NUREG-1092

Environmental Assessment for 10 CFR Part 72 "Licensing Requirements for the Independent Storage of Spent Fuel and High-Level Radioactive Waste"

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

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ABSTRACT

The Nuclear Waste Policy Act of 1982 (NWPA) addresses the need for development of monitored retrievable storage for spent fuel and high-level radioactive waste. The Commission has examined its regulations and determined that much of existing 10 CFR Part 72 regulations can be used during initial design development for a monitored retrievable storage installation (MRS), however changes are needed to 10 CFR Part 72 to clarify specific issues which have been raised by the NWPA. The proposed revisions to 10 CFR Part 72 establish licensing requirements for a monitored retrievable storage installation. However, unless Congress authorizes construction of an MRS promulgation of these requirements would not result in construction or operation of such an installation. The issues identified as requiring resolution by the proposed amendments are (1) establishing license criteria for the long-term storage of spent fuel and high-level radioactive waste in an MRS, (2) inclusion of license requirements for the long-term storage of spent fuel and high-level radioactive waste in an MRS under 10 CFR Part 72, and (3) elimination of the current restrictions placed on fuel cladding integrity in the present Part 72 which require the fuel cladding be protected against degradation and gross ruptures, and substitution of restrictions on radioactive releases to the environment.

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FOREWORD

This environmental assessment was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research (RES) in accordance with the Commission's regulation 10 CFR Part 51, "Licensing and Regulatory Policy Procedures for Environmental Protection," to implement the requirements of the National Environmental Policy Act of 1969 (NEPA).

The Staff's evaluation has led to the conclusion that the proposed revisions to 10 CFR Part 72, if promulgated, would not result in any activity that significantly affects the quality of the human environment. Promulgation of these revisions is not a major federal action significantly affecting the quality of the human environment within the meaning of NEPA. The proposed revisions establish licensing requirements for a monitored retrievable storage installation (MRS). However, promulgation of these requirements would not result in the construction or operation of an MRS.

Section 141 of the Nuclear Waste Policy Act provides that, on or before June 1, 1985, the Secretary of Energy shall complete a detailed study of the need for and feasibility of, and shall submit to the Congress a proposal for, the construction of one or more monitored retrievable storage facilities for high-level radioactive waste and spent nuclear fuel. Congress will then decide whether to authorize contruction of such a facility. Section 141 further provides that the preparation and submission of the proposal to the Congress shall not require the preparation of an environmental impact statement under section 102(2)(C) of NEPA. If the Congress specifically authorizes construction of an MRS, the requirements of NEPA shall apply to the construction of the facility, but any EIS that is prepared shall not consider need for the facility or any alternative to the design criteria for the facility set forth in Section 141(b). Thus, Congress recognized that there is no major federal action significantly affecting the quality of the human environment until the proposal is approved and construction of the facility is authorized. Prior to that time, no environmental effects will occur, and the nature of any potential environmental effects that might occur in the future as a result of construction and operation of the facility cannot be known with any degree of

certainty. Accordingly, an environmental impact statement need not be prepared in connection with this rulemaking action.

The staff recognizes, however, that an environmental assessment of these proposed revisions is desirable. This is because the MRS is a somewhat different storage concept that is not fully encompassed by the environmental impact statement previously prepared for 10 CFR Part 72. This environmental assessment examines the potential environmental impacts of a hypothetical MRS facility. It does not discuss the need for or alternatives to an MRS. This is because, as indicated previously, Congress has limited consideration of those issues in any EIS that may ultimately be prepared in connection with the facility. The purpose of this assessment is to ensure that environmental values receive appropriate consideration in the development and promulgation of these proposed rules.

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I. SUMMARY ASSESSMENT OF ENVIRONMENTAL IMPACTS OF RULEMAKING

1.1 The Proposed Action

The Nuclear Regulatory Commission (NRC) is proposing to amend its regulations to cover specific licensing requirements for the storage of spent nuclear fuel and high-level radioactive waste in installations independent of the spent fuel pools of nuclear power plants. The storage of spent fuel outside of pools is presently licensed under 10 CFR Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)." The existing regulation requires revision to incorporate provisions of the Nuclear Waste Policy Act of 1982 [2] for spent fuel and high-level radioactive waste storage in a monitored retrievable storage installation (MRS).

The Department of Energy (DOE) is required by the Nuclear Waste Policy Act of 1982 (NWPA) to provide to Congress by June 1985 a proposal for the construction of one or more monitored retrievable storage installations, based on DOE's study of the need for and feasibility of such an installation. Congress will then determine whether to authorize the construction of an MRS. The Commission has reviewed its regulations and determined that much of existing 10 CFR Part 72 regulations can be used during initial design development for an MRS, however, changes are needed to 10 CFR Part 72 to clarify specific issues which have been raised by the NWPA.

The proposed revision to 10 CFR Part 72 is intended to ensure that the Commission has in place the appropriate regulations to fulfill the requirements contained in the NWPA concerning the licensing of installations which could be part of the Federal monitored retrievable storage program.

The purpose of this environmental assessment is to provide a rationale that the major licensing issues of this proposed rulemaking have no significant environmental effects. The issues identified as requiring resolution by amendment of 10 CFR Part 72 are:

(1) establishing license criteria for the long-term storage of spent nuclear fuel and high-level radioactive waste in an MRS,

(2) inclusion of license requirements for the long-term storage of spent fuel and high-level radioactive waste in an MRS under 10 CFR Part 72, and

(3) elimination of the current restrictions placed on fuel cladding integrity in the present Part 72 which require the fuel cladding to be protected against degradation and gross ruptures, and substitution of restrictions on radioactive releases to the environment.

The staff is proposing to amend the ISFSI license requirements to include MRS license requirements because DOE's preliminary MRS design objectives indicate that the installation would function as an independent spent fuel storage installation storing both spent fuel and high-level radioactive waste but whose design would permit continuous monitoring and also provide for ready retrieval.

1.2 Environmental Review Status

In November 1980, the Code of Federal Regulations was amended to establish requirements, procedures and criteria for the issuance of licenses to possess power reactor spent fuel and other radioactive materials associated with spent fuel storage in independent spent fuel storage installations. Licenses issued under the regulations of 10 CFR Part 72 apply to fuel stored at a complex designed and constructed for the temporary storage of reactor fuel aged for at least one year, and are applicable to both wet and dry storage modes.

As part of the public rulemaking proceeding, the Nuclear Regulatory Commission staff prepared a final environmental impact statement pursuant to Section 102(2) of the National Environmental Policy Act of 1969 (NEPA) and pursuant to Nuclear Regulatory Commission regulations. This statement was published as NUREG-0575, "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel," dated August 1979.

The NRC staff is now proceeding to amend 10 CFR Part 72 to include licensing requirements for storing spent nuclear fuel and HLW pursuant to Title I, Subtitle C of the NWPA.

1.3 Potential Environmental Impacts of Rulemaking

The staff's evaluation of NEPA requirements, the provisions of the NWPA, and the Commission's regulations in 10 CFR Part 51 has led to the conclusion that the proposed revision to 10 CFR Part 72, if promulgated, would not result in any activity that significantly affects the quality of the human environment. Promulgation of these revisions is not a major federal action significantly affecting the quality of the human environment within the meaning of NEPA. The staff recognizes, however, that an environmental assessment of the proposed revision is desirable to ensure environmental values receive consideration in the development and promulgation of the proposed rules.

Accordingly, the staff prepared an environmental assessment that sets forth the basis that the proposed regulation is not a major Federal action significantly affecting the environment. The assessment of the rulemaking action indicates that long-term spent fuel and high-level radioactive waste storage in an MRS, if authorized, could be accomplished under the proposed requirements consistent with adequate protection of the environment and the health and safety of the public. The assessment also indicates in its analysis of license requirements for the long-term storage of spent fuel and high-level waste in an MRS under 10 CFR Part 72 that spent fuel and high-level waste are comparable hazards, and the protection of public health and safety and the environment would not be compromised. Furthermore, the assessment shows that for the long-term storage of spent fuel the cladding integrity need not be maintained if additional confinement is provided.

1.4 References

[1]. The National Environmental Policy Act of 1969, as amended, Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, and Pub.L. 94-83, August 9, 1975.

[2]. The Nuclear Waste Policy Act of 1982, January 7, 1982; Pub. L. 97-425; 96 Stat. 2201;

[3]. The Code of Federal Regulations, Title 10 Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection."

[4]. The Code of Federal Regulations, Title 10 Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories."

[5]. The Code of Federal Regulations, Title 10 Part 72, "Licensing Requirements for the Storage of Spent Nuclear Fuel in an Independent Spent Fuel Storage Installation (ISFSI)."

[6]. U.S. Nuclear Regulatory Commission, "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel," USNRC Report NUREG-0575; Volumes 1-3; August 1979. Copies are available from the National Technical Information Service, Springfield, VA 22161

[7]. U.S. Nuclear Regulatory Commission, "Fuel Inventory and Afterheat Power Studies of Uranium-Fueled Pressurized Water Reactor Fuel Assemblies Using the SAS2 and ORIGEN-S Modules of Scale with an ENDF/B-V Updated Cross Section Library." ORNL Report NUREG/CR-2397, September 1982. Copies are available from the National Technical Information Service, Springfield, VA 22161.

[8]. U.S. Nuclear Regulatory Commission, "Rulemaking on the Storage and Disposal of Nuclear Waste (Waste Confidence Rulemaking)," PR-50, 51 (44 FR 61372)

II. ENVIRONMENTAL IMPACTS OF RULEMAKING

This section provides the environmental assessment of issues arising from consideration of monitored retrievable storage installation (MRS) licensing requirements. By the Nuclear Waste Policy Act of 1982 (NWPA) the Commission is responsible for establishing criteria for licensing monitored retrievable storage for spent nuclear fuel and high-level radioactive waste (HLW). Monitored retrievable storage can, if one such installation is authorized, supply the nuclear industry's long-term waste storage requirements in the event repository storage is not available in the time table authorized by the NWPA.

The Commission has reviewed its regulations and has determined that the existing regulations in 10 CFR Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)," can be used during initial design development for an MRS. However, changes to 10 CFR Part 72 are needed to clarify specific issues which have been raised by the NWPA. An assessment of environmental consequences resulting from short-term, e.g., 20 year, storage times for spent fuel is analyzed in NUREG-0575, "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel."

