.753E-08	6.751E-08	6.749E-08	6.747E-08	6.742E-08	6.737E-08	5.836E-08
Cm-247	2.176E-13	2.176E-13	2.176E-13	2.176E-13	2.176E-13	2.176E-13	2.176E-13
Cm-248	5.834E-13	5.835E-13	5.835E-13	5.835E-13	5.835E-13	5.835E-13	5.823E-13
Bk-249	7.987E-11	1.641E-11	3.373E-12	6.933E-13	1.328E-14	2.542E-16	0.00
Bk-250	2.606E-16	4.153E-17	6.640E-18	1.062E-18	1.453E-20	3.982E-21	3.829E-21
Cf-249	6.400E-12	6.533E-12	6.539E-12	6.520E-12	6.458E-12	6.394E-12	9.205E-13
Cf-250	2.364E-11	2.126E-11	1.912E-11	1.720E-11	1.320E-11	1.013E-11	3.829E-21
Cf-251	1.685E-13	1.682E-13	1.680E-13	1.677E-13	1.671E-13	1.664E-13	7.812E-14
Cf-252	1.139E-11	6.737E-12	3.983E-12	2.355E-12	6.331E-13	1.702E-13	0.00
Es-254	2.604E-16	4.148E-17	6.633E-18	1.039E-18	0.00	0.00	0.00
Total	1.178E-01	1.077E-01	9.872E-02	9.052E-02	7.313E-02	5.941E-02	1.865E-03

TABLE F.3.a. Fission Product Inventory by Isotope at 10 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	1.029E-08	9.200E-09	8.223E-09	7.350E-09	5.552E-09	4.193E-09	5.414E-33
Li-6	9.959E-11	9.959E-11	9.959E-11	9.959E-11	9.959E-11	9.959E-11	9.959E-11
Li-7	3.084E-12	3.084E-12	3.084E-12	3.084E-12	3.084E-12	3.084E-12	3.084E-12
Be-9	5.945E-12	5.945E-12	5.945E-12	5.945E-12	5.945E-12	5.945E-12	5.945E-12
Be-10	3.964E-11	3.964E-11	3.964E-11	3.964E-11	3.964E-11	3.964E-11	3.963E-11
C-14	8.008E-12	8.006E-12	8.004E-12	8.002E-12	7.997E-12	7.993E-12	7.099E-12
Zn-66	1.091E-14	1.091E-14	1.091E-14	1.091E-14	1.091E-14	1.091E-14	1.091E-14
Zn-67	4.610E-16	4.610E-16	4.610E-16	4.610E-16	4.610E-16	4.610E-16	4.610E-16
Ga-71	2.029E-13	2.029E-13	2.029E-13	2.029E-13	2.029E-13	2.029E-13	2.029E-13
Ge-72	5.050E-09	5.050E-09	5.050E-09	5.050E-09	5.050E-09	5.050E-09	5.050E-09
Ge-73	1.196E-08	1.196E-08	1.196E-08	1.196E-08	1.196E-08	1.196E-08	1.196E-08
Ge-74	2.668E-08	2.668E-08	2.668E-08	2.668E-08	2.668E-08	2.668E-08	2.668E-08
As-75	5.944E-08	5.944E-08	5.944E-08	5.944E-08	5.944E-08	5.944E-08	5.944E-08
Ge-76	1.567E-07	1.567E-07	1.567E-07	1.567E-07	1.567E-07	1.567E-07	1.567E-07
Se-76	4.755E-10	4.755E-10	4.755E-10	4.755E-10	4.755E-10	4.755E-10	4.755E-10
Se-77	3.393E-07	3.393E-07	3.393E-07	3.393E-07	3.393E-07	3.393E-07	3.393E-07
Se-78	7.313E-07	7.313E-07	7.313E-07	7.313E-07	7.313E-07	7.313E-07	7.313E-07
Se-79	1.854E-06	1.854E-06	1.854E-06	1.854E-06	1.853E-06	1.853E-06	1.834E-06
Br-79	1.784E-10	2.180E-10	2.575E-10	2.971E-10	3.960E-10	4.949E-10	1.977E-08
Se-80	4.289E-06	4.289E-06	4.289E-06	4.289E-06	4.289E-06	4.289E-06	4.289E-06
Kr-80	4.795E-11	4.795E-11	4.795E-11	4.795E-11	4.795E-11	4.795E-11	4.795E-11
Br-81	7.261E-06	7.261E-06	7.261E-06	7.261E-06	7.261E-06	7.261E-06	7.261E-06
Kr-81	2.519E-12	2.519E-12	2.519E-12	2.519E-12	2.519E-12	2.519E-12	2.511E-12
Se-82	1.125E-05	1.125E-05	1.125E-05	1.125E-05	1.125E-05	1.125E-05	1.125E-05
Kr-82	1.057E-07	1.057E-07	1.057E-07	1.057E-07	1.057E-07	1.057E-07	1.057E-07
Kr-83	1.690E-05	1.690E-05	1.690E-05	1.690E-05	1.690E-05	1.690E-05	1.690E-05
Kr-84	3.585E-05	3.585E-05	3.585E-05	3.585E-05	3.585E-05	3.585E-05	3.585E-05
Kr-85	5.111E-06	4.491E-06	3.946E-06	3.467E-06	2.510E-06	1.816E-06	5.498E-34
Rb-85	3.739E-05	3.801E-05	3.855E-05	3.903E-05	3.999E-05	4.068E-05	4.250E-05
Kr-86	6.718E-05	6.718E-05	6.718E-05	6.718E-05	6.718E-05	6.718E-05	6.718E-05
Sr-86	4.224E-08	4.224E-08	4.224E-08	4.224E-08	4.224E-08	4.224E-08	4.224E-08
Rb-87	8.663E-05	8.663E-05	8.663E-05	8.663E-05	8.663E-05	8.663E-05	8.663E-05
Sr-87	3.356E-10	3.356E-10	3.356E-10	3.356E-10	3.356E-10	3.356E-10	3.369E-10
Sr-88	1.247E-04	1.247E-04	1.247E-04	1.247E-04	1.247E-04	1.247E-04	1.247E-04
Sr-89	6.792E-15	3.001E-19	1.326E-23	5.860E-28	0.00	0.00	0.00
Y-89	1.640E-04	1.640E-04	1.640E-04	1.640E-04	1.640E-04	1.640E-04	1.640E-04
Sr-90	1.597E-04	1.523E-04	1.452E-04	1.385E-04	1.229E-04	1.091E-04	8.085E-15
Y-90	4.006E-08	3.819E-08	3.642E-08	3.473E-08	3.083E-08	2.737E-08	2.027E-18
Zr-90	3.858E-05	4.601E-05	5.309E-05	5.985E-05	7.539E-05	8.918E-05	1.984E-04
Y-91	1.563E-13	2.726E-17	4.752E-21	8.286E-25	3.326E-34	0.00	0.00
Zr-91	2.077E-04	2.077E-04	2.077E-04	2.077E-04	2.077E-04	2.077E-04	2.077E-04
Zr-92	2.192E-04	2.192E-04	2.192E-04	2.192E-04	2.192E-04	2.192E-04	2.192E-04
Zr-93	2.431E-04	2.431E-04	2.431E-04	2.431E-04	2.431E-04	2.431E-04	2.430E-04
Nb-93	2.493E-10	3.433E-10	4.495E-10	5.668E-10	9.016E-10	1.285E-09	1.086E-07
Nb-93m	7.499E-10	8.762E-10	9.902E-10	1.093E-09	1.309E-09	1.476E-09	2.052E-09
Zr-94	2.420E-04	2.420E-04	2.420E-04	2.420E-04	2.420E-04	2.420E-04	2.420E-04
Nb-94	1.421E-10	1.421E-10	1.421E-10	1.421E-10	1.420E-10	1.420E-10	1.373E-10
Zr-95	9.598E-13	3.509E-16	1.283E-19	4.691E-23	1.199E-31	0.00	0.00

TABLE F.3.a. Fission Product Inventory by Isotope at 10 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nb-95	1.171E-12	4.280E-16	1.565E-19	5.722E-23	1.085E-33	0.00	0.00
Nb-95m	4.016E-16	1.468E-19	5.369E-23	1.963E-26	0.00	0.00	0.00
Mo-95	2.519E-04	2.519E-04	2.519E-04	2.519E-04	2.519E-04	2.519E-04	2.519E-04
Zr-96	2.554E-04	2.554E-04	2.554E-04	2.554E-04	2.554E-04	2.554E-04	2.554E-04
Mo-96	3.433E-06	3.433E-06	3.433E-06	3.433E-06	3.433E-06	3.433E-06	3.433E-06
Mo-97	2.470E-04	2.470E-04	2.470E-04	2.470E-04	2.470E-04	2.470E-04	2.470E-04
Mo-98	2.512E-04	2.512E-04	2.512E-04	2.512E-04	2.512E-04	2.512E-04	2.512E-04
Tc-98	4.142E-10	4.142E-10	4.142E-10	4.142E-10	4.142E-10	4.142E-10	4.141E-10
Tc-99	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.544E-04
Ru-99	7.433E-09	9.094E-09	1.075E-08	1.242E-08	1.657E-08	2.072E-08	8.333E-07
Mo-100	2.806E-04	2.806E-04	2.806E-04	2.806E-04	2.806E-04	2.806E-04	2.806E-04
Ru-100	8.364E-06	8.364E-06	8.364E-06	8.364E-06	8.364E-06	8.364E-06	8.364E-06
Ru-101	2.329E-04	2.329E-04	2.329E-04	2.329E-04	2.329E-04	2.329E-04	2.329E-04
Ru-102	2.112E-04	2.112E-04	2.112E-04	2.112E-04	2.112E-04	2.112E-04	2.112E-04
Rh-102	1.639E-11	1.016E-11	6.302E-12	3.907E-12	1.183E-12	3.580E-13	0.00
Ru-103	2.290E-17	5.780E-23	1.458E-28	3.681E-34	0.00	0.00	0.00
Rh-103	1.564E-04	1.564E-04	1.564E-04	1.564E-04	1.564E-04	1.564E-04	1.564E-04
Ru-104	1.251E-04	1.251E-04	1.251E-04	1.251E-04	1.251E-04	1.251E-04	1.251E-04
Pd-104	2.041E-05	2.041E-05	2.041E-05	2.041E-05	2.041E-05	2.041E-05	2.041E-05
Pd-105	8.619E-05	8.619E-05	8.619E-05	8.619E-05	8.619E-05	8.619E-05	8.619E-05
Ru-106	6.217E-07	1.571E-07	3.972E-08	1.004E-08	3.225E-10	1.036E-11	0.00
Rh-106	5.844E-13	1.477E-13	3.734E-14	9.437E-15	3.031E-16	9.737E-18	0.00
Pd-106	5.680E-05	5.727E-05	5.738E-05	5.741E-05	5.742E-05	5.742E-05	5.742E-05
Pd-107	3.614E-05	3.614E-05	3.614E-05	3.614E-05	3.614E-05	3.614E-05	3.613E-05
Ag-107	3.172E-11	3.943E-11	4.714E-11	5.485E-11	7.413E-11	9.341E-11	3.872E-09
Pd-108	2.368E-05	2.368E-05	2.368E-05	2.368E-05	2.368E-05	2.368E-05	2.368E-05
Ag-108m	1.692E-13	1.674E-13	1.656E-13	1.638E-13	1.594E-13	1.551E-13	7.375E-16
Cd-108	1.458E-11	1.458E-11	1.458E-11	1.458E-11	1.458E-11	1.458E-11	1.459E-11
Ag-109	1.406E-05	1.406E-05	1.406E-05	1.406E-05	1.406E-05	1.406E-05	1.406E-05
Cd-109	3.408E-16	1.144E-16	3.843E-17	1.290E-17	8.432E-19	5.510E-20	0.00
Pd-110	7.895E-06	7.895E-06	7.895E-06	7.895E-06	7.895E-06	7.895E-06	7.895E-06
Ag-110m	3.140E-10	4.139E-11	5.456E-12	7.192E-13	4.537E-15	2.863E-17	0.00
Cd-110	1.638E-06	1.638E-06	1.638E-06	1.638E-06	1.638E-06	1.638E-06	1.638E-06
Cd-111	4.749E-06	4.749E-06	4.749E-06	4.749E-06	4.749E-06	4.749E-06	4.749E-06
Cd-112	3.062E-06	3.062E-06	3.062E-06	3.062E-06	3.062E-06	3.062E-06	3.062E-06
Cd-113	1.083E-07	1.083E-07	1.083E-07	1.083E-07	1.083E-07	1.083E-07	1.083E-07
Cd-113m	3.243E-08	2.949E-08	2.682E-08	2.439E-08	1.923E-08	1.516E-08	9.116E-29
In-113	1.596E-08	1.890E-08	2.157E-08	2.400E-08	2.915E-08	3.321E-08	4.836E-08
Cd-114	4.601E-06	4.601E-06	4.601E-06	4.601E-06	4.601E-06	4.601E-06	4.601E-06
Sn-114	1.977E-10	1.977E-10	1.977E-10	1.977E-10	1.977E-10	1.977E-10	1.977E-10
In-115	1.255E-06	1.255E-06	1.255E-06	1.255E-06	1.255E-06	1.255E-06	1.255E-06
Sn-115	7.307E-08	7.307E-08	7.307E-08	7.307E-08	7.307E-08	7.307E-08	7.307E-08
Cd-116	1.910E-06	1.910E-06	1.910E-06	1.910E-06	1.910E-06	1.910E-06	1.910E-06
Sn-116	8.791E-07	8.791E-07	8.791E-07	8.791E-07	8.791E-07	8.791E-07	8.791E-07
Sn-117	1.940E-06	1.940E-06	1.940E-06	1.940E-06	1.940E-06	1.940E-06	1.940E-06
Sn-118	1.984E-06	1.984E-06	1.984E-06	1.984E-06	1.984E-06	1.984E-06	1.984E-06
Sn-119	1.959E-06	1.959E-06	1.959E-06	1.959E-06	1.959E-06	1.959E-06	1.959E-06
Sn-119m	4.882E-11	6.182E-12	7.828E-13	9.913E-14	5.655E-16	3.227E-18	0.00

TABLE F.3.a. Fission Product Inventory by Isotope at 10 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-120	2.008E-06	2.008E-06	2.008E-06	2.008E-06	2.008E-06	2.008E-06	2.008E-06
Sn-121m	6.877E-10	6.689E-10	6.506E-10	6.328E-10	5.904E-10	5.508E-10	6.879E-16
Sb-121	2.064E-06	2.064E-06	2.064E-06	2.064E-06	2.064E-06	2.064E-06	2.065E-06
Sn-122	2.230E-06	2.230E-06	2.230E-06	2.230E-06	2.230E-06	2.230E-06	2.230E-06
Te-122	3.861E-08	3.861E-08	3.861E-08	3.861E-08	3.861E-08	3.861E-08	3.861E-08
Sn-123	1.218E-11	2.416E-13	4.794E-15	9.511E-17	5.273E-21	2.923E-25	0.00
Sb-123	2.532E-06	2.532E-06	2.532E-06	2.532E-06	2.532E-06	2.532E-06	2.532E-06
Te-123	2.324E-10	2.324E-10	2.324E-10	2.324E-10	2.324E-10	2.324E-10	2.324E-10
Te-123m	2.426E-15	3.527E-17	5.127E-19	7.457E-21	1.900E-25	4.843E-30	0.00
Sn-124	3.109E-06	3.109E-06	3.109E-06	3.109E-06	3.109E-06	3.109E-06	3.109E-06
Sb-124	8.353E-17	1.857E-20	4.128E-24	9.176E-28	6.761E-37	0.00	0.00
Te-124	3.018E-08	3.018E-08	3.018E-08	3.018E-08	3.018E-08	3.018E-08	3.018E-08
Sb-125	5.980E-07	3.625E-07	2.198E-07	1.332E-07	3.813E-08	1.091E-08	0.00
Te-125	3.809E-06	4.048E-06	4.193E-06	4.281E-06	4.377E-06	4.405E-06	4.416E-06
Te-125m	8.364E-09	5.072E-09	3.075E-09	1.864E-09	5.333E-10	1.526E-10	0.00
Sn-126	6.664E-06	6.664E-06	6.664E-06	6.664E-06	6.664E-06	6.664E-06	6.619E-06
Sb-126	3.166E-13	3.166E-13	3.166E-13	3.166E-13	3.166E-13	3.166E-13	3.144E-13
Sb-126m	2.407E-15	2.407E-15	2.407E-15	2.407E-15	2.407E-15	2.407E-15	2.391E-15
Te-126	1.454E-07	1.455E-07	1.456E-07	1.457E-07	1.459E-07	1.461E-07	1.912E-07
Te-127	3.509E-14	3.371E-16	3.239E-18	3.112E-20	2.816E-25	2.548E-30	0.00
Te-127m	1.002E-11	9.629E-14	9.252E-16	8.889E-18	8.043E-23	7.278E-28	0.00
I-127	1.386E-05	1.386E-05	1.386E-05	1.386E-05	1.386E-05	1.386E-05	1.386E-05
Te-128	2.902E-05	2.902E-05	2.902E-05	2.902E-05	2.902E-05	2.902E-05	2.902E-05
Xe-128	2.114E-07	2.114E-07	2.114E-07	2.114E-07	2.114E-07	2.114E-07	2.114E-07
I-129	4.949E-05	4.949E-05	4.949E-05	4.949E-05	4.949E-05	4.949E-05	4.949E-05
Xe-129	3.804E-10	3.848E-10	3.891E-10	3.935E-10	4.044E-10	4.154E-10	2.557E-09
Te-130	9.838E-05	9.838E-05	9.838E-05	9.838E-05	9.838E-05	9.838E-05	9.838E-05
Xe-130	9.544E-07	9.544E-07	9.544E-07	9.544E-07	9.544E-07	9.544E-07	9.544E-07
Xe-131	1.597E-04	1.597E-04	1.597E-04	1.597E-04	1.597E-04	1.597E-04	1.597E-04
Xe-132	2.794E-04	2.794E-04	2.794E-04	2.794E-04	2.794E-04	2.794E-04	2.794E-04
Ba-132	1.244E-10	1.244E-10	1.244E-10	1.244E-10	1.244E-10	1.244E-10	1.244E-10
Cs-133	3.813E-04	3.813E-04	3.813E-04	3.813E-04	3.813E-04	3.813E-04	3.813E-04
Xe-134	4.490E-04	4.490E-04	4.490E-04	4.490E-04	4.490E-04	4.490E-04	4.490E-04
Cs-134	1.594E-06	8.138E-07	4.155E-07	2.121E-07	3.950E-08	7.356E-09	0.00
Ba-134	1.407E-05	1.485E-05	1.525E-05	1.546E-05	1.563E-05	1.566E-05	1.567E-05
Cs-135	2.547E-04	2.547E-04	2.547E-04	2.547E-04	2.547E-04	2.547E-04	2.546E-04
Ba-135	1.606E-08	1.621E-08	1.636E-08	1.652E-08	1.690E-08	1.728E-08	9.249E-08
Xe-136	5.292E-04	5.292E-04	5.292E-04	5.292E-04	5.292E-04	5.292E-04	5.292E-04
Ba-136	3.523E-06	3.523E-06	3.523E-06	3.523E-06	3.523E-06	3.523E-06	3.523E-06
Cs-137	3.026E-04	2.890E-04	2.759E-04	2.635E-04	2.347E-04	2.091E-04	3.065E-14
Ba-137	6.900E-05	8.266E-05	9.571E-05	1.082E-04	1.369E-04	1.625E-04	3.716E-04
Ba-137m	4.630E-11	4.421E-11	4.221E-11	4.031E-11	3.591E-11	3.199E-11	4.689E-21
Ba-138	3.997E-04	3.997E-04	3.997E-04	3.997E-04	3.997E-04	3.997E-04	3.997E-04
La-138	2.684E-09	2.684E-09	2.684E-09	2.684E-09	2.684E-09	2.684E-09	2.684E-09
La-139	3.832E-04	3.832E-04	3.832E-04	3.832E-04	3.832E-04	3.832E-04	3.832E-04
Ce-140	3.853E-04	3.853E-04	3.853E-04	3.853E-04	3.853E-04	3.853E-04	3.853E-04
Pr-141	3.555E-04	3.555E-04	3.555E-04	3.555E-04	3.555E-04	3.555E-04	3.555E-04
Ce-142	3.548E-04	3.548E-04	3.548E-04	3.548E-04	3.548E-04	3.548E-04	3.548E-04

TABLE F.3.a. Fission Product Inventory by Isotope at 10 MWd/kgM. g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nd-142	2.309E-06	2.309E-06	2.309E-06	2.309E-06	2.309E-06	2.309E-06	2.309E-06
Nd-143	3.217E-04	3.217E-04	3.217E-04	3.217E-04	3.217E-04	3.217E-04	3.217E-04
Ce-144	9.417E-07	1.586E-07	2.671E-08	4.499E-09	5.238E-11	6.097E-13	0.00
Pr-144	3.976E-11	6.697E-12	1.128E-12	1.900E-13	2.212E-15	2.575E-17	0.00
Pr-144m	1.988E-13	3.348E-14	5.639E-15	9.497E-16	1.106E-17	1.287E-19	0.00
Nd-144	3.548E-04	3.556E-04	3.557E-04	3.557E-04	3.557E-04	3.557E-04	3.557E-04
Nd-145	2.324E-04	2.324E-04	2.324E-04	2.324E-04	2.324E-04	2.324E-04	2.324E-04
Nd-146	1.951E-04	1.951E-04	1.951E-04	1.951E-04	1.951E-04	1.951E-04	1.951E-04
Pm-146	2.067E-10	1.607E-10	1.249E-10	9.706E-11	5.169E-11	2.752E-11	0.00
Sm-146	1.069E-09	1.086E-09	1.100E-09	1.110E-09	1.127E-09	1.136E-09	1.146E-09
Pm-147	1.399E-05	8.249E-06	4.863E-06	2.867E-06	7.651E-07	2.042E-07	0.00
Sm-147	1.036E-04	1.094E-04	1.127E-04	1.147E-04	1.168E-04	1.174E-04	1.176E-04
Nd-148	1.114E-04	1.114E-04	1.114E-04	1.114E-04	1.114E-04	1.114E-04	1.114E-04
Sm-148	2.498E-05	2.498E-05	2.498E-05	2.498E-05	2.498E-05	2.498E-05	2.498E-05
Sm-149	1.579E-06	1.579E-06	1.579E-06	1.579E-06	1.579E-06	1.579E-06	1.579E-06
Nd-150	4.871E-05	4.871E-05	4.871E-05	4.871E-05	4.871E-05	4.871E-05	4.871E-05
Sm-150	7.155E-05	7.155E-05	7.155E-05	7.155E-05	7.155E-05	7.155E-05	7.155E-05
Eu-150	2.302E-13	2.215E-13	2.131E-13	2.051E-13	1.863E-13	1.692E-13	1.082E-21
Sm-151	7.950E-06	7.829E-06	7.709E-06	7.591E-06	7.304E-06	7.029E-06	3.705E-09
Eu-151	3.440E-07	4.655E-07	5.852E-07	7.030E-07	9.898E-07	1.266E-06	8.291E-06
Sm-152	4.183E-05	4.184E-05	4.185E-05	4.186E-05	4.187E-05	4.188E-05	4.192E-05
Eu-152	1.181E-07	1.066E-07	9.631E-08	8.697E-08	6.741E-08	5.225E-08	1.064E-29
Gd-152	6.220E-08	6.539E-08	6.827E-08	7.087E-08	7.632E-08	8.054E-08	9.510E-08
Eu-153	2.043E-05	2.044E-05	2.044E-05	2.044E-05	2.044E-05	2.044E-05	2.044E-05
Gd-153	7.593E-11	9.371E-12	1.156E-12	1.427E-13	7.637E-16	4.087E-18	0.00
Sm-154	8.075E-06	8.075E-06	8.075E-06	8.075E-06	8.075E-06	8.075E-06	8.075E-06
Eu-154	2.045E-06	1.740E-06	1.481E-06	1.261E-06	8.426E-07	5.632E-07	0.00
Gd-154	1.619E-06	1.924E-06	2.183E-06	2.403E-06	2.822E-06	3.101E-06	3.664E-06
Eu-155	9.365E-07	7.081E-07	5.354E-07	4.048E-07	2.013E-07	1.001E-07	0.00
Gd-155	8.129E-07	1.041E-06	1.214E-06	1.345E-06	1.548E-06	1.649E-06	1.749E-06
Gd-156	6.141E-06	6.141E-06	6.141E-06	6.141E-06	6.141E-06	6.141E-06	6.141E-06
Gd-157	2.980E-08	2.980E-08	2.980E-08	2.980E-08	2.980E-08	2.980E-08	2.980E-08
Gd-158	2.474E-06	2.474E-06	2.474E-06	2.474E-06	2.474E-06	2.474E-06	2.474E-06
Tb-159	4.112E-07	4.112E-07	4.112E-07	4.112E-07	4.112E-07	4.112E-07	4.112E-07
Gd-160	1.983E-07	1.983E-07	1.983E-07	1.983E-07	1.983E-07	1.983E-07	1.983E-07
Tb-160	1.138E-15	1.035E-18	9.407E-22	8.552E-25	2.131E-32	0.00	0.00
Dy-160	1.620E-08	1.620E-08	1.620E-08	1.620E-08	1.620E-08	1.620E-08	1.620E-08
Dy-161	7.977E-08	7.977E-08	7.977E-08	7.977E-08	7.977E-08	7.977E-08	7.977E-08
Dy-162	5.602E-08	5.602E-08	5.602E-08	5.602E-08	5.602E-08	5.602E-08	5.602E-08
Dy-163	2.982E-08	2.982E-08	2.982E-08	2.982E-08	2.982E-08	2.982E-08	2.982E-08
Dy-164	7.029E-09	7.029E-09	7.029E-09	7.029E-09	7.029E-09	7.029E-09	7.029E-09
Ho-165	1.192E-08	1.192E-08	1.192E-08	1.192E-08	1.192E-08	1.192E-08	1.192E-08
Ho-166m	4.095E-11	4.090E-11	4.085E-11	4.081E-11	4.069E-11	4.057E-11	2.304E-11
Er-166	3.765E-09	3.766E-09	3.766E-09	3.766E-09	3.766E-09	3.766E-09	3.783E-09
Er-167	8.650E-10	8.650E-10	8.650E-10	8.650E-10	8.650E-10	8.650E-10	8.650E-10
Er-168	6.515E-10	6.515E-10	6.515E-10	6.515E-10	6.515E-10	6.515E-10	6.515E-10
Tm-169	1.502E-12	1.502E-12	1.502E-12	1.502E-12	1.502E-12	1.502E-12	1.502E-12
Er-170	1.968E-16	1.968E-16	1.968E-16	1.968E-16	1.968E-16	1.968E-16	1.968E-16

TABLE F.3.a. Fission Product Inventory by Isotope at 10 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Yb-170	1.335E-13	1.336E-13	1.336E-13	1.336E-13	1.336E-13	1.336E-13	1.336E-13
Tm-171	1.001E-16	4.863E-17	2.362E-17	1.148E-17	1.887E-18	3.104E-19	0.00
Yb-171	1.947E-15	1.998E-15	2.023E-15	2.035E-15	2.045E-15	2.047E-15	2.047E-15
Yb-172	2.543E-17	2.543E-17	2.543E-17	2.543E-17	2.543E-17	2.543E-17	2.543E-17
Total	1.034E-02	1.034E-02	1.034E-02	1.034E-02	1.034E-02	1.034E-02	1.034E-02

TABLE F.3.b. Fission Product Inventory by Isotope at 15 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	1.589E-08	1.420E-08	1.269E-08	1.135E-08	8.570E-09	6.472E-09	8.349E-33
Li-6	1.290E-10	1.290E-10	1.290E-10	1.290E-10	1.290E-10	1.290E-10	1.290E-10
Li-7	4.615E-12	4.615E-12	4.615E-12	4.615E-12	4.615E-12	4.615E-12	4.615E-12
Be-9	8.892E-12	8.892E-12	8.892E-12	8.892E-12	8.892E-12	8.892E-12	8.892E-12
Be-10	5.930E-11	5.930E-11	5.930E-11	5.930E-11	5.930E-11	5.930E-11	5.928E-11
C-14	1.198E-11	1.198E-11	1.197E-11	1.197E-11	1.196E-11	1.196E-11	1.062E-11
Zn-66	1.551E-14	1.551E-14	1.551E-14	1.551E-14	1.551E-14	1.551E-14	1.551E-14
Zn-67	6.538E-16	6.538E-16	6.538E-16	6.538E-16	6.538E-16	6.538E-16	6.538E-16
Ga-71	3.289E-13	3.289E-13	3.289E-13	3.289E-13	3.289E-13	3.289E-13	3.289E-13
Ge-72	7.887E-09	7.887E-09	7.887E-09	7.887E-09	7.887E-09	7.887E-09	7.887E-09
Ge-73	1.807E-08	1.807E-08	1.807E-08	1.807E-08	1.807E-08	1.807E-08	1.807E-08
Ge-74	4.024E-08	4.024E-08	4.024E-08	4.024E-08	4.024E-08	4.024E-08	4.024E-08
As-75	8.843E-08	8.843E-08	8.843E-08	8.843E-08	8.843E-08	8.843E-08	8.843E-08
Ge-76	2.304E-07	2.304E-07	2.304E-07	2.304E-07	2.304E-07	2.304E-07	2.304E-07
Se-76	1.074E-09	1.074E-09	1.074E-09	1.074E-09	1.074E-09	1.074E-09	1.074E-09
Se-77	4.955E-07	4.955E-07	4.955E-07	4.955E-07	4.955E-07	4.955E-07	4.955E-07
Se-78	1.097E-06	1.097E-06	1.097E-06	1.097E-06	1.097E-06	1.097E-06	1.097E-06
Se-79	2.744E-06	2.744E-06	2.744E-06	2.744E-06	2.744E-06	2.744E-06	2.715E-06
Br-79	2.645E-10	3.230E-10	3.816E-10	4.402E-10	5.866E-10	7.330E-10	2.928E-08
Se-80	6.339E-06	6.339E-06	6.339E-06	6.339E-06	6.339E-06	6.339E-06	6.339E-06
Kr-80	8.407E-11	8.407E-11	8.407E-11	8.407E-11	8.407E-11	8.407E-11	8.407E-11
Br-81	1.061E-05	1.061E-05	1.061E-05	1.061E-05	1.061E-05	1.061E-05	1.061E-05
Kr-81	5.322E-12	5.322E-12	5.322E-12	5.322E-12	5.322E-12	5.321E-12	5.304E-12
Se-82	1.639E-05	1.639E-05	1.639E-05	1.639E-05	1.639E-05	1.639E-05	1.639E-05
Kr-82	2.279E-07	2.279E-07	2.279E-07	2.279E-07	2.279E-07	2.279E-07	2.279E-07
Kr-83	2.359E-05	2.359E-05	2.359E-05	2.359E-05	2.359E-05	2.359E-05	2.359E-05
Kr-84	5.281E-05	5.281E-05	5.281E-05	5.281E-05	5.281E-05	5.281E-05	5.281E-05
Kr-85	7.358E-06	6.465E-06	5.681E-06	4.992E-06	3.613E-06	2.615E-06	7.905E-34
Rb-85	5.386E-05	5.476E-05	5.554E-05	5.623E-05	5.761E-05	5.861E-05	6.122E-05
Kr-86	9.644E-05	9.644E-05	9.644E-05	9.644E-05	9.644E-05	9.644E-05	9.644E-05
Sr-86	9.198E-08	9.198E-08	9.198E-08	9.198E-08	9.198E-08	9.198E-08	9.198E-08
Rb-87	1.242E-04	1.242E-04	1.242E-04	1.242E-04	1.242E-04	1.242E-04	1.242E-04
Sr-87	6.741E-10	6.741E-10	6.741E-10	6.741E-10	6.742E-10	6.742E-10	6.760E-10
Sr-88	1.786E-04	1.786E-04	1.786E-04	1.786E-04	1.786E-04	1.786E-04	1.786E-04
Sr-89	9.325E-15	4.120E-19	1.821E-23	8.045E-28	0.00	0.00	0.00
Y-89	2.346E-04	2.346E-04	2.346E-04	2.346E-04	2.346E-04	2.346E-04	2.346E-04
Sr-90	2.285E-04	2.178E-04	2.077E-04	1.981E-04	1.758E-04	1.561E-04	1.156E-14
Y-90	5.729E-08	5.463E-08	5.209E-08	4.967E-08	4.409E-08	3.915E-08	2.900E-18
Zr-90	5.557E-05	6.620E-05	7.633E-05	8.599E-05	1.082E-04	1.279E-04	2.841E-04
Y-91	2.171E-13	3.785E-17	6.600E-21	1.151E-24	4.619E-34	0.00	0.00
Zr-91	2.987E-04	2.987E-04	2.987E-04	2.987E-04	2.987E-04	2.987E-04	2.987E-04
Zr-92	3.173E-04	3.173E-04	3.173E-04	3.173E-04	3.173E-04	3.173E-04	3.173E-04
Zr-93	3.536E-04	3.536E-04	3.536E-04	3.536E-04	3.536E-04	3.536E-04	3.534E-04
Nb-93	3.656E-10	5.027E-10	6.576E-10	8.285E-10	1.316E-09	1.874E-09	1.580E-07
Nb-93m	1.095E-09	1.278E-09	1.444E-09	1.593E-09	1.907E-09	2.149E-09	2.985E-09
Zr-94	3.553E-04	3.553E-04	3.553E-04	3.553E-04	3.553E-04	3.553E-04	3.553E-04
Nb-94	2.604E-10	2.604E-10	2.604E-10	2.603E-10	2.603E-10	2.602E-10	2.517E-10
Zr-95	1.393E-12	5.095E-16	1.863E-19	6.810E-23	1.741E-31	0.00	0.00

TABLE F.3.b. Fission Product Inventory by Isotope at 15 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nb-95	1.700E-12	6.214E-16	2.272E-19	8.306E-23	1.574E-33	0.00	0.00
Nb-95m	5.830E-16	2.132E-19	7.794E-23	2.850E-26	0.00	0.00	0.00
Mo-95	3.682E-04	3.682E-04	3.682E-04	3.682E-04	3.682E-04	3.682E-04	3.682E-04
Zr-96	3.773E-04	3.773E-04	3.773E-04	3.773E-04	3.773E-04	3.773E-04	3.773E-04
Mo-96	7.814E-06	7.814E-06	7.814E-06	7.814E-06	7.814E-06	7.814E-06	7.814E-06
Mo-97	3.673E-04	3.673E-04	3.673E-04	3.673E-04	3.673E-04	3.673E-04	3.673E-04
Mo-98	3.752E-04	3.752E-04	3.752E-04	3.752E-04	3.752E-04	3.752E-04	3.752E-04
Tc-98	9.508E-10	9.508E-10	9.508E-10	9.508E-10	9.508E-10	9.508E-10	9.506E-10
Tc-99	3.764E-04	3.764E-04	3.764E-04	3.764E-04	3.763E-04	3.763E-04	3.751E-04
Ru-99	1.096E-08	1.341E-08	1.586E-08	1.831E-08	2.443E-08	3.056E-08	1.229E-06
Mo-100	4.215E-04	4.215E-04	4.215E-04	4.215E-04	4.215E-04	4.215E-04	4.215E-04
Ru-100	1.918E-05	1.918E-05	1.918E-05	1.918E-05	1.918E-05	1.918E-05	1.918E-05
Ru-101	3.501E-04	3.501E-04	3.501E-04	3.501E-04	3.501E-04	3.501E-04	3.501E-04
Ru-102	3.252E-04	3.252E-04	3.252E-04	3.252E-04	3.252E-04	3.252E-04	3.252E-04
Rh-102	3.833E-11	2.377E-11	1.474E-11	9.136E-12	2.765E-12	8.370E-13	0.00
Ru-103	3.711E-17	9.366E-23	2.364E-28	5.965E-34	0.00	0.00	0.00
Rh-103	2.318E-04	2.318E-04	2.318E-04	2.318E-04	2.318E-04	2.318E-04	2.318E-04
Ru-104	2.040E-04	2.040E-04	2.040E-04	2.040E-04	2.040E-04	2.040E-04	2.040E-04
Pd-104	4.729E-05	4.729E-05	4.729E-05	4.729E-05	4.729E-05	4.729E-05	4.729E-05
Pd-105	1.445E-04	1.445E-04	1.445E-04	1.445E-04	1.445E-04	1.445E-04	1.445E-04
Ru-106	1.151E-06	2.910E-07	7.355E-08	1.859E-08	5.971E-10	1.918E-11	0.00
Rh-106	1.082E-12	2.735E-13	6.913E-14	1.747E-14	5.613E-16	1.803E-17	0.00
Pd-106	1.037E-04	1.046E-04	1.048E-04	1.048E-04	1.049E-04	1.049E-04	1.049E-04
Pd-107	6.709E-05	6.709E-05	6.709E-05	6.709E-05	6.709E-05	6.709E-05	6.708E-05
Ag-107	5.832E-11	7.264E-11	8.696E-11	1.013E-10	1.371E-10	1.729E-10	7.188E-09
Pd-108	4.485E-05	4.485E-05	4.485E-05	4.485E-05	4.485E-05	4.485E-05	4.485E-05
Ag-108m	3.429E-13	3.391E-13	3.355E-13	3.318E-13	3.229E-13	3.142E-13	1.494E-15
Cd-108	4.132E-11	4.132E-11	4.132E-11	4.132E-11	4.132E-11	4.132E-11	4.135E-11
Ag-109	2.579E-05	2.579E-05	2.579E-05	2.579E-05	2.579E-05	2.579E-05	2.579E-05
Cd-109	1.484E-15	4.984E-16	1.674E-16	5.620E-17	3.672E-18	2.399E-19	0.00
Pd-110	1.464E-05	1.464E-05	1.464E-05	1.464E-05	1.464E-05	1.464E-05	1.464E-05
Ag-110m	9.114E-10	1.201E-10	1.584E-11	2.088E-12	1.317E-14	8.310E-17	0.00
Cd-110	4.647E-06	4.648E-06	4.648E-06	4.648E-06	4.648E-06	4.648E-06	4.648E-06
Cd-111	8.383E-06	8.383E-06	8.383E-06	8.383E-06	8.383E-06	8.383E-06	8.383E-06
Cd-112	5.176E-06	5.176E-06	5.176E-06	5.176E-06	5.176E-06	5.176E-06	5.176E-06
Cd-113	1.182E-07	1.182E-07	1.183E-07	1.183E-07	1.183E-07	1.183E-07	1.183E-07
Cd-113m	5.503E-08	5.004E-08	4.551E-08	4.138E-08	3.263E-08	2.573E-08	1.547E-28
In-113	2.643E-08	3.142E-08	3.595E-08	4.007E-08	4.881E-08	5.570E-08	8.141E-08
Cd-114	7.505E-06	7.505E-06	7.505E-06	7.505E-06	7.505E-06	7.505E-06	7.505E-06
Sn-114	4.993E-10	4.993E-10	4.993E-10	4.993E-10	4.993E-10	4.993E-10	4.993E-10
In-115	1.569E-06	1.569E-06	1.569E-06	1.569E-06	1.569E-06	1.569E-06	1.569E-06
Sn-115	1.143E-07	1.143E-07	1.143E-07	1.143E-07	1.143E-07	1.143E-07	1.143E-07
Cd-116	2.982E-06	2.982E-06	2.982E-06	2.982E-06	2.982E-06	2.982E-06	2.982E-06
Sn-116	1.798E-06	1.798E-06	1.798E-06	1.798E-06	1.798E-06	1.798E-06	1.798E-06
Sn-117	3.024E-06	3.024E-06	3.024E-06	3.024E-06	3.024E-06	3.024E-06	3.024E-06
Sn-118	3.085E-06	3.085E-06	3.085E-06	3.085E-06	3.085E-06	3.085E-06	3.085E-06
Sn-119	3.055E-06	3.055E-06	3.055E-06	3.055E-06	3.055E-06	3.055E-06	3.055E-06
Sn-119m	8.134E-11	1.030E-11	1.304E-12	1.652E-13	9.423E-16	5.378E-18	0.00

TABLE F.3.b. Fission Product Inventory by Isotope at 15 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-120	3.125E-06	3.125E-06	3.125E-06	3.125E-06	3.125E-06	3.125E-06	3.125E-06
Sn-121m	1.166E-09	1.134E-09	1.103E-09	1.072E-09	1.001E-09	9.336E-10	1.166E-15
Sb-121	3.178E-06	3.178E-06	3.178E-06	3.178E-06	3.179E-06	3.179E-06	3.180E-06
Sn-122	3.466E-06	3.466E-06	3.466E-06	3.466E-06	3.466E-06	3.466E-06	3.466E-06
Te-122	9.104E-08	9.104E-08	9.104E-08	9.104E-08	9.104E-08	9.104E-08	9.104E-08
Sn-123	1.931E-11	3.831E-13	7.601E-15	1.508E-16	8.360E-21	4.635E-25	0.00
Sb-123	3.909E-06	3.909E-06	3.909E-06	3.909E-06	3.909E-06	3.909E-06	3.909E-06
Te-123	7.451E-10	7.451E-10	7.451E-10	7.451E-10	7.451E-10	7.451E-10	7.451E-10
Te-123m	9.075E-15	1.320E-16	1.918E-18	2.789E-20	7.108E-25	1.812E-29	0.00
Sn-124	4.819E-06	4.819E-06	4.819E-06	4.819E-06	4.819E-06	4.819E-06	4.819E-06
Sb-124	2.038E-16	4.530E-20	1.007E-23	2.239E-27	1.649E-36	0.00	0.00
Te-124	7.084E-08	7.084E-08	7.084E-08	7.084E-08	7.084E-08	7.084E-08	7.084E-08
Sb-125	9.645E-07	5.847E-07	3.545E-07	2.149E-07	6.149E-08	1.760E-08	0.00
Te-125	6.059E-06	6.444E-06	6.678E-06	6.819E-06	6.975E-06	7.019E-06	7.037E-06
Te-125m	1.349E-08	8.181E-09	4.960E-09	3.007E-09	8.601E-10	2.461E-10	0.00
Sn-126	1.057E-05	1.057E-05	1.057E-05	1.057E-05	1.057E-05	1.057E-05	1.050E-05
Sb-126	5.023E-13	5.022E-13	5.022E-13	5.022E-13	5.022E-13	5.022E-13	4.988E-13
Sb-126m	3.819E-15	3.819E-15	3.819E-15	3.818E-15	3.818E-15	3.818E-15	3.792E-15
Te-126	2.484E-07	2.485E-07	2.487E-07	2.488E-07	2.492E-07	2.495E-07	3.211E-07
Te-127	5.769E-14	5.543E-16	5.326E-18	5.118E-20	4.631E-25	4.190E-30	0.00
Te-127m	1.648E-11	1.583E-13	1.522E-15	1.462E-17	1.323E-22	1.197E-27	0.00
I-127	2.207E-05	2.207E-05	2.207E-05	2.207E-05	2.207E-05	2.207E-05	2.207E-05
Te-128	4.535E-05	4.535E-05	4.535E-05	4.535E-05	4.535E-05	4.535E-05	4.535E-05
Xe-128	5.156E-07	5.156E-07	5.156E-07	5.156E-07	5.156E-07	5.156E-07	5.156E-07
I-129	7.669E-05	7.669E-05	7.669E-05	7.669E-05	7.669E-05	7.669E-05	7.668E-05
Xe-129	1.301E-09	1.307E-09	1.314E-09	1.321E-09	1.338E-09	1.355E-09	4.673E-09
Te-130	1.515E-04	1.515E-04	1.515E-04	1.515E-04	1.515E-04	1.515E-04	1.515E-04
Xe-130	2.245E-06	2.245E-06	2.245E-06	2.245E-06	2.245E-06	2.245E-06	2.245E-06
Xe-131	2.297E-04	2.297E-04	2.297E-04	2.297E-04	2.297E-04	2.297E-04	2.297E-04
Xe-132	4.359E-04	4.359E-04	4.359E-04	4.359E-04	4.359E-04	4.359E-04	4.359E-04
Ba-132	2.845E-10	2.845E-10	2.845E-10	2.845E-10	2.845E-10	2.845E-10	2.845E-10
Cs-133	5.587E-04	5.587E-04	5.587E-04	5.587E-04	5.587E-04	5.587E-04	5.587E-04
Xe-134	6.707E-04	6.707E-04	6.707E-04	6.707E-04	6.707E-04	6.707E-04	6.707E-04
Cs-134	3.633E-06	1.855E-06	9.469E-07	4.834E-07	9.002E-08	1.676E-08	0.00
Ba-134	3.163E-05	3.340E-05	3.431E-05	3.477E-05	3.517E-05	3.524E-05	3.526E-05
Cs-135	3.243E-04	3.243E-04	3.243E-04	3.243E-04	3.243E-04	3.243E-04	3.242E-04
Ba-135	5.437E-08	5.457E-08	5.476E-08	5.496E-08	5.545E-08	5.594E-08	1.517E-07
Xe-136	8.551E-04	8.551E-04	8.551E-04	8.551E-04	8.551E-04	8.551E-04	8.551E-04
Ba-136	6.693E-06	6.693E-06	6.693E-06	6.693E-06	6.693E-06	6.693E-06	6.693E-06
Cs-137	4.545E-04	4.340E-04	4.144E-04	3.957E-04	3.525E-04	3.140E-04	4.603E-14
Ba-137	1.036E-04	1.241E-04	1.437E-04	1.624E-04	2.056E-04	2.441E-04	5.581E-04
Ba-137m	6.953E-11	6.639E-11	6.340E-11	6.053E-11	5.393E-11	4.804E-11	7.042E-21
Ba-138	5.931E-04	5.931E-04	5.931E-04	5.931E-04	5.931E-04	5.931E-04	5.931E-04
La-138	3.627E-09	3.627E-09	3.627E-09	3.627E-09	3.627E-09	3.627E-09	3.627E-09
La-139	5.682E-04	5.682E-04	5.682E-04	5.682E-04	5.682E-04	5.682E-04	5.682E-04
Ce-140	5.739E-04	5.739E-04	5.739E-04	5.739E-04	5.739E-04	5.739E-04	5.739E-04
Pr-141	5.267E-04	5.267E-04	5.267E-04	5.267E-04	5.267E-04	5.267E-04	5.267E-04
Ce-142	5.258E-04	5.258E-04	5.258E-04	5.258E-04	5.258E-04	5.258E-04	5.258E-04

TABLE F.3.b. Fission Product Inventory by Isotope at 15 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nd-142	5.307E-06	5.307E-06	5.307E-06	5.307E-06	5.307E-06	5.307E-06	5.307E-06
Nd-143	4.502E-04	4.502E-04	4.502E-04	4.502E-04	4.502E-04	4.502E-04	4.502E-04
Ce-144	1.366E-06	2.301E-07	3.875E-08	6.527E-09	7.599E-11	8.846E-13	0.00
Pr-144	5.769E-11	9.716E-12	1.636E-12	2.756E-13	3.208E-15	3.735E-17	0.00
Pr-144m	2.884E-13	4.857E-14	8.180E-15	1.378E-15	1.604E-17	1.867E-19	0.00
Nd-144	5.456E-04	5.467E-04	5.469E-04	5.469E-04	5.469E-04	5.469E-04	5.469E-04
Nd-145	3.376E-04	3.376E-04	3.376E-04	3.376E-04	3.376E-04	3.376E-04	3.376E-04
Nd-146	2.956E-04	2.956E-04	2.956E-04	2.956E-04	2.956E-04	2.956E-04	2.956E-04
Pm-146	4.395E-10	3.416E-10	2.655E-10	2.063E-10	1.099E-10	5.851E-11	0.00
Sm-146	2.275E-09	2.311E-09	2.339E-09	2.361E-09	2.397E-09	2.416E-09	2.437E-09
Pm-147	1.888E-05	1.113E-05	6.563E-06	3.869E-06	1.033E-06	2.755E-07	0.00
Sm-147	1.382E-04	1.459E-04	1.505E-04	1.532E-04	1.560E-04	1.568E-04	1.571E-04
Nd-148	1.668E-04	1.668E-04	1.668E-04	1.668E-04	1.668E-04	1.668E-04	1.668E-04
Sm-148	5.059E-05	5.059E-05	5.059E-05	5.059E-05	5.059E-05	5.059E-05	5.059E-05
Sm-149	1.559E-06	1.559E-06	1.559E-06	1.559E-06	1.559E-06	1.559E-06	1.559E-06
Nd-150	7.492E-05	7.492E-05	7.492E-05	7.492E-05	7.492E-05	7.492E-05	7.492E-05
Sm-150	1.076E-04	1.076E-04	1.076E-04	1.076E-04	1.076E-04	1.076E-04	1.076E-04
Eu-150	2.987E-13	2.874E-13	2.766E-13	2.661E-13	2.417E-13	2.195E-13	1.403E-21
Sm-151	8.925E-06	8.788E-06	8.654E-06	8.522E-06	8.200E-06	7.890E-06	4.159E-09
Eu-151	3.436E-07	4.800E-07	6.144E-07	7.466E-07	1.069E-06	1.378E-06	9.264E-06
Sm-152	6.361E-05	6.362E-05	6.363E-05	6.364E-05	6.365E-05	6.367E-05	6.371E-05
Eu-152	1.301E-07	1.175E-07	1.061E-07	9.583E-08	7.427E-08	5.756E-08	1.173E-29
Gd-152	6.876E-08	7.227E-08	7.544E-08	7.831E-08	8.431E-08	8.897E-08	1.050E-07
Eu-153	3.638E-05	3.638E-05	3.638E-05	3.638E-05	3.638E-05	3.638E-05	3.638E-05
Gd-153	1.396E-10	1.723E-11	2.126E-12	2.624E-13	1.405E-15	7.518E-18	0.00
Sm-154	1.336E-05	1.336E-05	1.336E-05	1.336E-05	1.336E-05	1.336E-05	1.336E-05
Eu-154	5.024E-06	4.276E-06	3.640E-06	3.098E-06	2.070E-06	1.384E-06	0.00
Gd-154	3.910E-06	4.658E-06	5.295E-06	5.836E-06	6.864E-06	7.550E-06	8.934E-06
Eu-155	1.662E-06	1.257E-06	9.505E-07	7.187E-07	3.573E-07	1.776E-07	0.00
Gd-155	1.366E-06	1.772E-06	2.078E-06	2.310E-06	2.671E-06	2.851E-06	3.029E-06
Gd-156	1.228E-05	1.228E-05	1.228E-05	1.228E-05	1.228E-05	1.228E-05	1.228E-05
Gd-157	3.753E-08	3.753E-08	3.753E-08	3.753E-08	3.753E-08	3.753E-08	3.753E-08
Gd-158	4.593E-06	4.593E-06	4.593E-06	4.593E-06	4.593E-06	4.593E-06	4.593E-06
Tb-159	7.645E-07	7.645E-07	7.645E-07	7.645E-07	7.645E-07	7.645E-07	7.645E-07
Gd-160	3.714E-07	3.714E-07	3.714E-07	3.714E-07	3.714E-07	3.714E-07	3.714E-07
Tb-160	3.338E-15	3.034E-18	2.759E-21	2.508E-24	6.249E-32	0.00	0.00
Dy-160	4.347E-08	4.347E-08	4.347E-08	4.347E-08	4.347E-08	4.347E-08	4.347E-08
Dy-161	1.403E-07	1.403E-07	1.403E-07	1.403E-07	1.403E-07	1.403E-07	1.403E-07
Dy-162	1.067E-07	1.067E-07	1.067E-07	1.067E-07	1.067E-07	1.067E-07	1.067E-07
Dy-163	6.224E-08	6.224E-08	6.224E-08	6.224E-08	6.224E-08	6.224E-08	6.224E-08
Dy-164	1.199E-08	1.199E-08	1.199E-08	1.199E-08	1.199E-08	1.199E-08	1.199E-08
Ho-165	2.582E-08	2.582E-08	2.582E-08	2.582E-08	2.582E-08	2.582E-08	2.582E-08
Ho-166m	1.276E-10	1.274E-10	1.273E-10	1.271E-10	1.268E-10	1.264E-10	7.176E-11
Er-166	7.778E-09	7.778E-09	7.778E-09	7.779E-09	7.779E-09	7.779E-09	7.834E-09
Er-167	1.261E-09	1.261E-09	1.261E-09	1.261E-09	1.261E-09	1.261E-09	1.261E-09
Er-168	1.492E-09	1.492E-09	1.492E-09	1.492E-09	1.492E-09	1.492E-09	1.492E-09
Tm-169	5.105E-12	5.105E-12	5.105E-12	5.105E-12	5.105E-12	5.105E-12	5.105E-12
Er-170	1.037E-15	1.037E-15	1.037E-15	1.037E-15	1.037E-15	1.037E-15	1.037E-15

TABLE F.3.b. Fission Product Inventory by Isotope at 15 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Tm-170	5.324E-17	1.038E-18	2.022E-20	4.047E-22	2.147E-26	1.139E-30	0.00
Yb-170	7.005E-13	7.006E-13	7.006E-13	7.006E-13	7.006E-13	7.006E-13	7.006E-13
Tm-171	8.387E-16	4.074E-16	1.979E-16	9.614E-17	1.581E-17	2.600E-18	0.00
Yb-171	1.571E-14	1.614E-14	1.635E-14	1.645E-14	1.653E-14	1.654E-14	1.655E-14
Yb-172	3.164E-16	3.164E-16	3.164E-16	3.164E-16	3.164E-16	3.164E-16	3.164E-16
Total	1.548E-02	1.548E-02	1.548E-02	1.548E-02	1.548E-02	1.548E-02	1.548E-02

