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TECHNICAL REPORT
EPA-520/3-80-008

A REVIEW OF RADIATION EXPOSURE ESTIMATES FROM NORMAL OPERATIONS IN THE MANAGEMENT AND DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES AND SPENT NUCLEAR FUEL

William F. Holcomb

OFFICE OF RADIATION PROGRAMS
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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EPA REVIEW NOTICE

The Office of Radiation Programs, U.S. Environmental Protection Agency, has reviewed this report and approved it for publication. Mention of trade names, commercial products, or government proposals does not constitute endorsement.

ABSTRACT

The Office of Radiation Programs, Environmental Protection Agency, has prepared this analysis of the radioactive releases during normal waste management operations and the resulting radiation doses as technical support for EPA's proposed environmental radiation protection standards, 40 CFR 191. We reviewed the estimated releases and doses from preparation for storage or disposal, storage, and emplacement in a disposal repository. We found that they are small compared to the releases and doses in EPA's uranium fuel cycle standards, 40 CFR 190. For Subpart A of 40 CFR 191 on waste management and storage operations, EPA proposes to extend the limitations of 40 CFR 190 to these operations.

PREFACE

The Office of Radiation Programs of the U.S. Environmental Protection Agency carries out a national program designed to evaluate individual and population exposure to ionizing and non-ionizing radiation and to promote development of controls necessary for the protection of the public health and environment.

We prepared this report as a technical support document for EPA's proposed standards for the management and disposal of spent nuclear fuel and high-level radioactive wastes.

We encourage readers of this report to inform the Office of Radiation Programs of omissions or errors. We invite comments or requests for further information.

OFFICE OF RADIATION PROGRAMS
U.S. ENVIRONMENTAL PROTECTION AGENCY

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GLOSSARY

ABBREVIATIONS

40 CFR 190	-	Code of Federal Regulations, Title 40, Part 190
Ci	-	Curie
DOE	-	U.S. Department of Energy
EPA	-	U.S. Environmental Protection Agency
HLLW	-	High-Level Liquid Wastes
HLSW	-	High-Level Solidified Wastes
ISFS	-	Independent Spent Fuel Storage
ISFSF	-	ISFS Facility
LWR	-	Light-Water Reactor
MT	-	Metric Ton
MTHM	-	Metric Tons of Heavy Metals (i.e. uranium and plutonium)
MWd	-	Megawatt days
NRC	-	U.S. Nuclear Regulatory Commission
ORP	-	EPA's Office of Radiation Programs
UFC	-	Uranium Fuel Cycle

TERMS

High-Level Wastes:	High-level radioactive liquid wastes, or the products from solidification of high-level liquid waste, or spent fuel elements if discarded without processing.
Spent Nuclear Fuel:	Any fuel removed from a nuclear reactor after it has been irradiated, usually to the extent that it can no longer effectively sustain a chain reaction
E±00 Format:	Throughout this report, numeric values are frequently expressed in a modified scientific format. For example, 0.00456 = 4.56×10^{-3} may be written as 4.56 E-03 and 78900 = 7.89×10^{4} as 7.89 E+04.
Fuel Reprocessing:	The processing of spent reactor fuel to recover the unused fissionable uranium and plutonium.
Generic:	Characteristic of a whole class.
Off-Gas:	The normal gasborne discharge from any process vessel or process equipment.

1.0 INTRODUCTION

The Office of Radiation Programs, U.S. Environmental Protection Agency (EPA/ORP). is proposing generally applicable environmental radiation protection standards for the management and disposal of spent nuclear fuel, high-level, and transuranic radioactive wastes (1). These proposed standards would become Part 191 of the Code of Federal Regulations, Title 40 (40 CFR 191).

Subpart A of the proposed standards applies to normal waste management operations, which include preparation for storage or disposal (solidification and packaging of high-level liquid wastes, packaging of spent fuel), storage, and emplacement in a disposal repository.

EPA's uranium fuel cycle (UFC) standards, 40 CFR 190, do not include waste management operations (2). For Subpart A of the proposed 40 CFR 191 standards, EPA proposes to extend the limitations of 40 CFR 190 to these operations. We have assessed the potential airborne releases of radioactive materials during these operations and the radiation doses due to these releases to ascertain whether they can meet the UFC standards. Part 190.10 states that normal operations of the uranium fuel cycle shall be conducted in such a manner as to provide reasonable assurance that: (a) The annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations; and (b) the total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of

electrical energy produced by the fuel cycle, contains less than 50,000 curies of krypton-85, 5 millicuries of iodine-129, and 0.5 millicuries combined with plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one year.