The issues identified as requiring resolution by amendment of 10 CFR Part 72 are:

(1) establishing license criteria for the long-term storage of spent nuclear fuel and HLW in an MRS,

(2) inclusion of license requirements for the long-term storage of spent fuel and high-level radioactive wastes in an MRS under 10 CFR Part 72, and

(3) elimination of current restrictions placed on fuel cladding integrity in the present Part 72 which require the fuel cladding to be protected against degradation and gross ruptures, and substitution of restrictions on radioactive releases to the environment.

2.1 Monitored Retrievable Storage of Spent Nuclear Fuel and High-Level Radioactive Waste

2.1.1 Federal Monitored Retrievable Storage Program

Congress found that monitored retrievable storage is an option for the safe and reliable management of spent nuclear fuel and high-level radioactive waste in Title I, Subtitle C, "Monitored Retrievable Storage," of the Nuclear Waste Policy Act of 1982. In its consideration of nuclear wastes Congress found that the Federal Government is responsible for ensuring that MRS site-specific designs are available and that both Congress and the Executive Branch should consider fully proposals for construction of one or more MRS facilities. The Secretary of the Department of Energy has responsibility to complete a detailed study of the need for and the feasibility of constructing an MRS. This study is to be submitted to Congress by June 1, 1985. Congress will then decide whether to authorize construction of an MRS. The proposals will detail overall design criteria to accommodate the combined storage needs for both spent nuclear fuel and high-level radioactive wastes. Through the proper selection and design of confinement systems, the continuous monitoring, management and maintenance needs of the installation are to be accommodated for the forseeable future. The installation needs to be designed for ready retrieval of fuel for reprocessing and for ultimate disposal of stored spent nuclear fuel and HLW.

2.1.2 Developing Monitored Retrievable Storage Technology

The Department of Energy (DOE) monitored retrievable storage concepts for spent nuclear fuel and high-level radioactive wastes are based on using high-integrity hermetically sealed containers for the confinement of radionuclides and a structure of some type to protect the container from man-made or natural events. DOE has stated [9] that the prefered technology for heat transfer to the environment for the purpose of cooling the container is by a passive method such as natural convection to surrounding air in order to eliminate the need for operating machinery which requires external power.

Passive dry storage technologies are supported by experience from almost 40 years of dry storage of spent nuclear fuel, beginning with the extended vault and drywell tests conducted by Idaho Nuclear Engineering Laboratories (INEL) in 1964 on liquid metal fast breeder reactor (LMFBR) fuel and twelve years of research into passive dry storage technology here in the U.S. and abroad. U.S. research conducted by INEL includes operations began in 1971 with dry well storage of gas-cooled reactor (GCR) fuel, LMFBR fuel in drywell storage in 1974 and vault storage of both GCR and LMFBR fuel in 1975. The results showed that a passive dry MRS is practical.

2.1.3 Federal Monitored Retrievable Storage Program and the Civilian Nuclear Fuel Cycle

The Nuclear Waste Policy Act of 1982 does not address reprocessing civilian spent nuclear fuel. Consequently the MRS option can be viewed as a backup to repository storage, i.e., a method to provide needed storage in the absence of reprocessing and until repositories begin accepting spent nuclear fuel and high-level radioactive wastes for permanent disposal. The possible relationship of an MRS to repositories and the balance of the civilian nuclear fuel cycle is given in Figure 2.1.3. The principle operations to take place in the MRS are to provide spent nuclear fuel and HLW handling, transfer, and storage. Installations would have to be designed to ensure confinement of radioactive materials as well as provide for monitoring HLW and spent fuel storage containers. An MRS will have to be designed to permit spent nuclear fuel and high-level wastes to be retrieved and shipped to reprocessing facilities or geologic repositories. Verification of material integrity during the design lifetime of the MRS is necessary to ensure structural integrity of HLW and spent fuel storage containers for the protection of the public from releases of radioactive material into the environment.

2.1.4 Scope of MRS Design Criteria

DOE has conducted screenings and evaluations of spent fuel and HLW storage technologies for the purpose of establishing radioactive waste storage technology and to evaluate its environmental effects. Both wet-type (e.g., water-cooled storage) and dry-type (e.g., air cooled storage) storage

Nuclear Fuel Cycle Flowchart
Showing Options for Independent Spent Fuel Storage Installations
and Monitored Retrievable Storage Installations [9]

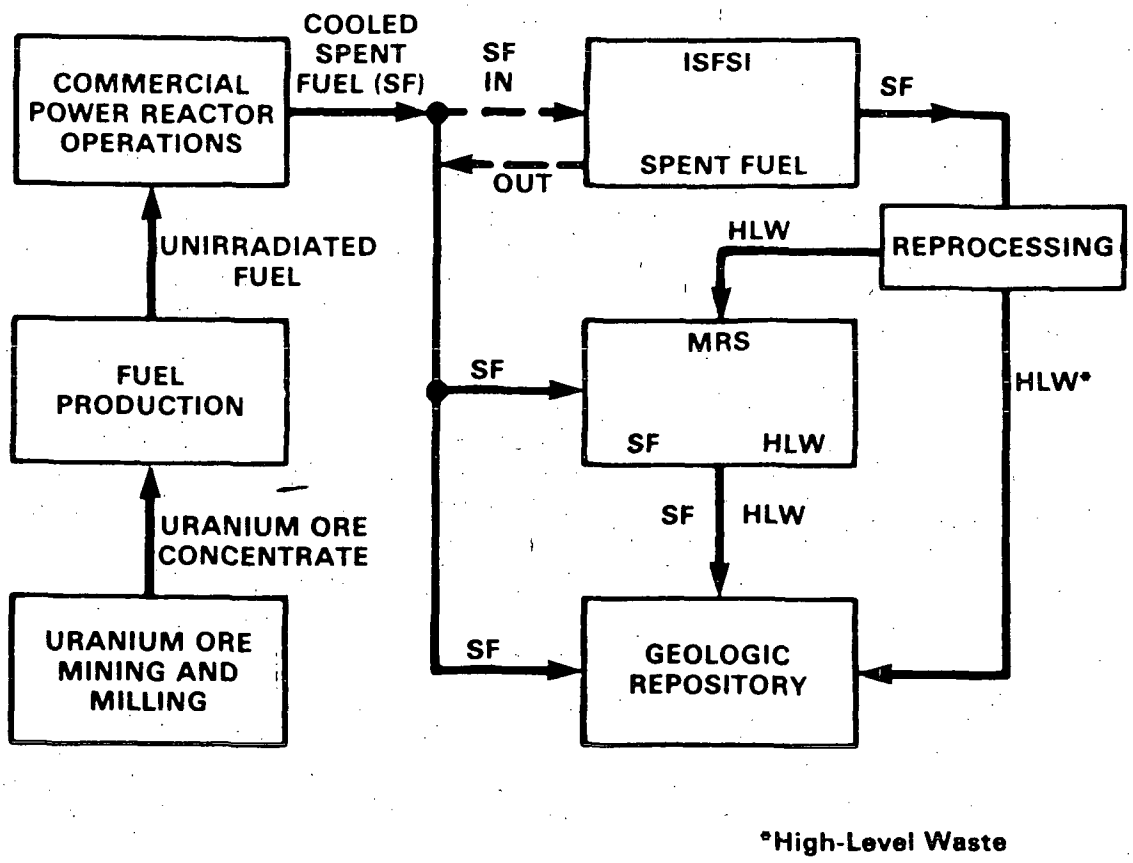

Figure 2.1.3

technologies were investigated through inhouse studies and studies done by Westinghouse Electric Corporation and Batelle Pacific Northwest Laboratories [9]. DOE's evaluations concluded that dry storage is preferred to wet storage. The dry storage design concepts DOE undertook to investigate included metal casks; sealed storage casks (concrete casks); dry wells designed for surface field or tunnel sitings; and vault designs applicable to surface or subsurface storage. DOE recently published MRS functional design criteria based on its preferred and alternate choices of storage technologies [19]. DOE's preferred technology for advanced conceptual MRS design work is the sealed storage cask; its preferred alternate MRS technology is the field drywell design. The criteria DOE established encompass the foreseeable storage requirements for the monitored retrievable storage program. The design includes provisions to receive, package, store and ship spent nuclear fuel and HLW at a facility having a modular design with a base storage capacity of 15,000 metric tons of uranium (MTU), expandable to a maximum storage capacity of 70,000 MTU. The DOE facility design is required to be maintainable or replaceable to extend its use in 20 year increments to double its lifetime based on a 40-year initial design lifetime [19].

2.2 Long-Term Storage of Spent Nuclear Fuel and High-Level Radioactive Waste in an MRS

2.2.1 Licensing Considerations

The basis chosen for evaluating license requirements for the long-term storage of spent nuclear fuel and high-level radioactive waste in an MRS is an installation having a 70-year design lifetime and a 70,000 MTU storage capability. This assessment focuses on the potential environmental consequences for a long-term storage period, a period for which the Commission needs to assure itself of the continued safe storage of spent fuel and high-level radioactive waste and the performance of materials of construction. This means the reliability of systems important to safety needs to be established to ensure that long-term storage of spent fuel and HLW does not adversely impact the environment.

For example, the staff needs to establish that systems, such as concrete shielding, have been evaluated to determine how their physical properties withstand the consequences of irradiation and heat flux for about a 70-year period. The Commission addressed structure and component safety for extended operation for storage of spent fuel in reactor water pools in the matter of waste confidence rulemaking proceeding [15]. The Commission's preliminary conclusion is that experience with spent fuel storage provides an adequate basis for confidence in the continued safe storage of spent fuel for at least 30 years after expiration of a plant's license. The Commission is therefore confident of the safe storage of spent fuel for at least 70 years in water pools at facilities designed for a 40-year lifetime. The Commission also stated that its authority to require continued safe management of spent fuel generated by licensed plants protects the public and assures them the risks remain acceptable. In consideration of the safety of dry storage of spent fuel, the Commission's preliminary conclusions were that their confidence in the extended dry storage of spent fuel is based on a reasonable understanding of the material degradation processes, together with the recognition that dry storage systems are simpler and more readily maintained. In response to Nuclear Waste Policy Act of 1982 authorizations, the Commission noted; "....the Commission believes the information (dry spent fuel storage research and demonstration) above is sufficient to reach a conclusion on the safety and

environmental effects of extended dry storage. All areas of safety and environmental concern (e.g., maintenance of systems and components, prevention of material degradation, protection against accidents and sabotage) have been addressed and shown to present no more potential for adverse impact on the environment and the public health and safety than storage of spent fuel in water pools." At this time, the Commission is confident it can evaluate the long-term integrity of material for constructing an installation and provide the needed assurance for safe storage of spent fuel and HLW to establish the licensibility of an MRS over extended periods of time. The MRS fuel storage concepts discussed here for revision of 10 CFR Part 72 covers only dry storage[2] concepts.