TABLE F.3.c. Fission Product Inventory by Isotope at 20 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	2.170E-08	1.940E-08	1.734E-08	1.550E-08	1.170E-08	8.840E-09	1.140E-32
Li-6	1.484E-10	1.484E-10	1.484E-10	1.484E-10	1.484E-10	1.484E-10	1.484E-10
Li-7	6.139E-12	6.139E-12	6.139E-12	6.139E-12	6.139E-12	6.139E-12	6.139E-12
Be-9	1.183E-11	1.183E-11	1.183E-11	1.183E-11	1.183E-11	1.183E-11	1.183E-11
Be-10	7.888E-11	7.888E-11	7.888E-11	7.888E-11	7.888E-11	7.888E-11	7.885E-11
C-14	1.593E-11	1.593E-11	1.593E-11	1.592E-11	1.591E-11	1.590E-11	1.413E-11
Zn-66	1.968E-14	1.968E-14	1.968E-14	1.968E-14	1.968E-14	1.968E-14	1.968E-14
Zn-67	8.277E-16	8.277E-16	8.277E-16	8.277E-16	8.277E-16	8.277E-16	8.277E-16
Ga-71	4.633E-13	4.633E-13	4.633E-13	4.633E-13	4.633E-13	4.633E-13	4.633E-13
Ge-72	1.089E-08	1.089E-08	1.089E-08	1.089E-08	1.089E-08	1.089E-08	1.089E-08
Ge-73	2.422E-08	2.422E-08	2.422E-08	2.422E-08	2.422E-08	2.422E-08	2.422E-08
Ge-74	5.392E-08	5.392E-08	5.392E-08	5.392E-08	5.392E-08	5.392E-08	5.392E-08
As-75	1.169E-07	1.169E-07	1.169E-07	1.169E-07	1.169E-07	1.169E-07	1.169E-07
Ge-76	3.017E-07	3.017E-07	3.017E-07	3.017E-07	3.017E-07	3.017E-07	3.017E-07
Se-76	1.924E-09	1.924E-09	1.924E-09	1.924E-09	1.924E-09	1.924E-09	1.924E-09
Se-77	6.434E-07	6.434E-07	6.434E-07	6.434E-07	6.434E-07	6.434E-07	6.434E-07
Se-78	1.460E-06	1.460E-06	1.460E-06	1.460E-06	1.460E-06	1.460E-06	1.460E-06
Se-79	3.612E-06	3.612E-06	3.612E-06	3.612E-06	3.612E-06	3.611E-06	3.574E-06
Br-79	3.482E-10	4.253E-10	5.024E-10	5.795E-10	7.722E-10	9.648E-10	3.853E-08
Se-80	8.328E-06	8.328E-06	8.328E-06	8.328E-06	8.328E-06	8.328E-06	8.328E-06
Kr-80	1.248E-10	1.248E-10	1.248E-10	1.248E-10	1.248E-10	1.248E-10	1.248E-10
Br-81	1.379E-05	1.379E-05	1.379E-05	1.379E-05	1.379E-05	1.379E-05	1.379E-05
Kr-81	9.110E-12	9.110E-12	9.110E-12	9.109E-12	9.109E-12	9.109E-12	9.080E-12
Se-82	2.129E-05	2.129E-05	2.129E-05	2.129E-05	2.129E-05	2.129E-05	2.129E-05
Kr-82	3.935E-07	3.935E-07	3.935E-07	3.935E-07	3.935E-07	3.935E-07	3.935E-07
Kr-83	2.927E-05	2.927E-05	2.927E-05	2.927E-05	2.927E-05	2.927E-05	2.927E-05
Kr-84	6.939E-05	6.939E-05	6.939E-05	6.939E-05	6.939E-05	6.939E-05	6.939E-05
Kr-85	9.452E-06	8.305E-06	7.298E-06	6.413E-06	4.641E-06	3.359E-06	1.015E-33
Rb-85	6.922E-05	7.036E-05	7.137E-05	7.225E-05	7.403E-05	7.531E-05	7.867E-05
Kr-86	1.236E-04	1.236E-04	1.236E-04	1.236E-04	1.236E-04	1.236E-04	1.236E-04
Sr-86	1.609E-07	1.609E-07	1.609E-07	1.609E-07	1.609E-07	1.609E-07	1.609E-07
Rb-87	1.590E-04	1.590E-04	1.590E-04	1.590E-04	1.590E-04	1.590E-04	1.590E-04
Sr-87	1.164E-09	1.164E-09	1.164E-09	1.164E-09	1.164E-09	1.164E-09	1.166E-09
Sr-88	2.285E-04	2.285E-04	2.285E-04	2.285E-04	2.285E-04	2.285E-04	2.285E-04
Sr-89	1.149E-14	5.078E-19	2.244E-23	9.915E-28	0.00	0.00	0.00
Y-89	2.996E-04	2.996E-04	2.996E-04	2.996E-04	2.996E-04	2.996E-04	2.996E-04
Sr-90	2.917E-04	2.781E-04	2.652E-04	2.528E-04	2.245E-04	1.993E-04	1.476E-14
Y-90	7.314E-08	6.974E-08	6.650E-08	6.341E-08	5.629E-08	4.998E-08	3.702E-18
Zr-90	7.141E-05	8.497E-05	9.790E-05	1.102E-04	1.386E-04	1.638E-04	3.631E-04
Y-91	2.705E-13	4.717E-17	8.224E-21	1.434E-24	5.755E-34	0.00	0.00
Zr-91	3.833E-04	3.833E-04	3.833E-04	3.833E-04	3.833E-04	3.833E-04	3.833E-04
Zr-92	4.098E-04	4.098E-04	4.098E-04	4.098E-04	4.098E-04	4.098E-04	4.098E-04
Zr-93	4.584E-04	4.584E-04	4.584E-04	4.584E-04	4.584E-04	4.584E-04	4.582E-04
Nb-93	4.774E-10	6.556E-10	8.567E-10	1.079E-09	1.712E-09	2.436E-09	2.048E-07
Nb-93m	1.424E-09	1.661E-09	1.875E-09	2.069E-09	2.474E-09	2.788E-09	3.870E-09
Zr-94	4.649E-04	4.649E-04	4.649E-04	4.649E-04	4.649E-04	4.649E-04	4.649E-04
Nb-94	3.957E-10	3.957E-10	3.957E-10	3.956E-10	3.956E-10	3.955E-10	3.825E-10
Zr-95	1.806E-12	6.604E-16	2.415E-19	8.829E-23	2.257E-31	0.00	0.00

TABLE F.3.c. Fission Product Inventory by Isotope at 20 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nb-95	2.203E-12	8.055E-16	2.945E-19	1.077E-22	2.041E-33	0.00	0.00
Nb-95m	7.558E-16	2.763E-19	1.010E-22	3.694E-26	0.00	0.00	0.00
Mo-95	4.791E-04	4.791E-04	4.791E-04	4.791E-04	4.791E-04	4.791E-04	4.791E-04
Zr-96	4.962E-04	4.962E-04	4.962E-04	4.962E-04	4.962E-04	4.962E-04	4.962E-04
Mo-96	1.409E-05	1.409E-05	1.409E-05	1.409E-05	1.409E-05	1.409E-05	1.409E-05
Mo-97	4.858E-04	4.858E-04	4.858E-04	4.858E-04	4.858E-04	4.858E-04	4.858E-04
Mo-98	4.981E-04	4.981E-04	4.981E-04	4.981E-04	4.981E-04	4.981E-04	4.981E-04
Tc-98	1.726E-09	1.726E-09	1.726E-09	1.726E-09	1.726E-09	1.726E-09	1.725E-09
Tc-99	4.930E-04	4.930E-04	4.930E-04	4.930E-04	4.930E-04	4.929E-04	4.914E-04
Ru-99	1.436E-08	1.757E-08	2.078E-08	2.398E-08	3.200E-08	4.003E-08	1.610E-06
Mo-100	5.625E-04	5.625E-04	5.625E-04	5.625E-04	5.625E-04	5.625E-04	5.625E-04
Ru-100	3.478E-05	3.478E-05	3.478E-05	3.478E-05	3.478E-05	3.478E-05	3.478E-05
Ru-101	4.671E-04	4.671E-04	4.671E-04	4.671E-04	4.671E-04	4.671E-04	4.671E-04
Ru-102	4.439E-04	4.439E-04	4.439E-04	4.439E-04	4.439E-04	4.439E-04	4.439E-04
Rh-102	6.988E-11	4.333E-11	2.686E-11	1.666E-11	5.041E-12	1.526E-12	0.00
Ru-103	5.207E-17	1.314E-22	3.316E-28	8.368E-34	0.00	0.00	0.00
Rh-103	3.019E-04	3.019E-04	3.019E-04	3.019E-04	3.019E-04	3.019E-04	3.019E-04
Ru-104	2.911E-04	2.911E-04	2.911E-04	2.911E-04	2.911E-04	2.911E-04	2.911E-04
Pd-104	8.596E-05	8.596E-05	8.596E-05	8.596E-05	8.596E-05	8.596E-05	8.596E-05
Pd-105	2.096E-04	2.096E-04	2.096E-04	2.096E-04	2.096E-04	2.096E-04	2.096E-04
Ru-106	1.781E-06	4.502E-07	1.138E-07	2.876E-08	9.238E-10	2.968E-11	0.00
Rh-106	1.674E-12	4.231E-13	1.070E-13	2.703E-14	8.684E-16	2.789E-17	0.00
Pd-106	1.611E-04	1.624E-04	1.627E-04	1.628E-04	1.628E-04	1.628E-04	1.628E-04
Pd-107	1.047E-04	1.047E-04	1.047E-04	1.047E-04	1.047E-04	1.047E-04	1.047E-04
Ag-107	9.048E-11	1.128E-10	1.352E-10	1.575E-10	2.133E-10	2.692E-10	1.122E-08
Pd-108	7.087E-05	7.087E-05	7.087E-05	7.087E-05	7.087E-05	7.087E-05	7.087E-05
Ag-108m	5.628E-13	5.567E-13	5.507E-13	5.447E-13	5.300E-13	5.158E-13	2.453E-15
Cd-108	8.735E-11	8.735E-11	8.735E-11	8.735E-11	8.736E-11	8.736E-11	8.740E-11
Ag-109	3.934E-05	3.934E-05	3.934E-05	3.934E-05	3.934E-05	3.934E-05	3.934E-05
Cd-109	4.264E-15	1.432E-15	4.808E-16	1.615E-16	1.055E-17	6.894E-19	0.00
Pd-110	2.291E-05	2.291E-05	2.291E-05	2.291E-05	2.291E-05	2.291E-05	2.291E-05
Ag-110	2.943E-17	3.880E-18	5.115E-19	6.742E-20	4.254E-22	2.684E-24	0.00
Ag-110m	1.942E-09	2.560E-10	3.375E-11	4.449E-12	2.807E-14	1.771E-16	0.00
Cd-110	9.818E-06	9.819E-06	9.820E-06	9.820E-06	9.820E-06	9.820E-06	9.820E-06
Cd-111	1.274E-05	1.274E-05	1.274E-05	1.274E-05	1.274E-05	1.274E-05	1.274E-05
Cd-112	7.657E-06	7.657E-06	7.657E-06	7.657E-06	7.657E-06	7.657E-06	7.657E-06
Cd-113	1.260E-07	1.260E-07	1.260E-07	1.260E-07	1.260E-07	1.260E-07	1.261E-07
Cd-113m	8.229E-08	7.483E-08	6.805E-08	6.188E-08	4.880E-08	3.848E-08	2.313E-28
In-113	3.868E-08	4.613E-08	5.291E-08	5.907E-08	7.214E-08	8.245E-08	1.209E-07
Cd-114	1.074E-05	1.074E-05	1.074E-05	1.074E-05	1.074E-05	1.074E-05	1.074E-05
Sn-114	9.880E-10	9.880E-10	9.880E-10	9.880E-10	9.880E-10	9.880E-10	9.880E-10
In-115	1.771E-06	1.771E-06	1.771E-06	1.771E-06	1.771E-06	1.771E-06	1.771E-06
Sn-115	1.583E-07	1.583E-07	1.583E-07	1.583E-07	1.583E-07	1.583E-07	1.583E-07
Cd-116	4.120E-06	4.120E-06	4.120E-06	4.120E-06	4.120E-06	4.120E-06	4.120E-06
Sn-116	2.931E-06	2.931E-06	2.931E-06	2.931E-06	2.931E-06	2.931E-06	2.931E-06
Sn-117	4.172E-06	4.172E-06	4.172E-06	4.172E-06	4.172E-06	4.172E-06	4.172E-06
Sn-118	4.249E-06	4.249E-06	4.249E-06	4.249E-06	4.249E-06	4.249E-06	4.249E-06
Sn-119	4.217E-06	4.217E-06	4.217E-06	4.217E-06	4.217E-06	4.217E-06	4.217E-06

TABLE F.3.c. Fission Product Inventory by Isotope at 20 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-119m	1.188E-10	1.504E-11	1.904E-12	2.411E-13	1.376E-15	7.853E-18	0.00
Sn-120	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06
Sn-120	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06
Sn-120	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06	4.305E-06
Sn-121m	1.695E-09	1.649E-09	1.603E-09	1.560E-09	1.455E-09	1.358E-09	1.695E-15
Sb-121	4.329E-06	4.330E-06	4.330E-06	4.330E-06	4.330E-06	4.330E-06	4.331E-06
Sn-122	4.767E-06	4.767E-06	4.767E-06	4.767E-06	4.767E-06	4.767E-06	4.767E-06
Te-122	1.693E-07	1.693E-07	1.693E-07	1.693E-07	1.693E-07	1.693E-07	1.693E-07
Sn-123	2.686E-11	5.328E-13	1.057E-14	2.097E-16	1.163E-20	6.446E-25	0.00
Sb-123	5.337E-06	5.337E-06	5.337E-06	5.337E-06	5.337E-06	5.337E-06	5.337E-06
Te-123	1.690E-09	1.690E-09	1.690E-09	1.690E-09	1.690E-09	1.690E-09	1.690E-09
Te-123m	2.366E-14	3.440E-16	5.001E-18	7.270E-20	1.853E-24	4.722E-29	0.00
Sn-124	6.607E-06	6.607E-06	6.607E-06	6.607E-06	6.607E-06	6.607E-06	6.607E-06
Sb-124	3.895E-16	8.659E-20	1.925E-23	4.279E-27	3.153E-36	0.00	0.00
Te-124	1.320E-07	1.320E-07	1.320E-07	1.320E-07	1.320E-07	1.320E-07	1.320E-07
Sb-125	1.358E-06	8.232E-07	4.991E-07	3.026E-07	8.658E-08	2.477E-08	0.00
Te-125	8.464E-06	9.006E-06	9.335E-06	9.534E-06	9.753E-06	9.816E-06	9.841E-06
Te-125m	1.899E-08	1.152E-08	6.982E-09	4.233E-09	1.211E-09	3.465E-10	0.00
Sn-126	1.473E-05	1.473E-05	1.473E-05	1.473E-05	1.473E-05	1.473E-05	1.463E-05
Sb-126	6.999E-13	6.999E-13	6.999E-13	6.999E-13	6.998E-13	6.998E-13	6.951E-13
Sb-126m	5.321E-15	5.321E-15	5.321E-15	5.321E-15	5.321E-15	5.321E-15	5.285E-15
Te-126	3.679E-07	3.681E-07	3.683E-07	3.685E-07	3.690E-07	3.696E-07	4.693E-07
Te-127	8.206E-14	7.884E-16	7.575E-18	7.277E-20	6.585E-25	5.958E-30	0.00
Te-127m	2.344E-11	2.252E-13	2.164E-15	2.079E-17	1.881E-22	1.702E-27	0.00
I-127	3.077E-05	3.077E-05	3.077E-05	3.077E-05	3.077E-05	3.077E-05	3.077E-05
Te-128	6.243E-05	6.243E-05	6.243E-05	6.243E-05	6.243E-05	6.243E-05	6.243E-05
Xe-128	9.848E-07	9.848E-07	9.848E-07	9.848E-07	9.848E-07	9.848E-07	9.848E-07
I-129	1.046E-04	1.046E-04	1.046E-04	1.046E-04	1.046E-04	1.046E-04	1.046E-04
Xe-129	3.274E-09	3.283E-09	3.293E-09	3.302E-09	3.325E-09	3.348E-09	7.875E-09
Te-130	2.062E-04	2.062E-04	2.062E-04	2.062E-04	2.062E-04	2.062E-04	2.062E-04
Xe-130	4.171E-06	4.171E-06	4.171E-06	4.171E-06	4.171E-06	4.171E-06	4.171E-06
Xe-131	2.922E-04	2.922E-04	2.922E-04	2.922E-04	2.922E-04	2.922E-04	2.922E-04
Xe-132	6.029E-04	6.029E-04	6.029E-04	6.029E-04	6.029E-04	6.029E-04	6.029E-04
Ba-132	5.140E-10	5.140E-10	5.140E-10	5.140E-10	5.140E-10	5.140E-10	5.140E-10
Cs-133	7.266E-04	7.266E-04	7.266E-04	7.266E-04	7.266E-04	7.266E-04	7.266E-04
Xe-134	8.913E-04	8.913E-04	8.913E-04	8.913E-04	8.913E-04	8.913E-04	8.913E-04
Cs-134	6.492E-06	3.314E-06	1.692E-06	8.638E-07	1.609E-07	2.996E-08	0.00
Ba-134	5.615E-05	5.933E-05	6.095E-05	6.178E-05	6.248E-05	6.262E-05	6.265E-05
Cs-135	3.746E-04	3.746E-04	3.746E-04	3.746E-04	3.746E-04	3.746E-04	3.744E-04
Ba-135	1.319E-07	1.321E-07	1.323E-07	1.326E-07	1.331E-07	1.337E-07	2.443E-07
Xe-136	1.203E-03	1.203E-03	1.203E-03	1.203E-03	1.203E-03	1.203E-03	1.203E-03
Ba-136	1.044E-05	1.044E-05	1.044E-05	1.044E-05	1.044E-05	1.044E-05	1.044E-05
Cs-137	6.065E-04	5.792E-04	5.530E-04	5.280E-04	4.704E-04	4.191E-04	6.143E-14
Ba-137	1.382E-04	1.656E-04	1.917E-04	2.167E-04	2.743E-04	3.256E-04	7.447E-04
Ba-137m	9.279E-11	8.860E-11	8.460E-11	8.078E-11	7.197E-11	6.412E-11	9.398E-21
Ba-138	7.835E-04	7.835E-04	7.835E-04	7.835E-04	7.835E-04	7.835E-04	7.835E-04
La-138	4.356E-09	4.356E-09	4.356E-09	4.356E-09	4.356E-09	4.356E-09	4.356E-09

TABLE F.3.c. Fission Product Inventory by Isotope at 20 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
La-139	7.499E-04	7.499E-04	7.499E-04	7.499E-04	7.499E-04	7.499E-04	7.499E-04
Ce-140	7.609E-04	7.609E-04	7.609E-04	7.609E-04	7.609E-04	7.609E-04	7.609E-04
Pr-141	6.939E-04	6.939E-04	6.939E-04	6.939E-04	6.939E-04	6.939E-04	6.939E-04
Ce-142	6.935E-04	6.935E-04	6.935E-04	6.935E-04	6.935E-04	6.935E-04	6.935E-04
Nd-142	9.643E-06	9.643E-06	9.643E-06	9.643E-06	9.643E-06	9.643E-06	9.643E-06
Nd-143	5.597E-04	5.597E-04	5.597E-04	5.597E-04	5.597E-04	5.597E-04	5.597E-04
Ce-144	1.772E-06	2.984E-07	5.026E-08	8.466E-09	9.855E-11	1.147E-12	0.00
Pr-144	7.482E-11	1.260E-11	2.122E-12	3.575E-13	4.161E-15	4.844E-17	0.00
Pr-144m	3.740E-13	6.300E-14	1.061E-14	1.787E-15	2.080E-17	2.422E-19	0.00
Nd-144	7.462E-04	7.477E-04	7.479E-04	7.480E-04	7.480E-04	7.480E-04	7.480E-04
Nd-145	4.362E-04	4.362E-04	4.362E-04	4.362E-04	4.362E-04	4.362E-04	4.362E-04
Nd-146	3.987E-04	3.987E-04	3.987E-04	3.987E-04	3.987E-04	3.987E-04	3.987E-04
Pm-146	7.402E-10	5.753E-10	4.471E-10	3.475E-10	1.850E-10	9.854E-11	0.00
Sm-146	3.812E-09	3.873E-09	3.921E-09	3.958E-09	4.018E-09	4.050E-09	4.086E-09
Pm-147	2.272E-05	1.340E-05	7.897E-06	4.656E-06	1.242E-06	3.315E-07	0.00
Sm-147	1.638E-04	1.731E-04	1.786E-04	1.819E-04	1.853E-04	1.862E-04	1.865E-04
Nd-148	2.221E-04	2.221E-04	2.221E-04	2.221E-04	2.221E-04	2.221E-04	2.221E-04
Sm-148	8.175E-05	8.175E-05	8.175E-05	8.175E-05	8.175E-05	8.175E-05	8.175E-05
Sm-149	1.555E-06	1.555E-06	1.555E-06	1.555E-06	1.555E-06	1.555E-06	1.555E-06
Nd-150	1.021E-04	1.021E-04	1.021E-04	1.021E-04	1.021E-04	1.021E-04	1.021E-04
Sm-150	1.432E-04	1.432E-04	1.432E-04	1.432E-04	1.432E-04	1.432E-04	1.432E-04
Eu-150	3.463E-13	3.332E-13	3.206E-13	3.085E-13	2.802E-13	2.545E-13	1.627E-21
Sm-151	9.754E-06	9.604E-06	9.458E-06	9.313E-06	9.161E-06	8.623E-06	4.545E-09
Eu-151	3.518E-07	5.009E-07	6.477E-07	7.923E-07	1.144E-05	1.483E-06	1.010E-05
Sm-152	8.327E-05	8.328E-05	8.329E-05	8.330E-05	8.331E-05	8.332E-05	8.336E-05
Eu-152	1.278E-07	1.154E-07	1.042E-07	9.413E-08	7.296E-08	5.655E-08	1.152E-29
Gd-152	6.764E-08	7.109E-08	7.421E-08	7.702E-08	8.292E-08	8.749E-08	1.032E-07
Eu-153	5.465E-05	5.465E-05	5.465E-05	5.465E-05	5.465E-05	5.465E-05	5.465E-05
Gd-153	2.006E-10	2.476E-11	3.056E-12	3.771E-13	2.018E-15	1.080E-17	0.00
Sm-154	1.929E-05	1.929E-05	1.929E-05	1.929E-05	1.929E-05	1.929E-05	1.929E-05
Eu-154	9.416E-06	8.014E-06	6.821E-06	5.805E-06	3.880E-06	2.593E-06	0.00
Gd-154	7.272E-06	8.673E-06	9.867E-06	1.088E-05	1.281E-05	1.409E-05	1.669E-05
Eu-155	2.703E-06	2.044E-06	1.545E-06	1.168E-06	5.809E-07	2.888E-07	0.00
Gd-155	2.168E-06	2.827E-06	3.326E-06	3.703E-06	4.290E-06	4.582E-06	4.871E-06
Gd-156	2.139E-05	2.139E-05	2.139E-05	2.139E-05	2.139E-05	2.139E-05	2.139E-05
Gd-157	4.544E-08	4.544E-08	4.544E-08	4.544E-08	4.544E-08	4.544E-08	4.544E-08
Gd-158	7.290E-06	7.290E-06	7.290E-06	7.290E-06	7.290E-06	7.290E-06	7.290E-06
Tb-159	1.198E-06	1.198E-06	1.198E-06	1.198E-06	1.198E-06	1.198E-06	1.198E-06
Gd-160	5.844E-07	5.844E-07	5.844E-07	5.844E-07	5.844E-07	5.844E-07	5.844E-07
Tb-160	7.289E-15	6.627E-18	6.024E-21	5.477E-24	1.365E-31	0.00	0.00
Dy-160	8.817E-08	8.817E-08	8.817E-08	8.817E-08	8.817E-08	8.817E-08	8.817E-08
Dy-161	2.085E-07	2.085E-07	2.085E-07	2.085E-07	2.085E-07	2.085E-07	2.085E-07
Dy-162	1.690E-07	1.690E-07	1.690E-07	1.690E-07	1.690E-07	1.690E-07	1.690E-07
Dy-163	1.080E-07	1.080E-07	1.080E-07	1.080E-07	1.080E-07	1.080E-07	1.080E-07
Dy-164	1.835E-08	1.835E-08	1.835E-08	1.835E-08	1.835E-08	1.835E-08	1.835E-08
Ho-165	4.644E-08	4.644E-08	4.644E-08	4.644E-08	4.644E-08	4.644E-08	4.644E-08
Ho-166m	3.003E-10	2.999E-10	2.996E-10	2.992E-10	2.984E-10	2.975E-10	1.689E-10
Er-166	1.388E-08	1.388E-08	1.388E-08	1.388E-08	1.388E-08	1.388E-08	1.401E-08

TABLE F.3.c. Fission Product Inventory by Isotope at 20 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Er-167	1.649E-09	1.649E-09	1.649E-09	1.649E-09	1.649E-09	1.649E-09	1.649E-09
Er-168	2.694E-09	2.694E-09	2.694E-09	2.694E-09	2.694E-09	2.694E-09	2.694E-09
Tm-169	1.213E-11	1.213E-11	1.213E-11	1.213E-11	1.213E-11	1.213E-11	1.213E-11
Er-170	3.400E-15	3.400E-15	3.400E-15	3.400E-15	3.400E-15	3.400E-15	3.400E-15
Tm-170	1.767E-16	3.444E-18	6.714E-20	1.300E-21	6.896E-26	3.658E-30	0.00
Yb-170	2.287E-12	2.288E-12	2.288E-12	2.288E-12	2.288E-12	2.288E-12	2.288E-12
Tm-171	3.845E-15	1.868E-15	9.073E-16	4.407E-16	7.248E-17	1.192E-17	0.00
Yb-171	7.037E-14	7.234E-14	7.330E-14	7.377E-14	7.414E-14	7.420E-14	7.421E-14
Yb-172	1.950E-15	1.950E-15	1.950E-15	1.950E-15	1.950E-15	1.950E-15	1.950E-15
Total	2.060E-02	2.060E-02	2.060E-02	2.060E-02	2.060E-02	2.060E-02	2.060E-02

TABLE F.3.d. Fission Product Inventory by Isotope at 25 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	2.772E-08	2.478E-08	2.215E-08	1.979E-08	1.495E-08	1.129E-08	1.456E-32
Li-6	1.595E-10	1.595E-10	1.595E-10	1.595E-10	1.595E-10	1.595E-10	1.595E-10
Li-7	7.657E-12	7.657E-12	7.657E-12	7.657E-12	7.657E-12	7.657E-12	7.657E-12
Be-9	1.475E-11	1.475E-11	1.475E-11	1.475E-11	1.475E-11	1.475E-11	1.475E-11
Be-10	9.838E-11	9.838E-11	9.838E-11	9.838E-11	9.838E-11	9.838E-11	9.834E-11
C-14	1.987E-11	1.987E-11	1.986E-11	1.986E-11	1.985E-11	1.984E-11	1.762E-11
Zn-66	2.348E-14	2.348E-14	2.348E-14	2.348E-14	2.348E-14	2.348E-14	2.348E-14
Zn-67	9.836E-16	9.836E-16	9.836E-16	9.836E-16	9.836E-16	9.836E-16	9.836E-16
Ga-71	6.040E-13	6.040E-13	6.040E-13	6.040E-13	6.040E-13	6.040E-13	6.040E-13
Ge-72	1.405E-08	1.405E-08	1.405E-08	1.405E-08	1.405E-08	1.405E-08	1.405E-08
Ge-73	3.043E-08	3.043E-08	3.043E-08	3.043E-08	3.043E-08	3.043E-08	3.043E-08
Ge-74	6.773E-08	6.773E-08	6.773E-08	6.773E-08	6.773E-08	6.773E-08	6.773E-08
As-75	1.449E-07	1.449E-07	1.449E-07	1.449E-07	1.449E-07	1.449E-07	1.449E-07
Ge-76	3.707E-07	3.707E-07	3.707E-07	3.707E-07	3.707E-07	3.707E-07	3.707E-07
Se-76	3.045E-09	3.045E-09	3.045E-09	3.045E-09	3.045E-09	3.045E-09	3.045E-09
Se-77	7.828E-07	7.828E-07	7.828E-07	7.828E-07	7.828E-07	7.828E-07	7.828E-07
Se-78	1.820E-06	1.820E-06	1.820E-06	1.820E-06	1.820E-06	1.820E-06	1.820E-06
Se-79	4.456E-06	4.456E-06	4.456E-06	4.456E-06	4.456E-06	4.455E-06	4.409E-06
Br-79	4.295E-10	5.246E-10	6.197E-10	7.148E-10	9.525E-10	1.190E-09	4.754E-08
Se-80	1.025E-05	1.025E-05	1.025E-05	1.025E-05	1.025E-05	1.025E-05	1.025E-05
Kr-80	1.691E-10	1.691E-10	1.691E-10	1.691E-10	1.691E-10	1.691E-10	1.691E-10
Br-81	1.680E-05	1.680E-05	1.680E-05	1.680E-05	1.680E-05	1.680E-05	1.680E-05
Kr-81	1.398E-11	1.398E-11	1.398E-11	1.398E-11	1.398E-11	1.398E-11	1.393E-11
Se-82	2.594E-05	2.594E-05	2.594E-05	2.594E-05	2.594E-05	2.594E-05	2.594E-05
Kr-82	6.031E-07	6.031E-07	6.031E-07	6.031E-07	6.031E-07	6.031E-07	6.031E-07
Kr-83	3.398E-05	3.398E-05	3.398E-05	3.398E-05	3.398E-05	3.398E-05	3.398E-05
Kr-84	8.565E-05	8.565E-05	8.565E-05	8.565E-05	8.565E-05	8.565E-05	8.565E-05
Kr-85	1.140E-05	1.002E-05	8.803E-06	7.735E-06	5.599E-06	4.052E-06	1.230E-33
Rb-85	8.351E-05	8.490E-05	8.611E-05	8.718E-05	8.932E-05	9.086E-05	9.492E-05
Kr-86	1.487E-04	1.487E-04	1.487E-04	1.487E-04	1.487E-04	1.487E-04	1.487E-04
Sr-86	2.502E-07	2.502E-07	2.502E-07	2.502E-07	2.502E-07	2.502E-07	2.502E-07
Rb-87	1.911E-04	1.911E-04	1.911E-04	1.911E-04	1.911E-04	1.911E-04	1.911E-04
Sr-87	1.857E-09	1.857E-09	1.857E-09	1.857E-09	1.857E-09	1.857E-09	1.860E-09
Sr-88	2.745E-04	2.745E-04	2.745E-04	2.745E-04	2.745E-04	2.745E-04	2.745E-04
Sr-89	1.328E-14	5.867E-19	2.592E-23	1.145E-27	0.00	0.00	0.00
Y-89	3.593E-04	3.593E-04	3.593E-04	3.593E-04	3.593E-04	3.593E-04	3.593E-04
Sr-90	3.497E-04	3.334E-04	3.179E-04	3.031E-04	2.691E-04	2.389E-04	1.770E-14
Y-90	8.769E-08	8.361E-08	7.972E-08	7.602E-08	6.749E-08	5.992E-08	4.438E-18
Zr-90	8.619E-05	1.024E-04	1.179E-04	1.327E-04	1.668E-04	1.970E-04	4.359E-04
Y-91	3.162E-13	5.512E-17	9.611E-21	1.676E-24	6.726E-34	0.00	0.00
Zr-91	4.618E-04	4.618E-04	4.618E-04	4.618E-04	4.618E-04	4.618E-04	4.618E-04
Zr-92	4.969E-04	4.969E-04	4.969E-04	4.969E-04	4.969E-04	4.969E-04	4.969E-04
Zr-93	5.578E-04	5.578E-04	5.578E-04	5.578E-04	5.578E-04	5.578E-04	5.575E-04
Nb-93	5.849E-10	8.022E-10	1.047E-09	1.318E-09	2.089E-09	2.971E-09	2.492E-07
Nb-93m	1.737E-09	2.026E-09	2.286E-09	2.521E-09	3.013E-09	3.395E-09	4.708E-09
Zr-94	5.708E-04	5.708E-04	5.708E-04	5.708E-04	5.708E-04	5.708E-04	5.708E-04
Nb-94	5.439E-10	5.439E-10	5.439E-10	5.438E-10	5.437E-10	5.436E-10	5.257E-10
Zr-95	2.197E-12	8.033E-16	2.937E-19	1.074E-22	2.745E-31	0.00	0.00

TABLE F.3.d. Fission Product Inventory by Isotope at 25 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nb-95	2.680E-12	9.798E-16	3.583E-19	1.310E-22	2.483E-33	0.00	0.00
Nb-95m	9.194E-16	3.361E-19	1.229E-22	4.493E-26	0.00	0.00	0.00
Mo-95	5.844E-04	5.844E-04	5.844E-04	5.844E-04	5.844E-04	5.844E-04	5.844E-04
Zr-96	6.121E-04	6.121E-04	6.121E-04	6.121E-04	6.121E-04	6.121E-04	6.121E-04
Mo-96	2.244E-05	2.244E-05	2.244E-05	2.244E-05	2.244E-05	2.244E-05	2.244E-05
Mo-97	6.025E-04	6.025E-04	6.025E-04	6.025E-04	6.025E-04	6.025E-04	6.025E-04
Mo-98	6.198E-04	6.198E-04	6.198E-04	6.198E-04	6.198E-04	6.198E-04	6.198E-04
Tc-98	2.763E-09	2.763E-09	2.763E-09	2.763E-09	2.763E-09	2.763E-09	2.763E-09
Tc-99	6.047E-04	6.047E-04	6.047E-04	6.047E-04	6.047E-04	6.047E-04	6.028E-04
Ru-99	1.762E-08	2.155E-08	2.549E-08	2.942E-08	3.926E-08	4.910E-08	1.974E-06
Mo-100	7.034E-04	7.034E-04	7.034E-04	7.034E-04	7.034E-04	7.034E-04	7.034E-04
Ru-100	5.562E-05	5.562E-05	5.562E-05	5.562E-05	5.562E-05	5.562E-05	5.562E-05
Ru-101	5.838E-04	5.838E-04	5.838E-04	5.838E-04	5.838E-04	5.838E-04	5.838E-04
Ru-102	5.673E-04	5.673E-04	5.673E-04	5.673E-04	5.673E-04	5.673E-04	5.673E-04
Rh-102	1.117E-10	6.924E-11	4.293E-11	2.662E-11	8.056E-12	2.438E-12	0.00
Ru-103	6.844E-17	1.727E-22	4.359E-28	1.100E-33	0.00	0.00	0.00
Rh-103	3.654E-04	3.654E-04	3.654E-04	3.654E-04	3.654E-04	3.654E-04	3.654E-04
Ru-104	3.859E-04	3.859E-04	3.859E-04	3.859E-04	3.859E-04	3.859E-04	3.859E-04
Pd-104	1.371E-04	1.371E-04	1.371E-04	1.371E-04	1.371E-04	1.371E-04	1.371E-04
Pd-105	2.804E-04	2.804E-04	2.804E-04	2.804E-04	2.804E-04	2.804E-04	2.804E-04
Ru-106	2.521E-06	6.372E-07	1.611E-07	4.071E-08	1.308E-09	4.201E-11	0.00
Rh-106	2.370E-12	5.989E-13	1.514E-13	3.827E-14	1.229E-15	3.948E-17	0.00
Pd-106	2.289E-04	2.308E-04	2.312E-04	2.314E-04	2.314E-04	2.314E-04	2.314E-04
Pd-107	1.486E-04	1.486E-04	1.486E-04	1.486E-04	1.486E-04	1.486E-04	1.486E-04
Ag-107	1.276E-10	1.593E-10	1.910E-10	2.228E-10	3.020E-10	3.813E-10	1.592E-08
Pd-108	1.015E-04	1.015E-04	1.015E-04	1.015E-04	1.015E-04	1.015E-04	1.015E-04
Ag-108m	8.297E-13	8.207E-13	8.117E-13	8.029E-13	7.813E-13	7.603E-13	3.616E-15
Cd-108	1.576E-10	1.576E-10	1.576E-10	1.576E-10	1.576E-10	1.576E-10	1.577E-10
Ag-109	5.425E-05	5.425E-05	5.425E-05	5.425E-05	5.425E-05	5.425E-05	5.425E-05
Cd-109	9.828E-15	3.300E-15	1.108E-15	3.721E-16	2.432E-17	1.589E-18	0.00
Pd-110	3.269E-05	3.269E-05	3.269E-05	3.269E-05	3.269E-05	3.269E-05	3.269E-05
Ag-110	5.322E-17	7.015E-18	9.248E-19	1.219E-19	7.693E-22	4.854E-24	0.00
Ag-110m	3.512E-09	4.629E-10	6.102E-11	8.044E-12	5.077E-14	3.203E-16	0.00
Cd-110	1.768E-05	1.769E-05	1.769E-05	1.769E-05	1.769E-05	1.769E-05	1.769E-05
Cd-111	1.783E-05	1.783E-05	1.783E-05	1.783E-05	1.783E-05	1.783E-05	1.783E-05
Cd-112	1.053E-05	1.053E-05	1.053E-05	1.053E-05	1.053E-05	1.053E-05	1.053E-05
Cd-113	1.326E-07	1.326E-07	1.326E-07	1.326E-07	1.326E-07	1.326E-07	1.327E-07
Cd-113m	1.150E-07	1.046E-07	9.514E-08	8.651E-08	6.822E-08	5.379E-08	3.233E-28
In-113	5.292E-08	6.334E-08	7.281E-08	8.142E-08	9.970E-08	1.141E-07	1.678E-07
Cd-114	1.434E-05	1.434E-05	1.434E-05	1.434E-05	1.434E-05	1.434E-05	1.434E-05
Sn-114	1.723E-09	1.723E-09	1.723E-09	1.723E-09	1.723E-09	1.723E-09	1.723E-09
In-115	1.901E-06	1.901E-06	1.901E-06	1.901E-06	1.901E-06	1.901E-06	1.901E-06
Sn-115	2.052E-07	2.052E-07	2.052E-07	2.052E-07	2.052E-07	2.052E-07	2.052E-07
Cd-116	5.330E-06	5.330E-06	5.330E-06	5.330E-06	5.330E-06	5.330E-06	5.330E-06
Sn-116	4.247E-06	4.247E-06	4.247E-06	4.247E-06	4.247E-06	4.247E-06	4.247E-06
Sn-117	5.388E-06	5.388E-06	5.388E-06	5.388E-06	5.388E-06	5.388E-06	5.388E-06
Sn-118	5.480E-06	5.480E-06	5.480E-06	5.480E-06	5.480E-06	5.480E-06	5.480E-06
Sn-119	5.448E-06	5.449E-06	5.449E-06	5.449E-06	5.449E-06	5.449E-06	5.449E-06

TABLE F.3.d. Fission Product Inventory by Isotope at 25 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-119m	1.622E-10	2.054E-11	2.601E-12	3.293E-13	1.880E-15	1.073E-17	0.00
Sn-120	5.551E-06	5.551E-06	5.551E-06	5.551E-06	5.551E-06	5.551E-06	5.551E-06
Sn-121m	2.266E-09	2.204E-09	2.144E-09	2.085E-09	1.945E-09	1.815E-09	2.267E-15
Sb-121	5.516E-06	5.516E-06	5.516E-06	5.516E-06	5.516E-06	5.516E-06	5.518E-06
Sn-122	6.137E-06	6.137E-06	6.137E-06	6.137E-06	6.137E-06	6.137E-06	6.137E-06
Te-122	2.776E-07	2.776E-07	2.776E-07	2.776E-07	2.776E-07	2.776E-07	2.776E-07
Sn-123	3.486E-11	6.916E-13	1.372E-14	2.722E-16	1.509E-20	8.367E-25	0.00
Sb-123	6.817E-06	6.817E-06	6.817E-06	6.817E-06	6.817E-06	6.817E-06	6.817E-06
Te-123	3.194E-09	3.194E-09	3.194E-09	3.194E-09	3.194E-09	3.194E-09	3.194E-09
Te-123m	5.091E-14	7.402E-16	1.076E-17	1.564E-19	3.987E-24	1.016E-28	0.00
Sn-124	8.474E-06	8.474E-06	8.474E-06	8.474E-06	8.474E-06	8.474E-06	8.474E-06
Sb-124	6.527E-16	1.451E-19	3.225E-23	7.170E-27	5.283E-36	0.00	0.00
Te-124	2.173E-07	2.173E-07	2.173E-07	2.173E-07	2.173E-07	2.173E-07	2.173E-07
Sb-125	1.779E-06	1.078E-06	6.537E-07	3.963E-07	1.134E-07	3.245E-08	0.00
Te-125	1.101E-05	1.172E-05	1.215E-05	1.241E-05	1.270E-05	1.278E-05	1.281E-05
Te-125m	2.488E-08	1.509E-08	9.146E-09	5.545E-09	1.586E-09	4.539E-10	0.00
Sn-126	1.912E-05	1.912E-05	1.912E-05	1.912E-05	1.912E-05	1.912E-05	1.899E-05
Sb-126	9.084E-13	9.084E-13	9.084E-13	9.084E-13	9.083E-13	9.083E-13	9.022E-13
Sb-126m	6.907E-15	6.907E-15	6.907E-15	6.906E-15	6.906E-15	6.906E-15	6.859E-15
Te-126	5.046E-07	5.048E-07	5.051E-07	5.053E-07	5.060E-07	5.067E-07	6.361E-07
Te-127	1.082E-13	1.040E-15	9.991E-18	9.600E-20	8.687E-25	7.860E-30	0.00
Te-127m	3.092E-11	2.970E-13	2.854E-15	2.742E-17	2.481E-22	2.245E-27	0.00
I-127	3.984E-05	3.984E-05	3.984E-05	3.984E-05	3.984E-05	3.984E-05	3.984E-05
Te-128	8.015E-05	8.015E-05	8.015E-05	8.015E-05	8.015E-05	8.015E-05	8.015E-05
Xe-128	1.649E-06	1.649E-06	1.649E-06	1.649E-06	1.649E-06	1.649E-06	1.649E-06
I-129	1.330E-04	1.330E-04	1.330E-04	1.330E-04	1.330E-04	1.330E-04	1.330E-04
Xe-129	6.917E-09	6.929E-09	6.940E-09	6.952E-09	6.982E-09	7.011E-09	1.276E-08
Te-130	2.623E-04	2.623E-04	2.623E-04	2.623E-04	2.623E-04	2.623E-04	2.623E-04
Xe-130	6.826E-06	6.826E-06	6.826E-06	6.826E-06	6.826E-06	6.826E-06	6.826E-06
Xe-131	3.468E-04	3.468E-04	3.468E-04	3.468E-04	3.468E-04	3.468E-04	3.468E-04
Xe-132	7.805E-04	7.805E-04	7.805E-04	7.805E-04	7.805E-04	7.805E-04	7.805E-04
Ba-132	8.190E-10	8.190E-10	8.190E-10	8.190E-10	8.190E-10	8.190E-10	8.190E-10
Cs-133	8.845E-04	8.845E-04	8.845E-04	8.845E-04	8.845E-04	8.845E-04	8.845E-04
Xe-134	1.111E-03	1.111E-03	1.111E-03	1.111E-03	1.111E-03	1.111E-03	1.111E-03
Cs-134	1.021E-05	5.214E-06	2.662E-06	1.359E-06	2.531E-07	4.713E-08	0.00
Ba-134	8.785E-05	9.285E-05	9.540E-05	9.670E-05	9.781E-05	9.801E-05	9.806E-05
Cs-135	4.117E-04	4.117E-04	4.117E-04	4.117E-04	4.117E-04	4.117E-04	4.116E-04
Ba-135	2.671E-07	2.673E-07	2.676E-07	2.678E-07	2.684E-07	2.691E-07	3.907E-07
Xe-136	1.567E-03	1.567E-03	1.567E-03	1.567E-03	1.567E-03	1.567E-03	1.567E-03
Ba-136	1.469E-05	1.469E-05	1.469E-05	1.469E-05	1.469E-05	1.469E-05	1.469E-05
Cs-137	7.587E-04	7.245E-04	6.918E-04	6.605E-04	5.885E-04	5.242E-04	7.684E-14
Ba-137	1.728E-04	2.071E-04	2.398E-04	2.710E-04	3.431E-04	4.073E-04	9.315E-04
Ba-137m	1.161E-10	1.108E-10	1.058E-10	1.011E-10	9.003E-11	8.020E-11	1.176E-20
Ba-138	9.712E-04	9.712E-04	9.712E-04	9.712E-04	9.712E-04	9.712E-04	9.712E-04
La-138	4.884E-09	4.884E-09	4.884E-09	4.884E-09	4.884E-09	4.884E-09	4.884E-09
La-139	9.284E-04	9.284E-04	9.284E-04	9.284E-04	9.284E-04	9.284E-04	9.284E-04
Ce-140	9.466E-04	9.466E-04	9.466E-04	9.466E-04	9.466E-04	9.466E-04	9.466E-04
Pr-141	8.571E-04	8.571E-04	8.571E-04	8.571E-04	8.571E-04	8.571E-04	8.571E-04

TABLE F.3.d. Fission Product Inventory by Isotope at 25 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ce-142	8.581E-04	8.581E-04	8.581E-04	8.581E-04	8.581E-04	8.581E-04	8.581E-04
Nd-142	1.547E-05	1.547E-05	1.547E-05	1.547E-05	1.547E-05	1.547E-05	1.547E-05
Nd-143	6.505E-04	6.505E-04	6.505E-04	6.505E-04	6.505E-04	6.505E-04	6.505E-04
Ce-144	2.158E-06	3.635E-07	6.122E-08	1.031E-08	1.200E-10	1.397E-12	0.00
Pr-144	9.113E-11	1.535E-11	2.585E-12	4.354E-13	5.069E-15	5.901E-17	0.00
Pr-144m	4.556E-13	7.673E-14	1.292E-14	2.176E-15	2.534E-17	2.950E-19	0.00
Nd-144	9.570E-04	9.588E-04	9.591E-04	9.592E-04	9.592E-04	9.592E-04	9.592E-04
Nd-145	5.284E-04	5.284E-04	5.284E-04	5.284E-04	5.284E-04	5.284E-04	5.284E-04
Nd-146	5.051E-04	5.051E-04	5.051E-04	5.051E-04	5.051E-04	5.051E-04	5.051E-04
Pm-146	1.100E-09	8.548E-10	6.643E-10	5.163E-10	2.749E-10	1.464E-10	0.00
Sm-146	5.636E-09	5.727E-09	5.797E-09	5.852E-09	5.942E-09	5.989E-09	6.043E-09
Pm-147	2.565E-05	1.512E-05	8.915E-06	5.255E-06	1.402E-06	3.742E-07	0.00
Sm-147	1.816E-04	1.922E-04	1.984E-04	2.020E-04	2.059E-04	2.069E-04	2.073E-04
Nd-148	2.773E-04	2.773E-04	2.773E-04	2.773E-04	2.773E-04	2.773E-04	2.773E-04
Sm-148	1.169E-04	1.169E-04	1.169E-04	1.169E-04	1.169E-04	1.169E-04	1.169E-04
Sm-149	1.559E-06	1.559E-06	1.559E-06	1.559E-06	1.559E-06	1.559E-06	1.559E-06
Nd-150	1.302E-04	1.302E-04	1.302E-04	1.302E-04	1.302E-04	1.302E-04	1.302E-04
Sm-150	1.785E-04	1.785E-04	1.785E-04	1.785E-04	1.785E-04	1.785E-04	1.785E-04
Eu-150	3.831E-13	3.686E-13	3.547E-13	3.413E-13	3.100E-13	2.815E-13	1.797E-21
Sm-151	1.051E-05	1.035E-05	1.020E-05	1.004E-05	9.660E-06	9.295E-06	4.900E-09
Eu-151	3.649E-07	5.256E-07	6.839E-07	8.397E-07	1.219E-06	1.584E-06	1.087E-05
Sm-152	1.007E-04	1.007E-04	1.008E-04	1.008E-04	1.008E-04	1.008E-04	1.008E-04
Eu-152	1.191E-07	1.075E-07	9.710E-08	8.769E-08	6.797E-08	5.268E-08	1.073E-29
Gd-152	6.310E-08	6.632E-08	6.922E-08	7.184E-08	7.734E-08	8.160E-08	9.627E-08
Eu-153	7.425E-05	7.425E-05	7.425E-05	7.425E-05	7.425E-05	7.425E-05	7.425E-05
Gd-153	2.570E-10	3.171E-11	3.914E-12	4.830E-13	2.584E-15	1.383E-17	0.00
Sm-154	2.585E-05	2.585E-05	2.585E-05	2.585E-05	2.585E-05	2.585E-05	2.585E-05
Eu-154	1.514E-05	1.288E-05	1.097E-05	9.333E-06	6.237E-06	4.169E-06	0.00
Gd-154	1.164E-05	1.390E-05	1.581E-05	1.745E-05	2.054E-05	2.261E-05	2.678E-05
Eu-155	4.110E-06	3.108E-06	2.350E-06	1.777E-06	8.833E-07	4.392E-07	0.00
Gd-155	3.252E-06	4.254E-06	5.012E-06	5.585E-06	6.479E-06	6.923E-06	7.362E-06
Gd-156	3.470E-05	3.470E-05	3.470E-05	3.470E-05	3.470E-05	3.470E-05	3.470E-05
Gd-157	5.478E-08	5.478E-08	5.478E-08	5.478E-08	5.478E-08	5.478E-08	5.478E-08
Gd-158	1.067E-05	1.067E-05	1.067E-05	1.067E-05	1.067E-05	1.067E-05	1.067E-05
Tb-159	1.711E-06	1.711E-06	1.711E-06	1.711E-06	1.711E-06	1.711E-06	1.711E-06
Gd-160	8.363E-07	8.363E-07	8.363E-07	8.363E-07	8.363E-07	8.363E-07	8.363E-07
Tb-160	1.356E-14	1.233E-17	1.121E-20	1.019E-23	2.539E-31	0.00	0.00
Dy-160	1.535E-07	1.535E-07	1.535E-07	1.535E-07	1.535E-07	1.535E-07	1.535E-07
Dy-161	2.839E-07	2.839E-07	2.839E-07	2.839E-07	2.839E-07	2.839E-07	2.839E-07
Dy-162	2.416E-07	2.416E-07	2.416E-07	2.416E-07	2.416E-07	2.416E-07	2.416E-07
Dy-163	1.689E-07	1.689E-07	1.689E-07	1.689E-07	1.689E-07	1.689E-07	1.689E-07
Dy-164	2.657E-08	2.657E-08	2.657E-08	2.657E-08	2.657E-08	2.657E-08	2.657E-08
Ho-165	7.595E-08	7.595E-08	7.595E-08	7.595E-08	7.595E-08	7.595E-08	7.595E-08
Ho-166m	6.091E-10	6.084E-10	6.077E-10	6.070E-10	6.053E-10	6.035E-10	3.427E-10
Er-166	2.302E-08	2.302E-08	2.302E-08	2.302E-08	2.302E-08	2.302E-08	2.328E-08
Er-167	2.080E-09	2.080E-09	2.080E-09	2.080E-09	2.080E-09	2.080E-09	2.080E-09
Er-168	4.322E-09	4.322E-09	4.322E-09	4.322E-09	4.322E-09	4.322E-09	4.322E-09
Tm-169	2.393E-11	2.393E-11	2.393E-11	2.393E-11	2.393E-11	2.393E-11	2.393E-11

TABLE F.3.d. Fission Product Inventory by Isotope at 25 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Er-170	8.688E-15	8.688E-15	8.688E-15	8.688E-15	8.688E-15	8.688E-15	8.688E-15
Tm-170	4.571E-16	8.910E-18	1.737E-19	3.391E-21	1.799E-25	9.543E-30	0.00
Yb-170	5.816E-12	5.817E-12	5.817E-12	5.817E-12	5.817E-12	5.817E-12	5.817E-12
Tm-171	1.293E-14	6.279E-15	3.050E-15	1.482E-15	2.437E-16	4.007E-17	0.00
Yb-171	2.307E-13	2.374E-13	2.406E-13	2.422E-13	2.434E-13	2.436E-13	2.437E-13
Yb-172	8.273E-15	8.273E-15	8.273E-15	8.273E-15	8.273E-15	8.273E-15	8.273E-15
Total	2.572E-02	2.572E-02	2.572E-02	2.572E-02	2.572E-02	2.572E-02	2.572E-02