During normal waste management operations, some of the radionuclides in the wastes are released to the operation's off-gas streams as volatile gases and particulates. Before the off-gases are released to the atmosphere, these off-gases are routed to treatment systems designed to remove the majority of the radionuclides.

Several major factors can affect the potential radiation dose to individuals and populations as a result of release of radionuclides to the atmosphere: proximity to the plant, the pathways by which the radionuclides can reach people, the length of time during which the radionuclides continue to pose a health hazard, decay time, meteorological factors, facility capacity, and off-gas treatment.

2.0 BASIC ASSUMPTIONS

In this analysis, we have examined operations that are the most likely major steps in the management of high-level liquid wastes and spent fuel. Figure 1 shows these operations.

The data comes from reports of the Department of Energy (DOE) and Nuclear Regulatory Commission (NRC). Some of the data concerns hypothetical generic facilities; some, actual operations at DOE or commercial facilities.

For practical purposes the basic assumption for this analysis is that the only radioactive materials entering the general environment from the generic facilities are airborne discharges to the atmosphere; liquid releases or accidental releases were not considered. Water streams associated with the operations are assumed to be recycled.

The exposure pathways, demography, and other parameters and the mathematical models relating dose to man for the estimated radionuclide releases from the generic facilities are described by DOE in reference 5. The maximum annual doses to an individual are based on a hypothetical area resident whose habits would tend to maximize his dose.