2.2.2 Ecological Impacts

Long-term storage of spent fuel and high-level waste at an MRS will cause agriculture and wildlife to be displaced from the site and it will cause thermal and airborne pollutants to be released for up to 70 years. Long-term storage of spent fuel and HLW at an MRS will also increase the likelihood that biota in adjacent or nearby lakes, rivers or streams would be adversely affected by pollutants transported from the site to their habitats by the hydrological cycle. DOE has estimated the ecological impacts for spent fuel and HLW storage in their publications [6, 10] wherein technologies[3] for different dry storage concepts are evaluated. DOE's report provides an assessment of ecological impacts for a site receiving 2000 metric tons of heavy metal (MTHM) as spent fuel per year for 10 years up to a maximum of 20,000 MTHM. Ecological impacts at such a site are predicted to be caused by nonradioactive air pollutants, but DOE concludes that the pollutants generated would represent only a fraction of existing rural air concentrations with the most severe concentrations occurring during construction. However, DOE does state that air pollution concentrations onsite may exceed the Federal ambient air quality standard of 75 $\mu g/m^3$ of particulates but they are not

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[2]Dry storage refers to air-cooled cask installations.

[3]DOE has indicated [19] its preferred MRS dry storage technology is sealed storage casks (surface casks), and its preferred alternate storage technology is drywell storage. Sealed storage cask technology for spent fuel is presented here for the purpose of simplifying the analysis. Section 2.3 develops technical arguments for concluding HLW is less of an environmental hazard than spent nuclear fuel.

expected to exceed this concentration offsite. The ecological impacts of long-term storage at an MRS are based on DOE MRS functional design criteria [19] whic propose construction of a 70,000 MTHM MRS that would receive 3600 MTHM per year. At this acceptance rate, MRS construction would last for 20 years. Even though the receiving rates at the MRS are double the rates of the 20,000 MTHM installation and even though there would be over three times the amount of fuel stored onsite, the ecological impacts from 70 years of operation of an MRS are not expected to be significant.

2.2.3 Environmental Impacts Related to Installation Operation

This section discusses the impacts that installation operation could have on the environment. Air, water and radiological effluents from a spent nuclear fuel and HLW storage installation are limited by regulations of the Environmental Protection Agency (EPA) and by NRC. To meet required effluent levels engineered control measures are used to reduce pollutants. Estimates of environmental impacts from routine releases during installation operation are given in this section. Section 2.2.4 discusses the extent to which accidents and releases associated with accidents impact the environment.

Total resource commitments to operate an extended storage installation are not expected to consume significant amounts of essential materials. Energy requirements are estimated to be 1.82×10^7 kilowatt-hours of electricity and 2.1×10^2 cubic meters of gasoline per year. Projection of equipment requirements include casks for storing up to 3,600 MTU per year or the equivalent amount of HLW. To estimate essential material requirements, we can assume two pressurized water reactor (PWR) fuel assemblies or five boiling water reactor (BWR) fuel assemblies per metric ton of uranium. For nominal loadings of 10 PWR assemblies (50 BWR assemblies) per cask, the MRS would store 180 casks per year. Thus, based on a cask weighing 65 metric tons, annual resources for cask construction would require 12,000 metric tons of metal.

Routine operation water requirements for a 210 person workforce comprised of 119 operators, 56 maintenance personnel and 35 radiation monitors is estimated to be 2.5×10^4 m^3 per year, chiefly for sanitary sewers. Table 2.2.3-1 summarizes the types and quantities of emissions predicted to result from a

surface cask storage installation for canistered fuel. Radionuclide releases for a dry cask installation are expected to be negligible since the low release rates already occurring during storage of spent fuel in water pools would be reduced by several orders of magnitude [15] through the use of multiple confinement barriers for storing fuel such as a sealed inerted canister placed in a cask.

Table 2.2.3-1. Emissions from an Installation for Surface Cask Storage of Canistered Fuel [10]*

Emissions	Description	Annual Quantity	Radioactivity Release to Atmosphere
Gaseous	Facility Air	1.8×10^9 m^3/yr	Negligible
	Minor Accident Integrated Releases	None Identified	None Identified
Other	Heat	less than 7.0×10^5 MW-hr (2.3×10^{12} BTU)	

*Data are normalized to an installation storing 70,000 MTU. Canistered fuel refers to fuel placed in sealed cans prior to its storage in a cask.

Neuman [17] evaluated downwind temperature changes for a 20,000 MTHM dry storage installation using an area point source model in studying industrial pollutants. Using this approach and a gaseous diffusion model, downwind temperatures were calculated to change less than 1°C within 1 kilometer of the installation and less than 0.5°C beyond this. These temperature changes are estimated for an installation one fourth the size that DOE expects could be required if repository operations are delayed. Without the benefit of a site specific design for analysis of local heating problems, it is assumed that MRS design variations such as satellite storage areas serviced by a central receiving and handling facility would be described by the above estimates of downwind temperature changes.

Radiological exposures to workers or the public from an MRS will be limited to levels required by the proposed revision to 10 CFR Part 72, Subpart E, "Siting Evaluation Factors." Radiological releases [10] and hence exposures are assumed to be minimal for the long-term license of an MRS because the already low release rates that are associated with the storage of uncanistered fuel in water storage pools would be further reduced by at least several orders of magnitude by confinement of fuel elements in high integrity packages. Table 2.2.3-2 gives

estimates of anticipated radiological waste from routine operation of an installation for dry cask storage of canistered fuel. The radiological wastes of the installation include wastes from installation operations for canistering spent fuel.

Table 2.2.3-2. Radiological Wastes from Surface Cask Handling and Storage of Canistered Fuel [10]

Description	Volume m^3/year	Radioactivity[a] (curies/year) Activation Products	Fission Products	Actinides
Combustible and Compactible Waste	305	1.26×10^{-2}	1.26×10^{-2}	0
Wet Wastes	9	1.26	Cs: 5.0×10^{1} All others: 1.26	0 0
Failed Equipment and Non-combustible Waste	18	1.26×10^{-3}	1.26×10^{-3}	0

[a] Reference [6], Table 5.7.78. Based on 3600 MTHM per year acceptance rate.

2.2.4 Environmental Impacts Related to Postulated Accidents

When accidents involving fuel occur, doses to workers and the public could result from fission product releases if there is a failure of an engineered system that is designed to mitigate releases to levels permissable by the license. The long-term safe storage of spent fuel depends on the reliability of engineered systems to prevent an accident from happening by lowering the risk of failure of important safety equipment, e.g., by employing redundant systems, and by mitigating a radiological release through proper confinement. NRC exposure limits for the proposed 10 CFR Part 72 protect workers and the public. It is assumed that the protection afforded the public also protects the environment. Accidents postulated by DOE for surface cask storage installations are given in Table 2.2.4-1. No accidents classified as severe accidents could be postulated for this type of storage installation. The releases of Table 2.2.4-1 are representative of accident events with the potential for material releases, equipment damage or the creation of radioactive fields in occupied zones which could result in occupational exposures that exceed 10 CFR Part 20 limits (5 rem/year).

From Table 2.2.4-1 the failure of a canistered assembly is judged by DOE to be the most severe and is taken as a limiting estimate of probable environmental impact. The accident is a corrosion failure of a can containing 1.7 MTHM as spent fuel. Release estimates are 7 curies of ^{85}Kr and 2×10^{-5} curies of ^{129}I over a 1 hour period with a postulated frequency of 5×10^{-5} per MTHM-yr of storage.

Table 2.2.4-1 Postulated Accidents for Surface Cask Storage of Canistered Fuel [10]

Accident Description	Sequence of Events	Safety System	Release
Minor			
Impaired waste cooling.	1. Air in-take to cask is restricted.	1. Surveillance and cleanout as needed will minimize plugging.	None
	2. Fuel self heats and sets off high temperature alarm.	2. Units designed to maintain fuel temperature below a value that ensures containment integrity during a complete air flow blockage.	
	3. Blockage removed after temperature alarm indicates blockage.		
	4. Fuel returns to normal temperature.	3. Remote temperature monitoring and alarms for each storage unit.	
Filled fuel rack dropped into storage cask.	1. Rack grapple, grapple lifting cable, or cable winch fails when filled fuel rack is over storage cask.	1. Overpack and rack designed to withstand such a fall without loss of integrity.	None
	2. Filled rack falls to bottom of storage cask.		
Moderate			
Canister fails in storage.	1. Canister containing a PWR assembly fails in storage due to corrosion and one PWR rod has a pinhole leak.	1. Surface cask designed to minimize corrosion.	Releases at ground level are as follows:
	2. Gases are released	2. Leak detection system is installed. Periodic tests are made.	$^{3}H = 5.6 \times 10^{-3}$ Ci $^{14}C = 4.1 \times 10^{-5}$ Ci $^{85}Kr = 3.5$ Ci
	3. Leaking canister detected and removed to cannning facility.	3. Special handling procedures are used for failed canisters to minimize releases.	$^{129}I = 5.9 \times 10^{-6}$ Ci All others = negligible
	4. Overpacked canister returned to surface cask.		Assume a release period of 1 hr.

The 70-year dose commitment to the individual receiving the maximum dose from the postulated canister failure were calculated [10] and are presented in Table 2.2.4-2. Background radiation an individual receives from naturally occurring sources is on the order of 1.5×10^{2} mrem.