TABLE F.3.e. Fission Product Inventory by Isotope at 30 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	3.393E-08	3.033E-08	2.711E-08	2.423E-08	1.830E-08	1.382E-08	1.781E-32
Li-6	1.635E-10	1.635E-10	1.635E-10	1.635E-10	1.635E-10	1.635E-10	1.635E-10
Li-7	9.170E-12	9.170E-12	9.170E-12	9.170E-12	9.170E-12	9.170E-12	9.170E-12
Be-9	1.765E-11	1.765E-11	1.765E-11	1.765E-11	1.765E-11	1.765E-11	1.765E-11
Be-10	1.178E-10	1.178E-10	1.178E-10	1.178E-10	1.178E-10	1.178E-10	1.178E-10
C-14	2.380E-11	2.379E-11	2.379E-11	2.378E-11	2.376E-11	2.375E-11	2.110E-11
Zn-66	2.691E-14	2.691E-14	2.691E-14	2.691E-14	2.691E-14	2.691E-14	2.691E-14
Zn-67	1.123E-15	1.123E-15	1.123E-15	1.123E-15	1.123E-15	1.123E-15	1.123E-15
Ga-71	7.495E-13	7.495E-13	7.495E-13	7.495E-13	7.495E-13	7.495E-13	7.495E-13
Ge-72	1.740E-08	1.740E-08	1.740E-08	1.740E-08	1.740E-08	1.740E-08	1.740E-08
Ge-73	3.671E-08	3.671E-08	3.671E-08	3.671E-08	3.671E-08	3.671E-08	3.671E-08
Ge-74	8.175E-08	8.175E-08	8.175E-08	8.175E-08	8.175E-08	8.175E-08	8.175E-08
As-75	1.724E-07	1.724E-07	1.724E-07	1.724E-07	1.724E-07	1.724E-07	1.724E-07
Ge-76	4.377E-07	4.377E-07	4.377E-07	4.377E-07	4.377E-07	4.377E-07	4.377E-07
Se-76	4.467E-09	4.467E-09	4.467E-09	4.467E-09	4.467E-09	4.467E-09	4.467E-09
Se-77	9.138E-07	9.138E-07	9.138E-07	9.138E-07	9.138E-07	9.138E-07	9.138E-07
Se-78	2.178E-06	2.178E-06	2.178E-06	2.178E-06	2.178E-06	2.178E-06	2.178E-06
Se-79	5.278E-06	5.278E-06	5.278E-06	5.277E-06	5.277E-06	5.277E-06	5.222E-06
Br-79	5.082E-10	6.208E-10	7.334E-10	8.460E-10	1.128E-09	1.409E-09	5.630E-08
Se-80	1.212E-05	1.212E-05	1.212E-05	1.212E-05	1.212E-05	1.212E-05	1.212E-05
Kr-80	2.164E-10	2.164E-10	2.164E-10	2.164E-10	2.164E-10	2.164E-10	2.164E-10
Br-81	1.963E-05	1.963E-05	1.963E-05	1.963E-05	1.963E-05	1.963E-05	1.963E-05
Kr-81	2.010E-11	2.010E-11	2.010E-11	2.010E-11	2.010E-11	2.010E-11	2.004E-11
Se-82	3.037E-05	3.037E-05	3.037E-05	3.037E-05	3.037E-05	3.037E-05	3.037E-05
Kr-82	8.591E-07	8.591E-07	8.591E-07	8.591E-07	8.591E-07	8.591E-07	8.591E-07
Kr-83	3.773E-05	3.773E-05	3.773E-05	3.773E-05	3.773E-05	3.773E-05	3.773E-05
Kr-84	1.017E-04	1.017E-04	1.017E-04	1.017E-04	1.017E-04	1.017E-04	1.017E-04
Kr-85	1.322E-05	1.161E-05	1.020E-05	8.966E-06	6.489E-06	4.697E-06	1.424E-33
Rb-85	9.682E-05	9.842E-05	9.983E-05	1.011E-04	1.035E-04	1.053E-04	1.100E-04
Kr-86	1.720E-04	1.720E-04	1.720E-04	1.720E-04	1.720E-04	1.720E-04	1.720E-04
Sr-86	3.623E-07	3.623E-07	3.623E-07	3.623E-07	3.623E-07	3.623E-07	3.623E-07
Rb-87	2.207E-04	2.207E-04	2.207E-04	2.207E-04	2.207E-04	2.207E-04	2.207E-04
Sr-87	2.826E-09	2.826E-09	2.826E-09	2.826E-09	2.826E-09	2.826E-09	2.830E-09
Sr-88	3.169E-04	3.169E-04	3.169E-04	3.169E-04	3.169E-04	3.169E-04	3.169E-04
Sr-89	1.462E-14	6.460E-19	2.855E-23	1.261E-27	0.00	0.00	0.00
Y-89	4.140E-04	4.140E-04	4.140E-04	4.140E-04	4.140E-04	4.140E-04	4.140E-04
Sr-90	4.028E-04	3.840E-04	3.662E-04	3.492E-04	3.100E-04	2.752E-04	2.039E-14
Y-90	1.010E-07	9.631E-08	9.183E-08	8.756E-08	7.774E-08	6.901E-08	5.112E-18
Zr-90	9.998E-05	1.187E-04	1.366E-04	1.536E-04	1.928E-04	2.276E-04	5.029E-04
Y-91	3.530E-13	6.155E-17	1.073E-20	1.871E-24	7.510E-34	0.00	0.00
Zr-91	5.347E-04	5.347E-04	5.347E-04	5.347E-04	5.347E-04	5.347E-04	5.347E-04
Zr-92	5.789E-04	5.789E-04	5.789E-04	5.789E-04	5.789E-04	5.789E-04	5.789E-04
Zr-93	6.518E-04	6.518E-04	6.518E-04	6.518E-04	6.518E-04	6.518E-04	6.515E-04
Nb-93	6.883E-10	9.428E-10	1.230E-09	1.547E-09	2.449E-09	3.480E-09	2.913E-07
Nb-93m	2.037E-09	2.373E-09	2.676E-09	2.951E-09	3.525E-09	3.970E-09	5.502E-09
Zr-94	6.733E-04	6.733E-04	6.733E-04	6.733E-04	6.733E-04	6.733E-04	6.733E-04
Nb-94	7.023E-10	7.022E-10	7.022E-10	7.021E-10	7.020E-10	7.019E-10	6.788E-10
Zr-95	2.563E-12	9.370E-16	3.426E-19	1.253E-22	3.202E-31	0.00	0.00

TABLE F.3.e. Fission Product Inventory by Isotope at 30 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nb-95	3.126E-12	1.143E-15	4.179E-19	1.528E-22	2.896E-33	0.00	0.00
Nb-95m	1.072E-15	3.921E-19	1.434E-22	5.241E-26	0.00	0.00	0.00
Mo-95	6.841E-04	6.841E-04	6.841E-04	6.841E-04	6.841E-04	6.841E-04	6.841E-04
Zr-96	7.253E-04	7.253E-04	7.253E-04	7.253E-04	7.253E-04	7.253E-04	7.253E-04
Mo-96	3.315E-05	3.315E-05	3.315E-05	3.315E-05	3.315E-05	3.315E-05	3.315E-05
Mo-97	7.174E-04	7.174E-04	7.174E-04	7.174E-04	7.174E-04	7.174E-04	7.174E-04
Mo-98	7.404E-04	7.404E-04	7.404E-04	7.404E-04	7.404E-04	7.404E-04	7.404E-04
Tc-98	4.099E-09	4.099E-09	4.099E-09	4.099E-09	4.099E-09	4.099E-09	4.098E-09
Tc-99	7.110E-04	7.110E-04	7.110E-04	7.110E-04	7.109E-04	7.109E-04	7.087E-04
Ru-99	2.072E-08	2.534E-08	2.997E-08	3.460E-08	4.617E-08	5.773E-08	2.321E-06
Mo-100	8.441E-04	8.441E-04	8.441E-04	8.441E-04	8.441E-04	8.441E-04	8.441E-04
Ru-100	8.240E-05	8.240E-05	8.240E-05	8.240E-05	8.240E-05	8.240E-05	8.240E-05
Ru-101	6.997E-04	6.997E-04	6.997E-04	6.997E-04	6.997E-04	6.997E-04	6.997E-04
Ru-102	6.954E-04	6.954E-04	6.954E-04	6.954E-04	6.954E-04	6.954E-04	6.954E-04
Rh-102	1.650E-10	1.023E-10	6.342E-11	3.932E-11	1.190E-11	3.603E-12	0.00
Ru-103	8.600E-17	2.170E-22	5.477E-28	1.382E-33	0.00	0.00	0.00
Rh-103	4.209E-04	4.209E-04	4.209E-04	4.209E-04	4.209E-04	4.209E-04	4.209E-04
Ru-104	4.880E-04	4.880E-04	4.880E-04	4.880E-04	4.880E-04	4.880E-04	4.880E-04
Pd-104	2.016E-04	2.016E-04	2.016E-04	2.016E-04	2.016E-04	2.016E-04	2.016E-04
Pd-105	3.560E-04	3.560E-04	3.560E-04	3.560E-04	3.560E-04	3.560E-04	3.560E-04
Ru-106	3.367E-06	8.511E-07	2.151E-07	5.438E-08	1.747E-09	5.610E-11	0.00
Rh-106	3.165E-12	8.000E-13	2.022E-13	5.111E-14	1.642E-15	5.274E-17	0.00
Pd-106	3.072E-04	3.097E-04	3.104E-04	3.105E-04	3.106E-04	3.106E-04	3.106E-04
Pd-107	1.982E-04	1.982E-04	1.982E-04	1.982E-04	1.982E-04	1.982E-04	1.982E-04
Ag-107	1.693E-10	2.116E-10	2.539E-10	2.962E-10	4.019E-10	5.076E-10	2.123E-08
Pd-108	1.363E-04	1.363E-04	1.363E-04	1.363E-04	1.363E-04	1.363E-04	1.363E-04
Ag-108m	1.148E-12	1.135E-12	1.123E-12	1.111E-12	1.081E-12	1.052E-12	5.001E-15
Cd-108	2.578E-10	2.578E-10	2.578E-10	2.578E-10	2.578E-10	2.578E-10	2.579E-10
Ag-109	7.002E-05	7.002E-05	7.002E-05	7.002E-05	7.002E-05	7.002E-05	7.002E-05
Cd-109	1.991E-14	6.685E-15	2.245E-15	7.538E-16	4.926E-17	3.219E-18	0.00
Pd-110	4.390E-05	4.390E-05	4.390E-05	4.390E-05	4.390E-05	4.390E-05	4.390E-05
Ag-110	8.786E-17	1.158E-17	1.527E-18	2.013E-19	1.270E-21	8.010E-24	0.00
Ag-110m	5.798E-09	7.643E-10	1.008E-10	1.328E-11	8.378E-14	5.285E-16	0.00
Cd-110	2.886E-05	2.886E-05	2.886E-05	2.886E-05	2.886E-05	2.886E-05	2.886E-05
Cd-111	2.365E-05	2.365E-05	2.365E-05	2.365E-05	2.365E-05	2.365E-05	2.365E-05
Cd-112	1.381E-05	1.381E-05	1.381E-05	1.381E-05	1.381E-05	1.381E-05	1.381E-05
Cd-113	1.369E-07	1.369E-07	1.370E-07	1.370E-07	1.370E-07	1.370E-07	1.371E-07
Cd-113m	1.543E-07	1.403E-07	1.276E-07	1.160E-07	9.148E-08	7.214E-08	4.336E-28
In-113	6.936E-08	8.333E-08	9.604E-08	1.076E-07	1.321E-07	1.514E-07	2.235E-07
Cd-114	1.828E-05	1.828E-05	1.828E-05	1.828E-05	1.828E-05	1.828E-05	1.828E-05
Sn-114	2.789E-09	2.789E-09	2.789E-09	2.789E-09	2.789E-09	2.789E-09	2.789E-09
In-115	1.979E-06	1.979E-06	1.979E-06	1.979E-06	1.979E-06	1.979E-06	1.979E-06
Sn-115	2.551E-07	2.551E-07	2.551E-07	2.551E-07	2.551E-07	2.551E-07	2.551E-07
Cd-116	6.615E-06	6.615E-06	6.615E-06	6.615E-06	6.615E-06	6.615E-06	6.615E-06
Sn-116	5.733E-06	5.733E-06	5.733E-06	5.733E-06	5.733E-06	5.733E-06	5.733E-06
Sn-117	6.676E-06	6.676E-06	6.676E-06	6.676E-06	6.676E-06	6.676E-06	6.676E-06
Sn-118	6.782E-06	6.782E-06	6.782E-06	6.782E-06	6.782E-06	6.782E-06	6.782E-06
Sn-119	6.753E-06	6.754E-06	6.754E-06	6.754E-06	6.754E-06	6.754E-06	6.754E-06

TABLE F.3.e. Fission Product Inventory by Isotope at 30 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-119m	2.143E-10	2.713E-11	3.436E-12	4.351E-13	2.482E-15	1.417E-17	0.00
Sn-120	6.867E-06	6.867E-06	6.867E-06	6.867E-06	6.867E-06	6.867E-06	6.867E-06
Sn-121m	2.874E-09	2.795E-09	2.719E-09	2.644E-09	2.467E-09	2.302E-09	2.875E-15
Sb-121	6.737E-06	6.737E-06	6.737E-06	6.737E-06	6.737E-06	6.737E-06	6.739E-06
Sn-122	7.581E-06	7.581E-06	7.581E-06	7.581E-06	7.581E-06	7.581E-06	7.581E-06
Te-122	4.212E-07	4.212E-07	4.212E-07	4.212E-07	4.212E-07	4.212E-07	4.212E-07
Sn-123	4.359E-11	8.648E-13	1.716E-14	3.404E-16	1.887E-20	1.046E-24	0.00
Sb-123	8.348E-06	8.348E-06	8.348E-06	8.348E-06	8.348E-06	8.348E-06	8.348E-06
Te-123	5.408E-09	5.408E-09	5.408E-09	5.408E-09	5.408E-09	5.408E-09	5.408E-09
Te-123m	9.927E-14	1.443E-15	2.098E-17	3.050E-19	7.774E-24	1.981E-28	0.00
Sn-124	1.043E-05	1.043E-05	1.043E-05	1.043E-05	1.043E-05	1.043E-05	1.043E-05
Sb-124	1.026E-15	2.282E-19	5.072E-23	1.127E-26	8.307E-36	0.00	0.00
Te-124	3.320E-07	3.320E-07	3.320E-07	3.320E-07	3.320E-07	3.320E-07	3.320E-07
Sb-125	2.229E-06	1.351E-06	8.192E-07	4.966E-07	1.421E-07	4.067E-08	0.00
Te-125	1.369E-05	1.458E-05	1.512E-05	1.544E-05	1.580E-05	1.591E-05	1.595E-05
Te-125m	3.118E-08	1.891E-08	1.146E-08	6.949E-09	1.988E-09	5.688E-10	0.00
Sn-126	2.373E-05	2.373E-05	2.373E-05	2.373E-05	2.373E-05	2.373E-05	2.357E-05
Sb-126	1.127E-12	1.127E-12	1.127E-12	1.127E-12	1.127E-12	1.127E-12	1.120E-12
Sb-126m	8.572E-15	8.572E-15	8.572E-15	8.572E-15	8.571E-15	8.571E-15	8.513E-15
Te-126	6.601E-07	6.604E-07	6.607E-07	6.611E-07	6.619E-07	6.627E-07	8.233E-07
Te-127	1.367E-13	1.313E-15	1.262E-17	1.212E-19	1.097E-24	9.924E-30	0.00
Te-127m	3.904E-11	3.751E-13	3.604E-15	3.462E-17	3.133E-22	2.835E-27	0.00
I-127	4.923E-05	4.923E-05	4.923E-05	4.923E-05	4.923E-05	4.923E-05	4.923E-05
Te-128	9.846E-05	9.846E-05	9.846E-05	9.846E-05	9.846E-05	9.846E-05	9.846E-05
Xe-128	2.548E-06	2.548E-06	2.548E-06	2.548E-06	2.548E-06	2.548E-06	2.548E-06
I-129	1.615E-04	1.615E-04	1.615E-04	1.615E-04	1.615E-04	1.615E-04	1.615E-04
Xe-129	1.309E-08	1.310E-08	1.312E-08	1.313E-08	1.316E-08	1.320E-08	2.019E-08
Te-130	3.197E-04	3.197E-04	3.197E-04	3.197E-04	3.197E-04	3.197E-04	3.197E-04
Xe-130	1.034E-05	1.034E-05	1.034E-05	1.034E-05	1.034E-05	1.034E-05	1.034E-05
Xe-131	3.928E-04	3.928E-04	3.928E-04	3.928E-04	3.928E-04	3.928E-04	3.928E-04
Xe-132	9.690E-04	9.690E-04	9.690E-04	9.690E-04	9.690E-04	9.690E-04	9.690E-04
Ba-132	1.209E-09	1.209E-09	1.209E-09	1.209E-09	1.209E-09	1.209E-09	1.209E-09
Cs-133	1.031E-03	1.031E-03	1.031E-03	1.031E-03	1.031E-03	1.031E-03	1.031E-03
Xe-134	1.330E-03	1.330E-03	1.330E-03	1.330E-03	1.330E-03	1.330E-03	1.330E-03
Cs-134	1.492E-05	7.619E-06	3.890E-06	1.986E-06	3.698E-07	6.886E-08	0.00
Ba-134	1.270E-04	1.344E-04	1.381E-04	1.400E-04	1.416E-04	1.419E-04	1.420E-04
Cs-135	4.399E-04	4.399E-04	4.399E-04	4.399E-04	4.399E-04	4.399E-04	4.398E-04
Ba-135	4.841E-07	4.844E-07	4.846E-07	4.849E-07	4.856E-07	4.862E-07	6.161E-07
Xe-136	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.943E-03
Ba-136	1.946E-05	1.946E-05	1.946E-05	1.946E-05	1.946E-05	1.946E-05	1.946E-05
Cs-137	9.110E-04	8.698E-04	8.305E-04	7.930E-04	7.065E-04	6.294E-04	9.226E-14
Ba-137	2.074E-04	2.485E-04	2.878E-04	3.253E-04	4.118E-04	4.889E-04	1.118E-03
Ba-137m	1.394E-10	1.331E-10	1.271E-10	1.213E-10	1.081E-10	9.629E-11	1.411E-20
Ba-138	1.156E-03	1.156E-03	1.156E-03	1.156E-03	1.156E-03	1.156E-03	1.156E-03
La-138	5.222E-09	5.222E-09	5.222E-09	5.222E-09	5.222E-09	5.222E-09	5.222E-09
La-139	1.104E-03	1.104E-03	1.104E-03	1.104E-03	1.104E-03	1.104E-03	1.104E-03
Ce-140	1.131E-03	1.131E-03	1.131E-03	1.131E-03	1.131E-03	1.131E-03	1.131E-03
Pr-141	1.016E-03	1.016E-03	1.016E-03	1.016E-03	1.016E-03	1.016E-03	1.016E-03

TABLE F.3.e. Fission Product Inventory by Isotope at 30 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ce-142	1.020E-03	1.020E-03	1.020E-03	1.020E-03	1.020E-03	1.020E-03	1.020E-03
Nd-142	2.300E-05	2.300E-05	2.300E-05	2.300E-05	2.300E-05	2.300E-05	2.300E-05
Nd-143	7.224E-04	7.224E-04	7.224E-04	7.224E-04	7.224E-04	7.224E-04	7.224E-04
Ce-144	2.524E-06	4.250E-07	7.159E-08	1.206E-08	1.404E-10	1.634E-12	0.00
Pr-144	1.066E-10	1.795E-11	3.023E-12	5.091E-13	5.927E-15	6.899E-17	0.00
Pr-144m	5.327E-13	8.972E-14	1.511E-14	2.545E-15	2.963E-17	3.449E-19	0.00
Nd-144	1.179E-03	1.181E-03	1.181E-03	1.181E-03	1.181E-03	1.181E-03	1.181E-03
Nd-145	6.137E-04	6.137E-04	6.137E-04	6.137E-04	6.137E-04	6.137E-04	6.137E-04
Nd-146	6.152E-04	6.152E-04	6.152E-04	6.152E-04	6.152E-04	6.152E-04	6.152E-04
Pm-146	1.514E-09	1.176E-09	9.143E-10	7.106E-10	3.784E-10	2.015E-10	0.00
Sm-146	7.720E-09	7.845E-09	7.942E-09	8.017E-09	8.140E-09	8.205E-09	8.280E-09
Pm-147	2.770E-05	1.633E-05	9.626E-06	5.675E-06	1.514E-06	4.041E-07	0.00
Sm-147	1.925E-04	2.039E-04	2.106E-04	2.146E-04	2.187E-04	2.198E-04	2.202E-04
Nd-148	3.323E-04	3.323E-04	3.323E-04	3.323E-04	3.323E-04	3.323E-04	3.323E-04
Sm-148	1.552E-04	1.552E-04	1.552E-04	1.552E-04	1.552E-04	1.552E-04	1.552E-04
Sm-149	1.550E-06	1.550E-06	1.550E-06	1.550E-06	1.550E-06	1.550E-06	1.550E-06
Nd-150	1.591E-04	1.591E-04	1.591E-04	1.591E-04	1.591E-04	1.591E-04	1.591E-04
Sm-150	2.136E-04	2.136E-04	2.136E-04	2.136E-04	2.136E-04	2.136E-04	2.136E-04
Eu-150	4.148E-13	3.991E-13	3.840E-13	3.695E-13	3.356E-13	3.048E-13	1.947E-21
Sm-151	1.113E-05	1.096E-05	1.079E-05	1.063E-05	1.023E-05	9.840E-06	5.187E-09
Eu-151	3.765E-07	5.467E-07	7.142E-07	8.792E-07	1.281E-06	1.667E-06	1.150E-05
Sm-152	1.160E-04	1.160E-04	1.160E-04	1.160E-04	1.160E-04	1.160E-04	1.160E-04
Eu-152	1.073E-07	9.692E-08	8.753E-08	7.905E-08	6.127E-08	4.748E-08	9.673E-30
Gd-152	5.696E-08	5.986E-08	6.248E-08	6.484E-08	6.979E-08	7.363E-08	8.686E-08
Eu-153	9.430E-05	9.430E-05	9.430E-05	9.430E-05	9.430E-05	9.430E-05	9.430E-05
Gd-153	3.126E-10	3.857E-11	4.760E-12	5.875E-13	3.145E-15	1.682E-17	0.00
Sm-154	3.302E-05	3.302E-05	3.302E-05	3.302E-05	3.302E-05	3.302E-05	3.302E-05
Eu-154	2.204E-05	1.876E-05	1.596E-05	1.359E-05	9.081E-06	6.069E-06	0.00
Gd-154	1.688E-05	2.016E-05	2.295E-05	2.533E-05	2.984E-05	3.285E-05	3.892E-05
Eu-155	5.882E-06	4.447E-06	3.363E-06	2.543E-06	1.264E-06	6.284E-07	0.00
Gd-155	4.609E-06	6.043E-06	7.128E-06	7.948E-06	9.226E-06	9.862E-06	1.049E-05
Gd-156	5.372E-05	5.372E-05	5.372E-05	5.372E-05	5.372E-05	5.372E-05	5.372E-05
Gd-157	6.615E-08	6.615E-08	6.615E-08	6.615E-08	6.615E-08	6.615E-08	6.615E-08
Gd-158	1.489E-05	1.489E-05	1.489E-05	1.489E-05	1.489E-05	1.489E-05	1.489E-05
Tb-159	2.299E-06	2.299E-06	2.299E-06	2.299E-06	2.299E-06	2.299E-06	2.299E-06
Gd-160	1.125E-06	1.125E-06	1.125E-06	1.125E-06	1.125E-06	1.125E-06	1.125E-06
Tb-160	2.318E-14	2.107E-17	1.916E-20	1.742E-23	4.340E-31	0.00	0.00
Dy-160	2.428E-07	2.428E-07	2.428E-07	2.428E-07	2.428E-07	2.428E-07	2.428E-07
Dy-161	3.666E-07	3.666E-07	3.666E-07	3.666E-07	3.666E-07	3.666E-07	3.666E-07
Dy-162	3.237E-07	3.237E-07	3.237E-07	3.237E-07	3.237E-07	3.237E-07	3.237E-07
Dy-163	2.464E-07	2.464E-07	2.464E-07	2.464E-07	2.464E-07	2.464E-07	2.464E-07
Dy-164	3.701E-08	3.701E-08	3.701E-08	3.701E-08	3.701E-08	3.701E-08	3.701E-08
Ho-165	1.175E-07	1.175E-07	1.175E-07	1.175E-07	1.175E-07	1.175E-07	1.175E-07
Ho-166m	1.132E-09	1.131E-09	1.129E-09	1.128E-09	1.125E-09	1.121E-09	6.367E-10
Er-166	3.664E-08	3.664E-08	3.664E-08	3.664E-08	3.665E-08	3.665E-08	3.713E-08
Er-167	2.610E-09	2.610E-09	2.610E-09	2.610E-09	2.610E-09	2.610E-09	2.610E-09
Er-168	6.512E-09	6.512E-09	6.512E-09	6.512E-09	6.512E-09	6.512E-09	6.512E-09
Tm-169	4.234E-11	4.234E-11	4.234E-11	4.234E-11	4.234E-11	4.234E-11	4.234E-11

TABLE F.3.e. Fission Product Inventory by Isotope at 30 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Er-170	1.911E-14	1.911E-14	1.911E-14	1.911E-14	1.911E-14	1.911E-14	1.911E-14
Tm-170	1.028E-15	2.004E-17	3.907E-19	7.628E-21	4.046E-25	2.146E-29	0.00
Yb-170	1.273E-11	1.273E-11	1.273E-11	1.273E-11	1.273E-11	1.273E-11	1.273E-11
Tm-171	3.651E-14	1.774E-14	8.615E-15	4.185E-15	6.883E-16	1.132E-16	0.00
Yb-171	6.267E-13	6.455E-13	6.546E-13	6.590E-13	6.625E-13	6.631E-13	6.632E-13
Yb-172	2.799E-14	2.799E-14	2.799E-14	2.799E-14	2.799E-14	2.799E-14	2.799E-14
Total	3.082E-02	3.082E-02	3.082E-02	3.082E-02	3.082E-02	3.082E-02	3.082E-02

TABLE F.3.f. Fission Product Inventory by Isotope at 35 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-3	4.032E-08	3.604E-08	3.221E-08	2.879E-08	2.174E-08	1.642E-08	2.118E-32
Li-6	1.633E-10	1.633E-10	1.633E-10	1.633E-10	1.633E-10	1.633E-10	1.633E-10
Li-7	1.068E-11	1.068E-11	1.068E-11	1.068E-11	1.068E-11	1.068E-11	1.068E-11
Be-9	2.055E-11	2.055E-11	2.055E-11	2.055E-11	2.055E-11	2.055E-11	2.055E-11
Be-10	1.371E-10	1.371E-10	1.371E-10	1.371E-10	1.371E-10	1.371E-10	1.371E-10
C-14	2.770E-11	2.770E-11	2.769E-11	2.768E-11	2.767E-11	2.765E-11	2.456E-11
Zn-66	3.000E-14	3.000E-14	3.000E-14	3.000E-14	3.000E-14	3.000E-14	3.000E-14
Zn-67	1.246E-15	1.246E-15	1.246E-15	1.246E-15	1.246E-15	1.246E-15	1.246E-15
Ga-71	8.985E-13	8.985E-13	8.985E-13	8.985E-13	8.985E-13	8.985E-13	8.985E-13
Ge-72	2.088E-08	2.088E-08	2.088E-08	2.088E-08	2.088E-08	2.088E-08	2.088E-08
Ge-73	4.300E-08	4.300E-08	4.300E-08	4.300E-08	4.300E-08	4.300E-08	4.300E-08
Ge-74	9.589E-08	9.589E-08	9.589E-08	9.589E-08	9.589E-08	9.589E-08	9.589E-08
As-75	1.993E-07	1.993E-07	1.993E-07	1.993E-07	1.993E-07	1.993E-07	1.993E-07
Ge-76	5.027E-07	5.027E-07	5.027E-07	5.027E-07	5.027E-07	5.027E-07	5.027E-07
Se-76	6.177E-09	6.177E-09	6.177E-09	6.177E-09	6.177E-09	6.177E-09	6.177E-09
Se-77	1.036E-06	1.036E-06	1.036E-06	1.036E-06	1.036E-06	1.036E-06	1.036E-06
Se-78	2.533E-06	2.533E-06	2.533E-06	2.533E-06	2.533E-06	2.533E-06	2.533E-06
Se-79	6.076E-06	6.076E-06	6.075E-06	6.075E-06	6.075E-06	6.075E-06	6.011E-06
Br-79	5.842E-10	7.138E-10	8.435E-10	9.731E-10	1.297E-09	1.621E-09	6.481E-08
Se-80	1.392E-05	1.392E-05	1.392E-05	1.392E-05	1.392E-05	1.392E-05	1.392E-05
Kr-80	2.662E-10	2.662E-10	2.662E-10	2.662E-10	2.662E-10	2.662E-10	2.662E-10
Br-81	2.229E-05	2.229E-05	2.229E-05	2.229E-05	2.229E-05	2.229E-05	2.229E-05
Kr-81	2.754E-11	2.754E-11	2.754E-11	2.754E-11	2.754E-11	2.754E-11	2.745E-11
Se-82	3.459E-05	3.459E-05	3.459E-05	3.459E-05	3.459E-05	3.459E-05	3.459E-05
Kr-82	1.157E-06	1.157E-06	1.157E-06	1.157E-06	1.157E-06	1.157E-06	1.157E-06
Kr-83	4.062E-05	4.062E-05	4.062E-05	4.062E-05	4.062E-05	4.062E-05	4.062E-05
Kr-84	1.174E-04	1.174E-04	1.174E-04	1.174E-04	1.174E-04	1.174E-04	1.174E-04
Kr-85	1.490E-05	1.309E-05	1.151E-05	1.011E-05	7.318E-06	5.296E-06	1.605E-33
Rb-85	1.092E-04	1.110E-04	1.126E-04	1.140E-04	1.168E-04	1.188E-04	1.241E-04
Kr-86	1.935E-04	1.935E-04	1.935E-04	1.935E-04	1.935E-04	1.935E-04	1.935E-04
Sr-86	4.960E-07	4.960E-07	4.960E-07	4.960E-07	4.960E-07	4.960E-07	4.960E-07
Rb-87	2.480E-04	2.480E-04	2.480E-04	2.480E-04	2.480E-04	2.480E-04	2.480E-04
Sr-87	4.135E-09	4.135E-09	4.135E-09	4.135E-09	4.135E-09	4.135E-09	4.139E-09
Sr-88	3.558E-04	3.558E-04	3.558E-04	3.558E-04	3.558E-04	3.558E-04	3.558E-04
Sr-89	1.567E-14	6.926E-19	3.061E-23	1.352E-27	0.00	0.00	0.00
Y-89	4.640E-04	4.640E-04	4.640E-04	4.640E-04	4.640E-04	4.640E-04	4.640E-04
Sr-90	4.513E-04	4.303E-04	4.103E-04	3.912E-04	3.473E-04	3.084E-04	2.284E-14
Y-90	1.132E-07	1.079E-07	1.029E-07	9.811E-08	8.710E-08	7.733E-08	5.728E-18
Zr-90	1.129E-04	1.338E-04	1.538E-04	1.729E-04	2.168E-04	2.558E-04	5.643E-04
Y-91	3.839E-13	6.694E-17	1.167E-20	2.035E-24	8.168E-34	0.00	0.00
Zr-91	6.022E-04	6.022E-04	6.022E-04	6.022E-04	6.022E-04	6.022E-04	6.022E-04
Zr-92	6.562E-04	6.562E-04	6.562E-04	6.562E-04	6.562E-04	6.562E-04	6.562E-04
Zr-93	7.409E-04	7.409E-04	7.409E-04	7.409E-04	7.409E-04	7.409E-04	7.405E-04
Nb-93	7.876E-10	1.078E-09	1.405E-09	1.765E-09	2.792E-09	3.965E-09	3.311E-07
Nb-93m	2.323E-09	2.704E-09	3.048E-09	3.359E-09	4.011E-09	4.516E-09	6.254E-09
Zr-94	7.727E-04	7.727E-04	7.727E-04	7.727E-04	7.727E-04	7.727E-04	7.727E-04
Nb-94	8.680E-10	8.679E-10	8.679E-10	8.678E-10	8.677E-10	8.675E-10	8.390E-10
Zr-95	2.910E-12	1.064E-15	3.891E-19	1.422E-22	3.636E-31	0.00	0.00

TABLE F.3.f. Fission Product Inventory by Isotope at 35 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Nb-95	3.550E-12	1.298E-15	4.745E-19	1.735E-22	3.288E-33	0.00	0.00
Nb-95m	1.218E-15	4.452E-19	1.628E-22	5.952E-26	0.00	0.00	0.00
Mo-95	7.783E-04	7.783E-04	7.783E-04	7.783E-04	7.783E-04	7.783E-04	7.783E-04
Zr-96	8.357E-04	8.357E-04	8.357E-04	8.357E-04	8.357E-04	8.357E-04	8.357E-04
Mo-96	4.617E-05	4.617E-05	4.617E-05	4.617E-05	4.617E-05	4.617E-05	4.617E-05
Mo-97	8.304E-04	8.304E-04	8.304E-04	8.304E-04	8.304E-04	8.304E-04	8.304E-04
Mo-98	8.598E-04	8.598E-04	8.598E-04	8.598E-04	8.598E-04	8.598E-04	8.598E-04
Tc-98	5.729E-09	5.729E-09	5.729E-09	5.729E-09	5.729E-09	5.729E-09	5.728E-09
Tc-99	8.118E-04	8.118E-04	8.118E-04	8.118E-04	8.118E-04	8.118E-04	8.092E-04
Ru-99	2.366E-08	2.894E-08	3.423E-08	3.951E-08	5.272E-08	6.593E-08	2.651E-06
Mo-100	9.845E-04	9.845E-04	9.845E-04	9.845E-04	9.845E-04	9.845E-04	9.845E-04
Ru-100	1.150E-04	1.150E-04	1.150E-04	1.150E-04	1.150E-04	1.150E-04	1.150E-04
Ru-101	8.146E-04	8.146E-04	8.146E-04	8.146E-04	8.146E-04	8.146E-04	8.146E-04
Ru-102	8.281E-04	8.281E-04	8.281E-04	8.281E-04	8.281E-04	8.281E-04	8.281E-04
Rh-102	2.277E-10	1.412E-10	8.752E-11	5.426E-11	1.642E-11	4.971E-12	0.00
Ru-103	1.042E-16	2.631E-22	6.639E-28	1.675E-33	0.00	0.00	0.00
Rh-103	4.690E-04	4.690E-04	4.690E-04	4.690E-04	4.690E-04	4.690E-04	4.690E-04
Ru-104	5.966E-04	5.966E-04	5.966E-04	5.966E-04	5.966E-04	5.966E-04	5.966E-04
Pd-104	2.782E-04	2.782E-04	2.782E-04	2.782E-04	2.782E-04	2.782E-04	2.782E-04
Pd-105	4.357E-04	4.357E-04	4.357E-04	4.357E-04	4.357E-04	4.357E-04	4.357E-04
Ru-106	4.307E-06	1.089E-06	2.752E-07	6.955E-08	2.234E-09	7.176E-11	0.00
Rh-106	4.048E-12	1.023E-12	2.586E-13	6.537E-14	2.100E-15	6.745E-17	0.00
Pd-106	3.960E-04	3.993E-04	4.001E-04	4.003E-04	4.003E-04	4.003E-04	4.003E-04
Pd-107	2.532E-04	2.532E-04	2.532E-04	2.532E-04	2.532E-04	2.532E-04	2.532E-04
Ag-107	2.150E-10	2.691E-10	3.231E-10	3.771E-10	5.122E-10	6.473E-10	2.712E-08
Pd-108	1.749E-04	1.749E-04	1.749E-04	1.749E-04	1.749E-04	1.749E-04	1.749E-04
Ag-108m	1.516E-12	1.500E-12	1.483E-12	1.467E-12	1.428E-12	1.389E-12	6.608E-15
Cd-108	3.908E-10	3.908E-10	3.908E-10	3.908E-10	3.908E-10	3.908E-10	3.910E-10
Ag-109	8.638E-05	8.638E-05	8.638E-05	8.638E-05	8.638E-05	8.638E-05	8.638E-05
Cd-109	3.593E-14	1.207E-14	4.052E-15	1.361E-15	8.890E-17	5.809E-18	0.00
Pd-110	5.648E-05	5.648E-05	5.648E-05	5.648E-05	5.648E-05	5.648E-05	5.648E-05
Ag-110	1.326E-16	1.747E-17	2.304E-18	3.037E-19	1.916E-21	1.209E-23	0.00
Ag-110m	8.748E-09	1.153E-09	1.520E-10	2.004E-11	1.264E-13	7.977E-16	0.00
Cd-110	4.362E-05	4.362E-05	4.362E-05	4.362E-05	4.362E-05	4.362E-05	4.362E-05
Cd-111	3.021E-05	3.021E-05	3.021E-05	3.021E-05	3.021E-05	3.021E-05	3.021E-05
Cd-112	1.750E-05	1.750E-05	1.750E-05	1.750E-05	1.750E-05	1.750E-05	1.750E-05
Cd-113	1.419E-07	1.419E-07	1.419E-07	1.419E-07	1.420E-07	1.420E-07	1.421E-07
Cd-113m	2.005E-07	1.823E-07	1.658E-07	1.507E-07	1.189E-07	9.373E-08	5.635E-28
In-113	8.821E-08	1.064E-07	1.229E-07	1.379E-07	1.697E-07	1.948E-07	2.885E-07
Cd-114	2.256E-05	2.256E-05	2.256E-05	2.256E-05	2.256E-05	2.256E-05	2.256E-05
Sn-114	4.232E-09	4.232E-09	4.232E-09	4.232E-09	4.232E-09	4.232E-09	4.232E-09
In-115	2.035E-06	2.035E-06	2.035E-06	2.035E-06	2.035E-06	2.035E-06	2.035E-06
Sn-115	3.075E-07	3.075E-07	3.075E-07	3.075E-07	3.075E-07	3.075E-07	3.075E-07
Cd-116	7.964E-06	7.964E-06	7.964E-06	7.964E-06	7.964E-06	7.964E-06	7.964E-06
Sn-116	7.348E-06	7.348E-06	7.348E-06	7.348E-06	7.348E-06	7.348E-06	7.348E-06
Sn-117	8.025E-06	8.025E-06	8.025E-06	8.025E-06	8.025E-06	8.025E-06	8.025E-06
Sn-118	8.145E-06	8.145E-06	8.145E-06	8.145E-06	8.145E-06	8.145E-06	8.145E-06
Sn-119	8.121E-06	8.122E-06	8.122E-06	8.122E-06	8.122E-06	8.122E-06	8.122E-06

TABLE F.3.f. Fission Product Inventory by Isotope at 35 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-119m	2.724E-10	3.449E-11	4.367E-12	5.530E-13	3.156E-15	1.800E-17	0.00
Sn-120	8.243E-06	8.243E-06	8.243E-06	8.243E-06	8.243E-06	8.243E-06	8.243E-06
Sn-121m	3.512E-09	3.416E-09	3.322E-09	3.232E-09	3.015E-09	2.813E-09	3.513E-15
Sb-121	7.977E-06	7.977E-06	7.977E-06	7.977E-06	7.977E-06	7.978E-06	7.981E-06
Sn-122	9.085E-06	9.085E-06	9.085E-06	9.085E-06	9.085E-06	9.085E-06	9.085E-06
Te-122	6.016E-07	6.016E-07	6.016E-07	6.016E-07	6.016E-07	6.016E-07	6.016E-07
Sn-123	5.261E-11	1.044E-12	2.071E-14	4.108E-16	2.277E-20	1.263E-24	0.00
Sb-123	9.914E-06	9.914E-06	9.914E-06	9.914E-06	9.914E-06	9.914E-06	9.914E-06
Te-123	8.417E-09	8.417E-09	8.417E-09	8.417E-09	8.417E-09	8.417E-09	8.417E-09
Te-123m	1.734E-13	2.522E-15	3.666E-17	5.330E-19	1.358E-23	3.462E-28	0.00
Sn-124	1.244E-05	1.244E-05	1.244E-05	1.244E-05	1.244E-05	1.244E-05	1.244E-05
Sb-124	1.492E-15	3.316E-19	7.372E-23	1.639E-26	1.207E-35	0.00	0.00
Te-124	4.783E-07	4.783E-07	4.783E-07	4.783E-07	4.783E-07	4.783E-07	4.783E-07
Sb-125	2.699E-06	1.636E-06	9.920E-07	6.014E-07	1.721E-07	4.924E-08	0.00
Te-125	1.648E-05	1.755E-05	1.821E-05	1.860E-05	1.904E-05	1.916E-05	1.921E-05
Te-125m	3.776E-08	2.289E-08	1.388E-08	8.414E-09	2.407E-09	6.888E-10	0.00
Sn-126	2.852E-05	2.852E-05	2.852E-05	2.852E-05	2.852E-05	2.852E-05	2.833E-05
Sb-126	1.355E-12	1.355E-12	1.355E-12	1.355E-12	1.355E-12	1.355E-12	1.346E-12
Sb-126m	1.030E-14	1.030E-14	1.030E-14	1.030E-14	1.030E-14	1.030E-14	1.023E-14
Te-126	8.345E-07	8.349E-07	8.353E-07	8.357E-07	8.366E-07	8.376E-07	1.031E-06
Te-127	1.661E-13	1.596E-15	1.533E-17	1.473E-19	1.333E-24	1.206E-29	0.00
Te-127m	4.744E-11	4.559E-13	4.380E-15	4.209E-17	3.808E-22	3.446E-27	0.00
I-127	5.881E-05	5.881E-05	5.881E-05	5.881E-05	5.881E-05	5.881E-05	5.881E-05
Te-128	1.172E-04	1.172E-04	1.172E-04	1.172E-04	1.172E-04	1.172E-04	1.172E-04
Xe-128	3.696E-06	3.696E-06	3.696E-06	3.696E-06	3.696E-06	3.696E-06	3.696E-06
I-129	1.901E-04	1.901E-04	1.901E-04	1.901E-04	1.901E-04	1.901E-04	1.901E-04
Xe-129	2.265E-08	2.267E-08	2.269E-08	2.270E-08	2.274E-08	2.279E-08	3.101E-08
Te-130	3.781E-04	3.781E-04	3.781E-04	3.781E-04	3.781E-04	3.781E-04	3.781E-04
Xe-130	1.474E-05	1.474E-05	1.474E-05	1.474E-05	1.474E-05	1.474E-05	1.474E-05
Xe-131	4.310E-04	4.310E-04	4.310E-04	4.310E-04	4.310E-04	4.310E-04	4.310E-04
Xe-132	1.167E-03	1.167E-03	1.167E-03	1.167E-03	1.167E-03	1.167E-03	1.167E-03
Ba-132	1.680E-09	1.680E-09	1.680E-09	1.680E-09	1.680E-09	1.680E-09	1.680E-09
Cs-133	1.167E-03	1.167E-03	1.167E-03	1.167E-03	1.167E-03	1.167E-03	1.167E-03
Xe-134	1.548E-03	1.548E-03	1.548E-03	1.548E-03	1.548E-03	1.548E-03	1.548E-03
Cs-134	2.038E-05	1.040E-05	5.311E-06	2.711E-06	5.049E-07	9.403E-08	0.00
Ba-134	1.730E-04	1.830E-04	1.880E-04	1.906E-04	1.928E-04	1.933E-04	1.934E-04
Cs-135	4.635E-04	4.635E-04	4.635E-04	4.635E-04	4.635E-04	4.635E-04	4.633E-04
Ba-135	8.018E-07	8.020E-07	8.023E-07	8.026E-07	8.033E-07	8.040E-07	9.409E-07
Xe-136	2.327E-03	2.327E-03	2.327E-03	2.327E-03	2.327E-03	2.327E-03	2.327E-03
Ba-136	2.466E-05	2.466E-05	2.466E-05	2.466E-05	2.466E-05	2.466E-05	2.466E-05
Cs-137	1.063E-03	1.015E-03	9.693E-04	9.256E-04	8.246E-04	7.346E-04	1.077E-13
Ba-137	2.419E-04	2.900E-04	3.358E-04	3.796E-04	4.806E-04	5.705E-04	1.305E-03
Ba-137m	1.627E-10	1.553E-10	1.483E-10	1.416E-10	1.261E-10	1.124E-10	1.647E-20
Ba-138	1.339E-03	1.339E-03	1.339E-03	1.339E-03	1.339E-03	1.339E-03	1.339E-03
La-138	5.400E-09	5.400E-09	5.400E-09	5.400E-09	5.400E-09	5.400E-09	5.400E-09
La-139	1.276E-03	1.276E-03	1.276E-03	1.276E-03	1.276E-03	1.276E-03	1.276E-03
Ce-140	1.315E-03	1.315E-03	1.315E-03	1.315E-03	1.315E-03	1.315E-03	1.315E-03
Pr-141	1.171E-03	1.171E-03	1.171E-03	1.171E-03	1.171E-03	1.171E-03	1.171E-03

TABLE F.3.f. Fission Product Inventory by Isotope at 35 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ce-142	1.179E-03	1.179E-03	1.179E-03	1.179E-03	1.179E-03	1.179E-03	1.179E-03
Nd-142	3.224E-05	3.224E-05	3.224E-05	3.224E-05	3.224E-05	3.224E-05	3.224E-05
Nd-143	7.781E-04	7.781E-04	7.781E-04	7.781E-04	7.781E-04	7.781E-04	7.781E-04
Ce-144	2.873E-06	4.839E-07	8.150E-08	1.373E-08	1.598E-10	1.861E-12	0.00
Pr-144	1.213E-10	2.043E-11	3.441E-12	5.796E-13	6.747E-15	7.856E-17	0.00
Pr-144m	6.064E-13	1.021E-13	1.720E-14	2.897E-15	3.373E-17	3.927E-19	0.00
Nd-144	1.409E-03	1.411E-03	1.412E-03	1.412E-03	1.412E-03	1.412E-03	1.412E-03
Nd-145	6.925E-04	6.925E-04	6.925E-04	6.925E-04	6.925E-04	6.925E-04	6.925E-04
Nd-146	7.289E-04	7.289E-04	7.289E-04	7.289E-04	7.289E-04	7.289E-04	7.289E-04
Pm-146	1.965E-09	1.527E-09	1.187E-09	9.226E-10	4.913E-10	2.616E-10	0.00
Sm-146	9.936E-09	1.010E-08	1.022E-08	1.032E-08	1.048E-08	1.057E-08	1.066E-08
Pm-147	2.921E-05	1.722E-05	1.015E-05	5.984E-06	1.597E-06	4.261E-07	0.00
Sm-147	1.983E-04	2.103E-04	2.174E-04	2.215E-04	2.259E-04	2.271E-04	2.275E-04
Nd-148	3.873E-04	3.873E-04	3.873E-04	3.873E-04	3.873E-04	3.873E-04	3.873E-04
Sm-148	1.947E-04	1.947E-04	1.947E-04	1.947E-04	1.947E-04	1.947E-04	1.947E-04
Sm-149	1.573E-06	1.573E-06	1.573E-06	1.573E-06	1.573E-06	1.573E-06	1.573E-06
Nd-150	1.888E-04	1.888E-04	1.888E-04	1.888E-04	1.888E-04	1.888E-04	1.888E-04
Sm-150	2.474E-04	2.474E-04	2.474E-04	2.474E-04	2.474E-04	2.474E-04	2.474E-04
Eu-150	4.413E-13	4.247E-13	4.086E-13	3.932E-13	3.571E-13	3.243E-13	2.073E-21
Sm-151	1.181E-05	1.163E-05	1.145E-05	1.127E-05	1.085E-05	1.044E-05	5.502E-09
Eu-151	3.932E-07	5.737E-07	7.514E-07	9.264E-07	1.352E-06	1.762E-06	1.219E-05
Sm-152	1.292E-04	1.292E-04	1.292E-04	1.292E-04	1.292E-04	1.292E-04	1.292E-04
Eu-152	9.550E-08	8.625E-08	7.789E-08	7.034E-08	5.452E-08	4.225E-08	8.605E-30
Gd-152	5.070E-08	5.328E-08	5.561E-08	5.771E-08	6.212E-08	6.553E-08	7.730E-08
Eu-153	1.137E-04	1.137E-04	1.137E-04	1.137E-04	1.137E-04	1.137E-04	1.137E-04
Gd-153	3.565E-10	4.399E-11	5.430E-12	6.701E-13	3.585E-15	1.918E-17	0.00
Sm-154	4.076E-05	4.076E-05	4.076E-05	4.076E-05	4.076E-05	4.076E-05	4.076E-05
Eu-154	2.959E-05	2.518E-05	2.143E-05	1.824E-05	1.219E-05	8.148E-06	0.00
Gd-154	2.269E-05	2.709E-05	3.084E-05	3.403E-05	4.008E-05	4.413E-05	5.227E-05
Eu-155	7.926E-06	5.993E-06	4.532E-06	3.427E-06	1.704E-06	8.469E-07	0.00
Gd-155	6.172E-06	8.105E-06	9.567E-06	1.067E-05	1.240E-05	1.325E-05	1.410E-05
Gd-156	7.963E-05	7.963E-05	7.963E-05	7.963E-05	7.963E-05	7.963E-05	7.963E-05
Gd-157	8.107E-08	8.107E-08	8.107E-08	8.107E-08	8.107E-08	8.107E-08	8.107E-08
Gd-158	2.018E-05	2.018E-05	2.018E-05	2.018E-05	2.018E-05	2.018E-05	2.018E-05
Tb-159	2.963E-06	2.963E-06	2.963E-06	2.963E-06	2.963E-06	2.963E-06	2.963E-06
Gd-160	1.448E-06	1.448E-06	1.448E-06	1.448E-06	1.448E-06	1.448E-06	1.448E-06
Tb-160	3.620E-14	3.291E-17	2.992E-20	2.720E-23	6.777E-31	0.00	0.00
Dy-160	3.564E-07	3.564E-07	3.564E-07	3.564E-07	3.564E-07	3.564E-07	3.564E-07
Dy-161	4.588E-07	4.588E-07	4.588E-07	4.588E-07	4.588E-07	4.588E-07	4.588E-07
Dy-162	4.145E-07	4.145E-07	4.145E-07	4.145E-07	4.145E-07	4.145E-07	4.145E-07
Dy-163	3.405E-07	3.405E-07	3.405E-07	3.405E-07	3.405E-07	3.405E-07	3.405E-07
Dy-164	4.985E-08	4.985E-08	4.985E-08	4.985E-08	4.985E-08	4.985E-08	4.985E-08
Ho-165	1.736E-07	1.736E-07	1.736E-07	1.736E-07	1.736E-07	1.736E-07	1.736E-07
Ho-166m	1.960E-09	1.958E-09	1.955E-09	1.953E-09	1.948E-09	1.942E-09	1.103E-09
Er-166	5.643E-08	5.643E-08	5.644E-08	5.644E-08	5.644E-08	5.645E-08	5.729E-08
Er-167	3.323E-09	3.323E-09	3.323E-09	3.323E-09	3.323E-09	3.323E-09	3.323E-09
Er-168	9.426E-09	9.426E-09	9.426E-09	9.426E-09	9.426E-09	9.426E-09	9.426E-09
Tm-169	6.925E-11	6.925E-11	6.925E-11	6.925E-11	6.925E-11	6.925E-11	6.925E-11

TABLE F.3.f. Fission Product Inventory by Isotope at 35 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Er-170	3.752E-14	3.752E-14	3.752E-14	3.752E-14	3.752E-14	3.752E-14	3.752E-14
Tm-170	2.045E-15	3.987E-17	7.772E-19	1.514E-20	8.033E-25	4.261E-29	0.00
Yb-170	2.486E-11	2.486E-11	2.486E-11	2.486E-11	2.486E-11	2.486E-11	2.486E-11
Tm-171	8.828E-14	4.288E-14	2.083E-14	1.012E-14	1.664E-15	2.737E-16	0.00
Yb-171	1.473E-12	1.518E-12	1.540E-12	1.551E-12	1.560E-12	1.561E-12	1.561E-12
Yb-172	7.954E-14	7.954E-14	7.954E-14	7.954E-14	7.954E-14	7.954E-14	7.954E-14
Total	3.590E-02	3.590E-02	3.590E-02	3.590E-02	3.590E-02	3.590E-02	3.590E-02