High-Level Radioactive Waste and Spent Nuclear Fuel Management Operations

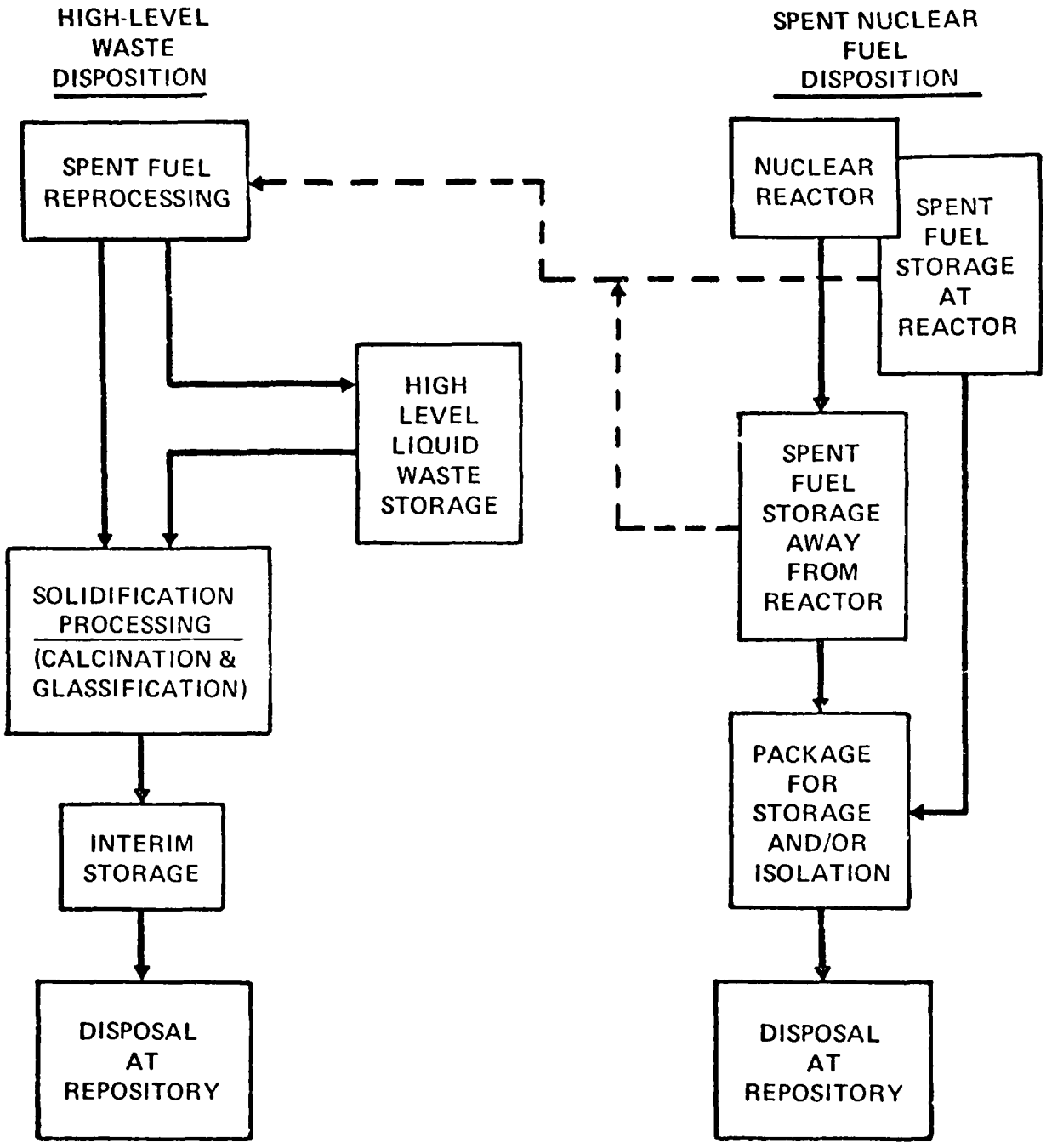

Figure 1

3.0 HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT OPERATIONS

We examined four operations in the management of high-level liquid wastes (HLLW) generated by the reprocessing of spent nuclear fuel: (i) liquid waste storage; (ii) solidification; (iii) interim storage of the solidified wastes; and (iv) disposal. The DOE/NRC generic operations described in this section are based on a 2000 MTHM per year fuel reprocessing plant, whereas the EPA generic solidification plant is based on waste received from a 1500 MTHM per year fuel reprocessing plant.

3.1 Storage of High-Level Liquid Wastes

Table 3.1-1 lists the major radionuclides released to the atmosphere during the normal operation of a high-level liquid waste storage facility. Table 3.1-2 indicates the maximum annual doses to an individual in the vicinity of the HLLW storage facility. DOE estimated the doses on the basis of the releases in Table 3.1-1.

Each storage tank has a net volume of 1140 cubic meters, and one tank per year will be filled. The release values are based on the assumption that the liquid waste generated from reprocessing 2000 MTHM will fill one tank (3-5). The technology for storage of HLLW is based on over 30 years' management of defense wastes.

TABLE 3.1-1

MAJOR RADIONUCLIDES RELEASED TO THE ATMOSPHERE DURING NORMAL OPERATION OF A HLLW STORAGE FACILITY (5)

Radionuclide	Release (Ci/yr)
H-3	2.7 E+04
Sr-90	4.9 E-05
Ru-106	1.5 E-03
I-129	1.4 E-04
Cs-134	9.6 E-05
Cs-137	7.4 E-05
Ce-144	1.9 E-04
Pu-239	1.4 E-09

TABLE 3.1-2

MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO ATMOSPHERIC RELEASES DURING STORAGE OF HLLW (5)

Organ	Dose (millirem)
Whole Body	9.5 E-02
Thyroid	9.5 E-02
Lung	9.5 E-02
Bone	3.6 E-07

3.2 Solidification of High-Level Liquid Wastes

The EPA/ORP staff has prepared a technical document on radiation exposures from solidification of high-level liquid wastes in support of EPA's proposed standards, 40 CFR 191. We developed a generic high-level liquid waste solidification plant and assessed the potential radiation exposures of atmospheric discharges during normal operations of calcination and glassification (6).

We used a newly developed computer code, AIRDOS-EPA, to perform the assessment. Our assessment involved seven radionuclides that account for 88% of the doses due to the solidification process: H-3, I-129, Ru-106, Cs-134, Cs-137, Sr-90, and Pu-239. Table 3.2-1 shows the estimated releases.

For purposes of comparison, we based our assessment on hypothetical rural and urban plant sites with widely different population size, food sources, and weather. After estimating the off-gas releases during normal operations of the generic plant, we determined the annual individual doses due to exposure to the radionuclide waste products from spent fuel that have decayed one year, five years, and ten years before reprocessing and solidification. Table 3.2-2 shows the maximum dose to an individual at the two plant sites only for the case where the waste products have decayed for one year. In the case of the radionuclide waste products that have decayed for five years or longer, the maximum annual dose to an individual at either site would be less than 15 millirem (6).