Table 2.2.4-2 70-Year Dose to an Individual as a Result of a Fuel Canister Failure Accident at a Surface Cask Storage Installation (rem) [6]

Pathway	Skin	Total Body	Thyroid	Lung
		70-Year Dose		
Air submersion	1.0×10^{-4}	1.1×10^{-6}	1.1×10^{-6}	1.1×10^{-6}
Inhalation		1.2×10^{-8}	1.1×10^{-5}	7.3×10^{-8}
Total	1.0×10^{-4}	1.1×10^{-6}	1.2×10^{-5}	1.1×10^{-6}

Note: The maximum individual is defined as a permanent resident at a location 1600 m southeast of the stack with a time-integrated atmospheric dispersion coefficient (E/Q of 1.5×10^{-4} sec/m^3). The accident involves failure of a fuel canister containing approximately 1.7 MTHM.

2.2.5 Irreversible and Irretrievable Commitments of Resources

Resources for constructing a MRS are for the most part irretrievable. Table 2.2.5 provides an estimate of resources required for initial construction and for annual additions, each supplying an incremental 3600 MTHM storage capacity over a 15-year period.

Table 2.2.5 Materials Estimate for Construction of a Surface Cask Storage Installation

Material	Initial Construction	Annual Additions for 15 Years
Concrete, m^3	36,000	720
Steel, MT	9,000	325
Copper, MT	34	8
Lumber, m^3	1,500	22

2.3 Inclusion of License Requirements for the Long-Term Storage of High-Level Radioactive Waste and Spent Nuclear Fuel in an MRS under 10 CFR Part 72

10 CFR Part 72 is being amended to include license criteria for the long-term storage of high-level radioactive waste and spent fuel in a monitored retrievable storage installation. The Nuclear Waste Policy Act of 1982 defines high-level radioactive waste to mean: (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (2) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation. For the purpose of proposed 10 CFR Part 72 regulations only solid high-level wastes are acceptable for storage in an MRS. This section discusses the environmental impacts of long-term storage of HLW in an MRS under 10 CFR Part 72.

2.3.1 Licensing Considerations

Impacts of storing HLW and spent nuclear fuel in an MRS are due to the thermal and radiological contents of these wastes. Spent fuel wastes are stored in engineered systems designed to safely dissipate fission product decay heat while providing sufficient shielding from radioactive decay products as well as confinement of gaseous and particulate radioactive nuclides. The extent to which HLW and spent nuclear fuel could affect the environment is largely determined by the driving force behind dispersion. The Commission has decided in a statement on its rationale for preliminary findings made in the matter of its Waste Confidence Proceeding [15] for extended spent fuel storage in reactor pools: "The absence of high temperature and pressure conditions (in stored spent fuel) that would provide a driving force essentially eliminates the likelihood that operator error (such as the TMI accident) would lead to a major release of radioactivity." The Commission also commented on the value of the intrinsic stability of the spent fuel waste form to resist the consequence of sabotage: "The consequences (of intentional sabotage) would be limited by the realities that, except for some gaseous fission products, the radioactive content of spent fuel is in the form of solid ceramic material encapsulated in

high integrity metal cladding and stored underwater in a reinforced concrete structure. Under these conditions the radioactive content of spent fuel is relatively invulnerable to dispersal to the environment . . . Similarly, dry storage of spent fuel in dry wells, vaults, silos and casks is also relatively invulnerable to sabotage and natural disruptive forces."

Thus, the premise for evaluation of the HLW storage problem is that the driving force for dispersion of solid HLW to the environment is no greater than the driving force for the dispersion of spent fuel. Unlike spent fuel, HLW is devoid of fission product gases and is encapsulated in a stable matrix making it almost impervious to leaching by water. Further, it would be confined in a storage vessel (canister and cask) relatively invulnerable to destructive forces. A second factor is that the magnitude of the HLW storage problem as it exists in the US today is limited by the quantities of commercially generated HLW available for solidification. Commercial reprocessing is not likely to be available in the future; however, to address the issue an estimate of HLW environmental storage hazards, postulated for a worst case,[4] will be considered. This worst case characterization of HLW assumes the solidified waste is from freshly reprocessed fuel 5 months out of the reactor having a 33 gigawatt-days per metric ton heavy metal (GWD/MTHM) burnup, and a 3.2% initial enrichment. Table 2.3.1-1 and table 2.3.1-2 give data to support comparing the relative hazards of spent nuclear fuel and HLW by establishing reference values for radiological and thermal contents. Figure 2.3.1 illustrates the data of each of these tables. For an MRS storing equal amounts of HLW and spent fuel given the above assumptions, on a metric ton of heavy metal (MTHM) basis, spent fuel is more of a potential thermal environmental hazard than is HLW because spent fuel would contribute more than 370 times as much thermal loading as would HLW. After two years in storage this difference is less than a factor of 1.3 and by five years of

[4]This is a worst case because all commercial HLW that exists at the date of this analysis is at a minimum 10 years older than assumed here. Results reported [17] on German dry storage experiences with the Castor type storage cask at Wuergassen, Nuclear Power Plant (for 16 fuel elements with approximately a one year decay, and 27 GWD/MTHM burnup) showed that fuel had on average a 10°C temperature drop per month of storage. Initial temperature equilibriums were between 380°C (cladding surface) and 190°C (cask bulk gas).

Table 2.3.1-1 Radioactivity and Thermal Power in Solidified High-Level Waste from the Uranium Recycle of LWR Spent Fuel [5]

Radionuclides	0 Years After Separation(a)	2 Years After Separation(a)	5 Years After Separation(a)
Fission Products, Ci/MTHM			
$^{90}Sr + ^{90}Y$	1.45×10^5	1.38×10^5	1.28×10^5
$^{106}Ru + ^{106}Rh$	8.61×10^5	2.18×10^5	2.77×10^4
$^{134}Cs + ^{137}Cs + ^{137m}Ba$	3.36×10^5	2.61×10^5	2.04×10^5
$^{144}Ce + ^{147}Pm$	9.75×10^5	2.16×10^5	4.27×10^4
All other FPs	2.28×10^6	1.69×10^5	2.54×10^4
Total FPs	4.60×10^6	1.00×10^6	4.28×10^5
Actinides Ci/MTHM			
^{241}Pu	6.18×10^2	5.60×10^2	4.85×10^2
^{241}Am	1.90×10^2	1.91×10^2	1.93×10^2
^{242}Cm	1.97×10^4	8.89×10^2	1.15×10^1
^{244}Cm	1.50×10^3	1.39×10^3	1.24×10^3
All other actinides	9.00×10^1	1.70×10^2	1.70×10^2
Total actinides	2.21×10^4	3.20×10^3	2.10×10^3
Heat Generation Rate, W/MTHM	1.92×10^4	4.04×10^3	1.48×10^3

[a] 0.5 years elapse between reactor discharges and chemical separation; calculated with the ORIGEN code for PWR high-level waste from fuel irradiated to 33 GWD/MTU at a specific power of 37.5 MW/MTU.

Table 2.3.1-2 Radioactivity and Thermal Power in Spent LWR Fuel[a] per Metric Ton Uranium Charged to the Reactor [5]

	Years After Discharge		
	0	2	5
Radionuclide Content, curies			
Important Activation Products			
^{55}Fe	5.62×10^3	3.30×10^3	1.48×10^3
^{60}Co	7.87×10^3	6.05×10^3	4.08×10^3
^{63}Ni	6.62×10^2	6.53×10^2	6.38×10^2
^{125}Sb	1.60×10^3	9.83×10^2	4.64×10^2
^{125m}Te	3.35×10^2	2.40×10^2	1.13×10^2
All Other Activation Products	4.53×10^5	1.20×10^3	2.40×10^2
Total Activation Products	4.69×10^5	1.24×10^4	7.02×10^3
Important Actinides Products			
^{238}Pu	2.19×10^3	2.36×10^3	2.31×10^3
^{239}Pu	3.07×10^2	3.13×10^2	3.13×10^2
^{239}Np	2.21×10^7	1.71×10^1	1.71×10^1
^{241}Pu	1.26×10^5	1.14×10^5	9.91×10^4
^{241}Am	1.02×10^2	4.87×10^2	9.90×10^2
^{244}Cm	1.53×10^3	1.41×10^3	1.26×10^3
All Other Actinides	2.39×10^7	2.40×10^3	1.00×10^3
Total Actinides	4.62×10^7	1.21×10^5	1.05×10^5
Important Fission Products			
^{144}Pr	1.27×10^6	2.12×10^5	1.47×10^4
^{144}Ce	1.26×10^6	2.12×10^5	1.47×10^4
^{137}Cs	1.04×10^6	9.96×10^4	9.29×10^4
^{134}Cs	1.56×10^5	7.98×10^4	2.91×10^4
^{106}Rh	6.56×10^5	1.47×10^5	1.87×10^4
^{90}Y	7.71×10^4	6.98×10^4	6.50×10^4
All Other Fission Products	9.60×10^8	4.33×10^5	2.32×10^5
Total Fission Products	9.65×10^8	1.25×10^6	4.67×10^5
Thermal Power, Watts	7.26×10^6	5.34×10^3	1.82×10^3

[a]Calculated with the ORIGEN code for PWR fuel irradiated to 33,000 MWD/MTU at a specific power of 37.5 MW/MTU.