TABLE F.4.a. Actinide Inventory by Isotope at 10 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He-4	1.146E-07	1.270E-07	1.400E-07	1.536E-07	1.901E-07	2.293E-07	6.024E-06
Pb-207	6.831E-15	1.064E-14	1.543E-14	2.122E-14	4.027E-14	6.612E-14	1.787E-10
Pb-208	4.246E-12	6.035E-12	7.944E-12	9.914E-12	1.489E-11	1.977E-11	1.196E-10
Pb-212	1.516E-15	1.660E-15	1.738E-15	1.773E-15	1.765E-15	1.706E-15	1.653E-19
Ra-224	1.323E-14	1.448E-14	1.516E-14	1.547E-14	1.540E-14	1.488E-14	1.442E-18
Ra-226	3.590E-13	4.889E-13	6.390E-13	8.093E-13	1.324E-12	1.965E-12	2.324E-09
Ac-227	5.780E-14	7.434E-14	9.138E-14	1.089E-13	1.545E-13	2.025E-13	1.249E-11
Th-228	2.567E-12	2.808E-12	2.939E-12	2.999E-12	2.990E-12	2.889E-12	2.803E-16
Th-229	1.468E-13	1.528E-13	1.593E-13	1.661E-13	1.852E-13	2.070E-13	1.062E-10
Th-230	6.786E-09	7.937E-09	9.089E-09	1.024E-08	1.313E-08	1.602E-08	6.016E-07
Th-231	7.928E-14	7.928E-14	7.928E-14	7.928E-14	7.929E-14	7.929E-14	7.967E-14
Th-232	4.738E-10	5.770E-10	6.801E-10	7.832E-10	1.041E-09	1.299E-09	5.274E-08
Th-234	1.399E-11	1.399E-11	1.399E-11	1.399E-11	1.399E-11	1.399E-11	1.399E-11
Pa-231	4.799E-10	5.177E-10	5.555E-10	5.934E-10	6.878E-10	7.821E-10	1.912E-08
Pa-233	2.555E-12	2.563E-12	2.573E-12	2.583E-12	2.615E-12	2.653E-12	8.655E-12
U-232	1.149E-10	1.169E-10	1.173E-10	1.167E-10	1.129E-10	1.082E-10	1.023E-14
U-233	6.781E-10	7.287E-10	7.794E-10	8.303E-10	9.521E-10	1.075E-09	5.958E-08
U-234	2.065E-04	2.067E-04	2.068E-04	2.070E-04	2.073E-04	2.077E-04	2.165E-04
U-235	1.950E-02	1.950E-02	1.950E-02	1.950E-02	1.950E-02	1.950E-02	1.959E-02
U-236	1.771E-03	1.772E-03	1.772E-03	1.772E-03	1.772E-03	1.773E-03	1.834E-03
U-237	5.102E-12	4.634E-12	4.209E-12	3.822E-12	3.005E-12	2.362E-12	4.025E-20
U-238	9.638E-01	9.638E-01	9.638E-01	9.638E-01	9.638E-01	9.638E-01	9.638E-01
Np-235	9.245E-15	2.574E-15	7.169E-16	1.996E-16	8.170E-18	3.343E-19	0.00
Np-236	2.870E-11	2.870E-11	2.870E-11	2.870E-11	2.870E-11	2.870E-11	2.853E-11
Np-237	7.524E-05	7.547E-05	7.575E-05	7.606E-05	7.700E-05	7.812E-05	2.548E-04
Np-238	7.329E-14	7.262E-14	7.196E-14	7.131E-14	6.970E-14	6.813E-14	7.809E-16
Np-239	8.907E-13	8.905E-13	8.904E-13	8.902E-13	8.898E-13	8.894E-13	8.112E-13
Pu-236	1.127E-11	6.932E-12	4.263E-12	2.621E-12	7.773E-13	2.305E-13	6.367E-17
Pu-238	1.029E-05	1.014E-05	9.982E-06	9.828E-06	9.454E-06	9.095E-06	8.406E-09
Pu-239	3.406E-03	3.405E-03	3.405E-03	3.405E-03	3.405E-03	3.404E-03	3.309E-03
Pu-240	6.364E-04	6.363E-04	6.362E-04	6.360E-04	6.357E-04	6.354E-04	5.727E-04
Pu-241	1.648E-04	1.497E-04	1.359E-04	1.235E-04	9.704E-05	7.628E-05	1.301E-12
Pu-242	1.983E-05	1.984E-05	1.984E-05	1.984E-05	1.984E-05	1.984E-05	1.987E-05
Pu-244	4.268E-11	4.268E-11	4.268E-11	4.268E-11	4.268E-11	4.268E-11	4.268E-11
Am-241	6.571E-05	8.061E-05	9.406E-05	1.062E-04	1.317E-04	1.513E-04	4.782E-05
Am-242m	3.909E-07	3.873E-07	3.838E-07	3.803E-07	3.717E-07	3.634E-07	4.165E-09
Am-242	4.676E-12	4.633E-12	4.591E-12	4.549E-12	4.447E-12	4.347E-12	4.982E-14
Am-243	1.036E-06	1.036E-06	1.036E-06	1.036E-06	1.035E-06	1.035E-06	9.439E-07
Cm-242	3.437E-09	1.050E-09	9.350E-10	9.218E-10	8.995E-10	8.793E-10	1.007E-11
Cm-243	7.194E-09	6.853E-09	6.527E-09	6.218E-09	5.506E-09	4.875E-09	2.172E-19
Cm-244	5.620E-08	5.206E-08	4.822E-08	4.467E-08	3.689E-08	3.046E-08	1.562E-24
Cm-245	8.456E-10	8.454E-10	8.453E-10	8.452E-10	8.448E-10	8.445E-10	7.796E-10
Cm-246	2.389E-11	2.388E-11	2.387E-11	2.387E-11	2.385E-11	2.383E-11	2.064E-11
Cm-247	5.855E-14	5.855E-14	5.855E-14	5.855E-14	5.855E-14	5.855E-14	5.855E-14
Total	9.896E-01	9.896E-01	9.896E-01	9.896E-01	9.896E-01	9.896E-01	9.896E-0

TABLE F.4.b. Actinide Inventory by Isotope at 15 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He-4	3.171E-07	3.419E-07	3.680E-07	3.955E-07	4.692E-07	5.485E-07	1.117E-05
Pb-207	7.641E-15	1.190E-14	1.720E-14	2.356E-14	4.413E-14	7.142E-14	1.465E-10
Pb-208	8.035E-12	1.166E-11	1.560E-11	1.971E-11	3.022E-11	4.059E-11	2.537E-10
Pb-212	3.037E-15	3.398E-15	3.609E-15	3.718E-15	3.745E-15	3.634E-15	3.557E-19
Ra-224	2.649E-14	2.964E-14	3.148E-14	3.243E-14	3.267E-14	3.170E-14	3.103E-18
Ra-226	3.334E-13	4.535E-13	5.925E-13	7.504E-13	1.228E-12	1.825E-12	2.335E-09
Ac-227	6.471E-14	8.270E-14	1.008E-13	1.190E-13	1.650E-13	2.115E-13	1.015E-11
Th-228	5.142E-12	5.748E-12	6.103E-12	6.287E-12	6.343E-12	6.155E-12	6.030E-16
Th-229	3.182E-13	3.269E-13	3.364E-13	3.468E-13	3.761E-13	4.103E-13	2.135E-10
Th-230	6.273E-09	7.346E-09	8.421E-09	9.498E-09	1.220E-08	1.492E-08	6.097E-07
Th-231	6.379E-14	6.379E-14	6.379E-14	6.379E-14	6.379E-14	6.380E-14	6.425E-14
Th-232	6.523E-10	7.926E-10	9.330E-10	1.073E-09	1.424E-09	1.775E-09	7.208E-08
Th-234	1.394E-11	1.394E-11	1.394E-11	1.394E-11	1.394E-11	1.394E-11	1.394E-11
Pa-231	5.304E-10	5.608E-10	5.912E-10	6.216E-10	6.976E-10	7.735E-10	1.554E-08
Pa-233	4.779E-12	4.796E-12	4.816E-12	4.839E-12	4.907E-12	4.989E-12	1.802E-11
U-232	2.373E-10	2.447E-10	2.473E-10	2.471E-10	2.405E-10	2.307E-10	2.222E-14
U-233	9.710E-10	1.066E-09	1.160E-09	1.256E-09	1.484E-09	1.716E-09	1.217E-07
U-234	1.922E-04	1.927E-04	1.931E-04	1.936E-04	1.947E-04	1.957E-04	2.222E-04
U-235	1.569E-02	1.569E-02	1.569E-02	1.569E-02	1.569E-02	1.569E-02	1.580E-02
U-236	2.411E-03	2.411E-03	2.412E-03	2.412E-03	2.412E-03	2.413E-03	2.515E-03
U-237	1.122E-11	1.019E-11	9.257E-12	8.407E-12	6.609E-12	5.195E-12	5.171E-19
U-238	9.603E-01	9.603E-01	9.603E-01	9.603E-01	9.603E-01	9.603E-01	9.603E-01
Np-235	2.569E-14	7.154E-15	1.992E-15	5.548E-16	2.270E-17	9.291E-19	0.00
Np-236	6.842E-11	6.842E-11	6.842E-11	6.842E-11	6.842E-11	6.842E-11	6.801E-11
Np-237	1.407E-04	1.412E-04	1.418E-04	1.425E-04	1.445E-04	1.469E-04	5.307E-04
Np-238	1.873E-13	1.856E-13	1.839E-13	1.822E-13	1.781E-13	1.741E-13	1.995E-15
Np-239	4.778E-12	4.777E-12	4.776E-12	4.775E-12	4.773E-12	4.770E-12	4.351E-12
Pu-236	3.187E-11	1.960E-11	1.205E-11	7.411E-12	2.198E-12	6.518E-13	1.518E-16
Pu-238	3.016E-05	2.971E-05	2.925E-05	2.880E-05	2.770E-05	2.664E-05	2.296E-08
Pu-239	4.095E-03	4.095E-03	4.095E-03	4.095E-03	4.094E-03	4.094E-03	3.980E-03
Pu-240	1.056E-03	1.056E-03	1.056E-03	1.055E-03	1.055E-03	1.054E-03	9.506E-04
Pu-241	3.625E-04	3.292E-04	2.990E-04	2.715E-04	2.134E-04	1.678E-04	1.672E-11
Pu-242	6.697E-05	6.697E-05	6.697E-05	6.697E-05	6.697E-05	6.698E-05	6.702E-05
Pu-244	3.741E-10	3.741E-10	3.741E-10	3.741E-10	3.740E-10	3.740E-10	3.740E-10
Am-241	1.380E-04	1.708E-04	2.004E-04	2.272E-04	2.832E-04	3.264E-04	1.039E-04
Am-242m	9.987E-07	9.897E-07	9.807E-07	9.718E-07	9.499E-07	9.285E-07	1.064E-08
Am-242	1.195E-11	1.184E-11	1.173E-11	1.162E-11	1.136E-11	1.111E-11	1.273E-13
Am-243	5.559E-06	5.558E-06	5.557E-06	5.556E-06	5.554E-06	5.551E-06	5.063E-06
Cm-242	1.030E-08	2.752E-09	2.392E-09	2.355E-09	2.298E-09	2.247E-09	2.574E-11
Cm-243	3.605E-08	3.434E-08	3.271E-08	3.115E-08	2.759E-08	2.443E-08	1.088E-18
Cm-244	4.862E-07	4.504E-07	4.172E-07	3.864E-07	3.191E-07	2.635E-07	1.351E-23
Cm-245	1.086E-08	1.086E-08	1.086E-08	1.086E-08	1.086E-08	1.085E-08	1.002E-08
Cm-246	5.004E-10	5.002E-10	5.001E-10	4.999E-10	4.996E-10	4.992E-10	4.324E-10
Cm-247	1.933E-12	1.933E-12	1.933E-12	1.933E-12	1.933E-12	1.933E-12	1.933E-12
Cm-248	3.848E-14	3.848E-14	3.848E-14	3.848E-14	3.848E-14	3.848E-14	3.840E-14
Total	9.845E-01	9.845E-01	9.845E-01	9.845E-01	9.845E-01	9.845E-01	9.845E-01

TABLE F.4.c. Actinide Inventory by Isotope at 20 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He-4	6.508E-07	6.925E-07	7.360E-07	7.813E-07	9.012E-07	1.029E-06	1.629E-05
Pb-207	8.208E-15	1.277E-14	1.844E-14	2.520E-14	4.679E-14	7.497E-14	1.189E-10
Pb-208	1.310E-11	1.932E-11	2.616E-11	3.337E-11	5.196E-11	7.038E-11	4.499E-10
Pb-212	5.161E-15	5.871E-15	6.302E-15	6.539E-15	6.643E-15	6.465E-15	6.317E-19
Ra-224	4.502E-14	5.121E-14	5.497E-14	5.704E-14	5.794E-14	5.639E-14	5.510E-18
Ra-226	3.086E-13	4.195E-13	5.480E-13	6.942E-13	1.138E-12	1.694E-12	2.465E-09
Ac-227	6.954E-14	8.856E-14	1.074E-13	1.260E-13	1.718E-13	2.167E-13	8.152E-12
Th-228	8.740E-12	9.930E-12	1.066E-11	1.106E-11	1.125E-11	1.095E-11	1.071E-15
Th-229	5.981E-13	6.093E-13	6.217E-13	6.354E-13	6.749E-13	7.220E-13	3.229E-10
Th-230	5.784E-09	6.784E-09	7.790E-09	8.801E-09	1.135E-08	1.393E-08	6.520E-07
Th-231	5.056E-14	5.056E-14	5.056E-14	5.056E-14	5.056E-14	5.056E-14	5.106E-14
Th-232	8.003E-10	9.706E-10	1.141E-09	1.311E-09	1.737E-09	2.163E-09	8.777E-08
Th-234	1.389E-11	1.389E-11	1.389E-11	1.389E-11	1.389E-11	1.389E-11	1.389E-11
Pa-231	5.666E-10	5.907E-10	6.148E-10	6.389E-10	6.991E-10	7.592E-10	1.248E-08
Pa-233	7.379E-12	7.404E-12	7.434E-12	7.468E-12	7.571E-12	7.693E-12	2.718E-11
U-232	4.125E-10	4.296E-10	4.368E-10	4.379E-10	4.278E-10	4.107E-10	3.966E-14
U-233	1.234E-09	1.380E-09	1.527E-09	1.674E-09	2.026E-09	2.384E-09	1.839E-07
U-234	1.790E-04	1.800E-04	1.810E-04	1.819E-04	1.842E-04	1.864E-04	2.419E-04
U-235	1.243E-02	1.243E-02	1.243E-02	1.243E-02	1.244E-02	1.244E-02	1.256E-02
U-236	2.926E-03	2.926E-03	2.926E-03	2.927E-03	2.927E-03	2.928E-03	3.072E-03
U-237	1.681E-11	1.527E-11	1.387E-11	1.260E-11	9.902E-12	7.784E-12	2.953E-18
U-238	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01	9.567E-01
Np-235	5.231E-14	1.457E-14	4.056E-15	1.130E-15	4.622E-17	1.892E-18	0.00
Np-236	1.233E-10	1.233E-10	1.233E-10	1.233E-10	1.233E-10	1.233E-10	1.226E-10
Np-237	2.173E-04	2.180E-04	2.189E-04	2.199E-04	2.229E-04	2.265E-04	8.003E-04
Np-238	3.223E-13	3.194E-13	3.165E-13	3.136E-13	3.065E-13	2.996E-13	3.434E-15
Np-239	1.463E-11	1.462E-11	1.462E-11	1.462E-11	1.461E-11	1.460E-11	1.332E-11
Pu-236	6.668E-11	4.100E-11	2.521E-11	1.550E-11	4.598E-12	1.364E-12	2.735E-16
Pu-238	5.312E-05	6.216E-05	6.120E-05	6.025E-05	5.795E-05	5.573E-05	4.380E-08
Pu-239	4.486E-03	4.486E-03	4.485E-03	4.485E-03	4.484E-03	4.484E-03	4.361E-03
Pu-240	1.485E-03	1.485E-03	1.485E-03	1.485E-03	1.484E-03	1.484E-03	1.338E-03
Pu-241	5.431E-04	4.932E-04	4.479E-04	4.068E-04	3.198E-04	2.514E-04	9.550E-11
Pu-242	1.476E-04	1.476E-04	1.476E-04	1.476E-04	1.477E-04	1.477E-04	1.477E-04
Pu-244	1.671E-09	1.671E-09	1.671E-09	1.671E-09	1.671E-09	1.671E-09	1.671E-09
Am-241	2.053E-04	2.544E-04	2.987E-04	3.388E-04	4.228E-04	4.875E-04	1.553E-04
Am-242m	1.719E-06	1.703E-06	1.688E-06	1.673E-06	1.635E-06	1.598E-06	1.832E-08
Am-242	2.056E-11	2.038E-11	2.019E-11	2.001E-11	1.956E-11	1.912E-11	2.191E-13
Am-243	1.702E-05	1.702E-05	1.701E-05	1.701E-05	1.700E-05	1.699E-05	1.550E-05
Cm-242	2.076E-08	4.873E-09	4.123E-09	4.054E-09	3.956E-09	3.867E-09	4.430E-11
Cm-243	1.058E-07	1.008E-07	9.602E-08	9.146E-08	8.099E-08	7.171E-08	3.195E-18
Cm-244	2.148E-06	1.990E-06	1.843E-06	1.708E-06	1.410E-06	1.164E-06	5.971E-23
Cm-245	6.204E-08	6.203E-08	6.202E-08	6.201E-08	6.199E-08	6.196E-08	5.720E-08
Cm-246	4.072E-09	4.071E-09	4.070E-09	4.069E-09	4.066E-09	4.063E-09	3.519E-09
Cm-247	2.189E-11	2.189E-11	2.189E-11	2.189E-11	2.189E-11	2.189E-11	2.139E-11
Cm-248	6.145E-13	6.145E-13	6.145E-13	6.145E-13	6.145E-13	6.145E-13	6.133E-13
Cf-249	4.325E-15	4.408E-15	4.411E-15	4.397E-15	4.355E-15	4.312E-15	6.208E-16
Total	9.794E-01	9.794E-01	9.794E-01	9.794E-01	9.794E-01	9.794E-01	9.794E-01

TABLE F.4.d. Actinide Inventory by Isotope at 25 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He-4	1.099E-06	1.163E-06	1.230E-06	1.298E-06	1.476E-06	1.661E-06	2.138E-05
Pb-207	8.557E-15	1.332E-14	1.922E-14	2.622E-14	4.843E-14	7.707E-14	9.551E-11
Pb-208	1.949E-11	2.911E-11	3.982E-11	5.119E-11	8.067E-11	1.100E-10	7.158E-10
Pb-212	7.936E-15	9.148E-15	9.903E-15	1.033E-14	1.057E-14	1.031E-14	9.996E-19
Ra-224	6.923E-14	7.980E-14	8.639E-14	9.013E-14	9.217E-14	8.990E-14	8.719E-18
Ra-226	2.846E-13	3.866E-13	5.050E-13	6.401E-13	1.052E-12	1.570E-12	2.706E-09
Ac-227	7.258E-14	9.230E-14	1.116E-13	1.304E-13	1.757E-13	2.189E-13	6.462E-12
Th-228	1.344E-11	1.547E-11	1.675E-11	1.747E-11	1.790E-11	1.746E-11	1.694E-15
Th-229	1.026E-12	1.040E-12	1.055E-12	1.072E-12	1.121E-12	1.181E-12	4.327E-10
Th-230	5.313E-09	6.247E-09	7.190E-09	8.142E-09	1.056E-08	1.303E-08	7.255E-07
Th-231	3.942E-14	3.942E-14	3.942E-14	3.942E-14	3.942E-14	3.943E-14	3.995E-14
Th-232	9.208E-10	1.114E-09	1.308E-09	1.501E-09	1.985E-09	2.470E-09	1.000E-07
Th-234	1.383E-11	1.383E-11	1.383E-11	1.383E-11	1.383E-11	1.383E-11	1.383E-11
Pa-231	5.912E-10	6.100E-10	6.288E-10	6.475E-10	6.945E-10	7.414E-10	9.892E-09
Pa-233	1.025E-11	1.028E-11	1.032E-11	1.036E-11	1.050E-11	1.065E-11	3.605E-11
U-232	6.461E-10	6.781E-10	6.925E-10	6.960E-10	6.818E-10	6.553E-10	6.294E-14
U-233	1.470E-09	1.673E-09	1.876E-09	2.080E-09	2.569E-09	3.064E-09	2.454E-07
U-234	1.668E-04	1.684E-04	1.701E-04	1.717E-04	1.756E-04	1.794E-04	2.744E-04
U-235	9.695E-03	9.695E-03	9.695E-03	9.695E-03	9.696E-03	9.697E-03	9.826E-03
U-236	3.325E-03	3.325E-03	3.326E-03	3.326E-03	3.327E-03	3.328E-03	3.510E-03
U-237	2.207E-11	2.004E-11	1.820E-11	1.653E-11	1.299E-11	1.021E-11	1.100E-17
U-238	9.528E-01	9.528E-01	9.528E-01	9.528E-01	9.528E-01	9.528E-01	9.528E-01
Np-235	8.999E-14	2.506E-14	6.978E-15	1.943E-15	7.952E-17	3.254E-18	0.00
Np-236	1.904E-10	1.904E-10	1.904E-10	1.904E-10	1.904E-10	1.904E-10	1.893E-10
Np-237	3.017E-04	3.027E-04	3.038E-04	3.051E-04	3.090E-04	3.137E-04	1.062E-03
Np-238	4.384E-13	4.344E-13	4.305E-13	4.266E-13	4.169E-13	4.075E-13	4.671E-15
Np-239	3.333E-11	3.332E-11	3.332E-11	3.331E-11	3.330E-11	3.328E-11	3.035E-11
Pu-236	1.184E-10	7.282E-11	4.478E-11	2.753E-11	8.165E-12	2.421E-12	4.224E-16
Pu-238	1.083E-04	1.066E-04	1.050E-04	1.033E-04	9.936E-05	9.555E-05	6.816E-08
Pu-239	4.706E-03	4.706E-03	4.706E-03	4.705E-03	4.705E-03	4.704E-03	4.577E-03
Pu-240	1.877E-03	1.877E-03	1.877E-03	1.877E-03	1.877E-03	1.877E-03	1.695E-03
Pu-241	7.127E-04	6.472E-04	5.878E-04	5.339E-04	4.197E-04	3.299E-04	3.557E-10
Pu-242	2.615E-04	2.615E-04	2.615E-04	2.615E-04	2.615E-04	2.615E-04	2.614E-04
Pu-244	5.214E-09	5.214E-09	5.214E-09	5.214E-09	5.214E-09	5.214E-09	5.214E-09
Am-241	2.626E-04	3.271E-04	3.853E-04	4.380E-04	5.482E-04	6.332E-04	2.024E-04
Am-242m	2.338E-06	2.317E-06	2.296E-06	2.275E-06	2.224E-06	2.174E-06	2.491E-08
Am-242	2.797E-11	2.772E-11	2.746E-11	2.721E-11	2.660E-11	2.600E-11	2.980E-13
Am-243	3.878E-05	3.878E-05	3.877E-05	3.876E-05	3.874E-05	3.873E-05	3.532E-05
Cm-242	3.319E-08	6.851E-09	5.619E-09	5.515E-09	5.381E-09	5.260E-09	6.026E-11
Cm-243	2.291E-07	2.182E-07	2.078E-07	1.980E-07	1.753E-07	1.552E-07	6.916E-18
Cm-244	6.601E-06	6.114E-06	5.664E-06	5.246E-06	4.333E-06	3.578E-06	1.835E-22
Cm-245	2.311E-07	2.310E-07	2.310E-07	2.310E-07	2.309E-07	2.308E-07	2.130E-07
Cm-246	2.030E-08	2.030E-08	2.029E-08	2.029E-08	2.027E-08	2.026E-08	1.755E-08
Cm-247	1.421E-10	1.421E-10	1.421E-10	1.421E-10	1.421E-10	1.421E-10	1.421E-10
Cm-248	5.277E-12	5.277E-12	5.277E-12	5.277E-12	5.277E-12	5.277E-12	5.266E-12
Bk-249	1.345E-15	2.764E-16	5.681E-17	1.168E-17	2.236E-19	4.289E-21	0.00
Cf-249	4.528E-14	4.616E-14	4.620E-14	4.606E-14	4.562E-14	4.517E-14	6.503E-15

TABLE F.4.d. Actinide Inventory by Isotope at 25 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Cf-250	5.067E-15	4.557E-15	4.099E-15	3.687E-15	2.829E-15	2.170E-15	5.150E-25
Cf-251	2.100E-15	2.096E-15	2.093E-15	2.090E-15	2.082E-15	2.074E-15	9.733E-16
Total	9.743E-01	9.743E-01	9.743E-01	9.743E-01	9.743E-01	9.743E-01	9.743E-01

TABLE F.4.e. Actinide Inventory by Isotope at 30 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He-4	1.651E-06	1.747E-06	1.844E-06	1.943E-06	2.195E-06	2.454E-06	2.672E-05
Pb-207	8.704E-15	1.356E-14	1.957E-14	2.670E-14	4.918E-14	7.792E-14	7.615E-11
Pb-208	2.715E-11	4.104E-11	5.665E-11	7.331E-11	1.168E-10	1.601E-10	1.057E-09
Pb-212	1.138E-14	1.328E-14	1.448E-14	1.518E-14	1.561E-14	1.525E-14	1.465E-18
Bi-209	1.077E-15	1.362E-15	1.651E-15	1.942E-15	2.688E-15	3.462E-15	1.425E-11
Bi-212	1.079E-15	1.259E-15	1.373E-15	1.439E-15	1.480E-15	1.447E-15	1.389E-19
Ra-224	9.927E-14	1.158E-13	1.263E-13	1.324E-13	1.361E-13	1.330E-13	1.278E-17
Ra-226	2.613E-13	3.546E-13	4.635E-13	5.880E-13	9.695E-13	1.454E-12	3.046E-09
Ac-227	7.400E-14	9.414E-14	1.136E-13	1.325E-13	1.771E-13	2.187E-13	5.066E-12
Th-228	1.927E-11	2.245E-11	2.449E-11	2.566E-11	2.643E-11	2.583E-11	2.483E-15
Th-229	1.650E-12	1.665E-12	1.682E-12	1.702E-12	1.762E-12	1.834E-12	5.466E-10
Th-230	4.858E-09	5.730E-09	6.616E-09	7.517E-09	9.826E-09	1.222E-08	8.278E-07
Th-231	3.024E-14	3.024E-14	3.024E-14	3.024E-14	3.025E-14	3.025E-14	3.079E-14
Th-232	1.015E-09	1.226E-09	1.436E-09	1.647E-09	2.173E-09	2.699E-09	1.090E-07
Th-234	1.377E-11	1.377E-11	1.377E-11	1.377E-11	1.377E-11	1.377E-11	1.377E-11
Pa-231	6.060E-10	6.204E-10	6.348E-10	6.492E-10	6.852E-10	7.211E-10	7.755E-09
Pa-233	1.332E-11	1.336E-11	1.341E-11	1.346E-11	1.362E-11	1.382E-11	4.516E-11
U-232	9.418E-10	9.950E-10	1.020E-09	1.027E-09	1.009E-09	9.702E-10	9.239E-14
U-233	1.679E-09	1.942E-09	2.207E-09	2.472E-09	3.106E-09	3.749E-09	3.088E-07
U-234	1.553E-04	1.578E-04	1.603E-04	1.628E-04	1.688E-04	1.745E-04	3.186E-04
U-235	7.437E-03	7.438E-03	7.438E-03	7.438E-03	7.439E-03	7.440E-03	7.573E-03
U-236	3.615E-03	3.616E-03	3.616E-03	3.617E-03	3.618E-03	3.619E-03	3.833E-03
U-237	2.754E-11	2.501E-11	2.272E-11	2.063E-11	1.622E-11	1.275E-11	3.130E-17
U-238	9.486E-01	9.486E-01	9.486E-01	9.486E-01	9.486E-01	9.486E-01	9.486E-01
Np-235	1.400E-13	3.900E-14	1.086E-14	3.024E-15	1.238E-16	5.064E-18	0.00
Np-236	2.670E-10	2.670E-10	2.670E-10	2.670E-10	2.670E-10	2.670E-10	2.654E-10
Np-237	3.922E-04	3.934E-04	3.947E-04	3.963E-04	4.011E-04	4.068E-04	1.330E-03
Np-238	5.165E-13	5.118E-13	5.071E-13	5.025E-13	4.912E-13	4.801E-13	5.503E-15
Np-239	6.399E-11	6.398E-11	6.397E-11	6.396E-11	6.393E-11	6.390E-11	5.828E-11
Pu-236	1.901E-10	1.169E-10	7.189E-11	4.420E-11	1.311E-11	3.887E-12	5.922E-16
Pu-238	1.647E-04	1.622E-04	1.596E-04	1.571E-04	1.511E-04	1.453E-04	9.451E-08
Pu-239	4.856E-03	4.856E-03	4.855E-03	4.855E-03	4.855E-03	4.854E-03	4.725E-03
Pu-240	2.191E-03	2.192E-03	2.192E-03	2.193E-03	2.194E-03	2.195E-03	1.986E-03
Pu-241	8.895E-04	8.079E-04	7.337E-04	6.664E-04	5.238E-04	4.118E-04	1.012E-09
Pu-242	4.024E-04	4.024E-04	4.024E-04	4.024E-04	4.024E-04	4.024E-04	4.021E-04
Pu-244	1.305E-08	1.305E-08	1.305E-08	1.305E-08	1.305E-08	1.305E-08	1.305E-08
Am-241	3.137E-04	3.942E-04	4.669E-04	5.327E-04	6.704E-04	7.766E-04	2.498E-04
Am-242m	2.755E-06	2.730E-06	2.705E-06	2.680E-06	2.620E-06	2.561E-06	2.935E-08
Am-242	3.295E-11	3.265E-11	3.235E-11	3.206E-11	3.134E-11	3.063E-11	3.511E-13
Am-243	7.446E-05	7.445E-05	7.443E-05	7.442E-05	7.439E-05	7.435E-05	6.781E-05
Cm-242	4.659E-08	8.407E-09	6.634E-09	6.498E-09	6.339E-09	6.196E-09	7.099E-11
Cm-243	4.163E-07	3.966E-07	3.778E-07	3.598E-07	3.186E-07	2.821E-07	1.257E-17
Cm-244	1.611E-05	1.492E-05	1.382E-05	1.280E-05	1.057E-05	8.733E-06	4.478E-22
Cm-245	6.576E-07	6.575E-07	6.574E-07	6.573E-07	6.571E-07	6.568E-07	6.063E-07
Cm-246	7.495E-08	7.492E-08	7.490E-08	7.488E-08	7.482E-08	7.477E-08	6.477E-08
Cm-247	6.578E-10	6.578E-10	6.578E-10	6.578E-10	6.578E-10	6.578E-10	6.578E-10
Cm-248	3.108E-11	3.109E-11	3.109E-11	3.109E-11	3.109E-11	3.109E-11	3.102E-11
Bk-249	9.528E-15	1.958E-15	4.024E-16	8.271E-17	1.584E-18	3.032E-20	0.00

TABLE F.4.e. Actinide Inventory by Isotope at 30 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Cf-249	3.118E-13	3.181E-13	3.184E-13	3.175E-13	3.144E-13	3.114E-13	4.482E-14
Cf-250	3.938E-14	3.542E-14	3.186E-14	2.865E-14	2.199E-14	1.687E-14	5.146E-24
Cf-251	1.798E-14	1.795E-14	1.792E-14	1.789E-14	1.782E-14	1.776E-14	8.333E-15
Cf-252	2.887E-15	1.707E-15	1.009E-15	5.966E-16	1.604E-16	4.311E-17	0.00
Total	9.692E-01	9.692E-01	9.692E-01	9.692E-01	9.692E-01	9.692E-01	9.692E-01

TABLE F.4.f. Actinide Inventory by Isotope at 35 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He-4	2.292E-06	2.431E-06	2.569E-06	2.708E-06	3.057E-06	3.406E-06	3.203E-05
Pb-207	8.670E-15	1.352E-14	1.951E-14	2.661E-14	4.893E-14	7.729E-14	6.044E-11
Pb-208	3.591E-11	5.479E-11	7.616E-11	9.907E-11	1.591E-10	2.192E-10	1.464E-09
Pb-212	1.538E-14	1.812E-14	1.988E-14	2.091E-14	2.160E-14	2.114E-14	2.010E-18
Bi-209	1.633E-15	2.062E-15	2.494E-15	2.930E-15	4.038E-15	5.180E-15	1.716E-11
Bi-212	1.459E-15	1.719E-15	1.886E-15	1.984E-15	2.049E-15	2.005E-15	1.906E-19
Ra-224	1.342E-13	1.581E-13	1.734E-13	1.824E-13	1.884E-13	1.844E-13	1.753E-17
Ra-226	2.389E-13	3.242E-13	4.241E-13	5.388E-13	8.928E-13	1.347E-12	3.472E-09
Ac-227	7.378E-14	9.394E-14	1.133E-13	1.319E-13	1.754E-13	2.151E-13	3.939E-12
Th-228	2.605E-11	3.065E-11	3.362E-11	3.537E-11	3.659E-11	3.580E-11	3.407E-15
Th-229	2.480E-12	2.497E-12	2.517E-12	2.540E-12	2.608E-12	2.693E-12	6.556E-10
Th-230	4.428E-09	5.245E-09	6.082E-09	6.938E-09	9.161E-09	1.150E-08	9.541E-07
Th-231	2.288E-14	2.288E-14	2.288E-14	2.288E-14	2.289E-14	2.289E-14	2.344E-14
Th-232	1.086E-09	1.307E-09	1.529E-09	1.751E-09	2.305E-09	2.860E-09	1.150E-07
Th-234	1.371E-11	1.371E-11	1.371E-11	1.371E-11	1.371E-11	1.371E-11	1.371E-11
Pa-231	6.078E-10	6.187E-10	6.296E-10	6.405E-10	6.677E-10	6.949E-10	6.030E-09
Pa-233	1.638E-11	1.642E-11	1.647E-11	1.654E-11	1.672E-11	1.695E-11	5.372E-11
U-232	1.290E-09	1.370E-09	1.408E-09	1.421E-09	1.398E-09	1.345E-09	1.269E-13
U-233	1.859E-09	2.183E-09	2.508E-09	2.834E-09	3.613E-09	4.402E-09	3.691E-07
U-234	1.449E-04	1.484E-04	1.519E-04	1.554E-04	1.637E-04	1.718E-04	3.726E-04
U-235	5.627E-03	5.627E-03	5.627E-03	5.628E-03	5.628E-03	5.629E-03	5.764E-03
U-236	3.807E-03	3.808E-03	3.808E-03	3.809E-03	3.810E-03	3.812E-03	4.049E-03
U-237	3.267E-11	2.967E-11	2.694E-11	2.447E-11	1.924E-11	1.512E-11	7.310E-17
U-238	9.443E-01	9.443E-01	9.443E-01	9.443E-01	9.443E-01	9.443E-01	9.443E-01
Np-235	1.984E-13	5.525E-14	1.539E-14	4.285E-15	1.753E-16	7.175E-18	0.00
Np-236	3.476E-10	3.476E-10	3.476E-10	3.476E-10	3.476E-10	3.476E-10	3.455E-10
Np-237	4.822E-04	4.835E-04	4.850E-04	4.869E-04	4.924E-04	4.991E-04	1.582E-03
Np-238	5.681E-13	5.630E-13	5.579E-13	5.528E-13	5.403E-13	5.281E-13	6.053E-15
Np-239	1.077E-10	1.077E-10	1.077E-10	1.077E-10	1.076E-10	1.076E-10	9.810E-11
Pu-236	2.796E-10	1.720E-10	1.057E-10	6.502E-11	1.928E-11	5.718E-12	7.710E-16
Pu-238	2.301E-04	2.266E-04	2.230E-04	2.196E-04	2.111E-04	2.030E-04	1.227E-07
Pu-239	4.926E-03	4.925E-03	4.925E-03	4.925E-03	4.924E-03	4.924E-03	4.798E-03
Pu-240	2.420E-03	2.422E-03	2.424E-03	2.425E-03	2.428E-03	2.431E-03	2.207E-03
Pu-241	1.055E-03	9.582E-04	8.702E-04	7.903E-04	6.213E-04	4.884E-04	2.364E-09
Pu-242	5.678E-04	5.678E-04	5.678E-04	5.678E-04	5.678E-04	5.678E-04	5.674E-04
Pu-244	2.786E-08	2.786E-08	2.786E-08	2.786E-08	2.786E-08	2.786E-08	2.786E-08
Am-241	3.564E-04	4.520E-04	5.383E-04	6.163E-04	7.798E-04	9.059E-04	2.932E-04
Am-242m	3.030E-06	3.003E-06	2.975E-06	2.948E-06	2.882E-06	2.817E-06	3.229E-08
Am-242	3.625E-11	3.592E-11	3.559E-11	3.527E-11	3.447E-11	3.370E-11	3.862E-13
Am-243	1.253E-04	1.253E-04	1.253E-04	1.253E-04	1.252E-04	1.252E-04	1.142E-04
Cm-242	6.025E-08	9.653E-09	7.316E-09	7.149E-09	6.973E-09	6.816E-09	7.809E-11
Cm-243	6.603E-07	6.290E-07	5.991E-07	5.707E-07	5.053E-07	4.475E-07	1.994E-17
Cm-244	3.354E-05	3.107E-05	2.878E-05	2.666E-05	2.202E-05	1.818E-05	9.322E-22
Cm-245	1.536E-06	1.536E-06	1.535E-06	1.535E-06	1.534E-06	1.534E-06	1.416E-06
Cm-246	2.197E-07	2.197E-07	2.196E-07	2.195E-07	2.194E-07	2.192E-07	1.899E-07
Cm-247	2.345E-09	2.345E-09	2.345E-09	2.345E-09	2.345E-09	2.345E-09	2.345E-09
Cm-248	1.372E-10	1.372E-10	1.372E-10	1.372E-10	1.372E-10	1.372E-10	1.369E-10
Bk-249	4.872E-14	1.001E-14	2.058E-15	4.229E-16	8.098E-18	1.551E-19	0.00

TABLE F.4.f. Actinide Inventory by Isotope at 35 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Cf-249	1.562E-12	1.594E-12	1.596E-12	1.591E-12	1.576E-12	1.560E-12	2.246E-13
Cf-250	2.162E-13	1.944E-13	1.749E-13	1.573E-13	1.207E-13	9.259E-14	3.501E-23
Cf-251	1.062E-13	1.060E-13	1.059E-13	1.057E-13	1.053E-13	1.049E-13	4.923E-14
Cf-252	2.118E-14	1.252E-14	7.404E-15	4.377E-15	1.177E-15	3.163E-16	0.00
Total	9.641E-01	9.641E-01	9.641E-01	9.641E-01	9.641E-01	9.641E-01	9.641E-01

TABLE F.5.a. Fission Product Inventory by Element at 10 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H	1.029E-08	9.200E-09	8.223E-09	7.350E-09	5.552E-09	4.193E-09	5.414E-33
Li	1.027E-10	1.027E-10	1.027E-10	1.027E-10	1.027E-10	1.027E-10	1.027E-10
Be	4.559E-11	4.559E-11	4.559E-11	4.559E-11	4.559E-11	4.559E-11	4.557E-11
C	8.008E-12	8.006E-12	8.004E-12	8.002E-12	7.997E-12	7.993E-12	7.099E-12
Zn	1.138E-14	1.138E-14	1.138E-14	1.138E-14	1.138E-14	1.138E-14	1.138E-14
Ga	2.029E-13	2.029E-13	2.029E-13	2.029E-13	2.029E-13	2.029E-13	2.029E-13
Ge	2.003E-07	2.003E-07	2.003E-07	2.003E-07	2.003E-07	2.003E-07	2.003E-07
As	5.944E-08	5.944E-08	5.944E-08	5.944E-08	5.944E-08	5.944E-08	5.944E-08
Se	1.846E-05	1.846E-05	1.846E-05	1.846E-05	1.846E-05	1.846E-05	1.844E-05
Br	7.261E-06	7.261E-06	7.261E-06	7.261E-06	7.261E-06	7.261E-06	7.280E-06
Kr	1.252E-04	1.245E-04	1.240E-04	1.235E-04	1.226E-04	1.219E-04	1.200E-04
Rb	1.240E-04	1.246E-04	1.252E-04	1.257E-04	1.266E-04	1.273E-04	1.291E-04
Sr	2.844E-04	2.770E-04	2.699E-04	2.632E-04	2.476E-04	2.338E-04	1.247E-04
Y	1.640E-04	1.640E-04	1.640E-04	1.640E-04	1.640E-04	1.640E-04	1.640E-04
Zr	1.206E-03	1.213E-03	1.220E-03	1.227E-03	1.243E-03	1.256E-03	1.366E-03
Nb	1.142E-09	1.362E-09	1.582E-09	1.802E-09	2.353E-09	2.903E-09	1.108E-07
Mo	1.034E-03	1.034E-03	1.034E-03	1.034E-03	1.034E-03	1.034E-03	1.034E-03
Tc	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.544E-04
Ru	5.782E-04	5.777E-04	5.776E-04	5.776E-04	5.776E-04	5.776E-04	5.784E-04
Rh	1.564E-04	1.564E-04	1.564E-04	1.564E-04	1.564E-04	1.564E-04	1.564E-04
Pd	2.311E-04	2.316E-04	2.317E-04	2.317E-04	2.317E-04	2.317E-04	2.317E-04
Ag	1.407E-05	1.406E-05	1.406E-05	1.406E-05	1.406E-05	1.406E-05	1.407E-05
Cd	1.610E-05	1.610E-05	1.610E-05	1.609E-05	1.609E-05	1.608E-05	1.607E-05
In	1.271E-06	1.274E-06	1.276E-06	1.279E-06	1.284E-06	1.288E-06	1.303E-06
Sn	2.085E-05	2.085E-05	2.085E-05	2.085E-05	2.085E-05	2.085E-05	2.080E-05
Sb	5.193E-06	4.958E-06	4.815E-06	4.729E-06	4.634E-06	4.607E-06	4.596E-06
Te	1.314E-04	1.317E-04	1.318E-04	1.319E-04	1.320E-04	1.320E-04	1.321E-04
I	6.334E-05	6.334E-05	6.334E-05	6.334E-05	6.334E-05	6.334E-05	6.334E-05
Xe	1.418E-03	1.418E-03	1.418E-03	1.418E-03	1.418E-03	1.418E-03	1.418E-03
Cs	9.402E-04	9.258E-04	9.123E-04	8.997E-04	8.707E-04	8.451E-04	6.359E-04
Ba	4.863E-04	5.008E-04	5.142E-04	5.269E-04	5.558E-04	5.815E-04	7.907E-04
La	3.832E-04	3.832E-04	3.832E-04	3.832E-04	3.832E-04	3.832E-04	3.832E-04
Ce	7.411E-04	7.403E-04	7.401E-04	7.401E-04	7.401E-04	7.401E-04	7.401E-04
Pr	3.555E-04	3.555E-04	3.555E-04	3.555E-04	3.555E-04	3.555E-04	3.555E-04
Nd	1.266E-03	1.267E-03	1.267E-03	1.267E-03	1.267E-03	1.267E-03	1.267E-03
Pm	1.399E-05	8.249E-06	4.863E-06	2.867E-06	7.651E-07	2.042E-07	0.00
Sm	2.596E-04	2.652E-04	2.685E-04	2.704E-04	2.722E-04	2.725E-04	2.657E-04
Eu	2.388E-05	2.346E-05	2.313E-05	2.289E-05	2.254E-05	2.242E-05	2.873E-05
Gd	1.134E-05	1.187E-05	1.231E-05	1.266E-05	1.329E-05	1.367E-05	1.435E-05
Tb	4.112E-07	4.112E-07	4.112E-07	4.112E-07	4.112E-07	4.112E-07	4.112E-07
Dy	1.888E-07	1.888E-07	1.888E-07	1.888E-07	1.888E-07	1.888E-07	1.888E-07
Ho	1.196E-08	1.196E-08	1.196E-08	1.196E-08	1.196E-08	1.196E-08	1.194E-08
Er	5.282E-09	5.282E-09	5.282E-09	5.282E-09	5.282E-09	5.282E-09	5.300E-09
Tm	1.502E-12	1.502E-12	1.502E-12	1.502E-12	1.502E-12	1.502E-12	1.502E-12
Yb	1.355E-13	1.356E-13	1.356E-13	1.356E-13	1.356E-13	1.356E-13	1.356E-13
Total	1.034E-02	1.034E-02	1.034E-02	1.034E-02	1.034E-02	1.034E-02	1.034E-02

TABLE F.5.b. Fission Product Inventory by Element at 15 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H	1.589E-08	1.420E-08	1.269E-08	1.135E-08	8.570E-09	6.472E-09	8.349E-33
Li	1.336E-10	1.336E-10	1.336E-10	1.336E-10	1.336E-10	1.336E-10	1.336E-10
Be	6.820E-11	6.820E-11	6.820E-11	6.820E-11	6.820E-11	6.820E-11	6.817E-11
C	1.198E-11	1.198E-11	1.197E-11	1.197E-11	1.196E-11	1.196E-11	1.062E-11
Zn	1.617E-14	1.617E-14	1.617E-14	1.617E-14	1.617E-14	1.617E-14	1.617E-14
Ga	3.289E-13	3.289E-13	3.289E-13	3.289E-13	3.289E-13	3.289E-13	3.289E-13
Ge	2.966E-07	2.966E-07	2.966E-07	2.966E-07	2.966E-07	2.966E-07	2.966E-07
As	8.843E-08	8.843E-08	8.843E-08	8.843E-08	8.843E-08	8.843E-08	8.843E-08
Se	2.707E-05	2.707E-05	2.707E-05	2.707E-05	2.707E-05	2.707E-05	2.704E-05
Br	1.061E-05	1.061E-05	1.061E-05	1.061E-05	1.061E-05	1.061E-05	1.064E-05
Kr	1.804E-04	1.795E-04	1.787E-04	1.781E-04	1.767E-04	1.757E-04	1.731E-04
Rb	1.781E-04	1.790E-04	1.798E-04	1.805E-04	1.818E-04	1.828E-04	1.854E-04
Sr	4.072E-04	3.966E-04	3.864E-04	3.768E-04	3.546E-04	3.348E-04	1.787E-04
Y	2.347E-04	2.347E-04	2.347E-04	2.347E-04	2.347E-04	2.347E-04	2.346E-04
Zr	1.758E-03	1.768E-03	1.779E-03	1.788E-03	1.810E-03	1.830E-03	1.986E-03
Nb	1.722E-09	2.041E-09	2.362E-09	2.682E-09	3.483E-09	4.284E-09	1.612E-07
Mo	1.540E-03	1.540E-03	1.540E-03	1.540E-03	1.540E-03	1.540E-03	1.540E-03
Tc	3.764E-04	3.764E-04	3.764E-04	3.764E-04	3.763E-04	3.763E-04	3.751E-04
Ru	8.997E-04	8.988E-04	8.986E-04	8.986E-04	8.985E-04	8.986E-04	8.998E-04
Rh	2.318E-04	2.318E-04	2.318E-04	2.318E-04	2.318E-04	2.318E-04	2.318E-04
Pd	4.221E-04	4.229E-04	4.232E-04	4.232E-04	4.232E-04	4.232E-04	4.232E-04
Ag	2.579E-05	2.579E-05	2.579E-05	2.579E-05	2.579E-05	2.579E-05	2.580E-05
Cd	2.887E-05	2.886E-05	2.886E-05	2.885E-05	2.884E-05	2.884E-05	2.881E-05
In	1.596E-06	1.601E-06	1.605E-06	1.610E-06	1.618E-06	1.625E-06	1.651E-06
Sn	3.306E-05	3.306E-05	3.306E-05	3.306E-05	3.306E-05	3.306E-05	3.299E-05
Sb	8.052E-06	7.672E-06	7.442E-06	7.302E-06	7.149E-06	7.105E-06	7.088E-06
Te	2.033E-04	2.037E-04	2.039E-04	2.041E-04	2.042E-04	2.043E-04	2.043E-04
I	9.875E-05	9.875E-05	9.875E-05	9.875E-05	9.875E-05	9.875E-05	9.875E-05
Xe	2.194E-03	2.194E-03	2.194E-03	2.194E-03	2.194E-03	2.194E-03	2.194E-03
Cs	1.341E-03	1.319E-03	1.298E-03	1.279E-03	1.236E-03	1.197E-03	8.829E-04
Ba	7.351E-04	7.574E-04	7.779E-04	7.971E-04	8.406E-04	8.792E-04	1.193E-03
La	5.682E-04	5.682E-04	5.682E-04	5.682E-04	5.682E-04	5.682E-04	5.682E-04
Ce	1.101E-03	1.100E-03	1.100E-03	1.100E-03	1.100E-03	1.100E-03	1.100E-03
Pr	5.267E-04	5.267E-04	5.267E-04	5.267E-04	5.267E-04	5.267E-04	5.267E-04
Nd	1.876E-03	1.877E-03	1.877E-03	1.877E-03	1.877E-03	1.877E-03	1.877E-03
Pm	1.889E-05	1.113E-05	6.564E-06	3.870E-06	1.033E-06	2.756E-07	0.00
Sm	3.838E-04	3.914E-04	3.959E-04	3.984E-04	4.010E-04	4.014E-04	3.939E-04
Eu	4.354E-05	4.251E-05	4.169E-05	4.104E-05	3.995E-05	3.938E-05	4.564E-05
Gd	2.262E-05	2.378E-05	2.473E-05	2.550E-05	2.690E-05	2.777E-05	2.935E-05
Tb	7.645E-07	7.645E-07	7.645E-07	7.645E-07	7.645E-07	7.645E-07	7.645E-07
Dy	3.648E-07	3.648E-07	3.648E-07	3.648E-07	3.648E-07	3.648E-07	3.648E-07
Ho	2.595E-08	2.595E-08	2.595E-08	2.595E-08	2.595E-08	2.595E-08	2.589E-08
Er	1.053E-08	1.053E-08	1.053E-08	1.053E-08	1.053E-08	1.053E-08	1.059E-08
Tm	5.106E-12	5.105E-12	5.105E-12	5.105E-12	5.105E-12	5.105E-12	5.105E-12
Yb	7.166E-13	7.170E-13	7.173E-13	7.174E-13	7.174E-13	7.175E-13	7.175E-13
Total	1.548E-02	1.548E-02	1.548E-02	1.548E-02	1.548E-02	1.548E-02	1.548E-02

TABLE F.5.c. Fission Product Inventory by Element at 20 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H	2.170E-08	1.940E-08	1.734E-08	1.550E-08	1.170E-08	8.840E-09	1.140E-32
Li	1.545E-10	1.545E-10	1.545E-10	1.545E-10	1.545E-10	1.545E-10	1.545E-10
Be	9.071E-11	9.071E-11	9.071E-11	9.071E-11	9.071E-11	9.071E-11	9.067E-11
C	1.593E-11	1.593E-11	1.593E-11	1.592E-11	1.591E-11	1.590E-11	1.413E-11
Zn	2.052E-14	2.052E-14	2.052E-14	2.052E-14	2.052E-14	2.052E-14	2.052E-14
Ga	4.633E-13	4.633E-13	4.633E-13	4.633E-13	4.633E-13	4.633E-13	4.633E-13
Ge	3.907E-07	3.907E-07	3.907E-07	3.907E-07	3.907E-07	3.907E-07	3.907E-07
As	1.169E-07	1.169E-07	1.169E-07	1.169E-07	1.169E-07	1.169E-07	1.169E-07
Se	3.533E-05	3.533E-05	3.533E-05	3.533E-05	3.533E-05	3.533E-05	3.529E-05
Br	1.379E-05	1.379E-05	1.379E-05	1.379E-05	1.379E-05	1.379E-05	1.383E-05
Kr	2.321E-04	2.309E-04	2.299E-04	2.290E-04	2.273E-04	2.260E-04	2.226E-04
Rb	2.282E-04	2.293E-04	2.303E-04	2.312E-04	2.330E-04	2.343E-04	2.376E-04
Sr	5.203E-04	5.068E-04	4.938E-04	4.815E-04	4.531E-04	4.279E-04	2.287E-04
Y	2.997E-04	2.997E-04	2.997E-04	2.997E-04	2.997E-04	2.996E-04	2.996E-04
Zr	2.284E-03	2.297E-03	2.310E-03	2.323E-03	2.351E-03	2.376E-03	2.575E-03
Nb	2.299E-09	2.712E-09	3.127E-09	3.543E-09	4.581E-09	5.620E-09	2.091E-07
Mo	2.040E-03	2.040E-03	2.040E-03	2.040E-03	2.040E-03	2.040E-03	2.040E-03
Tc	4.930E-04	4.930E-04	4.930E-04	4.930E-04	4.930E-04	4.929E-04	4.914E-04
Ru	1.239E-03	1.237E-03	1.237E-03	1.237E-03	1.237E-03	1.237E-03	1.239E-03
Rh	3.019E-04	3.019E-04	3.019E-04	3.019E-04	3.019E-04	3.019E-04	3.019E-04
Pd	6.550E-04	6.564E-04	6.567E-04	6.568E-04	6.568E-04	6.568E-04	6.568E-04
Ag	3.934E-05	3.934E-05	3.934E-05	3.934E-05	3.934E-05	3.934E-05	3.935E-05
Cd	4.528E-05	4.528E-05	4.527E-05	4.527E-05	4.525E-05	4.524E-05	4.520E-05
In	1.810E-06	1.817E-06	1.824E-06	1.830E-06	1.843E-06	1.854E-06	1.892E-06
Sn	4.614E-05	4.614E-05	4.614E-05	4.614E-05	4.614E-05	4.614E-05	4.604E-05
Sb	1.102E-05	1.049E-05	1.017E-05	9.969E-06	9.754E-06	9.692E-06	9.668E-06
Te	2.778E-04	2.783E-04	2.786E-04	2.788E-04	2.791E-04	2.791E-04	2.792E-04
I	1.354E-04	1.354E-04	1.354E-04	1.354E-04	1.354E-04	1.354E-04	1.354E-04
Xe	2.994E-03	2.994E-03	2.994E-03	2.994E-03	2.994E-03	2.994E-03	2.994E-03
Cs	1.714E-03	1.684E-03	1.656E-03	1.630E-03	1.572E-03	1.520E-03	1.101E-03
Ba	9.884E-04	1.019E-03	1.047E-03	1.073E-03	1.131E-03	1.182E-03	1.602E-03
La	7.499E-04	7.499E-04	7.499E-04	7.499E-04	7.499E-04	7.499E-04	7.499E-04
Ce	1.456E-03	1.455E-03	1.454E-03	1.454E-03	1.454E-03	1.454E-03	1.454E-03
Pr	6.939E-04	6.939E-04	6.939E-04	6.939E-04	6.939E-04	6.939E-04	6.939E-04
Nd	2.475E-03	2.476E-03	2.476E-03	2.476E-03	2.476E-03	2.476E-03	2.476E-03
Pm	2.272E-05	1.340E-05	7.898E-06	4.656E-06	1.243E-06	3.316E-07	0.00
Sm	5.026E-04	5.118E-04	5.171E-04	5.202E-04	5.233E-04	5.239E-04	5.156E-04
Eu	6.724E-05	6.532E-05	6.376E-05	6.251E-05	6.032E-05	5.907E-05	6.475E-05
Gd	3.881E-05	4.088E-05	4.257E-05	4.397E-05	4.649E-05	4.807E-05	5.097E-05
Tb	1.198E-06	1.198E-06	1.198E-06	1.198E-06	1.198E-06	1.198E-06	1.198E-06
Dy	5.920E-07	5.920E-07	5.920E-07	5.920E-07	5.920E-07	5.920E-07	5.920E-07
Ho	4.674E-08	4.674E-08	4.674E-08	4.674E-08	4.674E-08	4.674E-08	4.661E-08
Er	1.822E-08	1.823E-08	1.823E-08	1.823E-08	1.823E-08	1.823E-08	1.836E-08
Tm	1.214E-11	1.214E-11	1.213E-11	1.213E-11	1.213E-11	1.213E-11	1.213E-11
Yb	2.360E-12	2.362E-12	2.363E-12	2.363E-12	2.364E-12	2.364E-12	2.364E-12
Total	2.060E-02	2.060E-02	2.060E-02	2.060E-02	2.060E-02	2.060E-02	2.060E-02