TABLE 3.2-1

MAJOR RADIONUCLIDES RELEASED TO THE ATMOSPHERE
DURING NORMAL OPERATION OF
THE EPA GENERIC SOLIDIFICATION PLANT (6)

Radionuclide	Plant Release (One-year decayed fuel)
	(Ci/yr)
Iodine-129	2.94 E-03
Pu-239	5.02 E-07
H-3	5.21 E+04
Ru-106	4.80 E+01
Cs-137	1.59 E-02
Cs-134	2.88 E-02
Sr-90	1.12 E-02

TABLE 3.2-2

MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO ATMOSPHERIC
RELEASES DURING NORMAL OPERATION OF
THE EPA GENERIC SOLIDIFICATION PLANT (6)

Organ	Dose (One-year-decayed fuel) Rural Site	Urban Site
	(millirem)	(millirem)
Total body	2.1	14.5
Thyroid	2.2	15.7
Other organs		
lungs	3.5	21.3
liver	2.1	14.8
bone	2.4	17.3
endosteal cells	2.7	19.6
stomach wall	2.1	14.2
kidneys	2.1	14.9
lower large intestine wall	23.7	191.9
testes	2.3	16.3
ovaries	1.8	11.8

3.3 Storage of High-Level Solidified Wastes

High-level solidified wastes (HLSW) may be packaged and placed in interim storage for several years if a geologic repository is not available, or if heat generated by the packaged HLSW is too great to permit immediate disposal. DOE and NRC analyzed two generic interim storage systems for solidified wastes in sealed metal canisters: a water basin storage system and a sealed cask storage system (3-5, 7-10).

A. Water Basin Storage

The technology for water basin storage of HLSW is based on over 30 years' experience at DOE and commercial facilities in storing spent fuel. DOE is developing water basin storage of laboratory-generated HLSW packages. Water basin storage of spent nuclear fuel and of HLSW is basically the same, although the configuration of the package differs slightly.

Table 3.3-1 shows the major radionuclides released to the atmosphere from a water basin storage facility that can store 3500 canisters and requires five years to fill. Table 3.3-2 shows the maximum annual doses to an exposed individual from these radionuclides (5).

B. Sealed Cask Storage

In sealed cask storage, HLSW is stored in high-integrity metal casks shielded by reinforced concrete that are placed in the open at properly spaced intervals. Air circulates by natural convection between the shield and the sealed cask and removes heat generated by the wastes. Since this method does not require capital-intensive facilities, it is relatively economical. Moreover, the concrete shield provides better

direct gamma radiation protection than the water basins do. DOE is testing sealed cask storage at the Hanford Reservation with electrically heated dummy HLSW packages (4,7,10).

Releases of radioactive materials during normal operations of a sealed cask storage facility are very small. Table 3.3-3 shows estimated releases from a facility capable of storing some 20,000 canisters at a yearly maximum placement rate of 180 canisters; the spent fuel has decayed 1.5 years prior to reprocessing. Table 3.3-4 indicates the maximum annual doses to an individual in the vicinity of the sealed cask storage facility.

TABLE 3.3-1

MAJOR RADIONUCLIDES RELEASED TO THE ATMOSPHERE DURING NORMAL OPERATION OF A WATER BASIN STORAGE FACILITY FOR HLSW (5)

Radionuclide	Release (Ci/yr)
Sr-90	1.2 E-05
Ru-106	3.8 E-05
Cs-134	2.4 E-04
Cs-137	2.4 E-04
Ce-144	4.8 E-05
Pu-239	3.6 E-10

TABLE 3.3-2

MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO ATMOSPHERIC RELEASES DURING WATER BASIN STORAGE OF HLSW (5)

Organ	Dose (millirem)
Whole Body	6.4 E-07
Thyroid	3.0 E-09
Lung	4.6 E-06
Bone	1.1 E-06

TABLE 3.3-3

MAJOR RADIONUCLIDES RELEASED TO THE ATMOSPHERE DURING NORMAL OPERATION OF A SEALED CASK STORAGE FACILITY (5)

Radionuclide	Release (Ci/yr)
Sr-90	1.2 E-07
Ru-106	3.8 E-07
Cs-134/137	4.3 E-07
Pu-239	3.6 E-12

TABLE 3.3-4

MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO ATMOSPHERIC RELEASES DURING NORMAL OPERATION OF A SEALED CASK STORAGE FACILITY (5)

Organ	Dose (millirem)
Whole Body	1.5 E-08
Thyroid	3.9 E-10
Lung	1.4 E-06
Bone	1.5 E-07

3.4 Disposal of High-Level Solidified Wastes at a Repository

Disposal operations for high-level wastes includes: receiving, inspection, decontamination, repair, emplacement of waste canisters in the repository and backfilling (3,8,11).