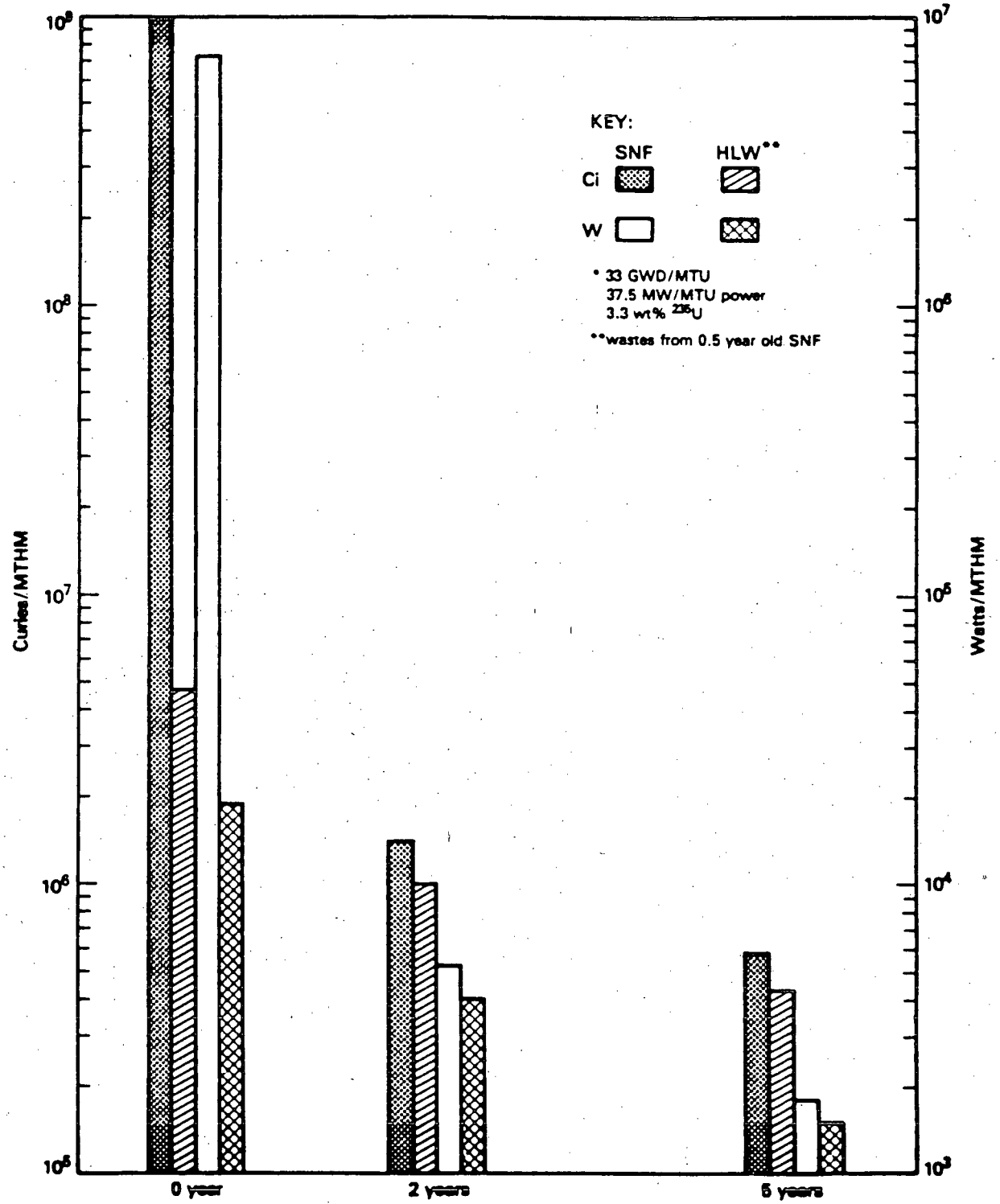

Figure 2.3.1 Comparison of Radiological & Thermal Contents of High-Level Radioactive Wastes With Comparable Ages of Spent Nuclear Fuel* (SNF)

storage it is further reduced to a factor of 1.2. Radioactive loadings in an MRS storing equal amounts of HLW and spent nuclear fuel would be dominated by the contribution from spent fuel. HLW curie content at zero years (Figure 2.3.1) is estimated as 4.6×10^6 curies per metric ton of heavy metal (Ci/MTHM), but spent fuel is more than a factor of 200 higher at 1.0×10^9 Ci/MTHM. Following two years of storage, spent nuclear fuel curie content is 1.4 times greater than the curie content of high-level radioactive waste, and after 5 years the difference is a factor of 1.54.

For long-term storage of spent nuclear fuel or high-level radioactive wastes, the significant probable impacts include doses attributable to off-normal and accident conditions over the 70 years of installation operation. In the event the contents of an MRS need to be transferred there will be some minimal increase in man-rem resulting from handling and transfer operations required for packaging and moving spent fuel and HLW to new or temporary storage installations. While the present schedule for the federal repository tends to reduce the likelihood of such installation replacement, certainly it can be done safely as the Commission has stated [15] in its preliminary conclusion with respect to environmentally safe and reliable management of spent fuel beyond the license period of an independent spent fuel storage installation.

2.3.2 Ecological Impacts

Site ecology in the area occupied by MRS structures could be disturbed because wildlife habitats are removed for the installation lifetime a period evaluated in this analysis as being 70 years. A 23,000 canister installation (approximately 70,000 MTHM) that has receiving and shipping operations is estimated to occupy about a 121 ha site with additional space, e.g., 8 ha, for workyards, temporary buildings and parking [10]. Transportation requirements include a road and a rail spur into the installation. The potential for serious ecological impacts from the thermal and radiological contents of HLW and spent fuel stored in dry casks for 50 years beyond current ISFSI license times decreases because thermal and radiological contents decrease.[5] However, the additional storage time increases the likelihood of a release, but as presented in Table 2.2.4-1 postulated accidents for surface cask storage of canistered fuel presents a minimum dose rock to the public and the same is true of the risk to the ecology.

[5]Refer to Appendix B, Figures B-1, B-2, B-3, and B-4.

2.3.3 Environmental Impacts Related to Installation Operation

MRS operations consume electricity and generate effluents during normal and off-normal operations. Radiological, chemical and thermal effluents from an MRS could result in adverse environmental consequences; however, technology exists to build systems to confine or mitigate accidental or off-normal releases, e.g., through effluent treatment, effluent retention or through multiple barriers. It is therefore practical to consider that the consequences that could result from extended storage of HLW and spent fuel in an MRS would be minimal; however, routine MRS operation will cause some local atmospheric heating. An evaluation of thermal releases for an MRS surface cask installation storing HLW has been made by DOE [6, 10]. Waste heat for the HLW installation is estimated to be 88 megawatts (MW).[6] Table 2.3.3-1 provides downwind temperature changes assuming waste heat generator rates reported in DOE's environmental study of commercial radioactive waste management for sealed dry casks containing HLW. Column 2 shows that the temperature difference drops from 2.1°C at 1 km from the installation to 0.1°C at 10 km from the installation. The third column gives normalized temperature change in Δt°C per metric ton of heavy metal for comparison of the effect of installation size on local heating. A dry spent fuel surface cask housing an equivalent thermal loading would have similar impacts on the environment.

[6]Note: A 300 Horsepower truck engine at full power releases approximately 150 kilowatts (0.15 MW).

Table 2.3.3-1 Temperature Change Downwind from a Solidified High-Level Radioactive Waste Storage Installation† [6]

Distance, Downwind (km)	Temperature Change ($\Delta t^{o}C$)	Normalized Temperature Change ($\Delta t^{o}C$/MTHM)
1.0	2.1	3.4×10^{-5}
1.6	0.9	1.4×10^{-5}
2.0	0.6	9.9×10^{-6}
3.0	0.3	4.9×10^{-6}
5.0	0.2	3.3×10^{-6}
10	0.1	1.6×10^{-6}

†Based on a facility storing HLW with equivalent thermal and radiological contents of 60,800 MTHM from reference [6] fuel 6.5 year out-of-the-reactor. Average exposure for fuel is 29.3 GWD/MTHM.

Thermal consequences, discussed earlier, are the major contributors to environmental problems from installation operation. Sealed HLW storage cask emissions (also typical of packaged spent fuel storage) are assumed to be controlled to levels required by regulation, and these levels which are prescribed for public health and safety are assumed to be environmentally safe. Table 2.3.3-2 characterizes installation emissions. The values listed here assume treatment of effluents results in a decrease of installation emissions by a factor of 10^6.

Table 2.3.3-2 Sealed Cask HLW Storage Installation Emissions [6][a]

Installation Wastes

Description	Volume (m^3/year)	Radioactivity (curies per year)
Combustible and Compactible Waste	250	1.2×10^{-1}
Failed Equipment	54	1.2×10^{-1}
Concentrated Wet Waste	54	1.2×10^{-1}

Installation Emissions

Emissions	Description	Annual Quantity	Radioactivity Release to the Atmosphere (curies per year)
Gaseous	Facility ventilation air and vaporized excess water	9.0×10^9 m^3	1.2×10^{-7}
	Minor accident integrated annual release		None identified
Other	Heat	5.0×10^5 MW-hr	

[a]Based on receipt of 3600 MTHM per year at an installation designed to store 70,000 MTHM.

The population bearing the greatest risk from an MRS operation is the installation work force. Worker exposure consists of contribution from off-normal operations and from accident situations. For a dry storage installation there are not expected to be any radioactive releases from normal operations. Table 2.3.3-3 compares annual total-body dose received from routine operation of a HLW sealed cask storage installation with the total-body dose received from routine operation of a spent fuel surface cask storage installation. From Table 2.3.3-3 an MRS filled to capacity with spent fuel is more hazardous to the work force than an installation filled to capacity with HLW.

Table 2.3.3-3 Summary of Annual Total-Body Dose from an MRS [6]

Source	Dose, man-rem
HLW Sealed Cask Installation	
Process Work Force*	136
Population within 80 km†	approx. 0
Spent Fuel Storage Installation	
Process Work Force*	207
Population within 80 km†	approx. 0
Naturally Occurring Sources	
Population within 80 km†	200,000

* Based on a 70,000 MTHM installation filled-to-capacity.
† Based on a 2.0×10^6 persons and a 70,000 MTHM installation filled-to-capacity.

At the end of an MRS operating life, process cells and associated installation equipment are expected to contain contamination. For a HLW sealed storage cask the estimated range of contamination is between 1 and 10 curies of mixed fission products with a 10-year equivalent time out-of-reactor. Decommissioning waste at the end of life for a surface cask installation storing spent fuel is estimated as less than 1 curie of mixed fission products. Radiation exposures for decommissioning the storage area of a 70,000 MTHM cask storage facility are estimated to be 438 man-rem [18].

2.3.4 Environmental Impacts Related to Postulated Accidents

The Commission found in its preliminary decision in the matter of the Waste Confidence Proceeding [15] that the high temperature and high pressure driving forces behind dispersion of radioactive material in operating reactors is absent in dry storage. The exposure pathways are further limited by the properties of spent fuel and reprocessed waste. Except for the fission product gases, spent fuel radioactive material is in the form of a ceramic encapsulated in high integrity metal cladding. HLW is usually an encapsulated waste form derived from the first waste stream of reprocessing which removes fission product gases along with uranium. The storage of spent fuel and high-level radioactive waste in sealed containers together with their waste forms makes them highly resistant to failure resulting in a release of radioactive material to the environment. This section compares the effects of accidents involving high-level radioactive waste in sealed cask storage installations and spent fuel in surface cask storage installation [6,10].