TABLE F.5.d. Fission Product Inventory by Element at 25 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H	2.772E-08	2.478E-08	2.215E-08	1.979E-08	1.495E-08	1.129E-08	1.456E-32
Li	1.671E-10	1.671E-10	1.671E-10	1.671E-10	1.671E-10	1.671E-10	1.671E-10
Be	1.131E-10	1.131E-10	1.131E-10	1.131E-10	1.131E-10	1.131E-10	1.131E-10
C	1.987E-11	1.987E-11	1.986E-11	1.986E-11	1.985E-11	1.984E-11	1.762E-11
Zn	2.447E-14	2.447E-14	2.447E-14	2.447E-14	2.447E-14	2.447E-14	2.447E-14
Ga	6.040E-13	6.040E-13	6.040E-13	6.040E-13	6.040E-13	6.040E-13	6.040E-13
Ge	4.829E-07	4.829E-07	4.829E-07	4.829E-07	4.829E-07	4.829E-07	4.829E-07
As	1.449E-07	1.449E-07	1.449E-07	1.449E-07	1.449E-07	1.449E-07	1.449E-07
Se	4.326E-05	4.326E-05	4.326E-05	4.326E-05	4.326E-05	4.326E-05	4.321E-05
Br	1.680E-05	1.680E-05	1.680E-05	1.680E-05	1.680E-05	1.680E-05	1.685E-05
Kr	2.803E-04	2.790E-04	2.777E-04	2.767E-04	2.745E-04	2.730E-04	2.689E-04
Rb	2.746E-04	2.760E-04	2.772E-04	2.783E-04	2.804E-04	2.820E-04	2.860E-04
Sr	6.244E-04	6.082E-04	5.927E-04	5.779E-04	5.439E-04	5.137E-04	2.747E-04
Y	3.594E-04	3.594E-04	3.594E-04	3.594E-04	3.594E-04	3.593E-04	3.593E-04
Zr	2.786E-03	2.802E-03	2.817E-03	2.832E-03	2.866E-03	2.896E-03	3.135E-03
Nb	2.869E-09	3.372E-09	3.877E-09	4.382E-09	5.646E-09	6.909E-09	2.545E-07
Mo	2.533E-03	2.533E-03	2.533E-03	2.533E-03	2.533E-03	2.533E-03	2.533E-03
Tc	6.047E-04	6.047E-04	6.047E-04	6.047E-04	6.047E-04	6.047E-04	6.028E-04
Ru	1.595E-03	1.593E-03	1.593E-03	1.593E-03	1.593E-03	1.593E-03	1.595E-03
Rh	3.654E-04	3.654E-04	3.654E-04	3.654E-04	3.654E-04	3.654E-04	3.654E-04
Pd	9.291E-04	9.310E-04	9.314E-04	9.316E-04	9.316E-04	9.316E-04	9.316E-04
Ag	5.426E-05	5.426E-05	5.426E-05	5.426E-05	5.426E-05	5.426E-05	5.427E-05
Cd	6.596E-05	6.595E-05	6.594E-05	6.593E-05	6.592E-05	6.590E-05	6.585E-05
In	1.954E-06	1.965E-06	1.974E-06	1.983E-06	2.001E-06	2.015E-06	2.069E-06
Sn	6.006E-05	6.005E-05	6.005E-05	6.005E-05	6.005E-05	6.005E-05	5.992E-05
Sb	1.411E-05	1.341E-05	1.299E-05	1.273E-05	1.245E-05	1.237E-05	1.234E-05
Te	3.545E-04	3.552E-04	3.556E-04	3.559E-04	3.562E-04	3.562E-04	3.564E-04
I	1.728E-04	1.728E-04	1.728E-04	1.728E-04	1.728E-04	1.728E-04	1.728E-04
Xe	3.813E-03	3.813E-03	3.813E-03	3.813E-03	3.813E-03	3.813E-03	3.813E-03
Cs	2.065E-03	2.026E-03	1.991E-03	1.958E-03	1.885E-03	1.821E-03	1.296E-03
Ba	1.247E-03	1.286E-03	1.321E-03	1.354E-03	1.427E-03	1.491E-03	2.016E-03
La	9.284E-04	9.284E-04	9.284E-04	9.284E-04	9.284E-04	9.284E-04	9.284E-04
Ce	1.807E-03	1.805E-03	1.805E-03	1.805E-03	1.805E-03	1.805E-03	1.805E-03
Pr	8.571E-04	8.571E-04	8.571E-04	8.571E-04	8.571E-04	8.571E-04	8.571E-04
Nd	3.064E-03	3.066E-03	3.066E-03	3.066E-03	3.066E-03	3.066E-03	3.066E-03
Pm	2.565E-05	1.512E-05	8.915E-06	5.256E-06	1.403E-06	3.744E-07	0.00
Sm	6.157E-04	6.261E-04	6.322E-04	6.357E-04	6.392E-04	6.399E-04	6.310E-04
Eu	9.398E-05	9.087E-05	8.834E-05	8.628E-05	8.265E-05	8.049E-05	8.512E-05
Gd	6.122E-05	6.448E-05	6.716E-05	6.936E-05	7.336E-05	7.588E-05	8.050E-05
Tb	1.711E-06	1.711E-06	1.711E-06	1.711E-06	1.711E-06	1.711E-06	1.711E-06
Dy	8.744E-07	8.744E-07	8.744E-07	8.744E-07	8.744E-07	8.744E-07	8.744E-07
Ho	7.656E-08	7.655E-08	7.655E-08	7.655E-08	7.655E-08	7.655E-08	7.629E-08
Er	2.942E-08	2.942E-08	2.942E-08	2.942E-08	2.942E-08	2.942E-08	2.969E-08
Tm	2.395E-11	2.394E-11	2.394E-11	2.393E-11	2.393E-11	2.393E-11	2.393E-11
Yb	6.055E-12	6.063E-12	6.066E-12	6.067E-12	6.069E-12	6.069E-12	6.069E-12
Total	2.572E-02	2.572E-02	2.572E-02	2.572E-02	2.572E-02	2.572E-02	2.572E-02

TABLE F.5.e. Fission Product Inventory by Element at 30 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H	3.393E-08	3.033E-08	2.711E-08	2.423E-08	1.830E-08	1.382E-08	1.781E-32
Li	1.727E-10	1.727E-10	1.727E-10	1.727E-10	1.727E-10	1.727E-10	1.727E-10
Be	1.355E-10	1.355E-10	1.355E-10	1.355E-10	1.355E-10	1.355E-10	1.354E-10
C	2.380E-11	2.379E-11	2.379E-11	2.378E-11	2.376E-11	2.375E-11	2.110E-11
Zn	2.805E-14	2.805E-14	2.805E-14	2.805E-14	2.805E-14	2.805E-14	2.805E-14
Ga	7.495E-13	7.495E-13	7.495E-13	7.495E-13	7.495E-13	7.495E-13	7.495E-13
Ge	5.736E-07	5.736E-07	5.736E-07	5.736E-07	5.736E-07	5.736E-07	5.736E-07
As	1.724E-07	1.724E-07	1.724E-07	1.724E-07	1.724E-07	1.724E-07	1.724E-07
Se	5.087E-05	5.087E-05	5.086E-05	5.086E-05	5.086E-05	5.086E-05	5.081E-05
Br	1.963E-05	1.963E-05	1.963E-05	1.963E-05	1.963E-05	1.963E-05	1.969E-05
Kr	3.254E-04	3.238E-04	3.224E-04	3.212E-04	3.187E-04	3.169E-04	3.122E-04
Rb	3.175E-04	3.191E-04	3.205E-04	3.218E-04	3.243E-04	3.260E-04	3.307E-04
Sr	7.200E-04	7.013E-04	6.834E-04	6.664E-04	6.272E-04	5.924E-04	3.172E-04
Y	4.141E-04	4.141E-04	4.141E-04	4.141E-04	4.141E-04	4.141E-04	4.140E-04
Zr	3.264E-03	3.283E-03	3.301E-03	3.318E-03	3.357E-03	3.392E-03	3.667E-03
Nb	3.431E-09	4.018E-09	4.609E-09	5.199E-09	6.676E-09	8.152E-09	2.975E-07
Mo	3.019E-03	3.019E-03	3.019E-03	3.019E-03	3.019E-03	3.019E-03	3.019E-03
Tc	7.110E-04	7.110E-04	7.110E-04	7.110E-04	7.109E-04	7.109E-04	7.087E-04
Ru	1.969E-03	1.966E-03	1.966E-03	1.966E-03	1.966E-03	1.966E-03	1.968E-03
Rh	4.209E-04	4.209E-04	4.209E-04	4.209E-04	4.209E-04	4.209E-04	4.209E-04
Pd	1.243E-03	1.246E-03	1.246E-03	1.246E-03	1.247E-03	1.247E-03	1.247E-03
Ag	7.002E-05	7.002E-05	7.002E-05	7.002E-05	7.002E-05	7.002E-05	7.004E-05
Cd	9.151E-05	9.150E-05	9.149E-05	9.147E-05	9.145E-05	9.143E-05	9.136E-05
In	2.048E-06	2.062E-06	2.075E-06	2.087E-06	2.111E-06	2.130E-06	2.203E-06
Sn	7.481E-05	7.481E-05	7.481E-05	7.481E-05	7.481E-05	7.481E-05	7.464E-05
Sb	1.731E-05	1.644E-05	1.590E-05	1.558E-05	1.523E-05	1.513E-05	1.509E-05
Te	4.333E-04	4.341E-04	4.347E-04	4.350E-04	4.354E-04	4.355E-04	4.357E-04
I	2.108E-04	2.108E-04	2.108E-04	2.108E-04	2.108E-04	2.108E-04	2.108E-04
Xe	4.647E-03	4.647E-03	4.647E-03	4.647E-03	4.647E-03	4.647E-03	4.647E-03
Cs	2.397E-03	2.348E-03	2.305E-03	2.266E-03	2.178E-03	2.101E-03	1.471E-03
Ba	1.511E-03	1.559E-03	1.602E-03	1.642E-03	1.730E-03	1.807E-03	2.437E-03
La	1.104E-03	1.104E-03	1.104E-03	1.104E-03	1.104E-03	1.104E-03	1.104E-03
Ce	2.153E-03	2.151E-03	2.151E-03	2.151E-03	2.151E-03	2.151E-03	2.151E-03
Pr	1.016E-03	1.016E-03	1.016E-03	1.016E-03	1.016E-03	1.016E-03	1.016E-03
Nd	3.644E-03	3.646E-03	3.647E-03	3.647E-03	3.647E-03	3.647E-03	3.647E-03
Pm	2.770E-05	1.633E-05	9.627E-06	5.676E-06	1.515E-06	4.043E-07	0.00
Sm	7.230E-04	7.342E-04	7.407E-04	7.445E-04	7.483E-04	7.490E-04	7.396E-04
Eu	1.227E-04	1.181E-04	1.144E-04	1.114E-04	1.060E-04	1.027E-04	1.058E-04
Gd	9.136E-05	9.607E-05	9.995E-05	1.032E-04	1.089E-04	1.126E-04	1.193E-04
Tb	2.299E-06	2.299E-06	2.299E-06	2.299E-06	2.299E-06	2.299E-06	2.299E-06
Dy	1.216E-06	1.216E-06	1.216E-06	1.216E-06	1.216E-06	1.216E-06	1.216E-06
Ho	1.186E-07	1.186E-07	1.186E-07	1.186E-07	1.186E-07	1.186E-07	1.181E-07
Er	4.576E-08	4.576E-08	4.576E-08	4.577E-08	4.577E-08	4.577E-08	4.626E-08
Tm	4.238E-11	4.236E-11	4.235E-11	4.235E-11	4.234E-11	4.234E-11	4.234E-11
Yb	1.338E-11	1.340E-11	1.341E-11	1.341E-11	1.342E-11	1.342E-11	1.342E-11
Total	3.082E-02	3.082E-02	3.082E-02	3.082E-02	3.082E-02	3.082E-02	3.082E-02

TABLE F.5.f. Fission Product Inventory by Element at 35 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H	4.032E-08	3.604E-08	3.221E-08	2.879E-08	2.174E-08	1.642E-08	2.118E-32
Li	1.740E-10	1.740E-10	1.740E-10	1.740E-10	1.740E-10	1.740E-10	1.740E-10
Be	1.577E-10	1.577E-10	1.577E-10	1.577E-10	1.577E-10	1.577E-10	1.576E-10
C	2.770E-11	2.770E-11	2.769E-11	2.768E-11	2.767E-11	2.765E-11	2.456E-11
Zn	3.127E-14	3.127E-14	3.127E-14	3.127E-14	3.127E-14	3.127E-14	3.127E-14
Ga	8.985E-13	8.985E-13	8.985E-13	8.985E-13	8.985E-13	8.985E-13	8.985E-13
Ge	6.625E-07	6.625E-07	6.625E-07	6.625E-07	6.625E-07	6.625E-07	6.625E-07
As	1.993E-07	1.993E-07	1.993E-07	1.993E-07	1.993E-07	1.993E-07	1.993E-07
Se	5.816E-05	5.816E-05	5.816E-05	5.816E-05	5.816E-05	5.816E-05	5.809E-05
Br	2.229E-05	2.229E-05	2.229E-05	2.229E-05	2.229E-05	2.229E-05	2.235E-05
Kr	3.676E-04	3.658E-04	3.642E-04	3.628E-04	3.600E-04	3.580E-04	3.527E-04
Rb	3.572E-04	3.590E-04	3.606E-04	3.620E-04	3.648E-04	3.668E-04	3.721E-04
Sr	8.076E-04	7.866E-04	7.666E-04	7.476E-04	7.037E-04	6.647E-04	3.563E-04
Y	4.641E-04	4.641E-04	4.641E-04	4.641E-04	4.641E-04	4.641E-04	4.640E-04
Zr	3.721E-03	3.742E-03	3.762E-03	3.781E-03	3.825E-03	3.863E-03	4.172E-03
Nb	3.982E-09	4.649E-09	5.321E-09	5.992E-09	7.670E-09	9.348E-09	3.382E-07
Mo	3.499E-03	3.499E-03	3.499E-03	3.499E-03	3.499E-03	3.499E-03	3.499E-03
Tc	8.118E-04	8.118E-04	8.118E-04	8.118E-04	8.118E-04	8.118E-04	8.092E-04
Ru	2.359E-03	2.356E-03	2.355E-03	2.355E-03	2.354E-03	2.354E-03	2.357E-03
Rh	4.690E-04	4.690E-04	4.690E-04	4.690E-04	4.690E-04	4.690E-04	4.690E-04
Pd	1.594E-03	1.598E-03	1.598E-03	1.599E-03	1.599E-03	1.599E-03	1.599E-03
Ag	8.639E-05	8.638E-05	8.638E-05	8.638E-05	8.638E-05	8.638E-05	8.640E-05
Cd	1.222E-04	1.222E-04	1.222E-04	1.222E-04	1.221E-04	1.221E-04	1.220E-04
In	2.123E-06	2.142E-06	2.158E-06	2.173E-06	2.205E-06	2.230E-06	2.324E-06
Sn	9.025E-05	9.025E-05	9.025E-05	9.025E-05	9.025E-05	9.025E-05	9.005E-05
Sb	2.059E-05	1.953E-05	1.888E-05	1.849E-05	1.806E-05	1.794E-05	1.789E-05
Te	5.138E-04	5.148E-04	5.155E-04	5.159E-04	5.163E-04	5.164E-04	5.167E-04
I	2.489E-04	2.489E-04	2.489E-04	2.489E-04	2.489E-04	2.489E-04	2.489E-04
Xe	5.491E-03	5.491E-03	5.491E-03	5.491E-03	5.491E-03	5.491E-03	5.491E-03
Cs	2.714E-03	2.656E-03	2.605E-03	2.559E-03	2.455E-03	2.365E-03	1.630E-03
Ba	1.780E-03	1.838E-03	1.889E-03	1.935E-03	2.038E-03	2.129E-03	2.863E-03
La	1.276E-03	1.276E-03	1.276E-03	1.276E-03	1.276E-03	1.276E-03	1.276E-03
Ce	2.496E-03	2.494E-03	2.494E-03	2.493E-03	2.493E-03	2.493E-03	2.493E-03
Pr	1.171E-03	1.171E-03	1.171E-03	1.171E-03	1.171E-03	1.171E-03	1.171E-03
Nd	4.217E-03	4.219E-03	4.219E-03	4.219E-03	4.220E-03	4.220E-03	4.220E-03
Pm	2.921E-05	1.722E-05	1.015E-05	5.985E-06	1.597E-06	4.264E-07	0.00
Sm	8.237E-04	8.356E-04	8.425E-04	8.465E-04	8.504E-04	8.512E-04	8.412E-04
Eu	1.517E-04	1.456E-04	1.405E-04	1.364E-04	1.290E-04	1.245E-04	1.259E-04
Gd	1.303E-04	1.366E-04	1.418E-04	1.461E-04	1.539E-04	1.588E-04	1.678E-04
Tb	2.963E-06	2.963E-06	2.963E-06	2.963E-06	2.963E-06	2.963E-06	2.963E-06
Dy	1.620E-06	1.620E-06	1.620E-06	1.620E-06	1.620E-06	1.620E-06	1.620E-06
Ho	1.756E-07	1.756E-07	1.756E-07	1.755E-07	1.755E-07	1.755E-07	1.747E-07
Er	6.918E-08	6.918E-08	6.919E-08	6.919E-08	6.919E-08	6.920E-08	7.004E-08
Tm	6.934E-11	6.930E-11	6.927E-11	6.926E-11	6.925E-11	6.925E-11	6.925E-11
Yb	2.641E-11	2.646E-11	2.648E-11	2.649E-11	2.650E-11	2.650E-11	2.650E-11
Total	3.590E-02	3.590E-02	3.590E-02	3.590E-02	3.590E-02	3.590E-02	3.590E-02

TABLE F.6.a. Actinide Inventory by Element at 10 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He	1.146E-07	1.270E-07	1.400E-07	1.536E-07	1.901E-07	2.293E-07	6.024E-06
Pb	4.255E-12	6.048E-12	7.962E-12	9.939E-12	1.494E-11	1.984E-11	6.340E-10
Ra	3.723E-13	5.035E-13	6.543E-13	8.250E-13	1.339E-12	1.980E-12	2.324E-09
Ac	5.780E-14	7.434E-14	9.138E-14	1.089E-13	1.545E-13	2.025E-13	1.249E-11
Th	7.277E-09	8.531E-09	9.786E-09	1.104E-08	1.419E-08	1.733E-08	6.545E-07
Pa	4.825E-10	5.203E-10	5.581E-10	5.959E-10	6.904E-10	7.848E-10	1.913E-08
U	9.853E-01	9.853E-01	9.853E-01	9.853E-01	9.853E-01	9.853E-01	9.854E-01
Np	7.524E-05	7.547E-05	7.575E-05	7.606E-05	7.700E-05	7.812E-05	2.548E-04
Pu	4.237E-03	4.221E-03	4.207E-03	4.194E-03	4.167E-03	4.145E-03	3.902E-03
Am	6.714E-05	8.203E-05	9.548E-05	1.076E-04	1.331E-04	1.527E-04	4.876E-05
Cm	6.770E-08	6.083E-08	5.656E-08	5.268E-08	4.416E-08	3.709E-08	8.104E-10
Total	9.896E-01	9.896E-01	9.896E-01	9.896E-01	9.896E-01	9.896E-01	9.896E-01

TABLE F.6.b. Actinide Inventory by Element at 15 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He	3.171E-07	3.419E-07	3.680E-07	3.955E-07	4.692E-07	5.485E-07	1.117E-05
Pb	8.046E-12	1.167E-11	1.562E-11	1.974E-11	3.028E-11	4.067E-11	7.349E-10
Ra	3.599E-13	4.832E-13	6.241E-13	7.830E-13	1.261E-12	1.857E-12	2.335E-09
Ac	6.471E-14	8.270E-14	1.008E-13	1.190E-13	1.650E-13	2.115E-13	1.015E-11
Th	6.945E-09	8.158E-09	9.374E-09	1.059E-08	1.365E-08	1.672E-08	6.820E-07
Pa	5.351E-10	5.656E-10	5.960E-10	6.265E-10	7.025E-10	7.785E-10	1.556E-08
U	9.786E-01	9.786E-01	9.786E-01	9.786E-01	9.786E-01	9.786E-01	9.789E-01
Np	1.407E-04	1.412E-04	1.418E-04	1.425E-04	1.445E-04	1.469E-04	5.307E-04
Pu	5.611E-03	5.577E-03	5.546E-03	5.517E-03	5.457E-03	5.409E-03	4.998E-03
Am	1.446E-04	1.774E-04	2.070E-04	2.337E-04	2.897E-04	3.329E-04	1.089E-04
Cm	5.439E-07	4.988E-07	4.636E-07	4.313E-07	3.604E-07	3.016E-07	1.048E-08
Total	9.845E-01	9.845E-01	9.845E-01	9.845E-01	9.845E-01	9.845E-01	9.845E-01

TABLE F.6.c. Actinide Inventory by Element at 20 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He	6.508E-07	6.925E-07	7.360E-07	7.813E-07	9.012E-07	1.029E-06	1.629E-05
Pb	1.312E-11	1.934E-11	2.619E-11	3.340E-11	5.201E-11	7.046E-11	9.184E-10
Ra	3.538E-13	4.708E-13	6.031E-13	7.514E-13	1.196E-12	1.750E-12	2.465E-09
Ac	6.954E-14	8.856E-14	1.074E-13	1.260E-13	1.718E-13	2.167E-13	8.153E-12
Th	6.608E-09	7.779E-09	8.956E-09	1.014E-08	1.311E-08	1.612E-08	7.401E-07
Pa	5.740E-10	5.981E-10	6.222E-10	6.464E-10	7.066E-10	7.669E-10	1.251E-08
U	9.722E-01	9.722E-01	9.722E-01	9.722E-01	9.722E-01	9.722E-01	9.725E-01
Np	2.173E-04	2.180E-04	2.189E-04	2.199E-04	2.229E-04	2.265E-04	8.003E-04
Pu	6.725E-03	6.674E-03	6.627E-03	6.585E-03	6.494E-03	6.422E-03	5.847E-03
Am	2.240E-04	2.731E-04	3.174E-04	3.575E-04	4.414E-04	5.061E-04	1.708E-04
Cm	2.341E-06	2.162E-06	2.010E-06	1.869E-06	1.561E-06	1.306E-06	6.079E-08
Cf	4.907E-15	4.942E-15	4.903E-15	4.854E-15	4.738E-15	4.640E-15	6.910E-16
Total	9.794E-01	9.794E-01	9.794E-01	9.794E-01	9.794E-01	9.794E-01	9.794E-01

TABLE F.6.d. Actinide Inventory by Element at 25 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He	1.099E-06	1.163E-06	1.230E-06	1.298E-06	1.476E-06	1.661E-06	2.138E-05
Pb	1.951E-11	2.914E-11	3.985E-11	5.123E-11	8.074E-11	1.101E-10	1.190E-09
Bi	1.418E-15	1.711E-15	1.963E-15	2.188E-15	2.683E-15	3.155E-15	1.126E-11
Ra	3.540E-13	4.665E-13	5.916E-13	7.305E-13	1.144E-12	1.661E-12	2.706E-09
Ac	7.258E-14	9.230E-14	1.116E-13	1.304E-13	1.757E-13	2.189E-13	6.464E-12
Th	6.262E-09	7.392E-09	8.530E-09	9.676E-09	1.258E-08	1.554E-08	8.260E-07
Pa	6.014E-10	6.203E-10	6.391E-10	6.579E-10	7.049E-10	7.520E-10	9.928E-09
U	9.660E-01	9.660E-01	9.660E-01	9.660E-01	9.660E-01	9.660E-01	9.664E-01
Np	3.017E-04	3.027E-04	3.038E-04	3.051E-04	3.090E-04	3.137E-04	1.062E-03
Pu	7.666E-03	7.599E-03	7.537E-03	7.482E-03	7.363E-03	7.268E-03	6.533E-03
Am	3.037E-04	3.682E-04	4.264E-04	4.790E-04	5.892E-04	6.741E-04	2.378E-04
Cm	7.115E-06	6.591E-06	6.129E-06	5.701E-06	4.765E-06	3.990E-06	2.308E-07
Bk	1.345E-15	2.764E-16	5.681E-17	1.168E-17	2.236E-19	4.289E-21	1.447E-29
Cf	5.270E-14	5.297E-14	5.248E-14	5.189E-14	5.054E-14	4.942E-14	7.476E-15
Total	9.743E-01	9.743E-01	9.743E-01	9.743E-01	9.743E-01	9.743E-01	9.743E-01

TABLE F.6.e. Actinide Inventory by Element at 30 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He	1.651E-06	1.747E-06	1.844E-06	1.943E-06	2.195E-06	2.454E-06	2.672E-05
Pb	2.717E-11	4.107E-11	5.669E-11	7.335E-11	1.168E-10	1.602E-10	1.555E-09
Bi	2.156E-15	2.622E-15	3.025E-15	3.383E-15	4.170E-15	4.912E-15	1.428E-11
Ra	3.606E-13	4.706E-13	5.899E-13	7.206E-13	1.106E-12	1.587E-12	3.046E-09
Ac	7.401E-14	9.415E-14	1.136E-13	1.325E-13	1.771E-13	2.187E-13	5.068E-12
Th	5.908E-09	6.994E-09	8.093E-09	9.205E-09	1.204E-08	1.496E-08	9.374E-07
Pa	6.193E-10	6.337E-10	6.482E-10	6.626E-10	6.988E-10	7.349E-10	7.800E-09
U	9.598E-01	9.598E-01	9.599E-01	9.599E-01	9.599E-01	9.599E-01	9.604E-01
Np	3.922E-04	3.934E-04	3.947E-04	3.963E-04	4.011E-04	4.068E-04	1.330E-03
Pu	8.504E-03	8.420E-03	8.344E-03	8.274E-03	8.126E-03	8.008E-03	7.113E-03
Am	3.909E-04	4.714E-04	5.441E-04	6.098E-04	7.474E-04	8.535E-04	3.177E-04
Cm	1.731E-05	1.606E-05	1.494E-05	1.390E-05	1.163E-05	9.753E-06	6.719E-07
Bk	9.528E-15	1.958E-15	4.024E-16	8.271E-17	1.584E-18	3.032E-20	1.446E-28
Cf	3.721E-13	3.732E-13	3.692E-13	3.646E-13	3.544E-13	3.460E-13	5.316E-14
Total	9.692E-01	9.692E-01	9.692E-01	9.692E-01	9.692E-01	9.692E-01	9.692E-01

TABLE F.6.f. Actinide Inventory by Element at 35 MWd/kgM, g/gU

Element	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
He	2.292E-06	2.431E-06	2.569E-06	2.708E-06	3.057E-06	3.406E-06	3.203E-05
Pb	3.593E-11	5.482E-11	7.620E-11	9.912E-11	1.592E-10	2.193E-10	1.999E-09
Bi	3.093E-15	3.781E-15	4.380E-15	4.915E-15	6.089E-15	7.187E-15	1.719E-11
Ra	3.732E-13	4.824E-13	5.976E-13	7.214E-13	1.082E-12	1.532E-12	3.472E-09
Ac	7.379E-14	9.394E-14	1.133E-13	1.319E-13	1.754E-13	2.151E-13	3.942E-12
Th	5.556E-09	6.600E-09	7.661E-09	8.741E-09	1.152E-08	1.441E-08	1.070E-06
Pa	6.242E-10	6.352E-10	6.461E-10	6.571E-10	6.844E-10	7.119E-10	6.084E-09
U	9.539E-01	9.539E-01	9.539E-01	9.539E-01	9.539E-01	9.539E-01	9.545E-01
Np	4.822E-04	4.835E-04	4.850E-04	4.869E-04	4.924E-04	4.991E-04	1.582E-03
Pu	9.198E-03	9.100E-03	9.010E-03	8.928E-03	8.753E-03	8.614E-03	7.572E-03
Am	4.848E-04	5.803E-04	6.666E-04	7.446E-04	9.079E-04	1.034E-03	4.073E-04
Cm	3.602E-05	3.347E-05	3.114E-05	2.899E-05	2.428E-05	2.039E-05	1.608E-06
Bk	4.872E-14	1.001E-14	2.058E-15	4.229E-16	8.098E-18	1.551E-19	9.839E-28
Cf	1.905E-12	1.907E-12	1.884E-12	1.858E-12	1.803E-12	1.758E-12	2.738E-13
Total	9.641E-01	9.641E-01	9.641E-01	9.641E-01	9.641E-01	9.641E-01	9.641E-01

TABLE F.7.a. Fuel Activation Product Inventory by Isotope at
10 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	2.798E-09	2.798E-09	2.798E-09	2.798E-09	2.798E-09	2.798E-09	2.798E-09
H-2	6.594E-13	6.594E-13	6.594E-13	6.594E-13	6.594E-13	6.594E-13	6.594E-13
He-4	4.761E-07	4.761E-07	4.761E-07	4.761E-07	4.761E-07	4.761E-07	4.761E-07
Li-6	1.666E-15	1.666E-15	1.666E-15	1.666E-15	1.666E-15	1.666E-15	1.666E-15
Be-9	2.986E-11	2.986E-11	2.986E-11	2.986E-11	2.986E-11	2.986E-11	2.986E-11
Be-10	3.278E-12	3.278E-12	3.278E-12	3.278E-12	3.278E-12	3.278E-12	3.276E-12
B-11	2.926E-09	2.926E-09	2.926E-09	2.926E-09	2.926E-09	2.926E-09	2.926E-09
C-12	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05
C-13	1.782E-06	1.782E-06	1.782E-06	1.782E-06	1.782E-06	1.782E-06	1.782E-06
C-14	4.006E-08	4.005E-08	4.004E-08	4.003E-08	4.001E-08	3.998E-08	3.551E-08
N-14	2.596E-05	2.596E-05	2.596E-05	2.596E-05	2.596E-05	2.596E-05	2.596E-05
N-15	1.043E-07	1.043E-07	1.043E-07	1.043E-07	1.043E-07	1.043E-07	1.043E-07
O-16	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01
O-17	5.428E-05	5.428E-05	5.428E-05	5.428E-05	5.428E-05	5.428E-05	5.428E-05
O-18	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04
F-19	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06
Ne-20	5.143E-11	5.143E-11	5.143E-11	5.143E-11	5.143E-11	5.143E-11	5.143E-11
Ne-21	6.896E-16	6.896E-16	6.896E-16	6.896E-16	6.896E-16	6.896E-16	6.896E-16
Ne-22	4.307E-16	4.307E-16	4.307E-16	4.307E-16	4.307E-16	4.307E-16	4.307E-16
Mg-24	3.388E-11	3.388E-11	3.388E-11	3.388E-11	3.388E-11	3.388E-11	3.388E-11
Mg-25	3.561E-11	3.561E-11	3.561E-11	3.561E-11	3.561E-11	3.561E-11	3.561E-11
Mg-26	1.624E-11	1.624E-11	1.624E-11	1.624E-11	1.624E-11	1.624E-11	1.624E-11
Al-27	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05
Si-28	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05
Si-29	1.752E-06	1.752E-06	1.752E-06	1.752E-06	1.752E-06	1.752E-06	1.752E-06
Si-30	1.201E-06	1.201E-06	1.201E-06	1.201E-06	1.201E-06	1.201E-06	1.201E-06
P-31	9.972E-11	9.972E-11	9.972E-11	9.972E-11	9.972E-11	9.972E-11	9.972E-11
S-32	3.809E-11	3.809E-11	3.809E-11	3.809E-11	3.809E-11	3.809E-11	3.809E-11
S-33	6.724E-15	6.724E-15	6.724E-15	6.724E-15	6.724E-15	6.724E-15	6.724E-15
S-34	2.568E-12	2.568E-12	2.568E-12	2.568E-12	2.568E-12	2.568E-12	2.568E-12
S-35	6.228E-16	1.974E-18	6.263E-21	2.073E-23	1.173E-29	6.639E-36	0.00
S-36	4.678E-14	5.723E-14	6.768E-14	7.813E-14	1.043E-13	1.304E-13	5.245E-12
Cl-35	4.143E-06	4.143E-06	4.143E-06	4.143E-06	4.143E-06	4.143E-06	4.143E-06
Cl-36	1.194E-07	1.194E-07	1.194E-07	1.194E-07	1.194E-07	1.194E-07	1.192E-07
Cl-37	1.440E-06	1.440E-06	1.440E-06	1.440E-06	1.440E-06	1.440E-06	1.440E-06
Ar-36	2.414E-12	2.954E-12	3.493E-12	4.033E-12	5.382E-12	6.731E-12	2.708E-10
Ar-38	4.449E-10	4.449E-10	4.449E-10	4.449E-10	4.449E-10	4.449E-10	4.449E-10
Ar-39	7.258E-12	7.220E-12	7.183E-12	7.146E-12	7.055E-12	6.965E-12	5.574E-13
Ar-40	6.022E-12	6.022E-12	6.022E-12	6.022E-12	6.022E-12	6.022E-12	6.022E-12
K-39	1.730E-13	2.103E-13	2.474E-13	2.844E-13	3.758E-13	4.662E-13	6.873E-12
K-40	2.636E-09	2.636E-09	2.636E-09	2.636E-09	2.636E-09	2.636E-09	2.636E-09
K-41	2.739E-11	2.755E-11	2.771E-11	2.787E-11	2.827E-11	2.868E-11	1.073E-10
Ca-40	3.508E-05	3.508E-05	3.508E-05	3.508E-05	3.508E-05	3.508E-05	3.508E-05
Ca-41	9.415E-09	9.415E-09	9.414E-09	9.414E-09	9.414E-09	9.414E-09	9.335E-09
Ca-42	2.456E-07	2.456E-07	2.456E-07	2.456E-07	2.456E-07	2.456E-07	2.456E-07
Ca-43	5.046E-08	5.046E-08	5.046E-08	5.046E-08	5.046E-08	5.046E-08	5.046E-08
Ca-44	8.318E-07	8.318E-07	8.318E-07	8.318E-07	8.318E-07	8.318E-07	8.318E-07

TABLE F.7.a. Fuel Activation Product Inventory by Isotope at
10 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ca-45	7.882E-14	3.526E-15	1.577E-16	7.054E-18	2.985E-21	1.263E-24	0.00
Ca-46	1.456E-09	1.456E-09	1.456E-09	1.456E-09	1.456E-09	1.456E-09	1.456E-09
Ca-48	8.247E-08	8.247E-08	8.247E-08	8.247E-08	8.247E-08	8.247E-08	8.247E-08
Sc-45	5.695E-10	5.695E-10	5.696E-10	5.696E-10	5.696E-10	5.696E-10	5.696E-10
Ti-46	4.043E-12	4.043E-12	4.043E-12	4.043E-12	4.043E-12	4.043E-12	4.043E-12
Ti-47	6.893E-13	6.893E-13	6.893E-13	6.893E-13	6.893E-13	6.893E-13	6.893E-13
Ti-48	4.502E-16	4.502E-16	4.502E-16	4.502E-16	4.502E-16	4.502E-16	4.502E-16
Ti-49	6.058E-11	6.058E-11	6.058E-11	6.058E-11	6.058E-11	6.058E-11	6.058E-11
Ti-50	4.736E-14	4.736E-14	4.736E-14	4.736E-14	4.736E-14	4.736E-14	4.736E-14
V-51	1.047E-11	1.047E-11	1.047E-11	1.047E-11	1.047E-11	1.047E-11	1.047E-11
Cr-52	1.706E-14	1.706E-14	1.706E-14	1.706E-14	1.706E-14	1.706E-14	1.706E-14
Cr-53	1.948E-11	1.948E-11	1.948E-11	1.948E-11	1.948E-11	1.948E-11	1.948E-11
Cr-54	3.109E-10	3.120E-10	3.122E-10	3.123E-10	3.123E-10	3.123E-10	3.123E-10
Mn-54	1.407E-12	2.783E-13	5.507E-14	1.089E-14	1.897E-16	3.302E-18	0.00
Mn-55	4.000E-09	4.215E-09	4.341E-09	4.415E-09	4.492E-09	4.512E-09	4.519E-09
Fe-54	2.863E-06	2.863E-06	2.863E-06	2.863E-06	2.863E-06	2.863E-06	2.863E-06
Fe-55	5.193E-10	3.047E-10	1.788E-10	1.049E-10	2.766E-11	7.293E-12	0.00
Fe-56	4.687E-05	4.687E-05	4.687E-05	4.687E-05	4.687E-05	4.687E-05	4.687E-05
Fe-57	1.208E-06	1.208E-06	1.208E-06	1.208E-06	1.208E-06	1.208E-06	1.208E-06
Fe-58	1.576E-07	1.576E-07	1.576E-07	1.576E-07	1.576E-07	1.576E-07	1.576E-07
Co-59	3.655E-10	3.665E-10	3.675E-10	3.685E-10	3.709E-10	3.734E-10	8.548E-10
Co-60	1.042E-11	8.012E-12	6.159E-12	4.734E-12	2.453E-12	1.271E-12	0.00
Ni-58	1.908E-05	1.908E-05	1.908E-05	1.908E-05	1.908E-05	1.908E-05	1.908E-05
Ni-59	5.695E-08	5.695E-08	5.694E-08	5.694E-08	5.694E-08	5.694E-08	5.546E-08
Ni-60	7.558E-06	7.558E-06	7.558E-06	7.558E-06	7.558E-06	7.558E-06	7.558E-06
Ni-61	3.470E-07	3.470E-07	3.470E-07	3.470E-07	3.470E-07	3.470E-07	3.470E-07
Ni-62	1.066E-06	1.066E-06	1.066E-06	1.066E-06	1.066E-06	1.066E-06	1.066E-06
Ni-63	9.460E-09	9.319E-09	9.179E-09	9.042E-09	8.708E-09	8.386E-09	5.211E-12
Ni-64	2.813E-07	2.813E-07	2.813E-07	2.813E-07	2.813E-07	2.813E-07	2.813E-07
Cu-63	6.577E-10	7.992E-10	9.385E-10	1.076E-09	1.410E-09	1.732E-09	1.011E-08
Cu-65	3.001E-10	3.001E-10	3.001E-10	3.001E-10	3.001E-10	3.001E-10	3.001E-10
Zn-64	1.243E-13	1.243E-13	1.243E-13	1.243E-13	1.243E-13	1.243E-13	1.243E-13
Zn-66	2.551E-13	2.551E-13	2.551E-13	2.551E-13	2.551E-13	2.551E-13	2.551E-13
Ru-104	2.903E-16	2.903E-16	2.903E-16	2.903E-16	2.903E-16	2.903E-16	2.903E-16
Pd-104	6.413E-14	6.413E-14	6.413E-14	6.413E-14	6.413E-14	6.413E-14	6.413E-14
Pd-105	1.497E-16	1.497E-16	1.497E-16	1.497E-16	1.497E-16	1.497E-16	1.497E-16
Pd-106	1.374E-12	1.374E-12	1.374E-12	1.374E-12	1.374E-12	1.374E-12	1.374E-12
Pd-107	6.262E-14	6.262E-14	6.262E-14	6.262E-14	6.262E-14	6.262E-14	6.262E-14
Pd-108	6.311E-10	6.472E-10	6.632E-10	6.789E-10	7.176E-10	7.552E-10	2.108E-09
Pd-110	3.832E-10	3.832E-10	3.832E-10	3.832E-10	3.832E-10	3.832E-10	3.832E-10
Ag-107	5.392E-07	5.392E-07	5.392E-07	5.392E-07	5.392E-07	5.392E-07	5.392E-07
Ag-108m	1.625E-09	1.607E-09	1.590E-09	1.572E-09	1.530E-09	1.489E-09	7.081E-12
Ag-109	4.014E-07	4.014E-07	4.014E-07	4.014E-07	4.014E-07	4.014E-07	4.014E-07
Ag-110m	1.040E-11	1.371E-12	1.807E-13	2.382E-14	1.502E-16	9.480E-19	0.00
Cd-108	2.376E-08	2.376E-08	2.376E-08	2.376E-08	2.376E-08	2.377E-08	2.390E-08
Cd-109	6.660E-13	2.236E-13	7.509E-14	2.522E-14	1.648E-15	1.077E-16	0.00
Cd-110	1.332E-07	1.332E-07	1.332E-07	1.332E-07	1.332E-07	1.332E-07	1.332E-07

TABLE F.7.a. Fuel Activation Product Inventory by Isotope at
10 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Cd-111	1.147E-09	1.147E-09	1.147E-09	1.147E-09	1.147E-09	1.147E-09	1.147E-09
Cd-112	9.947E-12	9.947E-12	9.947E-12	9.947E-12	9.947E-12	9.947E-12	9.947E-12
Cd-113	1.471E-15	1.471E-15	1.471E-15	1.471E-15	1.471E-15	1.471E-15	1.471E-15
Cd-114	1.013E-14	1.013E-14	1.013E-14	1.013E-14	1.013E-14	1.013E-14	1.013E-14
Total	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01

TABLE F.7.b. Fuel Activation Product Inventory by Isotope at
15 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	4.280E-09	4.280E-09	4.280E-09	4.280E-09	4.280E-09	4.280E-09	4.280E-09
H-2	1.544E-12	1.544E-12	1.544E-12	1.544E-12	1.544E-12	1.544E-12	1.544E-12
H-3	4.263E-16	3.811E-16	3.406E-16	3.044E-16	2.299E-16	1.737E-16	0.00
He-3	1.418E-16	1.871E-16	2.275E-16	2.637E-16	3.382E-16	3.944E-16	5.681E-16
He-4	7.287E-07	7.287E-07	7.287E-07	7.287E-07	7.287E-07	7.287E-07	7.287E-07
Li-6	3.559E-15	3.559E-15	3.559E-15	3.559E-15	3.559E-15	3.559E-15	3.559E-15
Be-9	4.569E-11	4.569E-11	4.569E-11	4.569E-11	4.569E-11	4.569E-11	4.569E-11
Be-10	7.034E-12	7.034E-12	7.034E-12	7.034E-12	7.034E-12	7.034E-12	7.031E-12
B-11	4.477E-09	4.477E-09	4.477E-09	4.477E-09	4.477E-09	4.477E-09	4.477E-09
C-12	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05
C-13	2.597E-06	2.597E-06	2.597E-06	2.597E-06	2.597E-06	2.597E-06	2.597E-06
C-14	6.130E-08	6.128E-08	6.127E-08	6.125E-08	6.121E-08	6.118E-08	5.434E-08
N-14	2.594E-05	2.594E-05	2.594E-05	2.594E-05	2.594E-05	2.594E-05	2.595E-05
N-15	1.054E-07	1.054E-07	1.054E-07	1.054E-07	1.054E-07	1.054E-07	1.054E-07
O-16	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01
O-17	5.429E-05	5.429E-05	5.429E-05	5.429E-05	5.429E-05	5.429E-05	5.429E-05
O-18	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04
F-19	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06
Ne-20	7.871E-11	7.871E-11	7.871E-11	7.871E-11	7.871E-11	7.871E-11	7.871E-11
Ne-21	1.615E-15	1.615E-15	1.615E-15	1.615E-15	1.615E-15	1.615E-15	1.615E-15
Ne-22	1.009E-15	1.009E-15	1.009E-15	1.009E-15	1.009E-15	1.009E-15	1.009E-15
Mg-24	5.182E-11	5.182E-11	5.182E-11	5.182E-11	5.182E-11	5.182E-11	5.182E-11
Mg-25	5.449E-11	5.449E-11	5.449E-11	5.449E-11	5.449E-11	5.449E-11	5.449E-11
Mg-26	2.487E-11	2.487E-11	2.487E-11	2.487E-11	2.487E-11	2.487E-11	2.487E-11
Al-27	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05
Si-28	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05
Si-29	1.754E-06	1.754E-06	1.754E-06	1.754E-06	1.754E-06	1.754E-06	1.754E-06
Si-30	1.201E-06	1.201E-06	1.201E-06	1.201E-06	1.201E-06	1.201E-06	1.201E-06
P-31	1.525E-10	1.525E-10	1.525E-10	1.525E-10	1.525E-10	1.525E-10	1.525E-10
S-32	5.787E-11	5.787E-11	5.787E-11	5.787E-11	5.787E-11	5.787E-11	5.787E-11
S-33	1.568E-14	1.568E-14	1.568E-14	1.568E-14	1.568E-14	1.568E-14	1.568E-14
S-34	3.931E-12	3.931E-12	3.931E-12	3.931E-12	3.931E-12	3.931E-12	3.931E-12
S-35	9.786E-16	3.101E-18	9.839E-21	3.260E-23	1.845E-29	1.044E-35	0.00
S-36	7.065E-14	8.650E-14	1.024E-13	1.182E-13	1.578E-13	1.975E-13	7.955E-12
Cl-35	4.083E-06	4.083E-06	4.083E-06	4.083E-06	4.083E-06	4.083E-06	4.083E-06
Cl-36	1.811E-07	1.811E-07	1.811E-07	1.811E-07	1.811E-07	1.811E-07	1.807E-07
Cl-37	1.441E-06	1.441E-06	1.441E-06	1.441E-06	1.441E-06	1.441E-06	1.441E-06
Ar-36	3.645E-12	4.464E-12	5.282E-12	6.100E-12	8.146E-12	1.019E-11	4.107E-10
Ar-38	6.809E-10	6.809E-10	6.809E-10	6.809E-10	6.809E-10	6.809E-10	6.809E-10
Ar-39	1.018E-11	1.013E-11	1.008E-11	1.003E-11	9.899E-12	9.772E-12	7.822E-13
Ar-40	1.334E-11	1.334E-11	1.334E-11	1.334E-11	1.334E-11	1.334E-11	1.334E-11
K-39	2.445E-13	2.968E-13	3.489E-13	4.007E-13	5.291E-13	6.558E-13	9.646E-12
K-40	4.010E-09	4.010E-09	4.010E-09	4.010E-09	4.010E-09	4.010E-09	4.010E-09
K-41	6.327E-11	6.351E-11	6.376E-11	6.400E-11	6.462E-11	6.524E-11	1.855E-10
Ca-40	3.507E-05	3.507E-05	3.507E-05	3.507E-05	3.507E-05	3.507E-05	3.507E-05
Ca-41	1.441E-08	1.441E-08	1.441E-08	1.441E-08	1.441E-08	1.441E-08	1.429E-08
Ca-42	2.455E-07	2.455E-07	2.455E-07	2.455E-07	2.455E-07	2.455E-07	2.455E-07

TABLE F.7.b. Fuel Activation Product Inventory by Isotope at
15 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ca-43	5.039E-08	5.039E-08	5.039E-08	5.039E-08	5.039E-08	5.039E-08	5.039E-08
Ca-44	8.316E-07	8.316E-07	8.316E-07	8.316E-07	8.316E-07	8.316E-07	8.316E-07
Ca-45	1.255E-13	5.612E-15	2.510E-16	1.123E-17	4.752E-21	2.011E-24	0.00
Ca-46	1.456E-09	1.456E-09	1.456E-09	1.456E-09	1.456E-09	1.456E-09	1.456E-09
Ca-48	8.243E-08	8.243E-08	8.243E-08	8.243E-08	8.243E-08	8.243E-08	8.243E-08
Sc-45	8.683E-10	8.684E-10	8.684E-10	8.684E-10	8.684E-10	8.684E-10	8.684E-10
Ti-46	9.469E-12	9.469E-12	9.469E-12	9.469E-12	9.469E-12	9.469E-12	9.469E-12
Ti-47	1.057E-12	1.057E-12	1.057E-12	1.057E-12	1.057E-12	1.057E-12	1.057E-12
Ti-48	1.055E-15	1.055E-15	1.055E-15	1.055E-15	1.055E-15	1.055E-15	1.055E-15
Ti-49	9.267E-11	9.267E-11	9.267E-11	9.267E-11	9.267E-11	9.267E-11	9.267E-11
Ti-50	1.109E-13	1.109E-13	1.109E-13	1.109E-13	1.109E-13	1.109E-13	1.109E-13
V-51	1.601E-11	1.601E-11	1.601E-11	1.601E-11	1.601E-11	1.601E-11	1.601E-11
Cr-52	3.993E-14	3.993E-14	3.993E-14	3.993E-14	3.993E-14	3.993E-14	3.993E-14
Cr-53	2.970E-11	2.970E-11	2.970E-11	2.970E-11	2.970E-11	2.970E-11	2.970E-11
Cr-54	4.755E-10	4.773E-10	4.777E-10	4.777E-10	4.777E-10	4.777E-10	4.777E-10
Mn-54	2.229E-12	4.409E-13	8.723E-14	1.726E-14	3.004E-16	5.231E-18	0.00
Mn-55	6.099E-09	6.432E-09	6.628E-09	6.743E-09	6.863E-09	6.894E-09	6.906E-09
Fe-54	2.860E-06	2.860E-06	2.860E-06	2.860E-06	2.860E-06	2.860E-06	2.860E-06
Fe-55	8.067E-10	4.733E-10	2.777E-10	1.629E-10	4.297E-11	1.133E-11	0.00
Fe-56	4.682E-05	4.682E-05	4.682E-05	4.682E-05	4.682E-05	4.682E-05	4.682E-05
Fe-57	1.254E-06	1.254E-06	1.254E-06	1.254E-06	1.254E-06	1.254E-06	1.254E-06
Fe-58	1.595E-07	1.595E-07	1.595E-07	1.595E-07	1.595E-07	1.595E-07	1.595E-07
Co-59	7.049E-10	7.064E-10	7.079E-10	7.094E-10	7.131E-10	7.168E-10	1.437E-09
Co-60	1.970E-11	1.515E-11	1.164E-11	8.950E-12	4.637E-12	2.402E-12	0.00
Ni-58	1.905E-05	1.905E-05	1.905E-05	1.905E-05	1.905E-05	1.905E-05	1.905E-05
Ni-59	8.517E-08	8.517E-08	8.517E-08	8.517E-08	8.516E-08	8.516E-08	8.444E-08
Ni-60	7.553E-06	7.553E-06	7.553E-06	7.553E-06	7.553E-06	7.553E-06	7.553E-06
Ni-61	3.543E-07	3.543E-07	3.543E-07	3.543E-07	3.543E-07	3.543E-07	3.543E-07
Ni-62	1.061E-06	1.061E-06	1.061E-06	1.061E-06	1.061E-06	1.061E-06	1.061E-06
Ni-63	1.439E-08	1.418E-08	1.397E-08	1.376E-08	1.325E-08	1.276E-08	7.928E-12
Ni-64	2.812E-07	2.812E-07	2.812E-07	2.812E-07	2.812E-07	2.812E-07	2.812E-07
Cu-63	9.955E-10	1.211E-09	1.423E-09	1.632E-09	2.140E-09	2.630E-09	1.538E-08
Cu-65	4.590E-10	4.590E-10	4.590E-10	4.590E-10	4.590E-10	4.590E-10	4.590E-10
Zn-64	2.936E-13	2.936E-13	2.936E-13	2.936E-13	2.936E-13	2.936E-13	2.936E-13
Zn-66	5.974E-13	5.974E-13	5.974E-13	5.974E-13	5.974E-13	5.974E-13	5.974E-13
Zn-67	1.947E-16	1.947E-16	1.947E-16	1.947E-16	1.947E-16	1.947E-16	1.947E-16
Ru-104	4.386E-16	4.386E-16	4.386E-16	4.386E-16	4.386E-16	4.386E-16	4.386E-16
Pd-104	9.683E-14	9.683E-14	9.683E-14	9.683E-14	9.683E-14	9.683E-14	9.683E-14
Pd-105	3.458E-16	3.458E-16	3.458E-16	3.458E-16	3.458E-16	3.458E-16	3.458E-16
Pd-106	2.072E-12	2.072E-12	2.072E-12	2.072E-12	2.072E-12	2.072E-12	2.072E-12
Pd-107	9.528E-14	9.528E-14	9.528E-14	9.528E-14	9.528E-14	9.528E-14	9.527E-14
Pd-108	9.418E-10	9.661E-10	9.902E-10	1.014E-09	1.072E-09	1.129E-09	3.175E-09
Pd-110	5.457E-10	5.457E-10	5.457E-10	5.457E-10	5.457E-10	5.457E-10	5.457E-10
Ag-107	5.260E-07	5.260E-07	5.260E-07	5.260E-07	5.260E-07	5.260E-07	5.260E-07
Ag-108m	2.457E-09	2.430E-09	2.404E-09	2.378E-09	2.314E-09	2.251E-09	1.071E-11
Ag-109	3.447E-07	3.447E-07	3.447E-07	3.447E-07	3.447E-07	3.447E-07	3.447E-07
Ag-110m	1.432E-11	1.887E-12	2.488E-13	3.279E-14	2.069E-16	1.305E-18	0.00