During the normal operations of disposal, small quantities of radioactive materials can be released to the atmosphere. The filtered effluents released from the stack of DOE's generic receiving facility consist of oxides of mixed fission products, such as Sr-90, and actinides, such as Pu-239. The estimated average annual discharge to the atmosphere is about 2 E-11 Ci per year; the estimated maximum annual dose to an individual is less than 1 E-09 millirem (3).

Some releases from a geologic repository can occur during backfilling operations. They include naturally occurring radon and its decay products, but the amount is negligible(5).

4.0 SPENT NUCLEAR FUEL MANAGEMENT OPERATIONS

Present United States Government policy is to defer commercial reprocessing of spent fuel from power reactors. DOE has proposed several methods of interim storage of spent fuel at either reactor sites or away-from-reactor independent spent fuel storage (ISFS) facilities (3-5, 8-25).

We have considered water basin storage of unpackaged spent fuel, packaging, and extended storage or disposal at an ISFS facility.

4.1 Storage of Unpackaged Spent Fuel

The main difference between water basin storage at a reactor storage facility and at an away-from-reactor ISFS facility is capacity. Most reactor storage facilities hold from 50 to 150 metric tons (MT) of spent fuel; a large ISFS facility could hold up to 18,000 MT of spent fuel. Consequently, releases and doses from spent fuel will probably be smaller at a reactor storage facility than at an ISFS facility (4,10,12). DOE's basic generic ISFS facility will hold 3000 MT of unpackaged spent fuel; an additional 1000 to 2000 MT could be stored if extra modules are added.

Releases of radionuclides to the environment from the DOE generic facility are through the off-gas and ventilation systems. During receiving and storage operations, ruptured fuel elements will release a small amount of radioactive material. The basin water will retain most of the material from ruptured fuel elements; however, the krypton-85 and carbon-14 in the fuel, and 1% of the iodine-129 will be released to the building ventilation system as off gases, and then to the atmosphere (4,5).

Table 4.1-1 shows the major radionuclides released during normal receiving and storage operations. DOE assumes the spent fuel is packaged at the generic storage facility; therefore the annual doses listed in Table 4.2-2 are due to the combined releases listed in both Tables 4.1-1 and 4.2-1.

TABLE 4.1-1

MAJOR RADIONUCLIDES RELEASED TO THE ATMOSPHERE
DURING NORMAL OPERATION OF AN ISFS FACILITY (5)

	Release (Ci/yr)	
Radionuclide	Receiving	Storage
H-3	1.3 E+00	1.1 E+00
C-14	3.3 E-03	1.9 E-05
Kr-85	8.7 E+02	1.7 E+01
Sr-90	2.0 E-04	3.8 E-05
I-129	5.0 E-05	8.9 E-07
Cs-137	9.9 E-03	2.4 E-03
Ce-144	1.8 E-03	2.5 E-05

4.2 Packaging Of Spent Fuel for Storage and/or Disposal

At the DOE generic ISFS facility, the whole spent nuclear fuel assembly is packaged in steel canisters, which are backfilled with helium and seal-welded to provide an inert atmosphere that will inhibit corrosion and aid in transferring the heat from the spent fuel (4,5,8,10,23,24).

The design characteristics of this generic fuel packaging facility are based on a processing capacity of 2000 MTHM per year. Table 4.2-1 shows the amounts of radioactive materials released to the atmosphere

during normal operation of the packaging facility (5). Table 4.2-2 lists the combined doses due to the releases to the atmosphere from the receiving, storage, and packaging operations listed in Tables 4.1-1 and 4.2-1

TABLE 4.2-1

MAJOR RADIONUCLIDES RELEASED TO THE ATMOSPHERE DURING NORMAL OPERATION OF A PACKAGING FACILITY FOR SPENT FUEL (5)