Canister failure (Table 2.2.4-1) is postulated to release radioactive material in the receiving cell. Other accidents can be postulated, such as breaking fuel rods during consolidation, but because they have similar consequences to canister failure accidents they are not discussed. Canister failure is a moderate accident and involves the rupture of a HLW canister and release of radioactive materials through high-efficiency particulate air filters. For this type of accident HLW is estimated to release on the order of 0.0019 mg of radioactive materials [6]. The estimated 70-year dose to the individual receiving the maximum exposure to the release is 9.11×10^{-3} rem [6].

The packaged fuel element failure during storage was judged most severe for surface cask storage of spent fuel [10]. In this analysis, the accident involves failure of a package containing 1.7 MTHM. Failure is corrosion induced. The accident would cause release of 7 Ci of ^{85}Kr and 2×10^{-5} Ci of ^{129}I over a 1 hour period. Numerically, the largest dose to the maximum exposed individual is less than 1% of the dose an individual would receive from naturally occurring sources during the same period. Dose to the maximum individual from air submersion and inhalation pathways to the skin, total body, thyroid and lung is estimated as 1.14×10^{-4} rem for 70 years.

2.3.5 Irreversible and Irretrievable Commitments of Resources

Materials resources and utilities for construction and operation of an MRS are summarized in Table 2.3.5 for a HLW sealed storage cask installation, (column 2) and a spent fuel surface cask installation (column 3). The construction of an MRS would consume an insignificant quantity of U.S. resources.

Table 2.3.5 Resources for Construction and Operation of a HLW Sealed-Cask and a Spent Fuel Surface Cask MRS [10]

Resource	HLW Sealed Storage Cask	Spent Fuel Surface Cask
Construction		
Steel, MT	34,500	44,100
Copper, MT	300	170
Aluminum, MT	200	0
Lumber, m^3	5,400	7,400
Concrete, m^3	149,700	176,500
Propane, m^3	3,000	4,800
Diesel fuel, m^3	30,500	47,800
Gasoline, m^3	21,900	32,000
Electricity, kWh	1.49×10^7	2.48×10^7
Manpower, man-year	13,800	21,700
Operation (Annual Use)		
Electricity, MWh	370	190
Water, m^3	3,500	--
Fuel Oil, m^3	7,600	2,200
Steel, MT		
Cask	13,800	--
Pads	5,800	--
Shields	21,900	--
Manpower, man-year	800	2,200

Data are normalized to a 70,000 MTHM storage installation.

2.4 Environmental Consequences of Substituting Restrictions on Radioactive Releases to the Environment for Restrictions Placed on Fuel Cladding Integrity

The proposed revisions to 10 CFR Part 72 permit fuel cladding degradation leading to gross rupture, if preventive measures are taken to restrict radioactivity releases. To ensure safe fuel storage and handling, the regulations currently require the fuel cladding be protected against degradation and gross ruptures. While gross cladding failures, if not contained, could provide a route for fuel fission products to be available for transport to the environment the proposed rule restricts releases of radioactive material and thus the safety of storage and handling operations are not compromised.

2.4.1 Licensing Considerations

Transportation, handling, and storage of degraded fuel requires special care to prevent accidental releases of fission product gases or oxidized fuel. Appropriate equipment and facilities must be available for the complete transfer of fuel having degraded cladding so that handling operations are designed to minimize exposure to fission product gas releases. Engineered remedies for design basis accidents and off-normal operations should be developed to ensure engineered safety equipment provides protection to the public from fission product gases or airborne fuel particles. Fuel removed for transport to an MRS or from an MRS is susceptible to packaging problems during handling operations, therefore an installation must consider the hazards associated with repackaging operations. Appropriate safety precautions need to be in place. Contingencies should be well thought out. In its preliminary findings in the Waste Confidence Proceeding [15] the Commission stated it has reasonable assurance that spent fuel generated by licensed plants will be managed by licensees in a safe manner. The Commission is confident that its authority to require continued safe management of spent fuel past the expiration of an operating license will provide the additional assurance that the conditions necessary for safe storage will be maintained until disposal facilities are available. Because fuel handling operations at existing reactor storage pools are routine and proceed with proven safety, the NRC does not anticipate public health and safety consequences resulting from this proposed revision since it is assumed the protection afforded the public also protects the environment.

The Commission addressed the environmental impacts of extended dry storage at reactor sites. The Commission stated that it was confident installations can provide continued safe storage for at least 30 years after expiration of a plant's license. Therefore, the proposed amendment to relax requirements that protect fuel cladding against degradation leading to gross fuel oxidation are consistent with the Commission position on extended storage because releases must be restricted even if cladding degradation were to occur.

2.4.2 Ecological Impacts

Fuel in an oxidized state could adversely impact site ecology, unless proper precautions are taken to design spent fuel storage installations to protect against radiological releases. Under current ISFSI licensing criterion minimum design requirements establish that fuel cladding shall be protected against degradation and gross ruptures. Proposed licensing criterion establish an alternate minimum design criterion: the fuel shall be otherwise confined such that the degradation of the fuel during storage shall not pose safety problems with respect to its removal from storage. Testing programs are being conducted by NRC, DOE, industry and foreign governments on the temperature-time dependence of failed fuel cladding and concomitant fuel oxidation in a variety of environments, including inert atmosphere, as part of their comprehensive dry storage research programs. Current knowledge on the subject indicates that fuel oxidation rates are affected by the temperature of the stored fuel, its environment and the integrity of the fuel cladding. The impact that the proposed alternate design criteria could have on ecology is the difference of the impact of an installation designed to confine degraded fuel rather than one designed to protect against cladding degradation. With the knowledge that degraded fuel cladding affects fuel oxidation which in turn affects cladding degradation, it is reasonable to expect that any differences in installation designs would not result in significant differences in facility structures and should not cause significant impacts on the ecology. Therefore, the confinement restrictions established for stored fuel protect the public and limit the impact that an ISFSI constructed to these criteria would have on the site ecology to a level commensurate with existing ISFSI design requirements.

2.4.3 Environmental Impacts Related to Installation Operation

The public is protected from radiological releases from spent fuel storage operations to the levels prescribed by the proposed rule 10 CFR Part 72, Subpart E, "Siting Evaluation Factors." The NRC experience in more than 100 individual safety evaluations of wet spent fuel storage shows that the possibility of significant releases of radioactivity from spent fuel under licensed conditions is remote. The safe operation of dry, spent fuel storage is based on over 40 years of DOE experience and on preliminary Commission findings [15] that the known degradation mechanisms permit confidence in engineered systems designed to limit radiological releases from dry spent fuel storage. Radiation releases to the environment from degraded fuel stored in a dry or wet installation are therefore expected to be minimal.

2.4.4 Environmental Impacts Related to Postulated Accidents

The proposed amendment to 10 CFR Part 72 general design criteria for confinement barriers and systems establishes an alternate design criteria that restricts radioactive releases. The criteria is: the fuel shall be otherwise confined such that the degradation of the fuel during storage shall not pose safety problems with respect to its removal. The design criteria permit canning consolidated fuel rods or unconsolidated fuel assemblies to meet the requirement. If fuel is canned for storage and the evaluation of postulated accidents determines that the canister protects the fuel cladding against degradation leading to gross ruptures, then the amendment of 10 CFR Part 72 to include restrictions on radioactive releases to the environment would not change the expected environmental impacts from postulated accidents. But, because the alternate design criteria permit fuel oxidation, there exists a potential for the release of oxidized fuel and radioactive gases if the canister containing the fuel becomes damaged to the extent its contents are released to the environment. The magnitude of a release has been evaluated by the staff [20] and doses have been calculated for accidents of 5 year-cooled and 1 year-cooled PWR fuel stored in a dry storage cask. The assumptions included 45,000 megawatt-days per metric ton of uranium burnup for a cast containing about 12 metric tons of uranium. For the 5-year-cooled fuel, doses were calculated at a distance of 500 meters to the site boundary; for the 1-year-cooled fuel,

doses were calculated at a distance of 100 meters to the site boundary. The calculated doses were well within the Environmental Protection Agency's (EPA) Protective Action Guidelines (PAG). The assumptions of the evaluation provided an estimated dose to an individual of 33 mrem to the whole body and 251 mrem to the thyroid in the case of the 5-year-cooled fuel and 700 mrem to the whole body and 3700 mrem to the thyroid for 1-year-cooled fuel.[7] EPA's PAG for dose to the whole body at 100 meters is 1000 mrem and the dose to the thyroid at 100 meters is 5,000-25,000 mrem. The staff concluded an accident of this magnitude would not exceed offsite doses. In a separate determination of the time-temperature dependency of fuel oxidation in unlimited air supply preliminary results of tests being conducted by NRC, DOE, industry and foreign countries [13] show that oxidation does occur; however, fuel fragments are large and would be unlikely to become airborne. Therefore, a postulated accident of a cask designed to store fuel under the conditions proposed for amendment of 10 CFR Part 72 are calculated to result in offsite doses to the whole body and to the thyroid that are within allowable guidelines and would not result in an environmental impact during postulated accidents.

2.4.5 Irreversible and Irretrievable Commitments of Resources

Changes to the requirements of 10 CFR Part 72 to permit gross fuel cladding degradation but restricting radiation releases would not require significant additional resource commitments. It is anticipated that the commitments of resources from this new requirement are within a utility's commitment to maintain safe storage of its spent fuel under existing licensing storage conditions.

7. Dose assessments are for a whloe-body immersion dose from Kr-85 and a thyroid inhalation dose from I-129.

2.5 References

[1] The Code of Federal Regulations, Title 10 Part 72, "Licensing Requirements for the Storage of Spent Nuclear Fuel in an Independent Spent Fuel Storage Installation (ISFSI)."

[2] The Code of Federal Regulations, Title 10 Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories."

[3] The Code of Federal Regulations, Title 40 Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

[4] U.S. Department of Energy, "A Preliminary Assessment of Alternative Dry Storage Methods for the Storage of Commercial Spent Nuclear Fuel, JAI-180," November 1980, DOE Report DOE/ET/47929-1. Available from the National Technical Information Service, Springfield, VA 22161.

[5] U.S Department of Energy, "Decay Characteristics of Once-Through LWR and LMFBR Spent Fuels, High-Level Wastes, and Fuel Assembly Structural Material Wastes," Oak Ridge National Laboratory Report ORNL/TM-7431; November 1980. Copies available from the National Technical Information Service, Springfield, VA 22161.