TABLE F.7.b. Fuel Activation Product Inventory by Isotope at
15 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Cd-108	3.590E-08	3.590E-08	3.590E-08	3.590E-08	3.591E-08	3.591E-08	3.611E-08
Cd-109	1.543E-12	5.181E-13	1.740E-13	5.842E-14	3.817E-15	2.494E-16	0.00
Cd-110	1.888E-07	1.888E-07	1.888E-07	1.888E-07	1.888E-07	1.888E-07	1.888E-07
Cd-111	2.539E-09	2.539E-09	2.539E-09	2.539E-09	2.539E-09	2.539E-09	2.539E-09
Cd-112	3.413E-11	3.413E-11	3.413E-11	3.413E-11	3.413E-11	3.413E-11	3.413E-11
Cd-113	5.234E-15	5.234E-15	5.234E-15	5.234E-15	5.234E-15	5.234E-15	5.234E-15
Cd-114	5.622E-14	5.622E-14	5.622E-14	5.622E-14	5.622E-14	5.622E-14	5.622E-14
Total	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01

TABLE F.7.c. Fuel Activation Product Inventory by Isotope at
20 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	5.832E-09	5.832E-09	5.832E-09	5.832E-09	5.832E-09	5.832E-09	5.832E-09
H-2	2.870E-12	2.870E-12	2.870E-12	2.870E-12	2.870E-12	2.870E-12	2.870E-12
H-3	1.021E-15	9.125E-16	8.156E-16	7.290E-16	5.506E-16	4.159E-16	0.00
He-3	3.195E-16	4.279E-16	5.248E-16	6.115E-16	7.898E-16	9.246E-16	1.340E-15
He-4	9.936E-07	9.936E-07	9.936E-07	9.936E-07	9.936E-07	9.936E-07	9.936E-07
Li-6	6.037E-15	6.037E-15	6.037E-15	6.037E-15	6.037E-15	6.037E-15	6.037E-15
Be-9	6.229E-11	6.229E-11	6.229E-11	6.229E-11	6.229E-11	6.229E-11	6.229E-11
Be-10	1.248E-11	1.248E-11	1.248E-11	1.248E-11	1.248E-11	1.248E-11	1.247E-11
B-11	6.102E-09	6.102E-09	6.102E-09	6.102E-09	6.102E-09	6.102E-09	6.102E-09
C-12	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05
C-13	3.452E-06	3.452E-06	3.452E-06	3.452E-06	3.452E-06	3.452E-06	3.452E-06
C-14	8.355E-08	8.353E-08	8.351E-08	8.349E-08	8.344E-08	8.339E-08	7.406E-08
N-14	2.592E-05	2.592E-05	2.592E-05	2.592E-05	2.592E-05	2.592E-05	2.593E-05
N-15	1.065E-07	1.065E-07	1.065E-07	1.065E-07	1.065E-07	1.065E-07	1.065E-07
O-16	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01
O-17	5.429E-05	5.429E-05	5.429E-05	5.429E-05	5.429E-05	5.429E-05	5.429E-05
O-18	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04
F-19	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06
Ne-20	1.073E-10	1.073E-10	1.073E-10	1.073E-10	1.073E-10	1.073E-10	1.073E-10
Ne-21	3.001E-15	3.001E-15	3.001E-15	3.001E-15	3.001E-15	3.001E-15	3.001E-15
Ne-22	1.876E-15	1.876E-15	1.876E-15	1.876E-15	1.876E-15	1.876E-15	1.876E-15
Na-23	1.518E-16	1.518E-16	1.518E-16	1.518E-16	1.518E-16	1.518E-16	1.518E-16
Mg-24	7.062E-11	7.062E-11	7.062E-11	7.062E-11	7.062E-11	7.062E-11	7.062E-11
Mg-25	7.430E-11	7.430E-11	7.430E-11	7.430E-11	7.430E-11	7.430E-11	7.430E-11
Mg-26	3.393E-11	3.393E-11	3.393E-11	3.393E-11	3.393E-11	3.393E-11	3.393E-11
Al-27	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05	3.629E-05
Si-28	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05	3.335E-05
Si-29	1.756E-06	1.756E-06	1.756E-06	1.756E-06	1.756E-06	1.756E-06	1.756E-06
Si-30	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06
P-31	2.080E-10	2.080E-10	2.080E-10	2.080E-10	2.080E-10	2.080E-10	2.080E-10
S-32	7.830E-11	7.830E-11	7.830E-11	7.830E-11	7.830E-11	7.830E-11	7.830E-11
S-33	2.900E-14	2.900E-14	2.900E-14	2.900E-14	2.900E-14	2.900E-14	2.900E-14
S-34	5.360E-12	5.360E-12	5.360E-12	5.360E-12	5.360E-12	5.360E-12	5.360E-12
S-35	1.356E-15	4.300E-18	1.364E-20	4.514E-23	2.555E-29	1.446E-35	0.00
S-36	9.514E-14	1.166E-13	1.380E-13	1.594E-13	2.129E-13	2.664E-13	1.074E-11
Cl-35	4.020E-06	4.020E-06	4.020E-06	4.020E-06	4.020E-06	4.020E-06	4.020E-06
Cl-36	2.446E-07	2.446E-07	2.446E-07	2.446E-07	2.446E-07	2.446E-07	2.441E-07
Cl-37	1.442E-06	1.442E-06	1.442E-06	1.442E-06	1.442E-06	1.442E-06	1.442E-06
Ar-36	4.907E-12	6.013E-12	7.118E-12	8.223E-12	1.099E-11	1.375E-11	5.547E-10
Ar-38	9.285E-10	9.285E-10	9.285E-10	9.285E-10	9.285E-10	9.285E-10	9.285E-10
Ar-39	1.273E-11	1.266E-11	1.260E-11	1.253E-11	1.237E-11	1.221E-11	9.777E-13
Ar-40	2.387E-11	2.387E-11	2.387E-11	2.387E-11	2.387E-11	2.387E-11	2.387E-11
K-39	3.081E-13	3.736E-13	4.386E-13	5.034E-13	6.638E-13	8.222E-13	1.206E-11
K-40	5.432E-09	5.432E-09	5.432E-09	5.432E-09	5.432E-09	5.432E-09	5.432E-09
K-41	1.165E-10	1.169E-10	1.172E-10	1.175E-10	1.184E-10	1.192E-10	2.832E-10
Ca-40	3.506E-05	3.506E-05	3.506E-05	3.506E-05	3.506E-05	3.506E-05	3.506E-05
Ca-41	1.964E-08	1.964E-08	1.964E-08	1.964E-08	1.964E-08	1.964E-08	1.948E-08

TABLE F.7.c. Fuel Activation Product Inventory by Isotope at
20 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ca-42	2.455E-07	2.455E-07	2.455E-07	2.455E-07	2.455E-07	2.455E-07	2.455E-07
Ca-43	5.033E-08	5.033E-08	5.033E-08	5.033E-08	5.033E-08	5.033E-08	5.033E-08
Ca-44	8.314E-07	8.314E-07	8.314E-07	8.314E-07	8.314E-07	8.314E-07	8.314E-07
Ca-45	1.759E-13	7.869E-15	3.520E-16	1.574E-17	6.662E-21	2.819E-24	0.00
Ca-46	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09
Ca-48	8.240E-08	8.240E-08	8.240E-08	8.240E-08	8.240E-08	8.240E-08	8.240E-08
Sc-45	1.179E-09	1.179E-09	1.179E-09	1.179E-09	1.179E-09	1.179E-09	1.179E-09
Ti-46	1.758E-11	1.758E-11	1.758E-11	1.758E-11	1.758E-11	1.758E-11	1.758E-11
Ti-47	1.447E-12	1.447E-12	1.447E-12	1.447E-12	1.447E-12	1.447E-12	1.447E-12
Ti-48	1.964E-15	1.964E-15	1.964E-15	1.964E-15	1.964E-15	1.964E-15	1.964E-15
Ti-49	1.263E-10	1.263E-10	1.263E-10	1.263E-10	1.263E-10	1.263E-10	1.263E-10
Ti-50	2.061E-13	2.061E-13	2.061E-13	2.061E-13	2.061E-13	2.061E-13	2.061E-13
V-51	2.180E-11	2.180E-11	2.180E-11	2.180E-11	2.180E-11	2.180E-11	2.180E-11
Cr-52	7.415E-14	7.415E-14	7.415E-14	7.415E-14	7.415E-14	7.415E-14	7.415E-14
Cr-53	4.034E-11	4.034E-11	4.034E-11	4.034E-11	4.034E-11	4.034E-11	4.034E-11
Cr-54	6.480E-10	6.505E-10	6.510E-10	6.511E-10	6.511E-10	6.511E-10	6.511E-10
Mn-54	3.109E-12	6.152E-13	1.217E-13	2.408E-14	4.192E-16	7.298E-18	0.00
Mn-55	8.288E-09	8.748E-09	9.017E-09	9.175E-09	9.341E-09	9.384E-09	9.400E-09
Fe-54	2.858E-06	2.858E-06	2.858E-06	2.858E-06	2.858E-06	2.858E-06	2.858E-06
Fe-55	1.111E-09	6.521E-10	3.826E-10	2.245E-10	5.920E-11	1.561E-11	0.00
Fe-56	4.678E-05	4.678E-05	4.678E-05	4.678E-05	4.678E-05	4.678E-05	4.678E-05
Fe-57	1.303E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06
Fe-58	1.615E-07	1.615E-07	1.615E-07	1.615E-07	1.615E-07	1.615E-07	1.615E-07
Co-59	1.144E-09	1.146E-09	1.148E-09	1.150E-09	1.154E-09	1.159E-09	2.118E-09
Co-60	3.347E-11	2.573E-11	1.978E-11	1.520E-11	7.876E-12	4.080E-12	0.00
Ni-58	1.901E-05	1.901E-05	1.901E-05	1.901E-05	1.901E-05	1.901E-05	1.901E-05
Ni-59	1.134E-07	1.134E-07	1.134E-07	1.134E-07	1.134E-07	1.134E-07	1.124E-07
Ni-60	7.550E-06	7.550E-06	7.550E-06	7.550E-06	7.550E-06	7.550E-06	7.550E-06
Ni-61	3.620E-07	3.620E-07	3.620E-07	3.620E-07	3.620E-07	3.620E-07	3.620E-07
Ni-62	1.056E-06	1.056E-06	1.056E-06	1.056E-06	1.056E-06	1.056E-06	1.056E-06
Ni-63	1.950E-08	1.921E-08	1.892E-08	1.864E-08	1.795E-08	1.729E-08	1.074E-11
Ni-64	2.812E-07	2.812E-07	2.812E-07	2.812E-07	2.812E-07	2.812E-07	2.812E-07
Cu-63	1.344E-09	1.635E-09	1.923E-09	2.206E-09	2.895E-09	3.558E-09	2.083E-08
Cu-65	6.255E-10	6.255E-10	6.255E-10	6.255E-10	6.255E-10	6.255E-10	6.255E-10
Zn-64	5.469E-13	5.469E-13	5.469E-13	5.469E-13	5.469E-13	5.469E-13	5.469E-13
Zn-66	1.110E-12	1.110E-12	1.110E-12	1.110E-12	1.110E-12	1.110E-12	1.110E-12
Zn-67	4.929E-16	4.929E-16	4.929E-16	4.929E-16	4.929E-16	4.929E-16	4.929E-16
Ru-104	5.901E-16	5.901E-16	5.901E-16	5.901E-16	5.901E-16	5.901E-16	5.901E-16
Pd-104	1.302E-13	1.302E-13	1.302E-13	1.302E-13	1.302E-13	1.302E-13	1.302E-13
Pd-105	6.336E-16	6.336E-16	6.336E-16	6.336E-16	6.336E-16	6.336E-16	6.336E-16
Pd-106	2.782E-12	2.782E-12	2.782E-12	2.782E-12	2.782E-12	2.782E-12	2.782E-12
Pd-107	1.291E-13	1.291E-13	1.291E-13	1.291E-13	1.291E-13	1.291E-13	1.291E-13
Pd-108	1.251E-09	1.283E-09	1.316E-09	1.348E-09	1.427E-09	1.503E-09	4.258E-09
Pd-110	6.911E-10	6.912E-10	6.912E-10	6.912E-10	6.912E-10	6.912E-10	6.912E-10
Ag-107	5.125E-07	5.125E-07	5.125E-07	5.125E-07	5.125E-07	5.125E-07	5.125E-07
Ag-108m	3.308E-09	3.272E-09	3.236E-09	3.201E-09	3.115E-09	3.031E-09	1.441E-11
Ag-109	2.939E-07	2.939E-07	2.939E-07	2.939E-07	2.939E-07	2.939E-07	2.939E-07

TABLE F.7.c. Fuel Activation Product Inventory by Isotope at
20 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ag-110m	1.724E-11	2.273E-12	2.996E-13	3.949E-14	2.492E-16	1.573E-18	0.00
Cd-108	4.830E-08	4.830E-08	4.830E-08	4.830E-08	4.831E-08	4.832E-08	4.858E-08
Cd-109	2.807E-12	9.427E-13	3.165E-13	1.063E-13	6.945E-15	4.538E-16	0.00
Cd-110	2.380E-07	2.381E-07	2.381E-07	2.381E-07	2.381E-07	2.381E-07	2.381E-07
Cd-111	4.454E-09	4.454E-09	4.454E-09	4.454E-09	4.454E-09	4.454E-09	4.454E-09
Cd-112	8.272E-11	8.272E-11	8.272E-11	8.272E-11	8.272E-11	8.272E-11	8.272E-11
Cd-113	1.292E-14	1.292E-14	1.292E-14	1.292E-14	1.292E-14	1.292E-14	1.292E-14
Cd-114	1.918E-13	1.918E-13	1.918E-13	1.918E-13	1.918E-13	1.918E-13	1.918E-13
Total	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01

TABLE F.7.d. Fuel Activation Product Inventory by Isotope at
25 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	7.478E-09	7.478E-09	7.478E-09	7.478E-09	7.478E-09	7.478E-09	7.478E-09
H-2	4.722E-12	4.722E-12	4.722E-12	4.722E-12	4.722E-12	4.722E-12	4.722E-12
H-3	2.028E-15	1.812E-15	1.620E-15	1.448E-15	1.094E-15	8.260E-16	0.00
He-3	6.067E-16	8.220E-16	1.014E-15	1.186E-15	1.541E-15	1.808E-15	2.634E-15
He-4	1.275E-06	1.275E-06	1.275E-06	1.275E-06	1.275E-06	1.275E-06	1.275E-06
Li-6	9.066E-15	9.066E-15	9.066E-15	9.066E-15	9.066E-15	9.066E-15	9.066E-15
Be-9	7.990E-11	7.990E-11	7.990E-11	7.990E-11	7.990E-11	7.990E-11	7.990E-11
Be-10	1.994E-11	1.994E-11	1.994E-11	1.994E-11	1.994E-11	1.994E-11	1.993E-11
B-11	7.826E-09	7.826E-09	7.826E-09	7.826E-09	7.826E-09	7.826E-09	7.826E-09
C-12	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05
C-13	4.359E-06	4.359E-06	4.359E-06	4.359E-06	4.359E-06	4.359E-06	4.359E-06
C-14	1.072E-07	1.071E-07	1.071E-07	1.071E-07	1.070E-07	1.070E-07	9.499E-08
N-14	2.590E-05	2.590E-05	2.590E-05	2.590E-05	2.590E-05	2.590E-05	2.591E-05
N-15	1.077E-07	1.077E-07	1.077E-07	1.077E-07	1.077E-07	1.077E-07	1.077E-07
O-16	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01
O-17	5.430E-05	5.430E-05	5.430E-05	5.430E-05	5.430E-05	5.430E-05	5.430E-05
O-18	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04
F-19	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06
Ne-20	1.377E-10	1.377E-10	1.377E-10	1.377E-10	1.377E-10	1.377E-10	1.377E-10
Ne-21	4.939E-15	4.939E-15	4.939E-15	4.939E-15	4.939E-15	4.939E-15	4.939E-15
Ne-22	3.089E-15	3.089E-15	3.089E-15	3.089E-15	3.089E-15	3.089E-15	3.089E-15
Na-23	2.500E-16	2.500E-16	2.500E-16	2.500E-16	2.500E-16	2.500E-16	2.500E-16
Mg-24	9.061E-11	9.061E-11	9.061E-11	9.061E-11	9.061E-11	9.061E-11	9.061E-11
Mg-25	9.533E-11	9.533E-11	9.533E-11	9.533E-11	9.533E-11	9.533E-11	9.533E-11
Mg-26	4.356E-11	4.356E-11	4.356E-11	4.356E-11	4.356E-11	4.356E-11	4.356E-11
Al-27	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05
Si-28	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05
Si-29	1.758E-06	1.758E-06	1.758E-06	1.758E-06	1.758E-06	1.758E-06	1.758E-06
Si-30	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06
P-31	2.668E-10	2.668E-10	2.668E-10	2.668E-10	2.668E-10	2.668E-10	2.668E-10
S-32	9.965E-11	9.965E-11	9.965E-11	9.965E-11	9.965E-11	9.965E-11	9.965E-11
S-33	4.750E-14	4.750E-14	4.750E-14	4.750E-14	4.750E-14	4.750E-14	4.750E-14
S-34	6.878E-12	6.878E-12	6.878E-12	6.878E-12	6.878E-12	6.878E-12	6.878E-12
S-35	1.756E-15	5.565E-18	1.764E-20	5.840E-23	3.305E-29	1.870E-35	0.00
S-36	1.205E-13	1.476E-13	1.748E-13	2.020E-13	2.700E-13	3.380E-13	1.367E-11
Cl-35	3.955E-06	3.955E-06	3.955E-06	3.955E-06	3.955E-06	3.955E-06	3.955E-06
Cl-36	3.107E-07	3.107E-07	3.107E-07	3.107E-07	3.107E-07	3.107E-07	3.100E-07
Cl-37	1.443E-06	1.443E-06	1.443E-06	1.443E-06	1.443E-06	1.443E-06	1.443E-06
Ar-36	6.211E-12	7.615E-12	9.018E-12	1.042E-11	1.393E-11	1.744E-11	7.045E-10
Ar-38	1.191E-09	1.191E-09	1.191E-09	1.191E-09	1.191E-09	1.191E-09	1.191E-09
Ar-39	1.496E-11	1.488E-11	1.481E-11	1.473E-11	1.454E-11	1.436E-11	1.149E-12
Ar-40	3.810E-11	3.810E-11	3.810E-11	3.810E-11	3.810E-11	3.810E-11	3.810E-11
K-39	3.651E-13	4.420E-13	5.185E-13	5.946E-13	7.832E-13	9.693E-13	1.418E-11
K-40	6.923E-09	6.923E-09	6.923E-09	6.923E-09	6.923E-09	6.923E-09	6.923E-09
K-41	1.903E-10	1.908E-10	1.912E-10	1.916E-10	1.927E-10	1.938E-10	4.042E-10
Ca-40	3.505E-05	3.505E-05	3.505E-05	3.505E-05	3.505E-05	3.505E-05	3.505E-05
Ca-41	2.520E-08	2.520E-08	2.520E-08	2.520E-08	2.520E-08	2.520E-08	2.499E-08

TABLE F.7.d. Fuel Activation Product Inventory by Isotope at
25 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ca-42	2.454E-07	2.454E-07	2.454E-07	2.454E-07	2.454E-07	2.454E-07	2.454E-07
Ca-43	5.025E-08	5.025E-08	5.025E-08	5.025E-08	5.025E-08	5.025E-08	5.025E-08
Ca-44	8.313E-07	8.313E-07	8.313E-07	8.313E-07	8.313E-07	8.313E-07	8.313E-07
Ca-45	2.313E-13	1.035E-14	4.628E-16	2.070E-17	8.760E-21	3.707E-24	0.00
Ca-46	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09
Ca-48	8.237E-08	8.237E-08	8.237E-08	8.237E-08	8.237E-08	8.237E-08	8.237E-08
Sc-45	1.506E-09	1.507E-09	1.507E-09	1.507E-09	1.507E-09	1.507E-09	1.507E-09
Ti-46	2.890E-11	2.890E-11	2.890E-11	2.890E-11	2.890E-11	2.890E-11	2.890E-11
Ti-47	1.866E-12	1.866E-12	1.866E-12	1.866E-12	1.866E-12	1.866E-12	1.866E-12
Ti-48	3.240E-15	3.240E-15	3.240E-15	3.240E-15	3.240E-15	3.240E-15	3.240E-15
Ti-49	1.619E-10	1.619E-10	1.619E-10	1.619E-10	1.619E-10	1.619E-10	1.619E-10
Ti-50	3.390E-13	3.390E-13	3.390E-13	3.390E-13	3.390E-13	3.390E-13	3.390E-13
V-51	2.793E-11	2.793E-11	2.793E-11	2.793E-11	2.793E-11	2.793E-11	2.793E-11
Cr-52	1.219E-13	1.219E-13	1.219E-13	1.219E-13	1.219E-13	1.219E-13	1.219E-13
Cr-53	5.155E-11	5.155E-11	5.155E-11	5.155E-11	5.155E-11	5.155E-11	5.155E-11
Cr-54	8.310E-10	8.343E-10	8.349E-10	8.351E-10	8.351E-10	8.351E-10	8.351E-10
Mn-54	4.079E-12	8.071E-13	1.597E-13	3.159E-14	5.499E-16	9.574E-18	0.00
Mn-55	1.060E-08	1.119E-08	1.154E-08	1.175E-08	1.196E-08	1.202E-08	1.204E-08
Fe-54	2.855E-06	2.855E-06	2.855E-06	2.855E-06	2.855E-06	2.855E-06	2.855E-06
Fe-55	1.442E-09	8.461E-10	4.965E-10	2.913E-10	7.681E-11	2.025E-11	0.00
Fe-56	4.672E-05	4.672E-05	4.672E-05	4.672E-05	4.672E-05	4.672E-05	4.672E-05
Fe-57	1.355E-06	1.355E-06	1.355E-06	1.355E-06	1.355E-06	1.355E-06	1.355E-06
Fe-58	1.636E-07	1.636E-07	1.636E-07	1.636E-07	1.636E-07	1.636E-07	1.636E-07
Co-59	1.683E-09	1.685E-09	1.688E-09	1.690E-09	1.696E-09	1.702E-09	2.901E-09
Co-60	5.346E-11	4.109E-11	3.159E-11	2.428E-11	1.258E-11	6.516E-12	0.00
Ni-58	1.898E-05	1.898E-05	1.898E-05	1.898E-05	1.898E-05	1.898E-05	1.898E-05
Ni-59	1.418E-07	1.418E-07	1.418E-07	1.418E-07	1.418E-07	1.418E-07	1.406E-07
Ni-60	7.547E-06	7.547E-06	7.547E-06	7.547E-06	7.547E-06	7.547E-06	7.547E-06
Ni-61	3.701E-07	3.701E-07	3.701E-07	3.701E-07	3.701E-07	3.701E-07	3.701E-07
Ni-62	1.051E-06	1.051E-06	1.051E-06	1.051E-06	1.051E-06	1.051E-06	1.051E-06
Ni-63	2.485E-08	2.448E-08	2.412E-08	2.375E-08	2.288E-08	2.203E-08	1.369E-11
Ni-64	2.813E-07	2.813E-07	2.813E-07	2.813E-07	2.813E-07	2.813E-07	2.813E-07
Cu-63	1.705E-09	2.077E-09	2.443E-09	2.804E-09	3.682E-09	4.528E-09	2.654E-08
Cu-65	8.021E-10	8.021E-10	8.021E-10	8.021E-10	8.021E-10	8.021E-10	8.021E-10
Zn-64	9.020E-13	9.020E-13	9.020E-13	9.020E-13	9.020E-13	9.020E-13	9.020E-13
Zn-66	1.826E-12	1.826E-12	1.826E-12	1.826E-12	1.826E-12	1.826E-12	1.826E-12
Zn-67	1.039E-15	1.039E-15	1.039E-15	1.039E-15	1.039E-15	1.039E-15	1.039E-15
Ru-104	7.465E-16	7.465E-16	7.465E-16	7.465E-16	7.465E-16	7.465E-16	7.465E-16
Pd-104	1.645E-13	1.645E-13	1.645E-13	1.645E-13	1.645E-13	1.645E-13	1.645E-13
Pd-105	1.027E-15	1.027E-15	1.027E-15	1.027E-15	1.027E-15	1.027E-15	1.027E-15
Pd-106	3.513E-12	3.513E-12	3.513E-12	3.513E-12	3.513E-12	3.513E-12	3.513E-12
Pd-107	1.646E-13	1.646E-13	1.646E-13	1.646E-13	1.646E-13	1.646E-13	1.646E-13
Pd-108	1.560E-09	1.602E-09	1.643E-09	1.683E-09	1.783E-09	1.880E-09	5.367E-09
Pd-110	8.219E-10	8.219E-10	8.219E-10	8.219E-10	8.219E-10	8.219E-10	8.219E-10
Ag-107	4.986E-07	4.986E-07	4.986E-07	4.986E-07	4.986E-07	4.986E-07	4.986E-07
Ag-108m	4.187E-09	4.142E-09	4.097E-09	4.052E-09	3.943E-09	3.837E-09	1.825E-11
Ag-109	2.481E-07	2.481E-07	2.481E-07	2.481E-07	2.481E-07	2.481E-07	2.481E-07

TABLE F.7.d. Fuel Activation Product Inventory by Isotope at
25 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Ag-110m	1.934E-11	2.549E-12	3.361E-13	4.430E-14	2.794E-16	1.763E-18	0.00
Cd-108	6.110E-08	6.110E-08	6.110E-08	6.111E-08	6.112E-08	6.113E-08	6.146E-08
Cd-109	4.511E-12	1.515E-12	5.087E-13	1.708E-13	1.116E-14	7.293E-16	0.00
Cd-110	2.816E-07	2.816E-07	2.816E-07	2.816E-07	2.816E-07	2.816E-07	2.816E-07
Cd-111	6.903E-09	6.903E-09	6.903E-09	6.903E-09	6.903E-09	6.903E-09	6.903E-09
Cd-112	1.667E-10	1.667E-10	1.667E-10	1.667E-10	1.667E-10	1.667E-10	1.667E-10
Cd-113	2.633E-14	2.633E-14	2.633E-14	2.633E-14	2.633E-14	2.633E-14	2.633E-14
Cd-114	5.098E-13	5.098E-13	5.098E-13	5.098E-13	5.098E-13	5.098E-13	5.098E-13
Total	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01

TABLE F.7.e. Fuel Activation Product Inventory by Isotope at
30 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	9.244E-09	9.244E-09	9.244E-09	9.244E-09	9.244E-09	9.244E-09	9.244E-09
H-2	7.221E-12	7.221E-12	7.221E-12	7.221E-12	7.221E-12	7.221E-12	7.221E-12
H-3	3.595E-15	3.214E-15	2.872E-15	2.567E-15	1.939E-15	1.465E-15	0.00
He-3	1.038E-15	1.420E-15	1.761E-15	2.066E-15	2.694E-15	3.169E-15	4.633E-15
He-4	1.577E-06	1.577E-06	1.577E-06	1.577E-06	1.577E-06	1.577E-06	1.577E-06
Li-6	1.264E-14	1.264E-14	1.264E-14	1.264E-14	1.264E-14	1.264E-14	1.264E-14
Be-9	9.881E-11	9.881E-11	9.881E-11	9.881E-11	9.881E-11	9.881E-11	9.881E-11
Be-10	2.988E-11	2.988E-11	2.988E-11	2.988E-11	2.988E-11	2.988E-11	2.986E-11
B-11	9.674E-09	9.674E-09	9.674E-09	9.674E-09	9.674E-09	9.674E-09	9.674E-09
C-12	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05
C-13	5.334E-06	5.334E-06	5.334E-06	5.334E-06	5.334E-06	5.334E-06	5.334E-06
C-14	1.325E-07	1.325E-07	1.324E-07	1.324E-07	1.323E-07	1.322E-07	1.174E-07
N-14	2.587E-05	2.587E-05	2.587E-05	2.587E-05	2.587E-05	2.587E-05	2.589E-05
N-15	1.089E-07	1.089E-07	1.089E-07	1.089E-07	1.089E-07	1.089E-07	1.089E-07
O-16	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01
O-17	5.430E-05	5.430E-05	5.430E-05	5.430E-05	5.430E-05	5.430E-05	5.430E-05
O-18	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04
F-19	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06	5.700E-06
Ne-20	1.703E-10	1.703E-10	1.703E-10	1.703E-10	1.703E-10	1.703E-10	1.703E-10
Ne-21	7.553E-15	7.553E-15	7.553E-15	7.553E-15	7.553E-15	7.553E-15	7.553E-15
Ne-22	4.726E-15	4.726E-15	4.726E-15	4.726E-15	4.726E-15	4.726E-15	4.726E-15
Na-23	3.825E-16	3.825E-16	3.825E-16	3.825E-16	3.825E-16	3.825E-16	3.825E-16
Mg-24	1.121E-10	1.121E-10	1.121E-10	1.121E-10	1.121E-10	1.121E-10	1.121E-10
Mg-25	1.179E-10	1.179E-10	1.179E-10	1.179E-10	1.179E-10	1.179E-10	1.179E-10
Mg-26	5.391E-11	5.391E-11	5.391E-11	5.391E-11	5.391E-11	5.391E-11	5.391E-11
Al-27	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05
Si-28	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05
Si-29	1.761E-06	1.761E-06	1.761E-06	1.761E-06	1.761E-06	1.761E-06	1.761E-06
Si-30	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06
P-31	3.300E-10	3.300E-10	3.300E-10	3.300E-10	3.300E-10	3.300E-10	3.300E-10
S-32	1.222E-10	1.222E-10	1.222E-10	1.222E-10	1.222E-10	1.222E-10	1.222E-10
S-33	7.225E-14	7.225E-14	7.225E-14	7.225E-14	7.225E-14	7.225E-14	7.225E-14
S-34	8.510E-12	8.510E-12	8.510E-12	8.510E-12	8.510E-12	8.510E-12	8.510E-12
S-35	2.224E-15	7.050E-18	2.234E-20	6.999E-23	3.961E-29	2.242E-35	0.00
S-36	1.467E-13	1.800E-13	2.133E-13	2.465E-13	3.297E-13	4.129E-13	1.670E-11
Cl-35	3.886E-06	3.886E-06	3.886E-06	3.886E-06	3.886E-06	3.886E-06	3.886E-06
Cl-36	3.802E-07	3.802E-07	3.802E-07	3.802E-07	3.802E-07	3.802E-07	3.793E-07
Cl-37	1.444E-06	1.444E-06	1.444E-06	1.444E-06	1.444E-06	1.444E-06	1.444E-06
Ar-36	7.564E-12	9.281E-12	1.100E-11	1.272E-11	1.701E-11	2.130E-11	8.620E-10
Ar-38	1.474E-09	1.474E-09	1.474E-09	1.474E-09	1.474E-09	1.474E-09	1.474E-09
Ar-39	1.693E-11	1.684E-11	1.676E-11	1.667E-11	1.646E-11	1.625E-11	1.300E-12
Ar-40	5.671E-11	5.671E-11	5.671E-11	5.671E-11	5.671E-11	5.671E-11	5.671E-11
K-39	4.161E-13	5.032E-13	5.897E-13	6.759E-13	8.893E-13	1.100E-12	1.605E-11
K-40	8.500E-09	8.500E-09	8.500E-09	8.500E-09	8.500E-09	8.500E-09	8.500E-09
K-41	2.891E-10	2.897E-10	2.902E-10	2.907E-10	2.921E-10	2.934E-10	5.536E-10
Ca-40	3.505E-05	3.505E-05	3.505E-05	3.505E-05	3.505E-05	3.505E-05	3.505E-05
Ca-41	3.117E-08	3.116E-08	3.116E-08	3.116E-08	3.116E-08	3.116E-08	3.090E-08

TABLE F.7.e. Fuel Activation Product Inventory by Isotope at
30 MWd/kgM, g/gU (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ca-42	2.453E-07	2.453E-07	2.453E-07	2.453E-07	2.453E-07	2.453E-07	2.453E-07
Ca-43	5.018E-08	5.018E-08	5.018E-08	5.018E-08	5.018E-08	5.018E-08	5.018E-08
Ca-44	8.310E-07	8.310E-07	8.310E-07	8.310E-07	8.310E-07	8.310E-07	8.310E-07
Ca-45	2.974E-13	1.330E-14	5.950E-16	2.661E-17	1.126E-20	4.765E-24	0.00
Ca-46	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09	1.455E-09
Ca-48	8.233E-08	8.233E-08	8.233E-08	8.233E-08	8.233E-08	8.233E-08	8.233E-08
Sc-45	1.855E-09	1.855E-09	1.855E-09	1.855E-09	1.855E-09	1.855E-09	1.855E-09
Ti-46	4.414E-11	4.414E-11	4.414E-11	4.414E-11	4.414E-11	4.414E-11	4.414E-11
Ti-47	2.325E-12	2.325E-12	2.325E-12	2.325E-12	2.325E-12	2.325E-12	2.325E-12
Ti-48	4.973E-15	4.973E-15	4.973E-15	4.973E-15	4.973E-15	4.973E-15	4.973E-15
Ti-49	2.001E-10	2.001E-10	2.001E-10	2.001E-10	2.001E-10	2.001E-10	2.001E-10
Ti-50	5.184E-13	5.184E-13	5.184E-13	5.184E-13	5.184E-13	5.184E-13	5.184E-13
V-51	3.449E-11	3.449E-11	3.449E-11	3.449E-11	3.449E-11	3.449E-11	3.449E-11
Cr-52	1.863E-13	1.863E-13	1.863E-13	1.863E-13	1.863E-13	1.863E-13	1.863E-13
Cr-53	6.348E-11	6.348E-11	6.348E-11	6.348E-11	6.348E-11	6.348E-11	6.348E-11
Cr-54	1.027E-09	1.031E-09	1.032E-09	1.032E-09	1.032E-09	1.032E-09	1.032E-09
Mn-54	5.214E-12	1.031E-12	2.041E-13	4.037E-14	7.029E-16	1.224E-17	0.00
Mn-55	1.305E-08	1.380E-08	1.424E-08	1.449E-08	1.476E-08	1.483E-08	1.486E-08
Fe-54	2.852E-06	2.852E-06	2.852E-06	2.852E-06	2.852E-06	2.852E-06	2.852E-06
Fe-55	1.810E-09	1.062E-09	6.232E-10	3.657E-10	9.642E-11	2.543E-11	0.00
Fe-56	4.667E-05	4.667E-05	4.667E-05	4.667E-05	4.667E-05	4.667E-05	4.667E-05
Fe-57	1.410E-06	1.410E-06	1.410E-06	1.410E-06	1.410E-06	1.410E-06	1.410E-06
Fe-58	1.658E-07	1.658E-07	1.658E-07	1.658E-07	1.658E-07	1.658E-07	1.658E-07
Co-59	2.329E-09	2.332E-09	2.335E-09	2.338E-09	2.345E-09	2.353E-09	3.796E-09
Co-60	8.193E-11	6.298E-11	4.841E-11	3.721E-11	1.928E-11	9.987E-12	0.00
Ni-58	1.894E-05	1.894E-05	1.894E-05	1.894E-05	1.894E-05	1.894E-05	1.894E-05
Ni-59	1.708E-07	1.708E-07	1.707E-07	1.707E-07	1.707E-07	1.707E-07	1.693E-07
Ni-60	7.546E-06	7.546E-06	7.546E-06	7.546E-06	7.546E-06	7.546E-06	7.546E-06
Ni-61	3.788E-07	3.788E-07	3.788E-07	3.788E-07	3.788E-07	3.788E-07	3.788E-07
Ni-62	1.045E-06	1.045E-06	1.045E-06	1.045E-06	1.045E-06	1.045E-06	1.045E-06
Ni-63	3.052E-08	3.006E-08	2.962E-08	2.917E-08	2.809E-08	2.706E-08	1.681E-11
Ni-64	2.814E-07	2.814E-07	2.814E-07	2.814E-07	2.814E-07	2.814E-07	2.814E-07
Cu-63	2.083E-09	2.539E-09	2.989E-09	3.432E-09	4.510E-09	5.549E-09	3.259E-08
Cu-65	9.916E-10	9.916E-10	9.916E-10	9.916E-10	9.916E-10	9.916E-10	9.916E-10
Zn-64	1.386E-12	1.386E-12	1.386E-12	1.386E-12	1.386E-12	1.386E-12	1.386E-12
Zn-66	2.792E-12	2.792E-12	2.792E-12	2.792E-12	2.792E-12	2.792E-12	2.792E-12
Zn-67	1.964E-15	1.964E-15	1.964E-15	1.964E-15	1.964E-15	1.964E-15	1.964E-15
Ru-104	9.095E-16	9.095E-16	9.095E-16	9.095E-16	9.095E-16	9.095E-16	9.095E-16
Pd-104	2.003E-13	2.003E-13	2.003E-13	2.003E-13	2.003E-13	2.003E-13	2.003E-13
Pd-105	1.546E-15	1.546E-15	1.546E-15	1.546E-15	1.546E-15	1.546E-15	1.546E-15
Pd-106	4.271E-12	4.271E-12	4.271E-12	4.271E-12	4.271E-12	4.271E-12	4.271E-12
Pd-107	2.021E-13	2.021E-13	2.021E-13	2.021E-13	2.021E-13	2.021E-13	2.021E-13
Pd-108	1.872E-09	1.923E-09	1.973E-09	2.022E-09	2.144E-09	2.262E-09	6.513E-09
Pd-110	9.394E-10	9.394E-10	9.394E-10	9.394E-10	9.394E-10	9.394E-10	9.394E-10
Ag-107	4.840E-07	4.840E-07	4.840E-07	4.840E-07	4.840E-07	4.840E-07	4.840E-07
Ag-108m	5.105E-09	5.050E-09	4.995E-09	4.941E-09	4.808E-09	4.678E-09	2.225E-11
Ag-109	2.069E-07	2.069E-07	2.069E-07	2.069E-07	2.069E-07	2.069E-07	2.069E-07

TABLE F.7.e. Fuel Activation Product Inventory by Isotope at
30 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Ag-110m	2.094E-11	2.760E-12	3.639E-13	4.797E-14	3.026E-16	1.909E-18	0.00
Cd-108	7.443E-08	7.444E-08	7.444E-08	7.445E-08	7.446E-08	7.447E-08	7.488E-08
Cd-109	6.766E-12	2.272E-12	7.629E-13	2.562E-13	1.674E-14	1.094E-15	0.00
Cd-110	3.199E-07	3.200E-07	3.200E-07	3.200E-07	3.200E-07	3.200E-07	3.200E-07
Cd-111	9.912E-09	9.912E-09	9.912E-09	9.912E-09	9.912E-09	9.912E-09	9.912E-09
Cd-112	3.002E-10	3.002E-10	3.002E-10	3.002E-10	3.002E-10	3.002E-10	3.002E-10
Cd-113	4.777E-14	4.777E-14	4.777E-14	4.777E-14	4.777E-14	4.777E-14	4.777E-14
Cd-114	1.156E-12	1.156E-12	1.156E-12	1.156E-12	1.156E-12	1.156E-12	1.156E-12
In-115	1.983E-16	1.983E-16	1.983E-16	1.983E-16	1.983E-16	1.983E-16	1.983E-16
Total	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01

TABLE F.7.f. Fuel Activation Product Inventory by Isotope at
35 MWd/kgM, g/gU

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	1.110E-08	1.110E-08	1.110E-08	1.110E-08	1.110E-08	1.110E-08	1.110E-08
H-2	1.043E-11	1.043E-11	1.043E-11	1.043E-11	1.043E-11	1.043E-11	1.043E-11
H-3	5.836E-15	5.216E-15	4.662E-15	4.167E-15	3.147E-15	2.377E-15	0.00
He-3	1.644E-15	2.264E-15	2.818E-15	3.313E-15	4.333E-15	5.103E-15	7.480E-15
He-4	1.895E-06	1.895E-06	1.895E-06	1.895E-06	1.895E-06	1.895E-06	1.895E-06
Li-6	1.665E-14	1.665E-14	1.665E-14	1.665E-14	1.665E-14	1.665E-14	1.665E-14
Be-9	1.187E-10	1.187E-10	1.187E-10	1.187E-10	1.187E-10	1.187E-10	1.187E-10
Be-10	4.252E-11	4.252E-11	4.252E-11	4.252E-11	4.252E-11	4.252E-11	4.251E-11
B-11	1.162E-08	1.162E-08	1.162E-08	1.162E-08	1.162E-08	1.162E-08	1.162E-08
C-12	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05	2.015E-05
C-13	6.361E-06	6.361E-06	6.361E-06	6.361E-06	6.361E-06	6.361E-06	6.361E-06
C-14	1.592E-07	1.591E-07	1.591E-07	1.591E-07	1.590E-07	1.589E-07	1.411E-07
N-14	2.585E-05	2.585E-05	2.585E-05	2.585E-05	2.585E-05	2.585E-05	2.586E-05
N-15	1.102E-07	1.102E-07	1.102E-07	1.102E-07	1.102E-07	1.102E-07	1.102E-07
O-16	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01	1.341E-01
O-17	5.431E-05	5.431E-05	5.431E-05	5.431E-05	5.431E-05	5.431E-05	5.431E-05
O-18	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04	3.085E-04
F-19	5.699E-06	5.699E-06	5.699E-06	5.699E-06	5.699E-06	5.699E-06	5.699E-06
Ne-20	2.047E-10	2.047E-10	2.047E-10	2.047E-10	2.047E-10	2.047E-10	2.047E-10
Ne-21	1.091E-14	1.091E-14	1.091E-14	1.091E-14	1.091E-14	1.091E-14	1.091E-14
Ne-22	6.829E-15	6.829E-15	6.829E-15	6.829E-15	6.829E-15	6.829E-15	6.829E-15
Na-23	5.529E-16	5.529E-16	5.529E-16	5.529E-16	5.529E-16	5.529E-16	5.529E-16
Mg-24	1.347E-10	1.347E-10	1.347E-10	1.347E-10	1.347E-10	1.347E-10	1.347E-10
Mg-25	1.417E-10	1.417E-10	1.417E-10	1.417E-10	1.417E-10	1.417E-10	1.417E-10
Mg-26	6.485E-11	6.485E-11	6.485E-11	6.485E-11	6.485E-11	6.485E-11	6.485E-11
Al-27	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05	3.628E-05
Si-28	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05	3.336E-05
Si-29	1.763E-06	1.763E-06	1.763E-06	1.763E-06	1.763E-06	1.763E-06	1.763E-06
Si-30	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06	1.202E-06
P-31	3.966E-10	3.966E-10	3.966E-10	3.966E-10	3.966E-10	3.966E-10	3.966E-10
S-32	1.455E-10	1.455E-10	1.455E-10	1.455E-10	1.455E-10	1.455E-10	1.455E-10
S-33	1.038E-13	1.038E-13	1.038E-13	1.038E-13	1.038E-13	1.038E-13	1.038E-13
S-34	1.023E-11	1.023E-11	1.023E-11	1.023E-11	1.023E-11	1.023E-11	1.023E-11
S-35	2.680E-15	8.494E-18	2.693E-20	8.437E-23	4.775E-29	2.702E-35	0.00
S-36	1.739E-13	2.134E-13	2.529E-13	2.925E-13	3.913E-13	4.901E-13	1.984E-11
Cl-35	3.815E-06	3.815E-06	3.815E-06	3.815E-06	3.815E-06	3.815E-06	3.815E-06
Cl-36	4.518E-07	4.518E-07	4.518E-07	4.518E-07	4.518E-07	4.518E-07	4.508E-07
Cl-37	1.446E-06	1.446E-06	1.446E-06	1.446E-06	1.446E-06	1.446E-06	1.446E-06
Ar-36	8.958E-12	1.100E-11	1.304E-11	1.508E-11	2.018E-11	2.529E-11	1.024E-09
Ar-38	1.772E-09	1.772E-09	1.772E-09	1.772E-09	1.772E-09	1.772E-09	1.772E-09
Ar-39	1.863E-11	1.854E-11	1.844E-11	1.835E-11	1.811E-11	1.788E-11	1.431E-12
Ar-40	7.992E-11	7.992E-11	7.992E-11	7.992E-11	7.992E-11	7.992E-11	7.992E-11
K-39	4.616E-13	5.574E-13	6.527E-13	7.475E-13	9.824E-13	1.214E-12	1.766E-11
K-40	1.014E-08	1.014E-08	1.014E-08	1.014E-08	1.014E-08	1.014E-08	1.014E-08
K-41	4.149E-10	4.155E-10	4.161E-10	4.168E-10	4.184E-10	4.200E-10	7.327E-10
Ca-40	3.504E-05	3.504E-05	3.504E-05	3.504E-05	3.504E-05	3.504E-05	3.504E-05
Ca-41	3.745E-08	3.745E-08	3.745E-08	3.745E-08	3.745E-08	3.745E-08	3.714E-08

TABLE F.7.f. Fuel Activation Product Inventory by Isotope at
35 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Ca-42	2.452E-07	2.452E-07	2.452E-07	2.452E-07	2.452E-07	2.452E-07	2.452E-07
Ca-43	5.010E-08	5.010E-08	5.010E-08	5.010E-08	5.010E-08	5.010E-08	5.010E-08
Ca-44	8.308E-07	8.308E-07	8.308E-07	8.308E-07	8.308E-07	8.308E-07	8.308E-07
Ca-45	3.649E-13	1.632E-14	7.300E-16	3.265E-17	1.382E-20	5.847E-24	0.00
Ca-46	1.454E-09	1.454E-09	1.454E-09	1.454E-09	1.454E-09	1.454E-09	1.454E-09
Ca-48	8.229E-08	8.229E-08	8.229E-08	8.229E-08	8.229E-08	8.229E-08	8.229E-08
Sc-45	2.219E-09	2.219E-09	2.219E-09	2.219E-09	2.219E-09	2.219E-09	2.219E-09
Ti-46	6.363E-11	6.363E-11	6.363E-11	6.363E-11	6.363E-11	6.363E-11	6.363E-11
Ti-47	2.821E-12	2.821E-12	2.821E-12	2.821E-12	2.821E-12	2.821E-12	2.821E-12
Ti-48	7.215E-15	7.215E-15	7.215E-15	7.215E-15	7.215E-15	7.215E-15	7.215E-15
Ti-49	2.403E-10	2.403E-10	2.403E-10	2.403E-10	2.403E-10	2.403E-10	2.403E-10
Ti-50	7.485E-13	7.485E-13	7.485E-13	7.485E-13	7.485E-13	7.485E-13	7.485E-13
V-51	4.139E-11	4.139E-11	4.139E-11	4.139E-11	4.139E-11	4.139E-11	4.139E-11
Cr-52	2.688E-13	2.688E-13	2.688E-13	2.688E-13	2.688E-13	2.688E-13	2.688E-13
Cr-53	7.595E-11	7.595E-11	7.595E-11	7.595E-11	7.595E-11	7.595E-11	7.595E-11
Cr-54	1.234E-09	1.239E-09	1.240E-09	1.240E-09	1.240E-09	1.240E-09	1.240E-09
Mn-54	6.389E-12	1.264E-12	2.501E-13	4.947E-14	8.613E-16	1.499E-17	0.00
Mn-55	1.562E-08	1.653E-08	1.707E-08	1.738E-08	1.771E-08	1.779E-08	1.782E-08
Fe-54	2.849E-06	2.849E-06	2.849E-06	2.849E-06	2.849E-06	2.849E-06	2.849E-06
Fe-55	2.199E-09	1.290E-09	7.569E-10	4.441E-10	1.171E-10	3.088E-11	0.00
Fe-56	4.661E-05	4.661E-05	4.661E-05	4.661E-05	4.661E-05	4.661E-05	4.661E-05
Fe-57	1.468E-06	1.468E-06	1.468E-06	1.468E-06	1.468E-06	1.468E-06	1.468E-06
Fe-58	1.681E-07	1.681E-07	1.681E-07	1.681E-07	1.681E-07	1.681E-07	1.681E-07
Co-58	1.563E-16	1.221E-19	9.547E-23	7.461E-26	1.274E-33	0.00	0.00
Co-59	3.074E-09	3.077E-09	3.081E-09	3.084E-09	3.093E-09	3.101E-09	4.788E-09
Co-60	1.203E-10	9.251E-11	7.111E-11	5.466E-11	2.832E-11	1.467E-11	0.00
Ni-58	1.890E-05	1.890E-05	1.890E-05	1.890E-05	1.890E-05	1.890E-05	1.890E-05
Ni-59	1.995E-07	1.995E-07	1.995E-07	1.995E-07	1.995E-07	1.995E-07	1.978E-07
Ni-60	7.546E-06	7.546E-06	7.546E-06	7.546E-06	7.546E-06	7.546E-06	7.546E-06
Ni-61	3.880E-07	3.880E-07	3.880E-07	3.880E-07	3.880E-07	3.880E-07	3.880E-07
Ni-62	1.039E-06	1.039E-06	1.039E-06	1.039E-06	1.039E-06	1.039E-06	1.039E-06
Ni-63	3.641E-08	3.586E-08	3.533E-08	3.480E-08	3.351E-08	3.227E-08	2.005E-11
Ni-64	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07
Cu-63	2.474E-09	3.019E-09	3.555E-09	4.083E-09	5.370E-09	6.609E-09	3.886E-08
Cu-65	1.191E-09	1.191E-09	1.191E-09	1.191E-09	1.191E-09	1.191E-09	1.191E-09
Zn-64	2.002E-12	2.002E-12	2.002E-12	2.002E-12	2.002E-12	2.002E-12	2.002E-12
Zn-66	4.032E-12	4.032E-12	4.032E-12	4.032E-12	4.032E-12	4.032E-12	4.032E-12
Zn-67	3.405E-15	3.405E-15	3.405E-15	3.405E-15	3.405E-15	3.405E-15	3.405E-15
Ru-104	1.076E-15	1.076E-15	1.076E-15	1.076E-15	1.076E-15	1.076E-15	1.076E-15
Pd-104	2.367E-13	2.367E-13	2.367E-13	2.367E-13	2.367E-13	2.367E-13	2.367E-13
Pd-105	2.195E-15	2.195E-15	2.195E-15	2.195E-15	2.195E-15	2.195E-15	2.195E-15
Pd-106	5.044E-12	5.044E-12	5.044E-12	5.044E-12	5.044E-12	5.044E-12	5.044E-12
Pd-107	2.411E-13	2.411E-13	2.411E-13	2.411E-13	2.411E-13	2.411E-13	2.411E-13
Pd-108	2.180E-09	2.240E-09	2.299E-09	2.358E-09	2.502E-09	2.642E-09	7.675E-09
Pd-110	1.042E-09	1.042E-09	1.042E-09	1.042E-09	1.042E-09	1.042E-09	1.042E-09
Ag-107	4.691E-07	4.691E-07	4.691E-07	4.691E-07	4.691E-07	4.691E-07	4.691E-07
Ag-108m	6.044E-09	5.979E-09	5.914E-09	5.850E-09	5.692E-09	5.539E-09	2.634E-11

TABLE F.7.f. Fuel Activation Product Inventory by Isotope at
35 MWd/kgM, g/gU (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Ag-109	1.709E-07	1.709E-07	1.709E-07	1.709E-07	1.709E-07	1.709E-07	1.709E-07
Ag-110m	2.151E-11	2.836E-12	3.738E-13	4.928E-14	3.109E-16	1.962E-18	0.00
Cd-108	8.806E-08	8.806E-08	8.807E-08	8.807E-08	8.809E-08	8.810E-08	8.858E-08
Cd-109	9.472E-12	3.181E-12	1.068E-12	3.586E-13	2.343E-14	1.531E-15	0.00
Cd-110	3.525E-07	3.526E-07	3.526E-07	3.526E-07	3.526E-07	3.526E-07	3.526E-07
Cd-111	1.342E-08	1.342E-08	1.342E-08	1.342E-08	1.342E-08	1.342E-08	1.342E-08
Cd-112	4.954E-10	4.954E-10	4.954E-10	4.954E-10	4.954E-10	4.954E-10	4.954E-10
Cd-113	7.925E-14	7.925E-14	7.925E-14	7.925E-14	7.925E-14	7.925E-14	7.925E-14
Cd-114	2.330E-12	2.330E-12	2.330E-12	2.330E-12	2.330E-12	2.330E-12	2.330E-12
In-115	4.500E-16	4.500E-16	4.500E-16	4.500E-16	4.500E-16	4.500E-16	4.500E-16
Sn-116	3.292E-16	3.292E-16	3.292E-16	3.292E-16	3.292E-16	3.292E-16	3.292E-16
Total	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01	1.347E-01

Table F.8.a. Cladding Activation Product Inventory by Isotope at
10 MWd/kgM, g/gZr