Radionuclide	Release (Ci/yr)
H-3	1.3 E+00
C-14	6.6 E-03
C-60	6.3 E-04
Kr-85	8.1 E+02
Sr-90	9.9 E-05
Ru-106	2.6 E-04
I-129	9.9 E-04
Cs-134	7.2 E-03
Cs-137	5.4 E-03
Ce-144	3.9 E-04

TABLE 4.2-2

MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO ATMOSPHERIC RELEASES DURING NORMAL OPERATION OF A COMBINED RECEIVING, STORAGE, AND PACKAGING FACILITY FOR SPENT FUEL(5)

Organ	Dose (millirem)
Whole Body	6.1 E-04
Thyroid	1.5 E-02
Lung	1.7 E-03
Bone	5.1 E-04

4.3 Storage Of Packaged Spent Fuel

Packaged spent fuel may have to be stored for an extended period before disposal in a geologic repository if transportation facilities or disposal facilities are not readily available or if Government policy prevents disposal (4,5,8,12). Storage alternatives for packaged spent fuel are: (i) water basin; (ii) air-cooled vault; (iii) surface cask; or (iv) dry caisson.

No identifiable radioactive releases or doses result from these storage methods (7). However, small quantities of krypton-85 (about 0.01 Ci/year) and iodine-129 (about 10^{-7} Ci/year) might be released at the receiving and handling facility during repairs to failed canisters. Table 4.3-1 shows the maximum annual doses to an individual.

TABLE 4.3-1

MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO RELEASES TO THE ATMOSPHERE DURING NORMAL RECEIVING AND HANDLING OPERATIONS AT A PACKAGED SPENT FUEL STORAGE FACILITY (5)

Organ	Dose (millirem)
Whole Body	1.0 E-09
Thyroid	8.5 E-07
Lung	6.5 E-10
Bone	1.1 E-09

4.4 Disposal of Packaged Spent Fuel at a Repository

Disposal of the packaged spent fuel involves operations similar to those for packaged HLSW. Estimated releases and doses due to geologic disposal of spent fuel are similar to those due to HLSW disposal. (See section 3.4.) Some releases from a geologic repository can occur during backfilling operations. They include naturally occurring radon and its decay products, but the amount is negligible (5).

5.0 DISCUSSION AND CONCLUSIONS

Since the UFC (40 CFR 190) standards exclude waste management operations, ORP/EPA prepared this review as technical support of EPA's proposed generally applicable environmental standards for the management and disposal of high-level radioactive wastes and spent nuclear fuel, 40 CFR 191. For Subpart A of the proposed standards, EPA proposes to extend the limitations of 40 CFR 190 to these operations. We found that the radionuclide releases during normal operations of typical facilities and the resulting radiation doses to be less than the limits in EPA's uranium fuel cycle standards, 40 CFR 190.

Table 5.1 presents a summary of the individual dose estimates resulting from each of the operations reviewed, as well as the EPA standards. Table 5.2 presents a summary of the radionuclide release estimates from the operations reviewed, as well as the EPA release limits.

TABLE 5.1

SUMMARY OF MAXIMUM ANNUAL DOSES TO AN INDIVIDUAL DUE TO ATMOSPHERIC RELEASES DURING WASTE MANAGMENT OPERATIONS

ORGAN	HLLW Storage	HLLW Solidification (Rural Site) (e)	HLSW Water Basin Storage	HLSW Sealed Cask Storage	HLSW Disposal	ISFSF Receiving Storage & Packaging (b)	Spent Fuel Storage After Packaging	Spent Fuel Disposal	EPA UFC Standards (d)
				(millirem)					
Whole Body	9.5 E-02	2.1 E+00	6.4 E-07	1.5 E-08	1.0 E-09	6.1 E-04	1.0 E-09	(c)	2.5 E+01
Thyroid	9.5 E-02	2.2 E+00	3.0 E-09	3.9 E-10	(a)	1.5 E-02	8.5 E-07	(c)	7.5 E+01
Lung	9.5 E-02	3.5 E+00	4.6 E-06	1.4 E-06	(a)	1.7 E-10	6.5 E-10	(c)	2.5 E+01
Bone	3.6 E-07	2.4 E+00	1.1 E-06	1.5 E-07	(a)	5.1 E-04	1.1 E-09	(c)	2.5 E+01

(a) - No data available
(b) - Includes receiving, storage, and packaging
(c) - neglible (less than for repository construction)
(d) - 40 CFR 190
(e) - For this summary, only the rural site was considered viable.