[6] U.S. Department of Energy, "Environmental Aspects of Commercial Radioactive Waste Management," DOE Report DOE/ET-0029, May 1979. Available from the National Technical Information Service, Springfield, VA 22161.

[7] U.S. Department of Energy, "Final Environmental Impact Statement Management of Commercially Generated Radioactive, Waste," DOE Report DOE/EIS-0046F, October 1980. Available from the National Technical Information Service, Springfield, VA 22161.

[8] U.S. Department of Energy, "Final Environmental Impact Statement U.S. Spent Fuel Policy," DOE Report DOE/EIS-0015, May 1980. Available from the National Technical Information Service, Springfield, VA 22161.

[9] U.S. Department of Energy, "Monitored Retrievable Storage Proposal Research and Development Report," June 1983, DOE Report DOE/S-0021. Available from the National Technical Information Service, Springfield, VA 22161.

[10] U.S. Department of Energy, "Technology for Commercial Radioactive Waste Management," DOE Report DOE/ET-0028, May 1979. Available from the National Technical Information Service, Springfield, VA 22161.

[11] The National Environmental Policy Act of 1969, as amended Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, and Pub. L. 94-83, August 9, 1975.

[12] The Nuclear Waste Policy Act of 1982, January 7, 1982; Pub. L. 97-425; 96 Stat. 2201.

[13] U.S. Nuclear Regulatory Commission, "Workshop on Spent Fuel/Cladding Reaction During Dry Storage," NRC Report NUREG/CR-0049, Available from the National Technical Information Service, Springfield, VA 22161.

[14] U.S. Nuclear Regulatory Commission, "Fuel Inventory and Afterheat Power Studies of Uranium-Fueled PWR Fuel Assemblies Using the SAS2 and ORIGEN-S Modules of Scale with an ENOF/B-V Updated Cross System Library," ORNL Report NUREG/CR-2397, September 1982. Available from the National Technical Information Service, Springfield, VA 22161.

[15] U.S. Nuclear Regulatory Commission, "Proposed Rulemaking on the Storage and Disposal of Nuclear Waste, Appendix - Rationale for Commission Findings in the Matter of the Waste Confidence Proceeding," PR-50, -51 (44 FR 61372).

[16] U.S. Department of Energy, "Functional Design Criteria for Monitored Retrievable Storage (MRS) Facility," DOE Project D-360, February 1984, Revision 1.

[17] J. Fleisch, K. Ramecke; Atomwirtschaft Atomtechnik, "Fuel Element Dry Storage - Experience With a Shipping and Storage Container of the Type Castor in the Nuclear Power Plant Wuergassen," DK 621.039.74 January 1983.

[18] U.S. Nuclear Regulatory Commission, "Technology, Safety and Costs of Decommissioning Reference Independent Spent Fuel Storage Installations," NRC Report NUREG/CR-2210, Available from the National Technical Information Service, Springfield, VA 22161.

[19] U.S. Department of Energy, "Functional Design Criteria for Monitored Retrievable Storage (MRS) Facility," Project D-360 (February 1984, Revision 1), Prepared by Pacific Northwest Laboratory for U.S. DOE Richland Operations Office, Richland, Washington.

[20] Internal NRC memorandum from L. Rouse, Chief, Advanced Fuel and Spent Fuel Licensing Branch to J. Norberg, Chief, Human Factors Branch, dated April 20, 1983.

III. FINDINGS

3.1 Purpose, Policy, and Mandate

The Nuclear Waste Policy Act of 1982 (NWPA) requires that facilities storing spent nuclear fuel and high-level radioactive waste (HLW) in a monitored retrievable storage installation (MRS) be subject to licensing by the NRC should Congress choose to authorize such an installation. In its consideration of rulemaking options, the Commission decided to revise existing spent nuclear fuel licensing criteria for independent spent fuel storage installations [1] to include licensing requirements for NWPA Federal interim storage installations and for monitored retrievable storage installation options.

This environmental assessment discusses the environmental impacts of the proposed revision to 10 CFR Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)," to cover specific license requirements for storing spent fuel and high-level radioactive wastes. The issues of this analysis are complementary to the final environmental impact statement published as NUREG-0575 [2] wherein the environmental impact for storing spent fuel was evaluated for storage of spent fuel independent of reactor pools only for a lifetime of approximately 20 years, and to the Commission's record in the matter of the Waste Confidence Proceedings. The issues identified as requiring resolution by the proposed revision to 10 CFR Part 72, are:

(1) establishing license criteria for long-term storage of spent nuclear fuel and HLW in an MRS,

(2) the inclusion of license requirements for the long-term storage of spent nuclear fuel and high-level radioactive waste in an MRS under 10 CFR Part 72, and

(3) elimination of the current restrictions placed on fuel cladding integrity in the present Part 72 which require the fuel cladding be protected against degradation and gross rupture, and replacement of these restrictions with limitations on radioactive releases to the environment.

The findings are:

- Past experience with water pool storage of spent fuel establishes the technology for long-term storage of spent fuel without affecting the health and safety of the public.

- The proposed rulemaking to include criteria in 10 CFR Part 72 for storing spent nuclear fuel and high-level radioactive waste does not significantly affect the environment.

- Solid high-level waste is comparable to spent nuclear fuel in its heat generation and in its radioactivity content on a per metric ton basis.

- Knowledge of material degradation mechanisms under dry storage conditions and the ability to institute repairs in a reasonable manner without endangering the health of the public shows dry storage technology options do not significantly impact the environment.

This assessment concludes that there are no significant environmental impacts, safeguards problems, or irreversible or irrevocable commitment of this Nation's resources that may occur as a result of promulgation of these proposed revisions to 10 CFR Part 72.

3.2 References

[1] The Code of Federal Regulations, Title 10, Part 72, "Licensing Requirement for the Storage of Spent Nuclear Fuel in an Independent Spent Fuel Storage Installation (ISFSI)."

[2] U.S. Nuclear Regulatory Commission, "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel," USNRC Report NUREG-0575; Volumes 1-3; August 1979. Copies are available from the National Technical Information Service III, Springfield, VA 22161.

APPENDIX A

SPENT FUEL STORAGE REQUIREMENTS

Forecasts of annual demands for spent nuclear fuel storage capacity are based on (1) the rate of expected growth of nuclear power facilities and (2) the rates at which operating reactors discharge spent nuclear fuel. Fuel consumption and hence rates of fuel discharge are wholly dependent on reactor operation time. To estimate future spent fuel storage capacity requirements, simplifying assumptions about the storage needs of the industry are needed to determine bounding limits to growth rates and how modifications to existing fuel storage practices (for example, full core reserve, consolidation, and transshipment) could change storage capacity. In this section, the objective is to compare the environmental impact statement (EIS) NUREG-0575, "Handling and Storage of Spent Light Water Power Reactor Fuel" (1979), predictions of industry wide requirements for fuel storage capacity to industry's storage capabilities since the EIS was published. In this way, insight is gained into how industry is meeting its fuel storage capacity needs at this time without constructing independent at-reactor (AR) or away-from-reactor (AFR) storage installations.

The projected spent fuel storage capabilities at nuclear power plants licensed to operate is provided in Table A-1. The source of this information is NUREG-0020 (Gray Book), "Licensed Operating Reactors, Status Summary Report, Vol. 8, No. 2, February 1984." Table A-2 provides a reactor-by-reactor breakdown of present storage capacities (column 3) and remaining storage capacities (column 6) from NUREG-0020. Table A-2 also provides data (columns 5 and 7) extracted from Appendix F, "Spent Fuel Generation and Storage Data," Vol. 2 of NUREG-0575, which modeled 1978 spent fuel storage and generation data to forecast requirements for fuel storage up to the year 2000. Appendix F data forecasted fuel discharge rates that were considerably higher than the discharge rates experienced because the model overestimated the growth of the nuclear industry. NRC's NUREG-0020 whose data is comparable to the Department of Energy Report DOE/RL-83-1 "Spent Fuel Storage Requirements" data, also projects fuel discharge rates up to the year 2000. The NUREG forecasts lower nuclear power growth rates than projected by NUREG-0575 to more accurately describe industry's projected fuel storage capabilities.

Table A-1 Projected Spent Fuel Storage Capability
of Reactors Licensed to Operate [2]
Data as of December 1983

Projected Year Present Authorized Capacity will be Filled

1984	1985	1986	1987	1988	1989	1990	1991	1992
Indian Point 2	Browns Ferry 3 Browns Ferry 1, 2 Dresden 2 Fort Calhoun 1 Robinson 2 San Onofre 1	Big Rock Point 1 Brunswick 1, 2 Three Mile Island, 1, 2	Maine Yankee Millstone 2 Oyster Creek Rancho Seco 1 Surry 1 Turkey Point 3	Palisades Prairie Island 1 Turkey Point 4 Yankee-Rowe 1		Dresden 1 La Crosse McGuire 1 Nine Mile Point 1 North Anna 2 Peach Bottom 2 Pilgrim 1 St. Lucie 1 Trojan	Calvert Cliffs, 1, 2 Farley 1 Fitzpatrick Kewaunee Millstone 1 Monticello North Anna 1 Peach Bottom 3 Oconee 1	Ginna Vermont Yankee Zion 1,2

1993	1994	1995	1996	1997	1998	1999	2000	2003
Davis Besse 1 Indian Point 3 Sequoyah 1	Cook 1 Farley 2 Haddam Neck Sequoyah 2	Beaver Valley 1 Point Beach 1	Cooper Station Salem 1	Susquehanna 1 Crystal River 3	Arkansas 1 Duane Arnold	Hatch 1, 2	Salem 2	Quad Cities 1,2 Arkansas 2

****
* PRESSURIZED *
* WATER *
* REACTORS *
****

Table A-2 Status of Spent Fuel Storage Capability [2]