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	1.201E-05	1.201E-05	1.201E-05	1.201E-05	1.201E-05	1.201E-05	1.201E-05
H-2	9.256E-09	9.256E-09	9.256E-09	9.256E-09	9.256E-09	9.256E-09	9.256E-09
H-3	3.437E-15	3.072E-15	2.746E-15	2.454E-15	1.854E-15	1.400E-15	0.00
He-3	1.325E-15	1.690E-15	2.016E-15	2.307E-15	2.908E-15	3.362E-15	4.762E-15
He-4	1.926E-08	1.926E-08	1.926E-08	1.926E-08	1.926E-08	1.926E-08	1.926E-08
Li-6	1.429E-14	1.429E-14	1.429E-14	1.429E-14	1.429E-14	1.429E-14	1.429E-14
Be-9	2.561E-10	2.561E-10	2.561E-10	2.561E-10	2.561E-10	2.561E-10	2.561E-10
Be-10	6.823E-12	6.823E-12	6.823E-12	6.823E-12	6.823E-12	6.823E-12	6.821E-12
B-11	3.924E-09	3.924E-09	3.924E-09	3.924E-09	3.924E-09	3.924E-09	3.924E-09
C-12	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04
C-13	2.117E-06	2.117E-06	2.117E-06	2.117E-06	2.117E-06	2.117E-06	2.117E-06
C-14	4.458E-08	4.457E-08	4.456E-08	4.455E-08	4.452E-08	4.449E-08	3.952E-08
N-14	3.481E-05	3.481E-05	3.481E-05	3.481E-05	3.481E-05	3.481E-05	3.482E-05
N-15	1.391E-07	1.391E-07	1.391E-07	1.391E-07	1.391E-07	1.391E-07	1.391E-07
O-16	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03
O-17	4.844E-07	4.844E-07	4.844E-07	4.844E-07	4.844E-07	4.844E-07	4.844E-07
O-18	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06
F-19	6.830E-13	6.830E-13	6.830E-13	6.830E-13	6.830E-13	6.830E-13	6.830E-13
Mg-24	3.733E-11	3.733E-11	3.733E-11	3.733E-11	3.733E-11	3.733E-11	3.733E-11
Mg-25	7.847E-11	7.847E-11	7.847E-11	7.847E-11	7.847E-11	7.847E-11	7.847E-11
Mg-26	3.579E-11	3.579E-11	3.579E-11	3.579E-11	3.579E-11	3.579E-11	3.579E-11
Al-27	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05
Si-28	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05
Si-29	3.862E-06	3.862E-06	3.862E-06	3.862E-06	3.862E-06	3.862E-06	3.862E-06
Si-30	2.647E-06	2.647E-06	2.647E-06	2.647E-06	2.647E-06	2.647E-06	2.647E-06
P-31	2.198E-10	2.198E-10	2.198E-10	2.198E-10	2.198E-10	2.198E-10	2.198E-10
S-32	1.337E-14	1.337E-14	1.337E-14	1.337E-14	1.337E-14	1.337E-14	1.337E-14
Ti-47	4.514E-11	4.514E-11	4.514E-11	4.514E-11	4.514E-11	4.514E-11	4.514E-11
Ti-48	3.114E-14	3.114E-14	3.114E-14	3.114E-14	3.114E-14	3.114E-14	3.114E-14
Ti-49	1.243E-10	1.243E-10	1.243E-10	1.243E-10	1.243E-10	1.243E-10	1.243E-10
Ti-50	4.887E-10	4.887E-10	4.887E-10	4.887E-10	4.887E-10	4.887E-10	4.887E-10
V-50	1.826E-09	1.826E-09	1.826E-09	1.826E-09	1.826E-09	1.826E-09	1.826E-09
V-51	4.888E-07	4.888E-07	4.888E-07	4.888E-07	4.888E-07	4.888E-07	4.888E-07
Cr-50	4.548E-05	4.548E-05	4.548E-05	4.548E-05	4.548E-05	4.548E-05	4.548E-05
Cr-52	9.188E-04	9.188E-04	9.188E-04	9.188E-04	9.188E-04	9.188E-04	9.188E-04
Cr-53	1.071E-04	1.071E-04	1.071E-04	1.071E-04	1.071E-04	1.071E-04	1.071E-04
Cr-54	2.824E-05	2.824E-05	2.824E-05	2.824E-05	2.824E-05	2.824E-05	2.824E-05
Mn-54	3.579E-11	7.081E-12	1.401E-12	2.772E-13	4.825E-15	8.400E-17	0.00
Mn-55	1.075E-07	1.129E-07	1.161E-07	1.180E-07	1.199E-07	1.204E-07	1.206E-07
Fe-54	7.283E-05	7.283E-05	7.283E-05	7.283E-05	7.283E-05	7.283E-05	7.283E-05
Fe-55	1.309E-08	7.680E-09	4.506E-09	2.644E-09	6.972E-10	1.838E-10	0.00
Fe-56	1.192E-03	1.192E-03	1.192E-03	1.192E-03	1.192E-03	1.192E-03	1.192E-03
Fe-57	3.073E-05	3.073E-05	3.073E-05	3.073E-05	3.073E-05	3.073E-05	3.073E-05
Fe-58	3.993E-06	3.993E-06	3.993E-06	3.993E-06	3.993E-06	3.993E-06	3.993E-06
Co-59	7.492E-09	7.509E-09	7.527E-09	7.544E-09	7.588E-09	7.631E-09	1.611E-08
Co-60	1.902E-10	1.462E-10	1.124E-10	8.641E-11	4.477E-11	2.319E-11	0.00

Table F.8.a. Cladding Activation Product Inventory by Isotope at
10 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Ni-58	3.359E-04	3.359E-04	3.359E-04	3.359E-04	3.359E-04	3.359E-04	3.359E-04
Ni-59	1.003E-06	1.003E-06	1.003E-06	1.003E-06	1.002E-06	1.002E-06	9.940E-07
Ni-60	1.331E-04	1.331E-04	1.331E-04	1.331E-04	1.331E-04	1.331E-04	1.331E-04
Ni-61	6.109E-06	6.109E-06	6.109E-06	6.109E-06	6.109E-06	6.109E-06	6.109E-06
Ni-62	1.878E-05	1.878E-05	1.878E-05	1.878E-05	1.878E-05	1.878E-05	1.878E-05
Ni-63	1.665E-07	1.641E-07	1.616E-07	1.592E-07	1.533E-07	1.476E-07	9.174E-11
Ni-64	4.952E-06	4.952E-06	4.952E-06	4.952E-06	4.952E-06	4.952E-06	4.952E-06
Cu-63	1.158E-08	1.407E-08	1.652E-08	1.894E-08	2.483E-08	3.049E-08	1.780E-07
Cu-65	5.283E-09	5.283E-09	5.283E-09	5.283E-09	5.283E-09	5.283E-09	5.283E-09
Zn-64	2.189E-12	2.189E-12	2.189E-12	2.189E-12	2.189E-12	2.189E-12	2.189E-12
Zn-66	4.492E-12	4.492E-12	4.492E-12	4.492E-12	4.492E-12	4.492E-12	4.492E-12
Sr-87	2.771E-09	2.771E-09	2.771E-09	2.771E-09	2.771E-09	2.771E-09	2.771E-09
Sr-88	2.568E-07	2.568E-07	2.568E-07	2.568E-07	2.568E-07	2.568E-07	2.568E-07
Sr-90	2.547E-12	2.429E-12	2.316E-12	2.208E-12	1.960E-12	1.741E-12	1.289E-22
Y-89	1.954E-08	1.954E-08	1.954E-08	1.954E-08	1.954E-08	1.954E-08	1.954E-08
Zr-90	4.976E-01	4.976E-01	4.976E-01	4.976E-01	4.976E-01	4.976E-01	4.976E-01
Zr-91	1.093E-01	1.093E-01	1.093E-01	1.093E-01	1.093E-01	1.093E-01	1.093E-01
Zr-92	1.691E-01	1.691E-01	1.691E-01	1.691E-01	1.691E-01	1.691E-01	1.691E-01
Zr-93	7.162E-05	7.162E-05	7.162E-05	7.162E-05	7.162E-05	7.16E-05	7.159E-05
Zr-94	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01
Zr-95	9.821E-14	3.591E-17	1.313E-20	4.800E-24	1.227E-32	0.00	0.00
Zr-96	2.883E-02	2.883E-02	2.883E-02	2.883E-02	2.883E-02	2.883E-02	2.883E-02
Nb-93	7.142E-11	9.888E-11	1.300E-10	1.643E-10	2.626E-10	3.752E-10	3.200E-08
Nb-93m	2.185E-10	2.559E-10	2.897E-10	3.203E-10	3.843E-10	4.339E-10	6.046E-10
Nb-94	1.776E-14	1.776E-14	1.776E-14	1.776E-14	1.775E-14	1.775E-14	1.717E-14
Nb-95	1.198E-13	4.380E-17	1.601E-20	5.855E-24	1.110E-34	0.00	0.00
Mo-95	2.426E-05	2.426E-05	2.426E-05	2.426E-05	2.426E-05	2.426E-05	2.426E-05
Mo-96	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07	3.191E-07
Mo-97	3.633E-05	3.633E-05	3.633E-05	3.633E-05	3.633E-05	3.633E-05	3.633E-05
Mo-98	9.017E-08	9.017E-08	9.017E-08	9.017E-08	9.017E-08	9.017E-08	9.017E-08
Mo-100	3.370E-15	3.370E-15	3.370E-15	3.370E-15	3.370E-15	3.370E-15	3.370E-15
Tc-99	2.881E-11	2.881E-11	2.881E-11	2.881E-11	2.881E-11	2.881E-11	2.872E-11
Ru-100	4.659E-13	4.659E-13	4.659E-13	4.659E-13	4.659E-13	4.659E-13	4.659E-13
Cd-111	2.871E-12	2.871E-12	2.871E-12	2.871E-12	2.871E-12	2.871E-12	2.871E-12
Cd-112	2.480E-11	2.480E-11	2.480E-11	2.480E-11	2.480E-11	2.480E-11	2.480E-11
Cd-113	2.598E-13	2.598E-13	2.598E-13	2.598E-13	2.598E-13	2.598E-13	2.598E-13
Cd-114	1.626E-09	1.626E-09	1.626E-09	1.626E-09	1.626E-09	1.626E-09	1.626E-09
Cd-116	1.776E-11	1.776E-11	1.776E-11	1.776E-11	1.776E-11	1.776E-11	1.776E-11
In-113	7.432E-07	7.432E-07	7.432E-07	7.432E-07	7.432E-07	7.432E-07	7.432E-07
In-113m	2.474E-15	3.038E-17	3.733E-19	4.588E-21	7.681E-26	1.286E-30	0.00
In-115	1.534E-11	1.534E-11	1.534E-11	1.534E-11	1.534E-11	1.534E-11	1.534E-11
Sn-112	1.407E-04	1.407E-04	1.407E-04	1.407E-04	1.407E-04	1.407E-04	1.407E-04
Sn-113	4.116E-12	5.058E-14	6.216E-16	7.639E-18	1.279E-22	2.141E-27	0.00
Sn-114	9.645E-05	9.645E-05	9.645E-05	9.645E-05	9.645E-05	9.645E-05	9.645E-05
Sn-115	5.352E-05	5.352E-05	5.352E-05	5.352E-05	5.352E-05	5.352E-05	5.352E-05
Sn-116	2.146E-03	2.146E-03	2.146E-03	2.146E-03	2.146E-03	2.146E-03	2.146E-03
Sn-117	1.148E-03	1.148E-03	1.148E-03	1.148E-03	1.148E-03	1.148E-03	1.148E-03

Table F.8.a. Cladding Activation Product Inventory by Isotope at
10 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-118	3.617E-03	3.617E-03	3.617E-03	3.617E-03	3.617E-03	3.617E-03	3.617E-03
Sn-119	1.302E-03	1.302E-03	1.302E-03	1.302E-03	1.302E-03	1.302E-03	1.302E-03
Sn-119m	6.991E-09	8.852E-10	1.121E-10	1.419E-11	8.098E-14	4.621E-16	0.00
Sn-120	4.909E-03	4.909E-03	4.909E-03	4.909E-03	4.909E-03	4.909E-03	4.909E-03
Sn-121m	1.075E-08	1.045E-08	1.017E-08	9.887E-09	9.225E-09	8.607E-09	1.075E-14
Sn-122	7.085E-04	7.085E-04	7.085E-04	7.085E-04	7.085E-04	7.085E-04	7.085E-04
Sn-123	4.682E-12	9.289E-14	1.843E-15	3.656E-17	2.027E-21	1.124E-25	0.00
Sn-124	8.744E-04	8.744E-04	8.744E-04	8.744E-04	8.744E-04	8.744E-04	8.744E-04
Sb-121	2.022E-06	2.023E-06	2.023E-06	2.023E-06	2.024E-06	2.025E-06	2.033E-06
Sb-123	2.100E-07	2.100E-07	2.100E-07	2.100E-07	2.100E-07	2.100E-07	2.100E-07
Sb-125	3.252E-07	1.972E-07	1.195E-07	7.246E-08	2.074E-08	5.934E-09	0.00
Te-122	3.859E-08	3.859E-08	3.859E-08	3.859E-08	3.859E-08	3.859E-08	3.859E-08
Te-123	2.347E-10	2.347E-10	2.347E-10	2.347E-10	2.347E-10	2.347E-10	2.347E-10
Te-123m	2.423E-15	3.523E-17	5.121E-19	7.448E-21	1.898E-25	4.838E-30	0.00
Te-124	2.179E-09	2.179E-09	2.179E-09	2.179E-09	2.179E-09	2.179E-09	2.179E-09
Te-125	2.173E-06	2.303E-06	2.382E-06	2.429E-06	2.482E-06	2.497E-06	2.503E-06
Te-125m	4.549E-09	2.759E-09	1.672E-09	1.014E-09	2.900E-10	8.299E-11	0.00
Te-126	7.248E-09	7.248E-09	7.248E-09	7.248E-09	7.248E-09	7.248E-09	7.248E-09
Te-128	3.854E-15	3.854E-15	3.854E-15	3.854E-15	3.854E-15	3.854E-15	3.854E-15
I-127	7.721E-12	7.721E-12	7.721E-12	7.721E-12	7.721E-12	7.721E-12	7.721E-12
Xe-128	6.033E-14	6.033E-14	6.033E-14	6.033E-14	6.033E-14	6.033E-14	6.033E-14
Lu-175	2.101E-08	2.101E-08	2.101E-08	2.101E-08	2.101E-08	2.101E-08	2.101E-08
Lu-176	3.498E-10	3.498E-10	3.498E-10	3.498E-10	3.498E-10	3.498E-10	3.498E-10
Hf-174	6.313E-08	6.313E-08	6.313E-08	6.313E-08	6.313E-08	6.313E-08	6.313E-08
Hf-176	2.439E-06	2.439E-06	2.439E-06	2.439E-06	2.439E-06	2.439E-06	2.439E-06
Hf-177	2.479E-06	2.479E-06	2.479E-06	2.479E-06	2.479E-06	2.479E-06	2.479E-06
Hf-178	1.641E-05	1.641E-05	1.641E-05	1.641E-05	1.641E-05	1.641E-05	1.641E-05
Hf-179	1.280E-05	1.280E-05	1.280E-05	1.280E-05	1.280E-05	1.280E-05	1.280E-05
Hf-180	2.057E-05	2.057E-05	2.057E-05	2.057E-05	2.057E-05	2.057E-05	2.057E-05
Hf-182	2.409E-10	2.409E-10	2.409E-10	2.409E-10	2.409E-10	2.409E-10	2.408E-10
Ta-181	2.798E-07	2.798E-07	2.798E-07	2.798E-07	2.798E-07	2.798E-07	2.798E-07
Ta-182	2.252E-13	2.764E-15	4.216E-17	8.839E-18	8.426E-18	8.426E-18	8.425E-18
W-182	1.387E-08	1.387E-08	1.387E-08	1.387E-08	1.387E-08	1.387E-08	1.387E-08
W-183	4.494E-09	4.494E-09	4.494E-09	4.494E-09	4.494E-09	4.494E-09	4.494E-09
W-184	1.016E-10	1.016E-10	1.016E-10	1.016E-10	1.016E-10	1.016E-10	1.016E-10
Re-185	8.090E-14	8.090E-14	8.090E-14	8.090E-14	8.090E-14	8.090E-14	8.090E-14
Os-186	4.367E-15	4.367E-15	4.367E-15	4.367E-15	4.367E-15	4.367E-15	4.367E-15
Total	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

Table F.8.b. Cladding Activation Product Inventory by Isotope at
15 MWd/kgM, g/gZr

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
H-1	1.201E-05	1.201E-05	1.201E-05	1.201E-05	1.201E-05	1.201E-05	1.201E-05
H-2	1.226E-08	1.226E-08	1.226E-08	1.226E-08	1.226E-08	1.226E-08	1.226E-08
H-3	8.259E-15	7.382E-15	6.598E-15	5.897E-15	4.454E-15	3.364E-15	0.00
He-3	2.828E-15	3.705E-15	4.489E-15	5.189E-15	6.632E-15	7.722E-15	1.109E-14
He-4	2.968E-08	2.968E-08	2.968E-08	2.968E-08	2.968E-08	2.968E-08	2.968E-08
Li-6	3.053E-14	3.053E-14	3.053E-14	3.053E-14	3.053E-14	3.053E-14	3.053E-14
Be-9	3.919E-10	3.919E-10	3.919E-10	3.919E-10	3.919E-10	3.919E-10	3.919E-10
Be-10	1.046E-11	1.046E-11	1.046E-11	1.046E-11	1.046E-11	1.046E-11	1.046E-11
B-11	6.004E-09	6.004E-09	6.004E-09	6.004E-09	6.004E-09	6.004E-09	6.004E-09
C-12	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04
C-13	2.124E-06	2.124E-06	2.124E-06	2.124E-06	2.124E-06	2.124E-06	2.124E-06
C-14	6.820E-08	6.819E-08	6.817E-08	6.815E-08	6.811E-08	6.807E-08	6.046E-08
N-14	3.478E-05	3.478E-05	3.478E-05	3.478E-05	3.478E-05	3.478E-05	3.479E-05
N-15	1.400E-07	1.400E-07	1.400E-07	1.400E-07	1.400E-07	1.400E-07	1.400E-07
O-16	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03
O-17	4.845E-07	4.845E-07	4.845E-07	4.845E-07	4.845E-07	4.845E-07	4.845E-07
O-18	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06
F-19	1.045E-12	1.045E-12	1.045E-12	1.045E-12	1.045E-12	1.045E-12	1.045E-12
Ne-22	2.223E-15	2.223E-15	2.223E-15	2.223E-15	2.223E-15	2.223E-15	2.223E-15
Mg-24	5.711E-11	5.711E-11	5.711E-11	5.711E-11	5.711E-11	5.711E-11	5.711E-11
Mg-25	1.201E-10	1.201E-10	1.201E-10	1.201E-10	1.201E-10	1.201E-10	1.201E-10
Mg-26	5.480E-11	5.480E-11	5.480E-11	5.480E-11	5.480E-11	5.480E-11	5.480E-11
Al-27	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05
Si-28	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05
Si-29	3.866E-06	3.866E-06	3.866E-06	3.866E-06	3.866E-06	3.866E-06	3.866E-06
Si-30	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06
P-31	3.362E-10	3.362E-10	3.362E-10	3.362E-10	3.362E-10	3.362E-10	3.362E-10
S-32	3.130E-14	3.130E-14	3.130E-14	3.130E-14	3.130E-14	3.130E-14	3.131E-14
Ti-47	6.887E-11	6.887E-11	6.887E-11	6.887E-11	6.887E-11	6.887E-11	6.887E-11
Ti-48	7.272E-14	7.272E-14	7.272E-14	7.272E-14	7.272E-14	7.272E-14	7.272E-14
Ti-49	1.900E-10	1.900E-10	1.900E-10	1.900E-10	1.900E-10	1.900E-10	1.900E-10
Ti-50	7.494E-10	7.494E-10	7.494E-10	7.494E-10	7.494E-10	7.494E-10	7.494E-10
V-50	2.749E-09	2.749E-09	2.749E-09	2.749E-09	2.749E-09	2.749E-09	2.749E-09
V-51	7.455E-07	7.455E-07	7.455E-07	7.455E-07	7.455E-07	7.455E-07	7.455E-07
Cr-50	4.523E-05	4.523E-05	4.523E-05	4.523E-05	4.523E-05	4.523E-05	4.523E-05
Cr-52	9.177E-04	9.177E-04	9.177E-04	9.177E-04	9.177E-04	9.177E-04	9.177E-04
Cr-53	1.075E-04	1.075E-04	1.075E-04	1.075E-04	1.075E-04	1.075E-04	1.075E-04
Cr-54	2.894E-05	2.894E-05	2.894E-05	2.894E-05	2.894E-05	2.894E-05	2.894E-05
Mn-54	5.670E-11	1.122E-11	2.219E-12	4.390E-13	7.643E-15	1.331E-16	0.00
Mn-55	1.641E-07	1.725E-07	1.774E-07	1.803E-07	1.833E-07	1.841E-07	1.844E-07
Fe-54	7.277E-05	7.277E-05	7.277E-05	7.277E-05	7.277E-05	7.277E-05	7.277E-05
Fe-55	2.034E-08	1.193E-08	7.001E-09	4.107E-09	1.083E-09	2.856E-10	0.00
Fe-56	1.191E-03	1.191E-03	1.191E-03	1.191E-03	1.191E-03	1.191E-03	1.191E-03
Fe-57	3.191E-05	3.191E-05	3.191E-05	3.191E-05	3.191E-05	3.191E-05	3.191E-05
Fe-58	4.036E-06	4.036E-06	4.036E-06	4.036E-06	4.036E-06	4.036E-06	4.036E-06
Co-58	1.134E-15	8.864E-19	6.927E-22	5.414E-25	9.245E-33	0.00	0.00

Table F.8.b. Cladding Activation Product Inventory by Isotope at
15 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	70 Years	1000 Years
Co-59	1.402E-08	1.405E-08	1.407E-08	1.410E-08	1.416E-08	1.423E-08	2.690E-08
Co-60	3.628E-10	2.789E-10	2.144E-10	1.648E-10	8.537E-11	4.422E-11	0.00
Ni-58	3.353E-04	3.353E-04	3.353E-04	3.353E-04	3.353E-04	3.353E-04	3.353E-04
Ni-59	1.499E-06	1.499E-06	1.499E-06	1.499E-06	1.499E-06	1.499E-06	1.487E-06
Ni-60	1.330E-04	1.330E-04	1.330E-04	1.330E-04	1.330E-04	1.330E-04	1.330E-04
Ni-61	6.238E-06	6.238E-06	6.238E-06	6.238E-06	6.238E-06	6.238E-06	6.238E-06
Ni-62	1.869E-05	1.869E-05	1.869E-05	1.869E-05	1.869E-05	1.869E-05	1.869E-05
Ni-63	2.534E-07	2.496E-07	2.459E-07	2.422E-07	2.332E-07	2.246E-07	1.396E-10
Ni-64	4.951E-06	4.951E-06	4.951E-06	4.951E-06	4.951E-06	4.951E-06	4.951E-06
Cu-63	1.753E-08	2.132E-08	2.505E-08	2.873E-08	3.768E-08	4.630E-08	2.708E-07
Cu-65	8.082E-09	8.082E-09	8.082E-09	8.082E-09	8.082E-09	8.082E-09	8.082E-09
Zn-64	5.168E-12	5.168E-12	5.168E-12	5.168E-12	5.168E-12	5.168E-12	5.168E-12
Zn-66	1.052E-11	1.052E-11	1.052E-11	1.052E-11	1.052E-11	1.052E-11	1.052E-11
Zn-67	3.428E-15	3.428E-15	3.428E-15	3.428E-15	3.428E-15	3.428E-15	3.428E-15
Sr-87	4.207E-09	4.207E-09	4.207E-09	4.207E-09	4.207E-09	4.207E-09	4.207E-09
Sr-88	3.929E-07	3.929E-07	3.929E-07	3.929E-07	3.929E-07	3.929E-07	3.929E-07
Sr-90	5.964E-12	5.687E-12	5.423E-12	5.171E-12	4.590E-12	4.075E-12	3.019E-22
Y-89	2.991E-08	2.991E-08	2.991E-08	2.991E-08	2.991E-08	2.991E-08	2.991E-08
Y-90	1.496E-15	1.426E-15	1.360E-15	1.297E-15	1.151E-15	1.022E-15	7.570E-26
Zr-90	4.975E-01	4.975E-01	4.975E-01	4.975E-01	4.975E-01	4.975E-01	4.975E-01
Zr-91	1.092E-01	1.092E-01	1.092E-01	1.092E-01	1.092E-01	1.092E-01	1.092E-01
Zr-92	1.691E-01	1.691E-01	1.691E-01	1.691E-01	1.691E-01	1.691E-01	1.691E-01
Zr-93	1.094E-04	1.094E-04	1.094E-04	1.094E-04	1.094E-04	1.094E-04	1.094E-04
Zr-94	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01
Zr-95	1.566E-13	5.725E-17	2.093E-20	7.653E-24	1.956E-32	0.00	0.00
Zr-96	2.881E-02	2.881E-02	2.881E-02	2.881E-02	2.881E-02	2.881E-02	2.881E-02
Nb-93	1.083E-10	1.501E-10	1.974E-10	2.498E-10	3.996E-10	5.715E-10	4.889E-08
Nb-93m	3.323E-10	3.897E-10	4.415E-10	4.883E-10	5.863E-10	6.623E-10	9.238E-10
Nb-94	4.211E-14	4.211E-14	4.211E-14	4.210E-14	4.210E-14	4.209E-14	4.071E-14
Nb-95	1.910E-13	6.982E-17	2.553E-20	9.334E-24	1.769E-34	0.00	0.00
Mo-95	3.688E-05	3.688E-05	3.688E-05	3.688E-05	3.688E-05	3.688E-05	3.688E-05
Mo-96	7.443E-07	7.443E-07	7.443E-07	7.443E-07	7.443E-07	7.443E-07	7.443E-07
Mo-97	5.551E-05	5.551E-05	5.551E-05	5.551E-05	5.551E-05	5.551E-05	5.551E-05
Mo-98	2.107E-07	2.107E-07	2.107E-07	2.107E-07	2.107E-07	2.107E-07	2.107E-07
Mo-100	1.854E-14	1.854E-14	1.854E-14	1.854E-14	1.854E-14	1.854E-14	1.854E-14
Tc-99	1.022E-10	1.022E-10	1.022E-10	1.022E-10	1.022E-10	1.022E-10	1.019E-10
Ru-99	2.267E-15	2.932E-15	3.597E-15	4.263E-15	5.926E-15	7.589E-15	3.331E-13
Ru-100	2.534E-12	2.534E-12	2.534E-12	2.534E-12	2.534E-12	2.534E-12	2.534E-12
Ru-101	4.247E-15	4.247E-15	4.247E-15	4.247E-15	4.247E-15	4.247E-15	4.247E-15
Cd-111	4.365E-12	4.365E-12	4.365E-12	4.365E-12	4.365E-12	4.365E-12	4.365E-12
Cd-112	3.761E-11	3.761E-11	3.761E-11	3.761E-11	3.761E-11	3.761E-11	3.761E-11
Cd-113	2.614E-13	2.614E-13	2.614E-13	2.614E-13	2.614E-13	2.614E-13	2.614E-13
Cd-114	3.672E-09	3.672E-09	3.672E-09	3.672E-09	3.672E-09	3.672E-09	3.672E-09
Cd-116	2.723E-11	2.723E-11	2.723E-11	2.723E-11	2.723E-11	2.723E-11	2.723E-11
In-113	1.113E-06	1.113E-06	1.113E-06	1.113E-06	1.113E-06	1.113E-06	1.113E-06
In-113m	3.941E-15	4.843E-17	5.952E-19	7.314E-21	1.225E-25	2.050E-30	0.00

Table F.8.b. Cladding Activation Product Inventory by Isotope at
15 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
In-115	1.849E-11	1.849E-11	1.849E-11	1.849E-11	1.849E-11	1.849E-11	1.849E-11
Sn-112	1.403E-04	1.403E-04	1.403E-04	1.403E-04	1.403E-04	1.403E-04	1.403E-04
Sn-113	6.561E-12	8.064E-14	9.910E-16	1.218E-17	2.039E-22	3.414E-27	0.00
Sn-114	9.648E-05	9.648E-05	9.648E-05	9.648E-05	9.648E-05	9.648E-05	9.648E-05
Sn-115	5.266E-05	5.266E-05	5.266E-05	5.266E-05	5.266E-05	5.266E-05	5.266E-05
Sn-116	2.141E-03	2.141E-03	2.141E-03	2.141E-03	2.141E-03	2.141E-03	2.141E-03
Sn-117	1.150E-03	1.150E-03	1.150E-03	1.150E-03	1.150E-03	1.150E-03	1.150E-03
Sn-118	3.615E-03	3.615E-03	3.615E-03	3.615E-03	3.615E-03	3.615E-03	3.615E-03
Sn-119	1.307E-03	1.307E-03	1.307E-03	1.307E-03	1.307E-03	1.307E-03	1.307E-03
Sn-119m	1.110E-08	1.406E-09	1.781E-10	2.255E-11	1.286E-13	7.341E-16	0.00
Sn-120	4.908E-03	4.908E-03	4.908E-03	4.908E-03	4.908E-03	4.908E-03	4.908E-03
Sn-121m	1.646E-08	1.601E-08	1.557E-08	1.514E-08	1.413E-08	1.318E-08	1.646E-14
Sn-122	7.084E-04	7.084E-04	7.084E-04	7.084E-04	7.084E-04	7.084E-04	7.084E-04
Sn-123	7.466E-12	1.481E-13	2.939E-15	5.830E-17	3.232E-21	1.792E-25	0.00
Sn-124	8.731E-04	8.731E-04	8.731E-04	8.731E-04	8.731E-04	8.731E-04	8.731E-04
Sb-121	3.064E-06	3.064E-06	3.065E-06	3.065E-06	3.066E-06	3.067E-06	3.080E-06
Sb-123	3.197E-07	3.197E-07	3.197E-07	3.197E-07	3.197E-07	3.197E-07	3.197E-07
Sb-125	5.041E-07	3.056E-07	1.853E-07	1.123E-07	3.214E-08	9.196E-09	0.00
Te-122	8.941E-08	8.941E-08	8.941E-08	8.941E-08	8.941E-08	8.941E-08	8.941E-08
Te-123	7.389E-10	7.389E-10	7.389E-10	7.389E-10	7.389E-10	7.389E-10	7.389E-10
Te-123m	8.927E-15	1.298E-16	1.887E-18	2.743E-20	6.992E-25	1.782E-29	0.00
Te-124	5.272E-09	5.272E-09	5.272E-09	5.272E-09	5.272E-09	5.272E-09	5.272E-09
Te-125	3.311E-06	3.512E-06	3.634E-06	3.708E-06	3.789E-06	3.813E-06	3.822E-06
Te-125m	7.051E-09	4.276E-09	2.592E-09	1.571E-09	4.495E-10	1.286E-10	0.00
Te-126	1.696E-08	1.696E-08	1.696E-08	1.696E-08	1.696E-08	1.696E-08	1.696E-08
Te-128	2.107E-14	2.107E-14	2.107E-14	2.107E-14	2.107E-14	2.107E-14	2.107E-14
I-127	2.755E-11	2.755E-11	2.755E-11	2.755E-11	2.755E-11	2.755E-11	2.755E-11
Xe-128	3.297E-13	3.297E-13	3.297E-13	3.297E-13	3.297E-13	3.297E-13	3.297E-13
Lu-175	2.849E-08	2.849E-08	2.849E-08	2.849E-08	2.849E-08	2.849E-08	2.849E-08
Lu-176	6.237E-10	6.237E-10	6.237E-10	6.237E-10	6.237E-10	6.237E-10	6.237E-10
Hf-174	5.366E-08	5.366E-08	5.366E-08	5.366E-08	5.366E-08	5.366E-08	5.366E-08
Hf-176	2.259E-06	2.259E-06	2.259E-06	2.259E-06	2.259E-06	2.259E-06	2.259E-06
Hf-177	1.249E-06	1.249E-06	1.249E-06	1.249E-06	1.249E-06	1.249E-06	1.249E-06
Hf-178	1.459E-05	1.459E-05	1.459E-05	1.459E-05	1.459E-05	1.459E-05	1.459E-05
Hf-179	1.509E-05	1.509E-05	1.509E-05	1.509E-05	1.509E-05	1.509E-05	1.509E-05
Hf-180	2.139E-05	2.139E-05	2.139E-05	2.139E-05	2.139E-05	2.139E-05	2.139E-05
Hf-182	5.664E-10	5.664E-10	5.664E-10	5.664E-10	5.664E-10	5.664E-10	5.663E-10
Ta-181	4.215E-07	4.215E-07	4.215E-07	4.215E-07	4.215E-07	4.215E-07	4.215E-07
Ta-182	4.893E-13	6.009E-15	9.312E-17	2.071E-17	1.981E-17	1.981E-17	1.981E-17
W-182	2.831E-08	2.831E-08	2.831E-08	2.831E-08	2.831E-08	2.831E-08	2.831E-08
W-183	1.407E-08	1.407E-08	1.407E-08	1.407E-08	1.407E-08	1.407E-08	1.407E-08
W-184	4.839E-10	4.839E-10	4.839E-10	4.839E-10	4.839E-10	4.839E-10	4.839E-10
W-186	3.255E-15	3.255E-15	3.255E-15	3.255E-15	3.255E-15	3.255E-15	3.255E-15
Re-185	5.761E-13	5.761E-13	5.761E-13	5.761E-13	5.761E-13	5.761E-13	5.761E-13
Os-186	4.797E-14	4.797E-14	4.797E-14	4.797E-14	4.797E-14	4.797E-14	4.797E-14
Total	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

Table F.8.c. Cladding Activation Product Inventory by Isotope at
20 MWd/kgM, g/gZr

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	1.202E-05	1.202E-05	1.202E-05	1.202E-05	1.202E-05	1.202E-05	1.202E-05
H-2	1.541E-08	1.541E-08	1.541E-08	1.541E-08	1.541E-08	1.541E-08	1.541E-08
H-3	1.642E-14	1.468E-14	1.312E-14	1.172E-14	8.855E-15	6.688E-15	0.00
He-3	5.215E-15	6.958E-15	8.517E-15	9.910E-15	1.278E-14	1.495E-14	2.163E-14
He-4	4.076E-08	4.076E-08	4.076E-08	4.076E-08	4.076E-08	4.076E-08	4.076E-08
Li-6	5.179E-14	5.179E-14	5.179E-14	5.179E-14	5.179E-14	5.179E-14	5.179E-14
Be-9	5.343E-10	5.343E-10	5.343E-10	5.343E-10	5.343E-10	5.343E-10	5.343E-10
Be-10	1.429E-11	1.429E-11	1.429E-11	1.429E-11	1.429E-11	1.429E-11	1.429E-11
B-11	8.183E-09	8.183E-09	8.183E-09	8.183E-09	8.183E-09	8.183E-09	8.183E-09
C-12	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04
C-13	2.132E-06	2.132E-06	2.132E-06	2.132E-06	2.132E-06	2.132E-06	2.132E-06
C-14	9.296E-08	9.293E-08	9.291E-08	9.289E-08	9.283E-08	9.278E-08	8.240E-08
N-14	3.476E-05	3.476E-05	3.476E-05	3.476E-05	3.476E-05	3.476E-05	3.477E-05
N-15	1.411E-07	1.411E-07	1.411E-07	1.411E-07	1.411E-07	1.411E-07	1.411E-07
O-16	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03
O-17	4.845E-07	4.845E-07	4.845E-07	4.845E-07	4.845E-07	4.845E-07	4.845E-07
O-18	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06
F-19	1.425E-12	1.425E-12	1.425E-12	1.425E-12	1.425E-12	1.425E-12	1.425E-12
Ne-22	4.133E-15	4.133E-15	4.133E-15	4.133E-15	4.133E-15	4.133E-15	4.133E-15
Mg-24	7.782E-11	7.782E-11	7.782E-11	7.782E-11	7.782E-11	7.782E-11	7.782E-11
Mg-25	1.637E-10	1.637E-10	1.637E-10	1.637E-10	1.637E-10	1.637E-10	1.637E-10
Mg-26	7.477E-11	7.477E-11	7.477E-11	7.477E-11	7.477E-11	7.477E-11	7.477E-11
Al-27	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05	3.999E-05
Si-28	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05	7.350E-05
Si-29	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Si-30	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06
P-31	4.583E-10	4.583E-10	4.583E-10	4.583E-10	4.583E-10	4.583E-10	4.583E-10
S-32	5.817E-14	5.817E-14	5.817E-14	5.817E-14	5.817E-14	5.817E-14	5.819E-14
Ti-47	9.359E-11	9.359E-11	9.359E-11	9.359E-11	9.359E-11	9.359E-11	9.359E-11
Ti-48	1.348E-13	1.348E-13	1.348E-13	1.348E-13	1.348E-13	1.348E-13	1.348E-13
Ti-49	2.588E-10	2.588E-10	2.588E-10	2.588E-10	2.588E-10	2.588E-10	2.588E-10
Ti-50	1.024E-09	1.024E-09	1.024E-09	1.024E-09	1.024E-09	1.024E-09	1.024E-09
V-50	3.685E-09	3.685E-09	3.685E-09	3.685E-09	3.685E-09	3.685E-09	3.685E-09
V-51	1.013E-06	1.013E-06	1.013E-06	1.013E-06	1.013E-06	1.013E-06	1.013E-06
Cr-50	4.496E-05	4.496E-05	4.496E-05	4.496E-05	4.496E-05	4.496E-05	4.496E-05
Cr-52	9.167E-04	9.167E-04	9.167E-04	9.167E-04	9.167E-04	9.167E-04	9.167E-04
Cr-53	1.078E-04	1.078E-04	1.078E-04	1.078E-04	1.078E-04	1.078E-04	1.078E-04
Cr-54	2.967E-05	2.967E-05	2.967E-05	2.967E-05	2.967E-05	2.967E-05	2.967E-05
Mn-54	7.911E-11	1.565E-11	3.096E-12	6.126E-13	1.066E-14	1.857E-16	0.00
Mn-55	2.231E-07	2.347E-07	2.415E-07	2.455E-07	2.497E-07	2.508E-07	2.512E-07
Fe-54	7.270E-05	7.270E-05	7.270E-05	7.270E-05	7.270E-05	7.270E-05	7.270E-05
Fe-55	2.802E-08	1.644E-08	9.646E-09	5.659E-09	1.492E-09	3.935E-10	0.00
Fe-56	1.190E-03	1.190E-03	1.190E-03	1.190E-03	1.190E-03	1.190E-03	1.190E-03
Fe-57	3.315E-05	3.315E-05	3.315E-05	3.315E-05	3.315E-05	3.315E-05	3.315E-05
Fe-58	4.080E-06	4.080E-06	4.080E-06	4.080E-06	4.080E-06	4.080E-06	4.080E-06
Co-58	1.530E-15	1.196E-18	9.344E-22	7.303E-25	1.247E-32	0.00	0.00
Co-59	2.232E-08	2.235E-08	2.238E-08	2.242E-08	2.251E-08	2.259E-08	3.947E-08

Table F.8.c. Cladding Activation Product Inventory by Isotope at
20 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Co-60	6.189E-10	4.757E-10	3.657E-10	2.811E-10	1.456E-10	7.544E-11	0.00
Ni-58	3.347E-04	3.347E-04	3.347E-04	3.347E-04	3.347E-04	3.347E-04	3.347E-04
Ni-59	1.996E-06	1.996E-06	1.996E-06	1.996E-06	1.996E-06	1.996E-06	1.979E-06
Ni-60	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04
Ni-61	6.373E-06	6.373E-06	6.373E-06	6.373E-06	6.373E-06	6.373E-06	6.373E-06
Ni-62	1.860E-05	1.860E-05	1.860E-05	1.860E-05	1.860E-05	1.860E-05	1.860E-05
Ni-63	3.433E-07	3.382E-07	3.331E-07	3.282E-07	3.160E-07	3.043E-07	1.891E-10
Ni-64	4.951E-06	4.951E-06	4.951E-06	4.951E-06	4.951E-06	4.951E-06	4.951E-06
Cu-63	2.366E-08	2.879E-08	3.385E-08	3.883E-08	5.096E-08	6.265E-08	3.668E-07
Cu-65	1.101E-08	1.101E-08	1.101E-08	1.101E-08	1.101E-08	1.101E-08	1.101E-08
Zn-64	9.628E-12	9.628E-12	9.628E-12	9.628E-12	9.628E-12	9.628E-12	9.628E-12
Zn-66	1.954E-11	1.954E-11	1.954E-11	1.954E-11	1.954E-11	1.954E-11	1.954E-11
Zn-67	8.677E-15	8.677E-15	8.677E-15	8.677E-15	8.677E-15	8.677E-15	8.677E-15
Sr-87	5.689E-09	5.689E-09	5.689E-09	5.689E-09	5.689E-09	5.689E-09	5.689E-09
Sr-88	5.356E-07	5.356E-07	5.356E-07	5.356E-07	5.356E-07	5.356E-07	5.356E-07
Sr-90	1.108E-11	1.057E-11	1.008E-11	9.607E-12	8.529E-12	7.572E-12	5.609E-22
Y-89	4.078E-08	4.078E-08	4.078E-08	4.078E-08	4.078E-08	4.078E-08	4.078E-08
Y-90	2.779E-15	2.650E-15	2.527E-15	2.409E-15	2.139E-15	1.899E-15	1.407E-25
Zr-90	4.975E-01	4.975E-01	4.975E-01	4.975E-01	4.975E-01	4.975E-01	4.975E-01
Zr-91	1.092E-01	1.092E-01	1.092E-01	1.092E-01	1.092E-01	1.092E-01	1.092E-01
Zr-92	1.692E-01	1.692E-01	1.692E-01	1.692E-01	1.692E-01	1.692E-01	1.692E-01
Zr-93	1.489E-04	1.489E-04	1.489E-04	1.489E-04	1.489E-04	1.489E-04	1.489E-04
Zr-94	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01
Zr-95	2.203E-13	8.055E-17	2.945E-20	1.077E-23	2.752E-32	0.00	0.00
Zr-96	2.879E-02	2.879E-02	2.879E-02	2.879E-02	2.879E-02	2.879E-02	2.879E-02
Nb-93	1.464E-10	2.032E-10	2.675E-10	3.387E-10	5.423E-10	7.761E-10	6.654E-08
Nb-93m	4.508E-10	5.290E-10	5.996E-10	6.634E-10	7.971E-10	9.008E-10	1.257E-09
Nb-94	7.860E-14	7.859E-14	7.859E-14	7.858E-14	7.857E-14	7.856E-14	7.597E-14
Nb-95	2.687E-13	9.824E-17	3.592E-20	1.313E-23	2.489E-34	0.00	0.00
Mo-95	4.992E-05	4.992E-05	4.992E-05	4.992E-05	4.992E-05	4.992E-05	4.992E-05
Mo-96	1.377E-06	1.377E-06	1.377E-06	1.377E-06	1.377E-06	1.377E-06	1.377E-06
Mo-97	7.556E-05	7.556E-05	7.556E-05	7.556E-05	7.556E-05	7.556E-05	7.556E-05
Mo-98	3.907E-07	3.907E-07	3.907E-07	3.907E-07	3.907E-07	3.907E-07	3.907E-07
Mo-100	6.443E-14	6.443E-14	6.443E-14	6.443E-14	6.443E-14	6.443E-14	6.443E-14
Tc-99	2.564E-10	2.564E-10	2.564E-10	2.564E-10	2.564E-10	2.564E-10	2.556E-10
Ru-99	5.642E-15	7.311E-15	8.979E-15	1.065E-14	1.482E-14	1.899E-14	8.353E-13
Ru-100	8.677E-12	8.677E-12	8.677E-12	8.677E-12	8.677E-12	8.677E-12	8.677E-12
Ru-101	1.982E-14	1.982E-14	1.982E-14	1.982E-14	1.982E-14	1.982E-14	1.982E-14
Cd-111	5.912E-12	5.912E-12	5.912E-12	5.912E-12	5.912E-12	5.912E-12	5.912E-12
Cd-112	5.080E-11	5.080E-11	5.080E-11	5.080E-11	5.080E-11	5.080E-11	5.080E-11
Cd-113	2.630E-13	2.630E-13	2.630E-13	2.630E-13	2.630E-13	2.630E-13	2.630E-13
Cd-114	6.644E-09	6.644E-09	6.644E-09	6.644E-09	6.644E-09	6.644E-09	6.644E-09
Cd-116	3.718E-11	3.718E-11	3.718E-11	3.718E-11	3.718E-11	3.718E-11	3.718E-11
In-113	1.483E-06	1.483E-06	1.483E-06	1.483E-06	1.483E-06	1.483E-06	1.483E-06
In-113m	5.503E-15	6.761E-17	8.309E-19	1.021E-20	1.710E-25	2.862E-30	0.00
In-115	2.044E-11	2.044E-11	2.044E-11	2.044E-11	2.044E-11	2.044E-11	2.044E-11

Table F.8.c. Cladding Activation Product Inventory by Isotope at
20 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Sn-112	1.398E-04	1.398E-04	1.398E-04	1.398E-04	1.398E-04	1.398E-04	1.398E-04
Sn-113	9.160E-12	1.126E-13	1.383E-15	1.700E-17	2.847E-22	4.766E-27	0.00
Sn-114	9.652E-05	9.652E-05	9.652E-05	9.652E-05	9.652E-05	9.652E-05	9.652E-05
Sn-115	5.177E-05	5.177E-05	5.177E-05	5.177E-05	5.177E-05	5.177E-05	5.177E-05
Sn-116	2.137E-03	2.137E-03	2.137E-03	2.137E-03	2.137E-03	2.137E-03	2.137E-03
Sn-117	1.152E-03	1.152E-03	1.152E-03	1.152E-03	1.152E-03	1.152E-03	1.152E-03
Sn-118	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03
Sn-119	1.312E-03	1.312E-03	1.312E-03	1.312E-03	1.312E-03	1.312E-03	1.312E-03
Sn-119m	1.553E-08	1.967E-09	2.490E-10	3.153E-11	1.799E-13	1.027E-15	0.00
Sn-120	4.908E-03	4.908E-03	4.908E-03	4.908E-03	4.908E-03	4.908E-03	4.908E-03
Sn-121m	2.245E-08	2.183E-08	2.124E-08	2.066E-08	1.927E-08	1.798E-08	2.246E-14
Sn-122	7.082E-04	7.082E-04	7.082E-04	7.082E-04	7.082E-04	7.082E-04	7.082E-04
Sn-123	1.047E-11	2.077E-13	4.121E-15	8.176E-17	4.533E-21	2.513E-25	0.00
Sn-124	8.717E-04	8.717E-04	8.717E-04	8.717E-04	8.717E-04	8.717E-04	8.717E-04
Sb-121	4.133E-06	4.133E-06	4.134E-06	4.135E-06	4.136E-06	4.137E-06	4.155E-06
Sb-123	4.334E-07	4.334E-07	4.334E-07	4.334E-07	4.334E-07	4.334E-07	4.334E-07
Sb-125	6.931E-07	4.202E-07	2.547E-07	1.544E-07	4.419E-08	1.264E-08	0.00
Te-122	1.643E-07	1.643E-07	1.643E-07	1.643E-07	1.643E-07	1.643E-07	1.643E-07
Te-123	1.653E-09	1.654E-09	1.654E-09	1.654E-09	1.654E-09	1.654E-09	1.654E-09
Te-123m	2.312E-14	3.361E-16	4.887E-18	7.104E-20	1.810E-24	4.614E-29	0.00
Te-124	1.020E-08	1.020E-08	1.020E-08	1.020E-08	1.020E-08	1.020E-08	1.020E-08
Te-125	4.496E-06	4.773E-06	4.940E-06	5.042E-06	5.154E-06	5.186E-06	5.199E-06
Te-125m	9.695E-09	5.879E-09	3.564E-09	2.161E-09	6.181E-10	1.769E-10	0.00
Te-126	3.147E-08	3.147E-08	3.147E-08	3.147E-08	3.147E-08	3.147E-08	3.147E-08
Te-128	7.252E-14	7.252E-14	7.252E-14	7.252E-14	7.252E-14	7.252E-14	7.252E-14
I-127	6.945E-11	6.945E-11	6.945E-11	6.945E-11	6.945E-11	6.945E-11	6.945E-11
Xe-128	1.134E-12	1.134E-12	1.134E-12	1.134E-12	1.134E-12	1.134E-12	1.134E-12
Xe-129	2.250E-15	2.250E-15	2.250E-15	2.250E-15	2.250E-15	2.250E-15	2.250E-15
Yb-172	1.492E-15	1.492E-15	1.492E-15	1.492E-15	1.492E-15	1.492E-15	1.492E-15
Lu-175	3.423E-08	3.423E-08	3.423E-08	3.423E-08	3.423E-08	3.423E-08	3.423E-08
Lu-176	8.840E-10	8.840E-10	8.840E-10	8.840E-10	8.840E-10	8.840E-10	8.840E-10
Hf-174	4.525E-08	4.525E-08	4.525E-08	4.525E-08	4.525E-08	4.525E-08	4.525E-08
Hf-176	2.085E-06	2.085E-06	2.085E-06	2.085E-06	2.085E-06	2.085E-06	2.085E-06
Hf-177	6.647E-07	6.647E-07	6.647E-07	6.647E-07	6.647E-07	6.647E-07	6.647E-07
Hf-178	1.240E-05	1.240E-05	1.240E-05	1.240E-05	1.240E-05	1.240E-05	1.240E-05
Hf-179	1.689E-05	1.689E-05	1.689E-05	1.689E-05	1.689E-05	1.689E-05	1.689E-05
Hf-180	2.240E-05	2.240E-05	2.240E-05	2.240E-05	2.240E-05	2.240E-05	2.240E-05
Hf-182	1.064E-09	1.064E-09	1.064E-09	1.064E-09	1.064E-09	1.064E-09	1.064E-09
Ta-181	5.674E-07	5.674E-07	5.674E-07	5.674E-07	5.674E-07	5.674E-07	5.674E-07
Ta-182	8.352E-13	1.026E-14	1.624E-16	3.876E-17	3.722E-17	3.722E-17	3.722E-17
W-182	4.610E-08	4.610E-08	4.610E-08	4.610E-08	4.610E-08	4.610E-08	4.610E-08
W-183	3.146E-08	3.146E-08	3.146E-08	3.146E-08	3.146E-08	3.146E-08	3.146E-08
W-184	1.469E-09	1.469E-09	1.469E-09	1.469E-09	1.469E-09	1.469E-09	1.469E-09
W-186	1.784E-14	1.784E-14	1.784E-14	1.784E-14	1.784E-14	1.784E-14	1.784E-14

Table F.8.c. Cladding Activation Product Inventory by Isotope at
20 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Re-185	2.324E-12	2.324E-12	2.324E-12	2.324E-12	2.324E-12	2.324E-12	2.324E-12
Os-186	2.653E-13	2.653E-13	2.653E-13	2.653E-13	2.653E-13	2.653E-13	2.653E-13
Total	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

Table F.8.d. Cladding Activation Product Inventory by Isotope at
25 MWd/kgM, g/gZr

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
H-1	1.203E-05	1.203E-05	1.203E-05	1.203E-05	1.203E-05	1.203E-05	1.203E-05
H-2	1.876E-08	1.876E-08	1.876E-08	1.876E-08	1.876E-08	1.876E-08	1.876E-08
H-3	2.910E-14	2.601E-14	2.325E-14	2.078E-14	1.569E-14	1.185E-14	1.528E-38
He-3	8.773E-15	1.186E-14	1.462E-14	1.709E-14	2.218E-14	2.602E-14	3.787E-14
He-4	5.267E-08	5.267E-08	5.267E-08	5.267E-08	5.267E-08	5.267E-08	5.267E-08
Li-6	7.777E-14	7.777E-14	7.777E-14	7.777E-14	7.777E-14	7.777E-14	7.777E-14
Be-9	6.854E-10	6.854E-10	6.854E-10	6.854E-10	6.854E-10	6.854E-10	6.854E-10
Be-10	1.838E-11	1.838E-11	1.838E-11	1.838E-11	1.838E-11	1.838E-11	1.837E-11
B-11	1.049E-08	1.049E-08	1.049E-08	1.049E-08	1.049E-08	1.049E-08	1.049E-08
C-12	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04
C-13	2.140E-06	2.140E-06	2.140E-06	2.140E-06	2.140E-06	2.140E-06	2.140E-06
C-14	1.192E-07	1.192E-07	1.192E-07	1.191E-07	1.191E-07	1.190E-07	1.057E-07
N-14	3.473E-05	3.473E-05	3.473E-05	3.473E-05	3.473E-05	3.473E-05	3.474E-05
N-15	1.421E-07	1.421E-07	1.421E-07	1.421E-07	1.421E-07	1.421E-07	1.421E-07
O-16	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03
O-17	4.846E-07	4.846E-07	4.846E-07	4.846E-07	4.846E-07	4.846E-07	4.846E-07
O-18	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06
F-19	1.829E-12	1.829E-12	1.829E-12	1.829E-12	1.829E-12	1.829E-12	1.829E-12
Ne-22	6.803E-15	6.803E-15	6.803E-15	6.803E-15	6.803E-15	6.803E-15	6.803E-15
Mg-24	9.984E-11	9.984E-11	9.984E-11	9.984E-11	9.984E-11	9.984E-11	9.984E-11
Mg-25	2.101E-10	2.101E-10	2.101E-10	2.101E-10	2.101E-10	2.101E-10	2.101E-10
Mg-26	9.600E-11	9.600E-11	9.600E-11	9.600E-11	9.600E-11	9.600E-11	9.600E-11
Al-27	3.998E-05	3.998E-05	3.998E-05	3.998E-05	3.998E-05	3.998E-05	3.998E-05
Si-28	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05
Si-29	3.875E-06	3.875E-06	3.875E-06	3.875E-06	3.875E-06	3.875E-06	3.875E-06
Si-30	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06	2.648E-06
P-31	5.880E-10	5.880E-10	5.880E-10	5.880E-10	5.880E-10	5.880E-10	5.880E-10
S-32	9.576E-14	9.576E-14	9.576E-14	9.576E-14	9.576E-14	9.576E-14	9.579E-14
Ca-44	1.340E-15	1.340E-15	1.340E-15	1.340E-15	1.340E-15	1.340E-15	1.340E-15
Ti-47	1.197E-10	1.197E-10	1.197E-10	1.197E-10	1.197E-10	1.197E-10	1.197E-10
Ti-48	2.211E-13	2.211E-13	2.211E-13	2.211E-13	2.211E-13	2.211E-13	2.211E-13
Ti-49	3.317E-10	3.317E-10	3.317E-10	3.317E-10	3.317E-10	3.317E-10	3.317E-10
Ti-50	1.316E-09	1.316E-09	1.316E-09	1.316E-09	1.316E-09	1.316E-09	1.316E-09
V-50	4.642E-09	4.642E-09	4.642E-09	4.642E-09	4.642E-09	4.642E-09	4.642E-09
V-51	1.294E-06	1.294E-06	1.294E-06	1.294E-06	1.294E-06	1.294E-06	1.294E-06
Cr-50	4.468E-05	4.468E-05	4.468E-05	4.468E-05	4.468E-05	4.468E-05	4.468E-05
Cr-52	9.155E-04	9.155E-04	9.155E-04	9.155E-04	9.155E-04	9.155E-04	9.155E-04
Cr-53	1.082E-04	1.082E-04	1.082E-04	1.082E-04	1.082E-04	1.082E-04	1.082E-04
Cr-54	3.045E-05	3.045E-05	3.045E-05	3.045E-05	3.045E-05	3.045E-05	3.045E-05
Mn-54	1.038E-10	2.053E-11	4.062E-12	8.036E-13	1.399E-14	2.436E-16	0.00
Mn-55	2.855E-07	3.005E-07	3.094E-07	3.145E-07	3.199E-07	3.214E-07	3.219E-07
Fe-54	7.263E-05	7.263E-05	7.263E-05	7.263E-05	7.263E-05	7.263E-05	7.263E-05
Fe-55	3.635E-08	2.133E-08	1.252E-08	7.343E-09	1.936E-09	5.106E-10	0.00
Fe-56	1.189E-03	1.189E-03	1.189E-03	1.189E-03	1.189E-03	1.189E-03	1.189E-03
Fe-57	3.446E-05	3.446E-05	3.446E-05	3.446E-05	3.446E-05	3.446E-05	3.446E-05
Fe-58	4.126E-06	4.126E-06	4.126E-06	4.126E-06	4.126E-06	4.126E-06	4.126E-06
Co-58	1.927E-15	1.506E-18	1.177E-21	9.197E-25	1.571E-32	0.00	0.00