TABLE 5.2

SUMMARY OF MAJOR RADIONUCLIDES RELEASED
TO THE ATMOSPHERE DURING WASTE MANAGEMENT OPERATIONS

Radionuclide	UFC Standard (Ci/GWe-yr)	UFC Standard (Ci/yr) (a)	Operational Releases (Ci/yr)								
			HLLW Storage	HLLW Solidification	HLSW Water Basin Storage	HLSW Sealed Cask Storage	HLSW Repository	Spent Fuel Receiving & Storage	Spent Fuel Packaging	Spent Fuel Storage after Packaged	Spent Fuel Repository Disposal
Krypton-85	5 E+04	2.27 E+06	(c)	(c)	(c)	(c)	(d)	1.7 E+01	8.1 E+02	1 E-02	(e)
Iodine-129	5 E-03	2.27 E-01	1.4 E-04	2.94 E-03	(c)	(c)	(d)	8.9 E-07	9.9 E-04	1 E-07	(e)
Alpha (Pu-239)	5 E-04	2.27 E-02	1.4 E-09	5.02 E-07	3.6 E-10	3.6 E-12	(d)	(c)	(c)	(c)	(e)
H-3	(b)	--	2.7 E+04	5.21 E+04	(c)	(c)	(d)	1.1 E+00	1.3 E+00	(c)	(e)
Sr-90	(b)	--	4.9 E-05	1.12 E+02	1.2 E-05	1.2 E-07	(d)	3.8 E-05	9.9 E-05	(c)	(e)
Ru-106	(b)	--	1.5 E-03	4.80 E+01	3.8 E-05	3.8 E-07	(d)	(c)	2.6 E-04	(c)	(e)
Cs-134	(b)	--	9.6 E-05	2.88 E-02	2.4 E-04	2.4 E-07	(d)	(c)	7.2 E-03	(c)	(e)
Cs-137	(b)	--	7.4 E-05	1.59 E-02	2.4 E-04	1.9 E-07	(d)	2.4 E-03	5.4 E-03	(c)	(e)
Ce-144	(b)	--	1.9 E-04	(c)	4.8 E-05	4.8 E-07	(d)	2.5 E-05	3.9 E-04	(c)	(e)

(a) The conversion from Ci/GWe-yr to Ci/yr is based on an LWR operating at 33% thermal efficiency and producing approximately 33 MTHM of spent fuel at a burnup of 33000 MWd/MTHM; all of the releases are based on a 1500 MTHM per year fuel processing plant (26)
(b) Not included in EPA's UFC standard, 40 CFR 190
(c) Radionuclide not indicated or expected
(d) Estimated release values for all fission products and actinides is 2 E-11
(e) Release values for packaged spent fuel disposal is estimated to be similar to HLSW disposal operations - see (d)

6.0 REFERENCES

1. "Environmental Radiation Protection Standards for High-Level Radioactive Waste," Federal Register, Vol. 41, No. 235, Monday, December 6, 1976, page 53363.

2. "Environmental Radiation Protection Standards for Nuclear Power Operations," Code of Federal Regulations, Title 40, Chap, I, Subchapter F, Part 190, U.S. Government Printing Office, Washington, D.C. 1978.

3. Management of Commercially Generated Radioactive Waste - Draft Environmental Impact Statement, Two Volumes, Report No. DOE/EIS-0046-D, U.S. Department of Energy, Washington, D.C., April 1979.

4. Technology for Commercial Radioactive Waste Management, Five Volumes, Report No. DOE-ET-0028, U.S. Department of Energy, Washington, D.C., May 1979.

5. Environmental Aspects of Commercial Radioactive Waste Management, Three Volumes, Report No. DOE-ET-0029, U.S. Department of Energy, Washington, D.C., May 1979.

6. W.F. Holcomb, et al., Radiation Exposures From Solidification Processes For High-Level Radioactive Liquid Wastes, Technical Report EPA-520/3-80-007, U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C., May 1980.

7. Retrievable Surface Storage Facility Alternative Concepts Engineering Studies, USAEC Report No. ARH-2888 Rev., Atlantic Richfield Hanford Company and Kaiser Engineers, Richland, Washington, July 1974.

8. W.P. Bishop and F.J. Miraglia, Jr. (Eds), Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle, Report NUREG-0116 (Supp. 1 to WASH-1248), U.S. Nuclear Regulatory Commission, Washington, D.C., October 1976.

9. J. M. Davis, "Demonstration of a Surface Storage System For Spent Fuel or Waste," paper presented at 70th Annual American Institute of Chemical Engineer's Meeting, New York, N.Y., November 13-17, 1977.

10. Alternatives For Managing Wastes From Reactors and Post-Fission Operations In The LWR Fuel Cycle, Volume 3: Alternatives For Interim Storage And Transportation, Report No. ERDA-76-43, Vol. 3, U.S., Energy Research and Development Administration, Washington, D.C. May 1976.

11. Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors, Volume 3: Health, Safety and Environment, Report NUREG-0002, Vol. 3, U.S. Nuclear Regulatory Commission, Washington, D.C., August 1976.

12. Storage of U.S. Spent Power Reactor Fuel, Draft Environmental Impact Statement, Report DOE/EIS-0015-D, U.S. Department of Energy, Washington, D.C., August 1978.

13. Storage of U.S. Spent Power Reactor Fuel - Draft Environmental Impact Statement Supplement, Report DOE/EIS-0015-DS, U.S. Department of Energy, Washington, D.C., December 1978.

14. Draft Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel, Report NUREG-0404, U.S. Nuclear Regulatory Commission, Washington, D.C., March 1978.

15. Spent Fuel Storage Requirements - The Need for Away-From-Reactor Storage, Report DOE/ET-0075, U.S. Department of Energy, Washington, D.C., February 1979.

16. Analytical Methodology and Facility Description Spent Fuel Policy, Report DOE-ET-0054, U.S. Department of Energy, Washington, D.C., August 1978.

17. Independent Spent Fuel Storage Installations (ISFSF), Report NUREG/CR-0601, U.S. Nuclear Regulatory Commission, Washington, D.C., March 1979.

18. Preliminary Estimates of the Charge for Spent-Fuel Storage and Disposal Services, Report DOE/ET-0055, U.S. Department of Energy, Washington, D.C., July 1978.

19. "Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI), Proposed Licensing Requirements," Federal Register, Vol. 43, No. 195, Friday, October 6, 1978, page 46309.

20. P. A. Anderson and H. S. Meyer, Dry Storage of Spent Nuclear Fuel, Report NUREG/CR-1223, U.S. Nuclear Regulatory Commission, Washington, D.C. April 1980.

21. G. E. Zima, Independent Spent Fuel Storage Installations (ISFSI) Annual Report for FY 1978, Report NUREG/CR-0601 (PNL-2880-Battelle Pacific Northwest Laboratory), U.s. Nuclear Regulatory Commission, Washington, D.C., March 1979.

22. Spent Fuel Interim Storage, USDOE Contract EY-77-C-06-1030 Report, Rockwell Hanford Operations, Richland, Washington, April 12, 1978.

23. M.N. Menon, Spent Fuel Handling and Packaging Program, A Survey of Hot Cell Facilities, USDOE Report No. HEDL-TME-78-53, Westinghouse Hanford Engineering Development Laboratory, Richland, Washington, July 1978.

24. Spent Fuel Packaging For Dry Repositories, USDOE Contract EY-77-C-06-1030 Report, Rockwell Hanford Operations, Richland, Washington, April 12, 1978.

25. G.E. Zima, An Evaluation of Potential Chemical/Mechanical Degradation Processes Affecting Fuel and Structural Materials Under Long-Term Water Storage, Report NUREG/CR-0668 (PNL-2379-Battelle Pacific Northwest Laboratory). U.S. Nuclear Regulatory Commission, Washington, D.C., May 1979.

26. Environmental Analysis of the Uranium Fuel Cycle: Part IV - Supplementary Analysis - 1976, Report No. EPA-520/4-76-017, U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C., July 1976.

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15. Supplementary Notes

16. Abstracts

The Office of Radiation Progrms, Environmental Protection Agency, has prepared this analysis of the radioactive releases during normal waste management operations and the resulting radiation doses as technical support for EPA's proposed environmental radiation protection standards, 40 CFR 191. Our review includes preparation for storage or disposal, storage, and emplacement in a disposal repository. We found that they are small compared to the releases and doses in EPA's uranium fuel cycle standards, 40 CFR 190. For Subpart A of 40 CFR 191 on waste management and storage operations, EPA proposes to extend the limitations of 40 CFR 190 to these operations.

17. Key Words and Document Analysis. 17a. Descriptors

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