Table F.8.d. Cladding Activation Product Inventory by Isotope at
25 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Co-59	3.241E-08	3.245E-08	3.249E-08	3.254E-08	3.265E-08	3.275E-08	5.386E-08
Co-60	9.899E-10	7.609E-10	5.849E-10	4.496E-10	2.329E-10	1.207E-10	0.00
Ni-58	3.341E-04	3.341E-04	3.341E-04	3.341E-04	3.341E-04	3.341E-04	3.341E-04
Ni-59	2.497E-06	2.497E-06	2.497E-06	2.497E-06	2.497E-06	2.497E-06	2.476E-06
Ni-60	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04
Ni-61	6.516E-06	6.516E-06	6.516E-06	6.516E-06	6.516E-06	6.516E-06	6.516E-06
Ni-62	1.850E-05	1.850E-05	1.850E-05	1.850E-05	1.850E-05	1.850E-05	1.850E-05
Ni-63	4.376E-07	4.310E-07	4.246E-07	4.182E-07	4.028E-07	3.879E-07	2.410E-10
Ni-64	4.952E-06	4.952E-06	4.952E-06	4.952E-06	4.952E-06	4.952E-06	4.952E-06
Cu-63	3.002E-08	3.657E-08	4.301E-08	4.936E-08	6.482E-08	7.971E-08	4.673E-07
Cu-65	1.412E-08	1.412E-08	1.412E-08	1.412E-08	1.412E-08	1.412E-08	1.412E-08
Zn-64	1.588E-11	1.588E-11	1.588E-11	1.588E-11	1.588E-11	1.588E-11	1.588E-11
Zn-66	3.215E-11	3.215E-11	3.215E-11	3.215E-11	3.215E-11	3.215E-11	3.215E-11
Zn-67	1.830E-14	1.830E-14	1.830E-14	1.830E-14	1.830E-14	1.830E-14	1.830E-14
Sr-87	7.235E-09	7.235E-09	7.235E-09	7.235E-09	7.235E-09	7.235E-09	7.235E-09
Sr-88	6.870E-07	6.870E-07	6.870E-07	6.870E-07	6.870E-07	6.870E-07	6.870E-07
Sr-90	1.823E-11	1.738E-11	1.658E-11	1.581E-11	1.403E-11	1.246E-11	9.228E-22
Y-89	5.232E-08	5.232E-08	5.232E-08	5.232E-08	5.232E-08	5.232E-08	5.232E-08
Y-90	4.572E-15	4.359E-15	4.157E-15	3.964E-15	3.519E-15	3.124E-15	2.314E-25
Zr-90	4.974E-01	4.974E-01	4.974E-01	4.974E-01	4.974E-01	4.974E-01	4.974E-01
Zr-91	1.091E-01	1.091E-01	1.091E-01	1.091E-01	1.091E-01	1.091E-01	1.091E-01
Zr-92	1.693E-01	1.693E-01	1.693E-01	1.693E-01	1.693E-01	1.693E-01	1.693E-01
Zr-93	1.907E-04	1.907E-04	1.907E-04	1.907E-04	1.907E-04	1.907E-04	1.907E-04
Zr-94	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01	1.756E-01
Zr-95	2.900E-13	1.060E-16	3.877E-20	1.418E-23	3.623E-32	0.00	0.00
Zr-96	2.877E-02	2.877E-02	2.877E-02	2.877E-02	2.877E-02	2.877E-02	2.877E-02
Nb-93	1.862E-10	2.586E-10	3.408E-10	4.318E-10	6.923E-10	9.914E-10	8.520E-08
Nb-93m	5.751E-10	6.755E-10	7.661E-10	8.480E-10	1.020E-09	1.153E-09	1.610E-09
Nb-94	1.298E-13	1.298E-13	1.298E-13	1.298E-13	1.298E-13	1.298E-13	1.255E-13
Nb-95	3.538E-13	1.293E-16	4.729E-20	1.729E-23	3.277E-34	0.00	0.00
Mo-95	6.355E-05	6.355E-05	6.355E-05	6.355E-05	6.355E-05	6.355E-05	6.355E-05
Mo-96	2.255E-06	2.255E-06	2.255E-06	2.255E-06	2.255E-06	2.255E-06	2.255E-06
Mo-97	9.678E-05	9.678E-05	9.678E-05	9.678E-05	9.678E-05	9.678E-05	9.678E-05
Mo-98	6.415E-07	6.415E-07	6.415E-07	6.415E-07	6.415E-07	6.415E-07	6.415E-07
Mo-100	1.756E-13	1.756E-13	1.756E-13	1.756E-13	1.756E-13	1.756E-13	1.756E-13
Tc-98	1.155E-15	1.155E-15	1.155E-15	1.155E-15	1.155E-15	1.155E-15	1.154E-15
Tc-99	5.355E-10	5.355E-10	5.355E-10	5.355E-10	5.355E-10	5.355E-10	5.338E-10
Ru-99	1.169E-14	1.517E-14	1.866E-14	2.214E-14	3.085E-14	3.957E-14	1.744E-12
Ru-100	2.329E-11	2.329E-11	2.329E-11	2.329E-11	2.329E-11	2.329E-11	2.329E-11
Ru-101	6.823E-14	6.823E-14	6.823E-14	6.823E-14	6.823E-14	6.823E-14	6.823E-14
Cd-111	7.532E-12	7.532E-12	7.532E-12	7.532E-12	7.532E-12	7.532E-12	7.532E-12
Cd-112	6.452E-11	6.452E-11	6.452E-11	6.452E-11	6.452E-11	6.452E-11	6.452E-11
Cd-113	2.647E-13	2.647E-13	2.647E-13	2.647E-13	2.647E-13	2.647E-13	2.647E-13
Cd-114	1.068E-08	1.068E-08	1.068E-08	1.068E-08	1.068E-08	1.068E-08	1.068E-08
Cd-116	4.778E-11	4.778E-11	4.778E-11	4.778E-11	4.778E-11	4.778E-11	4.778E-11
In-113	1.858E-06	1.858E-06	1.858E-06	1.858E-06	1.858E-06	1.858E-06	1.858E-06

Table F.8.d. Cladding Activation Product Inventory by Isotope at
25 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
In-113m	7.218E-15	8.820E-17	1.084E-18	1.332E-20	2.231E-25	3.735E-30	0.00
In-115	2.190E-11	2.190E-11	2.190E-11	2.190E-11	2.190E-11	2.190E-11	2.190E-11
Sn-112	1.394E-04	1.394E-04	1.394E-04	1.394E-04	1.394E-04	1.394E-04	1.394E-04
Sn-113	1.195E-11	1.469E-13	1.805E-15	2.218E-17	3.714E-22	6.219E-27	0.00
Sn-114	9.657E-05	9.657E-05	9.657E-05	9.657E-05	9.657E-05	9.657E-05	9.657E-05
Sn-115	5.084E-05	5.084E-05	5.084E-05	5.084E-05	5.084E-05	5.084E-05	5.084E-05
Sn-116	2.132E-03	2.132E-03	2.132E-03	2.132E-03	2.132E-03	2.132E-03	2.132E-03
Sn-117	1.154E-03	1.154E-03	1.154E-03	1.154E-03	1.154E-03	1.154E-03	1.154E-03
Sn-118	3.610E-03	3.610E-03	3.610E-03	3.610E-03	3.610E-03	3.610E-03	3.610E-03
Sn-119	1.317E-03	1.317E-03	1.317E-03	1.317E-03	1.317E-03	1.317E-03	1.317E-03
Sn-119m	2.041E-08	2.584E-09	3.272E-10	4.143E-11	2.364E-13	1.349E-15	0.00
Sn-120	4.907E-03	4.907E-03	4.907E-03	4.907E-03	4.907E-03	4.907E-03	4.907E-03
Sn-121m	2.882E-08	2.803E-08	2.726E-08	2.652E-08	2.474E-08	2.308E-08	2.883E-14
Sn-122	7.081E-04	7.081E-04	7.081E-04	7.081E-04	7.081E-04	7.081E-04	7.081E-04
Sn-123	1.377E-11	2.732E-13	5.420E-15	1.075E-16	5.962E-21	3.305E-25	0.00
Sn-124	8.702E-04	8.702E-04	8.702E-04	8.702E-04	8.702E-04	8.702E-04	8.702E-04
Sb-121	5.243E-06	5.244E-06	5.244E-06	5.245E-06	5.247E-06	5.249E-06	5.272E-06
Sb-123	5.528E-07	5.528E-07	5.528E-07	5.528E-07	5.528E-07	5.528E-07	5.528E-07
Sb-125	8.973E-07	5.440E-07	3.298E-07	1.999E-07	5.721E-08	1.637E-08	0.00
Te-122	2.672E-07	2.672E-07	2.672E-07	2.672E-07	2.672E-07	2.672E-07	2.672E-07
Te-123	3.095E-09	3.095E-09	3.095E-09	3.095E-09	3.095E-09	3.095E-09	3.095E-09
Te-123m	4.937E-14	7.178E-16	1.044E-17	1.517E-19	3.866E-24	9.854E-29	0.00
Te-124	1.758E-08	1.758E-08	1.758E-08	1.758E-08	1.758E-08	1.758E-08	1.758E-08
Te-125	5.743E-06	6.102E-06	6.319E-06	6.451E-06	6.595E-06	6.637E-06	6.653E-06
Te-125m	1.255E-08	7.611E-09	4.614E-09	2.797E-09	8.002E-10	2.290E-10	0.00
Te-126	5.170E-08	5.170E-08	5.170E-08	5.170E-08	5.170E-08	5.170E-08	5.170E-08
Te-128	1.956E-13	1.956E-13	1.956E-13	1.956E-13	1.956E-13	1.956E-13	1.956E-13
I-127	1.458E-10	1.458E-10	1.458E-10	1.458E-10	1.458E-10	1.458E-10	1.458E-10
Xe-128	3.059E-12	3.059E-12	3.059E-12	3.059E-12	3.059E-12	3.059E-12	3.059E-12
Xe-129	7.751E-15	7.751E-15	7.751E-15	7.751E-15	7.751E-15	7.751E-15	7.751E-15
Yb-172	2.256E-15	2.256E-15	2.256E-15	2.256E-15	2.256E-15	2.256E-15	2.256E-15
Yb-173	1.601E-15	1.601E-15	1.601E-15	1.601E-15	1.601E-15	1.601E-15	1.601E-15
Lu-175	3.842E-08	3.842E-08	3.842E-08	3.842E-08	3.842E-08	3.842E-08	3.842E-08
Lu-176	1.108E-09	1.108E-09	1.108E-09	1.108E-09	1.108E-09	1.108E-09	1.108E-09
Lu-177m	1.375E-15	5.242E-17	1.999E-18	7.621E-20	2.164E-23	6.143E-27	0.00
Hf-174	3.776E-08	3.776E-08	3.776E-08	3.776E-08	3.776E-08	3.776E-08	3.776E-08
Hf-176	1.916E-06	1.916E-06	1.916E-06	1.916E-06	1.916E-06	1.916E-06	1.916E-06
Hf-177	3.902E-07	3.902E-07	3.902E-07	3.902E-07	3.902E-07	3.902E-07	3.902E-07
Hf-178	1.022E-05	1.022E-05	1.022E-05	1.022E-05	1.022E-05	1.022E-05	1.022E-05
Hf-179	1.816E-05	1.816E-05	1.816E-05	1.816E-05	1.816E-05	1.816E-05	1.816E-05
Hf-180	2.357E-05	2.357E-05	2.357E-05	2.357E-05	2.357E-05	2.357E-05	2.357E-05
Hf-182	1.775E-09	1.775E-09	1.775E-09	1.775E-09	1.775E-09	1.775E-09	1.774E-09
Ta-181	7.204E-07	7.204E-07	7.204E-07	7.204E-07	7.204E-07	7.204E-07	7.204E-07
Ta-182	1.253E-12	1.540E-14	2.498E-16	6.438E-17	6.208E-17	6.208E-17	6.208E-17
W-182	6.675E-08	6.675E-08	6.675E-08	6.675E-08	6.675E-08	6.675E-08	6.675E-08
W-183	5.889E-08	5.889E-08	5.889E-08	5.889E-08	5.889E-08	5.889E-08	5.889E-08

Table F.8.d. Cladding Activation Product Inventory by Isotope at
25 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
W-184	3.518E-09	3.518E-09	3.518E-09	3.518E-09	3.518E-09	3.518E-09	3.518E-09
W-186	6.811E-14	6.811E-14	6.811E-14	6.811E-14	6.811E-14	6.811E-14	6.811E-14
Re-185	6.949E-12	6.949E-12	6.949E-12	6.949E-12	6.949E-12	6.949E-12	6.949E-12
Re-187	2.913E-15	2.913E-15	2.913E-15	2.913E-15	2.913E-15	2.913E-15	2.913E-15
Os-186	1.023E-12	1.023E-12	1.023E-12	1.023E-12	1.023E-12	1.023E-12	1.023E-12
Total	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

Table F.8.e. Cladding Activation Product Inventory by Isotope at
30 MWd/kgM, g/gZr

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	1.203E-05	1.203E-05	1.203E-05	1.203E-05	1.203E-05	1.203E-05	1.203E-05
H-2	2.235E-08	2.235E-08	2.235E-08	2.235E-08	2.235E-08	2.235E-08	2.235E-08
H-3	4.780E-14	4.273E-14	3.819E-14	3.413E-14	2.578E-14	1.947E-14	2.511E-38
He-3	1.385E-14	1.893E-14	2.347E-14	2.752E-14	3.587E-14	4.218E-14	6.165E-14
He-4	6.564E-08	6.564E-08	6.564E-08	6.564E-08	6.564E-08	6.564E-08	6.564E-08
Li-6	1.084E-13	1.084E-13	1.084E-13	1.084E-13	1.084E-13	1.084E-13	1.084E-13
Be-9	8.476E-10	8.476E-10	8.476E-10	8.476E-10	8.476E-10	8.476E-10	8.476E-10
Be-10	2.278E-11	2.278E-11	2.278E-11	2.278E-11	2.278E-11	2.278E-11	2.277E-11
B-11	1.297E-08	1.297E-08	1.297E-08	1.297E-08	1.297E-08	1.297E-08	1.297E-08
C-12	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04
C-13	2.149E-06	2.149E-06	2.149E-06	2.149E-06	2.149E-06	2.149E-06	2.149E-06
C-14	1.474E-07	1.473E-07	1.473E-07	1.473E-07	1.472E-07	1.471E-07	1.307E-07
N-14	3.469E-05	3.469E-05	3.469E-05	3.469E-05	3.469E-05	3.469E-05	3.471E-05
N-15	1.433E-07	1.433E-07	1.433E-07	1.433E-07	1.433E-07	1.433E-07	1.433E-07
O-16	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03
O-17	4.846E-07	4.846E-07	4.846E-07	4.846E-07	4.846E-07	4.846E-07	4.846E-07
O-18	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06
F-19	2.262E-12	2.262E-12	2.262E-12	2.262E-12	2.262E-12	2.262E-12	2.262E-12
Ne-22	1.041E-14	1.041E-14	1.041E-14	1.041E-14	1.041E-14	1.041E-14	1.041E-14
Mg-24	1.235E-10	1.235E-10	1.235E-10	1.235E-10	1.235E-10	1.235E-10	1.235E-10
Mg-25	2.598E-10	2.598E-10	2.598E-10	2.598E-10	2.598E-10	2.598E-10	2.598E-10
Mg-26	1.188E-10	1.188E-10	1.188E-10	1.188E-10	1.188E-10	1.188E-10	1.188E-10
Al-27	3.998E-05	3.998E-05	3.998E-05	3.998E-05	3.998E-05	3.998E-05	3.998E-05
Si-28	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05
Si-29	3.880E-06	3.880E-06	3.880E-06	3.880E-06	3.880E-06	3.880E-06	3.880E-06
Si-30	2.649E-06	2.649E-06	2.649E-06	2.649E-06	2.649E-06	2.649E-06	2.649E-06
P-31	7.273E-10	7.273E-10	7.273E-10	7.273E-10	7.273E-10	7.273E-10	7.273E-10
S-32	1.465E-13	1.465E-13	1.465E-13	1.465E-13	1.465E-13	1.465E-13	1.465E-13
Ca-44	2.045E-15	2.045E-15	2.045E-15	2.045E-15	2.045E-15	2.045E-15	2.045E-15
Ti-47	1.475E-10	1.475E-10	1.475E-10	1.475E-10	1.475E-10	1.475E-10	1.475E-10
Ti-48	3.370E-13	3.370E-13	3.370E-13	3.370E-13	3.370E-13	3.370E-13	3.370E-13
Ti-49	4.098E-10	4.098E-10	4.098E-10	4.098E-10	4.098E-10	4.098E-10	4.098E-10
Ti-50	1.631E-09	1.631E-09	1.631E-09	1.631E-09	1.631E-09	1.631E-09	1.631E-09
V-50	5.630E-09	5.630E-09	5.630E-09	5.630E-09	5.630E-09	5.630E-09	5.630E-09
V-51	1.594E-06	1.594E-06	1.594E-06	1.594E-06	1.594E-06	1.594E-06	1.594E-06
Cr-50	4.439E-05	4.439E-05	4.439E-05	4.439E-05	4.439E-05	4.439E-05	4.439E-05
Cr-52	9.143E-04	9.143E-04	9.143E-04	9.143E-04	9.143E-04	9.143E-04	9.143E-04
Cr-53	1.086E-04	1.086E-04	1.086E-04	1.086E-04	1.086E-04	1.086E-04	1.086E-04
Cr-54	3.130E-05	3.130E-05	3.130E-05	3.130E-05	3.130E-05	3.130E-05	3.130E-05
Mn-54	1.326E-10	2.624E-11	5.192E-12	1.027E-12	1.788E-14	3.113E-16	0.00
Mn-55	3.520E-07	3.708E-07	3.819E-07	3.884E-07	3.952E-07	3.970E-07	3.976E-07
Fe-54	7.256E-05	7.256E-05	7.256E-05	7.256E-05	7.256E-05	7.256E-05	7.256E-05
Fe-55	4.564E-08	2.678E-08	1.571E-08	9.218E-09	2.431E-09	6.409E-10	0.00
Fe-56	1.187E-03	1.187E-03	1.187E-03	1.187E-03	1.187E-03	1.187E-03	1.187E-03
Fe-57	3.587E-05	3.587E-05	3.587E-05	3.587E-05	3.587E-05	3.587E-05	3.587E-05
Fe-58	4.176E-06	4.176E-06	4.176E-06	4.176E-06	4.176E-06	4.176E-06	4.176E-06
Co-58	2.358E-15	1.843E-18	1.440E-21	1.126E-24	1.922E-32	0.00	0.00

Table F.8.e. Cladding Activation Product Inventory by Isotope at
30 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
Co-59	4.443E-08	4.448E-08	4.453E-08	4.458E-08	4.471E-08	4.484E-08	7.026E-08
Co-60	1.517E-09	1.166E-09	8.965E-10	6.891E-10	3.570E-10	1.850E-10	0.00
Ni-58	3.334E-04	3.334E-04	3.334E-04	3.334E-04	3.334E-04	3.334E-04	3.334E-04
Ni-59	3.006E-06	3.006E-06	3.006E-06	3.006E-06	3.006E-06	3.006E-06	2.980E-06
Ni-60	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04
Ni-61	6.669E-06	6.669E-06	6.669E-06	6.669E-06	6.669E-06	6.669E-06	6.669E-06
Ni-62	1.840E-05	1.840E-05	1.840E-05	1.840E-05	1.840E-05	1.840E-05	1.840E-05
Ni-63	5.374E-07	5.293E-07	5.214E-07	5.136E-07	4.946E-07	4.763E-07	2.960E-10
Ni-64	4.953E-06	4.953E-06	4.953E-06	4.953E-06	4.953E-06	4.953E-06	4.953E-06
Cu-63	3.667E-08	4.471E-08	5.262E-08	6.042E-08	7.941E-08	9.769E-08	5.737E-07
Cu-65	1.746E-08	1.746E-08	1.746E-08	1.746E-08	1.746E-08	1.746E-08	1.746E-08
Zn-64	2.440E-11	2.440E-11	2.440E-11	2.440E-11	2.440E-11	2.440E-11	2.440E-11
Zn-66	4.916E-11	4.916E-11	4.916E-11	4.916E-11	4.916E-11	4.916E-11	4.916E-11
Zn-67	3.458E-14	3.458E-14	3.458E-14	3.458E-14	3.458E-14	3.458E-14	3.458E-14
Sr-87	8.864E-09	8.864E-09	8.864E-09	8.864E-09	8.864E-09	8.864E-09	8.864E-09
Sr-88	8.495E-07	8.495E-07	8.495E-07	8.495E-07	8.495E-07	8.495E-07	8.495E-07
Sr-90	2.788E-11	2.658E-11	2.535E-11	2.417E-11	2.146E-11	1.905E-11	1.411E-21
Y-89	6.472E-08	6.472E-08	6.472E-08	6.472E-08	6.472E-08	6.472E-08	6.472E-08
Y-90	6.992E-15	6.667E-15	6.357E-15	6.061E-15	5.381E-15	4.777E-15	3.539E-25
Zr-90	4.974E-01	4.974E-01	4.974E-01	4.974E-01	4.974E-01	4.974E-01	4.974E-01
Zr-91	1.090E-01	1.090E-01	1.090E-01	1.090E-01	1.090E-01	1.090E-01	1.090E-01
Zr-92	1.694E-01	1.694E-01	1.694E-01	1.694E-01	1.694E-01	1.694E-01	1.694E-01
Zr-93	2.354E-04	2.354E-04	2.354E-04	2.354E-04	2.354E-04	2.354E-04	2.353E-04
Zr-94	1.755E-01	1.755E-01	1.755E-01	1.755E-01	1.755E-01	1.755E-01	1.755E-01
Zr-95	3.735E-13	1.366E-16	4.993E-20	1.826E-23	4.666E-32	0.00	0.00
Zr-96	2.874E-02	2.874E-02	2.874E-02	2.874E-02	2.874E-02	2.874E-02	2.874E-02
Nb-93	2.278E-10	3.169E-10	4.180E-10	5.301E-10	8.510E-10	1.220E-09	1.052E-07
Nb-93m	7.065E-10	8.307E-10	9.429E-10	1.044E-09	1.257E-09	1.421E-09	1.987E-09
Nb-94	2.000E-13	2.000E-13	2.000E-13	2.000E-13	1.999E-13	1.999E-13	1.933E-13
Nb-95	4.556E-13	1.666E-16	6.090E-20	2.227E-23	4.221E-34	0.00	0.00
Mo-95	7.796E-05	7.796E-05	7.796E-05	7.796E-05	7.796E-05	7.796E-05	7.796E-05
Mo-96	3.429E-06	3.429E-06	3.429E-06	3.429E-06	3.429E-06	3.429E-06	3.429E-06
Mo-97	1.195E-04	1.195E-04	1.195E-04	1.195E-04	1.195E-04	1.195E-04	1.195E-04
Mo-98	9.784E-07	9.784E-07	9.784E-07	9.784E-07	9.784E-07	9.784E-07	9.784E-07
Mo-100	4.141E-13	4.141E-13	4.141E-13	4.141E-13	4.141E-13	4.141E-13	4.141E-13
Tc-98	2.676E-15	2.676E-15	2.676E-15	2.676E-15	2.676E-15	2.676E-15	2.676E-15
Tc-99	1.001E-09	1.001E-09	1.001E-09	1.001E-09	1.001E-09	1.001E-09	9.978E-10
Ru-99	2.161E-14	2.813E-14	3.464E-14	4.116E-14	5.745E-14	7.373E-14	3.261E-12
Ru-100	5.393E-11	5.393E-11	5.393E-11	5.393E-11	5.393E-11	5.393E-11	5.393E-11
Ru-101	1.953E-13	1.953E-13	1.953E-13	1.953E-13	1.953E-13	1.953E-13	1.953E-13
Ru-102	2.305E-15	2.305E-15	2.305E-15	2.305E-15	2.305E-15	2.305E-15	2.305E-15
Cd-111	9.246E-12	9.246E-12	9.246E-12	9.246E-12	9.246E-12	9.246E-12	9.246E-12
Cd-112	7.894E-11	7.894E-11	7.894E-11	7.894E-11	7.894E-11	7.894E-11	7.894E-11
Cd-113	2.665E-13	2.665E-13	2.665E-13	2.665E-13	2.665E-13	2.665E-13	2.665E-13
Cd-114	1.598E-08	1.598E-08	1.598E-08	1.598E-08	1.598E-08	1.598E-08	1.598E-08
Cd-116	5.920E-11	5.920E-11	5.920E-11	5.920E-11	5.920E-11	5.920E-11	5.920E-11

Table F.8.e. Cladding Activation Product Inventory by Isotope at
30 MWd/kgM, g/gZr (contd)

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
In-113	2.240E-06	2.240E-06	2.240E-06	2.240E-06	2.240E-06	2.240E-06	2.240E-06
In-113m	9.260E-15	1.137E-16	1.397E-18	1.717E-20	2.875E-25	4.814E-30	0.00
In-115	2.335E-11	2.335E-11	2.335E-11	2.335E-11	2.335E-11	2.335E-11	2.335E-11
Sn-112	1.389E-04	1.389E-04	1.389E-04	1.389E-04	1.389E-04	1.389E-04	1.389E-04
Sn-113	1.541E-11	1.893E-13	2.327E-15	2.859E-17	4.788E-22	8.016E-27	0.00
Sn-114	9.666E-05	9.666E-05	9.666E-05	9.666E-05	9.666E-05	9.666E-05	9.666E-05
Sn-115	4.986E-05	4.986E-05	4.986E-05	4.986E-05	4.986E-05	4.986E-05	4.986E-05
Sn-116	2.128E-03	2.128E-03	2.128E-03	2.128E-03	2.128E-03	2.128E-03	2.128E-03
Sn-117	1.156E-03	1.156E-03	1.156E-03	1.156E-03	1.156E-03	1.156E-03	1.156E-03
Sn-118	3.607E-03	3.607E-03	3.607E-03	3.607E-03	3.607E-03	3.607E-03	3.607E-03
Sn-119	1.323E-03	1.323E-03	1.323E-03	1.323E-03	1.323E-03	1.323E-03	1.323E-03
Sn-119m	2.616E-08	3.313E-09	4.195E-10	5.311E-11	3.031E-13	1.730E-15	0.00
Sn-120	4.906E-03	4.906E-03	4.906E-03	4.906E-03	4.906E-03	4.906E-03	4.906E-03
Sn-121m	3.567E-08	3.469E-08	3.374E-08	3.282E-08	3.062E-08	2.857E-08	3.568E-14
Sn-122	7.080E-04	7.080E-04	7.080E-04	7.080E-04	7.080E-04	7.080E-04	7.080E-04
Sn-123	1.770E-11	3.512E-13	6.968E-15	1.382E-16	7.664E-21	4.249E-25	0.00
Sn-124	8.687E-04	8.687E-04	8.687E-04	8.687E-04	8.687E-04	8.687E-04	8.687E-04
Sb-121	6.406E-06	6.407E-06	6.408E-06	6.409E-06	6.411E-06	6.414E-06	6.442E-06
Sb-123	6.793E-07	6.793E-07	6.793E-07	6.793E-07	6.793E-07	6.793E-07	6.793E-07
Sb-125	1.124E-06	6.811E-07	4.129E-07	2.503E-07	7.163E-08	2.050E-08	0.00
Te-122	4.035E-07	4.035E-07	4.035E-07	4.035E-07	4.035E-07	4.035E-07	4.035E-07
Te-123	5.203E-09	5.203E-09	5.203E-09	5.203E-09	5.203E-09	5.203E-09	5.203E-09
Te-123m	9.515E-14	1.383E-15	2.011E-17	2.924E-19	7.452E-24	1.899E-28	0.00
Te-124	2.829E-08	2.829E-08	2.829E-08	2.829E-08	2.829E-08	2.829E-08	2.829E-08
Te-125	7.067E-06	7.516E-06	7.788E-06	7.953E-06	8.134E-06	8.186E-06	8.207E-06
Te-125m	1.572E-08	9.530E-09	5.777E-09	3.502E-09	1.002E-09	2.867E-10	0.00
Te-126	7.893E-08	7.893E-08	7.893E-08	7.893E-08	7.893E-08	7.893E-08	7.893E-08
Te-128	4.557E-13	4.557E-13	4.557E-13	4.557E-13	4.557E-13	4.557E-13	4.557E-13
I-127	2.743E-10	2.743E-10	2.743E-10	2.743E-10	2.743E-10	2.743E-10	2.743E-10
Xe-128	7.120E-12	7.120E-12	7.120E-12	7.120E-12	7.120E-12	7.120E-12	7.120E-12
Xe-129	2.221E-14	2.221E-14	2.221E-14	2.221E-14	2.221E-14	2.221E-14	2.221E-14
Yb-172	3.153E-15	3.153E-15	3.153E-15	3.153E-15	3.153E-15	3.153E-15	3.153E-15
Yb-173	2.432E-15	2.432E-15	2.432E-15	2.432E-15	2.432E-15	2.432E-15	2.432E-15
Lu-175	4.118E-08	4.118E-08	4.118E-08	4.118E-08	4.118E-08	4.118E-08	4.118E-08
Lu-176	1.284E-09	1.284E-09	1.284E-09	1.284E-09	1.284E-09	1.284E-09	1.284E-09
Lu-177m	2.074E-15	7.907E-17	3.015E-18	1.150E-19	3.264E-23	9.267E-27	0.00
Hf-174	3.109E-08	3.109E-08	3.109E-08	3.109E-08	3.109E-08	3.109E-08	3.109E-08
Hf-176	1.750E-06	1.750E-06	1.750E-06	1.750E-06	1.750E-06	1.750E-06	1.750E-06
Hf-177	2.614E-07	2.614E-07	2.614E-07	2.614E-07	2.614E-07	2.614E-07	2.614E-07
Hf-178	8.228E-06	8.228E-06	8.228E-06	8.228E-06	8.228E-06	8.228E-06	8.228E-06
Hf-179	1.891E-05	1.891E-05	1.891E-05	1.891E-05	1.891E-05	1.891E-05	1.891E-05
Hf-180	2.490E-05	2.490E-05	2.490E-05	2.490E-05	2.490E-05	2.490E-05	2.490E-05
Hf-182	2.760E-09	2.760E-09	2.760E-09	2.760E-09	2.760E-09	2.760E-09	2.759E-09
Ta-181	8.835E-07	8.835E-07	8.835E-07	8.835E-07	8.835E-07	8.835E-07	8.835E-07
Ta-182	1.772E-12	2.178E-14	3.619E-16	9.979E-17	9.655E-17	9.655E-17	9.654E-17
W-182	8.987E-08	8.987E-08	8.987E-08	8.987E-08	8.987E-08	8.987E-08	8.987E-08

Table F.8.e. Cladding Activation Product Inventory by Isotope at
30 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
W-183	9.920E-08	9.920E-08	9.920E-08	9.920E-08	9.920E-08	9.920E-08	9.920E-08
W-184	7.299E-09	7.299E-09	7.299E-09	7.299E-09	7.299E-09	7.299E-09	7.299E-09
W-186	2.085E-13	2.085E-13	2.085E-13	2.085E-13	2.085E-13	2.085E-13	2.085E-13
Re-185	1.733E-11	1.733E-11	1.733E-11	1.733E-11	1.733E-11	1.733E-11	1.733E-11
Re-187	1.109E-14	1.109E-14	1.109E-14	1.109E-14	1.109E-14	1.109E-14	1.109E-14
Os-186	3.164E-12	3.164E-12	3.164E-12	3.164E-12	3.164E-12	3.164E-12	3.164E-12
Total	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

Table F.8.f. Cladding Activation Product Inventory by Isotope at
35 MWd/kgM, g/gZr

Isotope	4 Years	6 Years	8 Years	10 Years	15 Years	20 Years	1000 Years
H-1	1.204E-05	1.204E-05	1.204E-05	1.204E-05	1.204E-05	1.204E-05	1.204E-05
H-2	2.614E-08	2.614E-08	2.614E-08	2.614E-08	2.614E-08	2.614E-08	2.614E-08
H-3	7.355E-14	6.574E-14	5.876E-14	5.252E-14	3.967E-14	2.996E-14	3.865E-38
He-3	2.077E-14	2.858E-14	3.556E-14	4.180E-14	5.466E-14	6.436E-14	9.433E-14
He-4	7.949E-08	7.949E-08	7.949E-08	7.949E-08	7.949E-08	7.949E-08	7.949E-08
Li-6	1.429E-13	1.429E-13	1.429E-13	1.429E-13	1.429E-13	1.429E-13	1.429E-13
Be-9	1.019E-09	1.019E-09	1.019E-09	1.019E-09	1.019E-09	1.019E-09	1.019E-09
Be-10	2.744E-11	2.744E-11	2.744E-11	2.744E-11	2.744E-11	2.744E-11	2.743E-11
B-11	1.559E-08	1.559E-08	1.559E-08	1.559E-08	1.559E-08	1.559E-08	1.559E-08
C-12	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04	1.729E-04
C-13	2.159E-06	2.159E-06	2.159E-06	2.159E-06	2.159E-06	2.159E-06	2.159E-06
C-14	1.771E-07	1.770E-07	1.770E-07	1.769E-07	1.768E-07	1.767E-07	1.570E-07
N-14	3.466E-05	3.466E-05	3.466E-05	3.466E-05	3.466E-05	3.466E-05	3.468E-05
N-15	1.445E-07	1.445E-07	1.445E-07	1.445E-07	1.445E-07	1.445E-07	1.445E-07
O-16	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03	1.197E-03
O-17	4.847E-07	4.847E-07	4.847E-07	4.847E-07	4.847E-07	4.847E-07	4.847E-07
O-18	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06	2.753E-06
F-19	2.718E-12	2.718E-12	2.718E-12	2.718E-12	2.718E-12	2.718E-12	2.718E-12
Ne-22	1.503E-14	1.503E-14	1.503E-14	1.503E-14	1.503E-14	1.503E-14	1.503E-14
Na-23	1.218E-15	1.218E-15	1.218E-15	1.218E-15	1.218E-15	1.218E-15	1.218E-15
Mg-24	1.484E-10	1.484E-10	1.484E-10	1.484E-10	1.484E-10	1.484E-10	1.484E-10
Mg-25	3.122E-10	3.122E-10	3.122E-10	3.122E-10	3.122E-10	3.122E-10	3.122E-10
Mg-26	1.429E-10	1.429E-10	1.429E-10	1.429E-10	1.429E-10	1.429E-10	1.429E-10
Al-27	3.997E-05	3.997E-05	3.997E-05	3.997E-05	3.997E-05	3.997E-05	3.997E-05
Si-28	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05	7.349E-05
Si-29	3.885E-06	3.885E-06	3.885E-06	3.885E-06	3.885E-06	3.885E-06	3.885E-06
Si-30	2.649E-06	2.649E-06	2.649E-06	2.649E-06	2.649E-06	2.649E-06	2.649E-06
P-31	8.741E-10	8.741E-10	8.741E-10	8.741E-10	8.741E-10	8.741E-10	8.741E-10
S-32	2.116E-13	2.116E-13	2.116E-13	2.116E-13	2.116E-13	2.116E-13	2.116E-13
Ca-44	2.946E-15	2.946E-15	2.946E-15	2.946E-15	2.946E-15	2.946E-15	2.946E-15
Ca-46	1.204E-15	1.204E-15	1.204E-15	1.204E-15	1.204E-15	1.204E-15	1.204E-15
Ti-47	1.765E-10	1.765E-10	1.765E-10	1.765E-10	1.765E-10	1.765E-10	1.765E-10
Ti-48	4.851E-13	4.851E-13	4.851E-13	4.851E-13	4.851E-13	4.851E-13	4.851E-13
Ti-49	4.920E-10	4.920E-10	4.920E-10	4.920E-10	4.920E-10	4.920E-10	4.920E-10
Ti-50	1.965E-09	1.965E-09	1.965E-09	1.965E-09	1.965E-09	1.965E-09	1.965E-09
V-50	6.629E-09	6.629E-09	6.629E-09	6.629E-09	6.629E-09	6.629E-09	6.629E-09
V-51	1.907E-06	1.907E-06	1.907E-06	1.907E-06	1.907E-06	1.907E-06	1.907E-06
Cr-50	4.407E-05	4.407E-05	4.407E-05	4.407E-05	4.407E-05	4.407E-05	4.407E-05
Cr-52	9.130E-04	9.130E-04	9.130E-04	9.130E-04	9.130E-04	9.130E-04	9.130E-04
Cr-53	1.091E-04	1.091E-04	1.091E-04	1.091E-04	1.091E-04	1.091E-04	1.091E-04
Cr-54	3.219E-05	3.219E-05	3.219E-05	3.219E-05	3.219E-05	3.219E-05	3.219E-05
Mn-54	1.625E-10	3.216E-11	6.362E-12	1.259E-12	2.191E-14	3.815E-16	0.00
Mn-55	4.219E-07	4.448E-07	4.582E-07	4.661E-07	4.743E-07	4.765E-07	4.773E-07
Fe-54	7.248E-05	7.248E-05	7.248E-05	7.248E-05	7.248E-05	7.248E-05	7.248E-05
Fe-55	5.543E-08	3.252E-08	1.908E-08	1.120E-08	2.952E-09	7.785E-10	0.00
Fe-56	1.186E-03	1.186E-03	1.186E-03	1.186E-03	1.186E-03	1.186E-03	1.186E-03

Table F.8.f. Cladding Activation Product Inventory by Isotope at
35 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Fe-57	3.735E-05	3.735E-05	3.735E-05	3.735E-05	3.735E-05	3.735E-05	3.735E-05
Fe-58	4.228E-06	4.228E-06	4.228E-06	4.228E-06	4.228E-06	4.228E-06	4.228E-06
Co-58	2.752E-15	2.151E-18	1.681E-21	1.314E-24	2.243E-32	0.00	0.00
Co-59	5.820E-08	5.826E-08	5.832E-08	5.838E-08	5.854E-08	5.869E-08	8.839E-08
Co-60	2.227E-09	1.712E-09	1.316E-09	1.012E-09	5.240E-10	2.715E-10	0.00
Ni-58	3.327E-04	3.327E-04	3.327E-04	3.327E-04	3.327E-04	3.327E-04	3.327E-04
Ni-59	3.513E-06	3.513E-06	3.513E-06	3.513E-06	3.513E-06	3.512E-06	3.483E-06
Ni-60	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04	1.329E-04
Ni-61	6.831E-06	6.831E-06	6.831E-06	6.831E-06	6.831E-06	6.831E-06	6.831E-06
Ni-62	1.829E-05	1.829E-05	1.829E-05	1.829E-05	1.829E-05	1.829E-05	1.829E-05
Ni-63	6.410E-07	6.314E-07	6.219E-07	6.126E-07	5.900E-07	5.682E-07	3.531E-10
Ni-64	4.956E-06	4.956E-06	4.956E-06	4.956E-06	4.956E-06	4.956E-06	4.956E-06
Cu-63	4.356E-08	5.315E-08	6.259E-08	7.189E-08	9.454E-08	1.164E-07	6.842E-07
Cu-65	2.097E-08	2.097E-08	2.097E-08	2.097E-08	2.097E-08	2.097E-08	2.097E-08
Zn-64	3.524E-11	3.524E-11	3.524E-11	3.524E-11	3.524E-11	3.524E-11	3.524E-11
Zn-66	7.098E-11	7.098E-11	7.098E-11	7.098E-11	7.098E-11	7.098E-11	7.098E-11
Zn-67	5.995E-14	5.995E-14	5.995E-14	5.995E-14	5.995E-14	5.995E-14	5.995E-14
Sr-87	1.055E-08	1.055E-08	1.055E-08	1.055E-08	1.055E-08	1.055E-08	1.055E-08
Sr-88	1.021E-06	1.021E-06	1.021E-06	1.021E-06	1.021E-06	1.021E-06	1.021E-06
Sr-90	4.025E-11	3.838E-11	3.660E-11	3.489E-11	3.098E-11	2.750E-11	2.037E-21
Y-89	7.779E-08	7.779E-08	7.779E-08	7.779E-08	7.779E-08	7.779E-08	7.779E-08
Y-90	1.009E-14	9.624E-15	9.177E-15	8.750E-15	7.769E-15	6.897E-15	5.109E-25
Zr-90	4.973E-01	4.973E-01	4.973E-01	4.973E-01	4.973E-01	4.973E-01	4.973E-01
Zr-91	1.089E-01	1.089E-01	1.089E-01	1.089E-01	1.089E-01	1.089E-01	1.089E-01
Zr-92	1.695E-01	1.695E-01	1.695E-01	1.695E-01	1.695E-01	1.695E-01	1.695E-01
Zr-93	2.824E-04	2.824E-04	2.824E-04	2.824E-04	2.824E-04	2.824E-04	2.822E-04
Zr-94	1.755E-01	1.755E-01	1.755E-01	1.755E-01	1.755E-01	1.755E-01	1.755E-01
Zr-95	4.581E-13	1.675E-16	6.124E-20	2.239E-23	5.723E-32	0.00	0.00
Zr-96	2.872E-02	2.872E-02	2.872E-02	2.872E-02	2.872E-02	2.872E-02	2.872E-02
Nb-93	2.712E-10	3.778E-10	4.989E-10	6.330E-10	1.017E-09	1.459E-09	1.261E-07
Nb-93m	8.442E-10	9.935E-10	1.128E-09	1.250E-09	1.505E-09	1.703E-09	2.384E-09
Nb-94	2.891E-13	2.890E-13	2.890E-13	2.890E-13	2.890E-13	2.889E-13	2.794E-13
Nb-95	5.587E-13	2.043E-16	7.469E-20	2.731E-23	5.176E-34	0.00	0.00
Mo-95	9.289E-05	9.289E-05	9.289E-05	9.289E-05	9.289E-05	9.289E-05	9.289E-05
Mo-96	4.922E-06	4.922E-06	4.922E-06	4.922E-06	4.922E-06	4.922E-06	4.922E-06
Mo-97	1.433E-04	1.433E-04	1.433E-04	1.433E-04	1.433E-04	1.433E-04	1.433E-04
Mo-98	1.409E-06	1.409E-06	1.409E-06	1.409E-06	1.409E-06	1.409E-06	1.409E-06
Mo-100	8.705E-13	8.705E-13	8.705E-13	8.705E-13	8.705E-13	8.705E-13	8.705E-13
Tc-98	5.528E-15	5.528E-15	5.528E-15	5.528E-15	5.528E-15	5.528E-15	5.527E-15
Tc-99	1.716E-09	1.716E-09	1.716E-09	1.716E-09	1.716E-09	1.716E-09	1.711E-09
Ru-99	3.677E-14	4.794E-14	5.911E-14	7.028E-14	9.821E-14	1.261E-13	5.591E-12
Ru-100	1.113E-10	1.113E-10	1.113E-10	1.113E-10	1.113E-10	1.113E-10	1.113E-10
Ru-101	4.844E-13	4.844E-13	4.844E-13	4.844E-13	4.844E-13	4.844E-13	4.844E-13
Ru-102	6.881E-15	6.881E-15	6.881E-15	6.881E-15	6.881E-15	6.881E-15	6.881E-15
Cd-111	1.103E-11	1.103E-11	1.103E-11	1.103E-11	1.103E-11	1.103E-11	1.103E-11
Cd-112	9.381E-11	9.381E-11	9.381E-11	9.381E-11	9.381E-11	9.381E-11	9.381E-11

Table F.8.f. Cladding Activation Product Inventory by Isotope at
35 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Cd-113	2.683E-13	2.683E-13	2.683E-13	2.683E-13	2.683E-13	2.683E-13	2.683E-13
Cd-114	2.257E-08	2.257E-08	2.257E-08	2.257E-08	2.257E-08	2.257E-08	2.257E-08
Cd-116	7.129E-11	7.129E-11	7.129E-11	7.129E-11	7.129E-11	7.129E-11	7.129E-11
In-113	2.621E-06	2.621E-06	2.621E-06	2.621E-06	2.621E-06	2.621E-06	2.621E-06
In-113m	1.138E-14	1.398E-16	1.718E-18	2.112E-20	3.535E-25	5.919E-30	0.00
In-115	2.504E-11	2.504E-11	2.504E-11	2.504E-11	2.504E-11	2.504E-11	2.504E-11
Sn-112	1.384E-04	1.384E-04	1.384E-04	1.384E-04	1.384E-04	1.384E-04	1.384E-04
Sn-113	1.894E-11	2.328E-13	2.861E-15	3.516E-17	5.887E-22	9.857E-27	0.00
Sn-114	9.676E-05	9.676E-05	9.676E-05	9.676E-05	9.676E-05	9.676E-05	9.676E-05
Sn-115	4.885E-05	4.885E-05	4.885E-05	4.885E-05	4.885E-05	4.885E-05	4.885E-05
Sn-116	2.122E-03	2.122E-03	2.122E-03	2.122E-03	2.122E-03	2.122E-03	2.122E-03
Sn-117	1.158E-03	1.158E-03	1.158E-03	1.158E-03	1.158E-03	1.158E-03	1.158E-03
Sn-118	3.605E-03	3.605E-03	3.605E-03	3.605E-03	3.605E-03	3.605E-03	3.605E-03
Sn-119	1.330E-03	1.330E-03	1.330E-03	1.330E-03	1.330E-03	1.330E-03	1.330E-03
Sn-119m	3.210E-08	4.064E-09	5.147E-10	6.517E-11	3.719E-13	2.122E-15	0.00
Sn-120	4.906E-03	4.906E-03	4.906E-03	4.906E-03	4.906E-03	4.906E-03	4.906E-03
Sn-121m	4.289E-08	4.172E-08	4.058E-08	3.947E-08	3.682E-08	3.435E-08	4.291E-14
Sn-122	7.079E-04	7.079E-04	7.079E-04	7.079E-04	7.079E-04	7.079E-04	7.079E-04
Sn-123	2.174E-11	4.313E-13	8.557E-15	1.698E-16	9.411E-21	5.218E-25	0.00
Sn-124	8.670E-04	8.670E-04	8.670E-04	8.670E-04	8.670E-04	8.670E-04	8.670E-04
Sb-121	7.603E-06	7.604E-06	7.605E-06	7.606E-06	7.609E-06	7.611E-06	7.646E-06
Sb-123	8.110E-07	8.110E-07	8.110E-07	8.110E-07	8.110E-07	8.110E-07	8.110E-07
Sb-125	1.361E-06	8.253E-07	5.003E-07	3.033E-07	8.680E-08	2.484E-08	0.00
Te-122	5.750E-07	5.750E-07	5.750E-07	5.750E-07	5.750E-07	5.750E-07	5.750E-07
Te-123	8.063E-09	8.063E-09	8.063E-09	8.063E-09	8.063E-09	8.063E-09	8.063E-09
Te-123m	1.670E-13	2.427E-15	3.529E-17	5.131E-19	1.308E-23	3.333E-28	0.00
Te-124	4.308E-08	4.308E-08	4.308E-08	4.308E-08	4.308E-08	4.308E-08	4.308E-08
Te-125	8.455E-06	8.999E-06	9.328E-06	9.528E-06	9.748E-06	9.810E-06	9.836E-06
Te-125m	1.904E-08	1.155E-08	7.000E-09	4.244E-09	1.214E-09	3.474E-10	0.00
Te-126	1.138E-07	1.138E-07	1.138E-07	1.138E-07	1.138E-07	1.138E-07	1.138E-07
Te-128	9.460E-13	9.460E-13	9.460E-13	9.460E-13	9.460E-13	9.460E-13	9.460E-13
I-127	4.730E-10	4.730E-10	4.730E-10	4.730E-10	4.730E-10	4.730E-10	4.730E-10
Xe-128	1.477E-11	1.477E-11	1.477E-11	1.477E-11	1.477E-11	1.477E-11	1.477E-11
Xe-129	5.513E-14	5.513E-14	5.513E-14	5.513E-14	5.513E-14	5.513E-14	5.513E-14
Xe-130	2.187E-15	2.187E-15	2.187E-15	2.187E-15	2.187E-15	2.187E-15	2.187E-15
Yb-172	4.148E-15	4.148E-15	4.148E-15	4.148E-15	4.148E-15	4.148E-15	4.148E-15
Yb-173	3.386E-15	3.386E-15	3.386E-15	3.386E-15	3.386E-15	3.386E-15	3.386E-15
Lu-175	4.260E-08	4.260E-08	4.260E-08	4.260E-08	4.260E-08	4.260E-08	4.260E-08
Lu-176	1.404E-09	1.404E-09	1.404E-09	1.404E-09	1.404E-09	1.404E-09	1.404E-09
Lu-177m	2.821E-15	1.076E-16	4.101E-18	1.564E-19	4.440E-23	1.261E-26	0.00
Hf-174	2.533E-08	2.533E-08	2.533E-08	2.533E-08	2.533E-08	2.533E-08	2.533E-08
Hf-176	1.591E-06	1.591E-06	1.591E-06	1.591E-06	1.591E-06	1.591E-06	1.591E-06
Hf-177	1.997E-07	1.997E-07	1.997E-07	1.997E-07	1.997E-07	1.997E-07	1.997E-07
Hf-178	6.522E-06	6.522E-06	6.522E-06	6.522E-06	6.522E-06	6.522E-06	6.522E-06
Hf-179	1.918E-05	1.918E-05	1.918E-05	1.918E-05	1.918E-05	1.918E-05	1.918E-05
Hf-180	2.634E-05	2.634E-05	2.634E-05	2.634E-05	2.634E-05	2.634E-05	2.634E-05

Table F.8.f. Cladding Activation Product Inventory by Isotope at
35 MWd/kgM, g/gZr (contd)

<u>Isotope</u>	<u>4 Years</u>	<u>6 Years</u>	<u>8 Years</u>	<u>10 Years</u>	<u>15 Years</u>	<u>20 Years</u>	<u>1000 Years</u>
Hf-182	4.071E-09	4.071E-09	4.070E-09	4.070E-09	4.070E-09	4.070E-09	4.070E-09
Ta-181	1.055E-06	1.055E-06	1.055E-06	1.055E-06	1.055E-06	1.055E-06	1.055E-06
Ta-182	2.318E-12	2.851E-14	4.897E-16	1.467E-16	1.424E-16	1.424E-16	1.424E-16
W-182	1.147E-07	1.147E-07	1.147E-07	1.147E-07	1.147E-07	1.147E-07	1.147E-07
W-183	1.539E-07	1.539E-07	1.539E-07	1.539E-07	1.539E-07	1.539E-07	1.539E-07
W-184	1.358E-08	1.358E-08	1.358E-08	1.358E-08	1.358E-08	1.358E-08	1.358E-08
W-186	5.394E-13	5.394E-13	5.394E-13	5.394E-13	5.394E-13	5.394E-13	5.394E-13
Re-185	3.763E-11	3.763E-11	3.763E-11	3.763E-11	3.763E-11	3.763E-11	3.763E-11
Re-187	3.462E-14	3.462E-14	3.462E-14	3.462E-14	3.462E-14	3.462E-14	3.462E-14
Os-186	8.278E-12	8.278E-12	8.278E-12	8.278E-12	8.278E-12	8.278E-12	8.278E-12
Os-188	1.760E-15	1.760E-15	1.760E-15	1.760E-15	1.760E-15	1.760E-15	1.760E-15
Total	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

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