FACILITY	(a) CORE SIZE NO. OF ASSEMBLIES)	PRESENT AUTH. STORAGE POOL CAP. (FUEL ASSEMBLIES)	NO. OF ASSEMBLIES STORED	REMAINING CAPACITY (NO. OF ASSEMBLIES) 1978 [1] DATA(P)	1984 DATA	(b) WILL FILL PRESENT AUTH. CAPACITY 1978 [1] DATA(P)	1984 DATA
Arkansas 1	177	968	316	478	652	1988+	1998
Arkansas 2	177	988	168	484	820	1988+	2003
Beaver Valley 1	157	833	52	833	781	1999-	1995
Calvert Cliffs 1	217	1830(c)	796(c)	828	1034(c)(m) 1170(o)	1985+	1991
Calvert Cliffs 2	217					1985+	1991
Cook 1	193	2050(c)	494(c)	371	1556(c)	1993+	1994
Cook 2	193			772		1993+	1994
Crystal River 3	177	1163	171	252	992	1999-	1997
Davis-Besse 1	177	735	140	260	595	no date	1993
Diablo Canyon 1(d)							
Farley 1	157	675	62	675	613, 1345(o)	1994-	1991
Farley 2	157	675	62		1345(o)	new	1994
Fort Calhoun 1	133	483	265	326	218, 463(o)	1986-	1985
Ginna	121	595	300	439	295	1989+	1992
Haddam Neck	157	1168	493	880	675	1995-	1994
Indian Point 1	0	288	160	668	128		
Indian Point 2	193	482	268	350	214, 980 (o)	1984 nc	1984
Indian Point 3	193	837	140	773	697	1991+	1993
Kewaunee	121	990	228	48	762(m)	2000-	1991
Maine Yankee	217	953	577	520	376, 1678(o)	1986+	1987
McGuire 1	193	500	31	new	469(n)	new	1990
McGuire 2							
Millstone 2	217	667	376	595	291	1987 nc	1987
North Anna 1	157	966(c)	116(c)	400	850	1998-	1991
North Anna 2	157					----	1990
Oconee 1	177	1312(l)	1123	282	189(l)(n)	1990+	1991
Oconee 2	177						
Oconee 3	177	825	0	new	825		
Palisades	204	784	480	525	304	1986+	1988
Point Beach 1	121	1058(c)	484(c)	171	1078(c)	1995 nc	1995
Point Beach 2	121						1995

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* PRESSURIZED *
* WATER *
* REACTORS *
****

Table A-2 Status of Spent Fuel Storage Capability (Cont.)

FACILITY	(a) CORE SIZE NO. OF ASSEMBLIES)	PRESENT AUTH. STORAGE POOL CAP. (FUEL ASSEMBLIES)	NO. OF ASSEMBLIES STORED	REMAINING CAPACITY (NO. OF ASSEMBLIES) 1978 [1] DATA(P)	1984 DATA	(b) WILL FILL PRESENT AUTH. CAPACITY 1978 [1] DATA(P)	1984 DATA
Prairie Island 1	121	1017(c)	561(c)	487	456(c)(m), 720(o)	1985+	1988
Prairie Island 2	121						
Rancho Seco 1	177	579	280	467	299	1987 nc	1987
Robinson 2	157	276	152	277	124(e), 431(o)	1984+	1985(g)
Salem 1	193	1170	212	264	958	1996 nc	1996 nc
Salem 2	193	1170	72		1098		2000
San Onofre 1	157	216	94	158	122	1993-	1985
San Onofre 2	217	800	0	new	800		
San Onofre 3	217	800	0	new	800		
Sequoyah 1	193	800	0	new	800		1993
Sequoyah 2(d)	193	800	65	new	735		1994
St. Lucie 1	217	728	352	668	376	1995-	1990
St. Lucie 2							
Summer 1	157	682	0	new	682, 1276(o)		
Surry 1	157	1044(c)	556(c)	608	484(c)	1984+	1987
Surry 2	157						
Three Mile Island 1	177	752	208	592	544	1989-	1986
Three Mile Island 2	177	442	0	442	442	1989-	1986
Trojan	193	651	248	587	403	1988+	1990
Turkey Point 3	157	621	445	274	175(m)	1981+	1987
Turkey Point 4	157	621	378		243	1981+	1988
Yankee-Rowe 1	76	391	225	242	166, 496(o)	no date	1988
Zion 1	193	2112(c)	795(c)	560	1317(c)	1993-	1992
Zion 2	193					1993-	1992

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Table A-2 Status of Spent Fuel Storage Capability (Cont.)

********** * BOILING WATER REACTORS * ********** FACILITY	(a) CORE SIZE NO. OF ASSEMBLIES)	PRESENT AUTH. STORAGE POOL CAP. (FUEL ASSEMBLIES)	NO. OF ASSEMBLIES STORED	REMAINING CAPACITY (NO. OF ASSEMBLIES) 1978 [1] DATA(P)	1984 DATA	(b) WILL FILL PRESENT AUTH. CAPACITY 1978 [1] DATA(P)	1984 DATA
Big Rock Point 1	84	193	152	131	41, 289(o)	1985-	1986
Browns Ferry 1	764	3471	1068	3147	2403	1996-	1985
Browns Ferry 2	764	3471	889	3339	861(m), 2582(o)	1996-	1985
Browns Ferry 3	764	3471	1520	3263	398(m), 2650(o)	1996-	1985
Brunswick 1	560	(f)	160PWR+ 656 BWR	1944	2116	1986 nc	1986
Brunswick 2	560		144 PWR+ 564 BWR		2208	1986 nc	1986
Cooper Station	548	2366	848	2082	1518	1994+	1996
Dresden 1	464	672	221	451	451	1993-	1990
Dresden 2	724	2659(c)	2014 (c)	1771	996(c), 6129(o)	1993-	1985
Dresden 3	724						
Duane Arnold	368	2050	576	1774	1474	1998 nc	1998
Fitzpatrick	560	2244	816	492	1428	1992-	1991
Hatch 1	560	3021	0	580	3021	1986+	1999
Hatch 2	560	2750	1284	1120	1466	1986+	1999
Humboldt Bay	172	487	251		236	1984	
La Crosse	72	440	207	215	233	1997-	1990
La Salle 1							
Millstone 1	580	2184	1136	1555	1048	1989-	1991
Monticello	484	2237	1016	1621	1221	1992-	1991
Nine Mile Point 1	532	1984	1044	1324	940, 1965(o)	no date	1990
Oyster Creek 1	560	1800	1375	1130	425, 1225(o)	1987 nc	1987
Peach Bottom 2	764	2816	1170	2198	1646	1991-	1990
Peach Bottom 3	764	2816	1212	2376	1604	1991 nc	1991
Pilgrim 1	580	2320	1708	1740	62(m)	1990 nc	1990
Quad Cities 1	724	3657	1730	1309	1927	1984+	2003
Quad Cities 2	724	3897	412	715	3485	1984+	2003
Susquehanna 1	368	2000	1082	1106	918	1991-	1992
Vermont Yankee 1	764	2840	0	new	2840		1997

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***************
*   BOILING   *
*    WATER    *
*   REACTORS  *
***************
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Table A-2 Status of Spent Fuel Storage Capability (Cont.)

FACILITY	(a) CORE SIZE NO. OF ASSEMBLIES)	PRESENT AUTH. STORAGE POOL CAP. (FUEL ASSEMBLIES)	NO. OF ASSEMBLIES STORED	REMAINING CAPACITY (NO. OF ASSEMBLIES) 1978 [1] DATA(P)	REMAINING CAPACITY (NO. OF ASSEMBLIES) 1984 DATA	(b) WILL FILL PRESENT AUTH. CAPACITY 1978 [1] DATA(P)	(b) WILL FILL PRESENT AUTH. CAPACITY 1984 DATA
Morris Operations (h)		750 MTU(j)	315		385 MTU(j)	1490 MTU(o)	
NFS (h)(i)		250 MTU	170 MTU		80 MTU		

(a) At each refueling outage approximately 1/3 of a PWR core and 1/4 of a BWR core is off-loaded.
(b) Some of these data have been adjusted by staff assumptions.
(c) This is the total for both units.
(d) Plant not in commercial operation.
(e) Some spent fuel stored at Brunswick.
(f) Authorized a total 2772 BWR and 1232 PWR assemblies for both pools.
(g) Robinson 2 assemblies being shipped to Brunswick for storage.
(h) Capacity is in metric tons of uranium; 1 MTU = 2 PWR assemblies or 5 BWR assemblies.
(i) No longer accepting spent fuel.
(j) Racked for 700 MTU.
(k) Reserved.
(l) This is the station total.
(m) Installed capacity is less than that authorized.
(n) McGuire 1 authorized to accept Oconee fuel assemblies.
(o) Remaining capacity in no. of assemblies, if pending request approved.
(p) Table F.1, NUREG-0575
\+ increased storage capacity since 1978 estimated date to fill authorized capacity.
\- decreased storage capacity since 1978 estimated date to fill authorized capacity.
nc no change in storage capacity since 1978 estimated date to fill authorized capacity.

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NUREG-0575 estimates of future fuel storage are calculated based on two cases, a low and a high rate of expected spent nuclear fuel generation. The low rate is a 230 gigawatt-electric (GWe) reactor power plant output in the year 2000 with 88% of this capacity discharging fuel. The high growth rate, also for the year 2000, is 280 GWe of reactor power with 88% of this capacity discharging fuel. The reason for the difference between the assumed capacity (GWe) of reactors installed in the year 2000 and those discharging fuel is due to the length of time between the first fuel loading and the first discharge.

Demand for Spent Fuel Storage Capacity in the U.S.

NUREG-0575 spent fuel storage capacity estimates discussed above concluded that by the end of 1978, about 4260 metric tons of heavy metal (MTHM) of spent fuel was in storage at reactors. At the time of the study about 170 MTHM of spent fuel were in storage at the West Valley NFS facility and 310 MTHM at the Morris, Illinois, GE facility. The total away from reactor storage being 480 MTHM.

Table A-3 shows annual spent fuel discharges will approach the 2700 MTHM level by 1986 and will increase to at least 5800 MTHM by the year 2000 for the low growth model of projected reactor installations.

Summary Spent Fuel Storage Capacities in 1983

Table A-2 summarizes changes made in reactor pool capacities since storage capacities for spent nuclear fuel were predicted by NUREG 0575 [1] in 1979. This table is divided into two sections, one for pressurized water reactor facilities, the other for boiling water reactor facilities. Data are compared for power reactor spent fuel storage status reported by NUREG-0020 [2] in 1983 and NUREG-0575 [1] reported in 1979. For dates (Table A-2) when authorized storage capacities at pressurized water reactors will be filled, 16 facilities have dates at least one year later than reported in 1979, 13 have dates earlier than the dates reported in 1979, and 5 are unchanged. For dates when BWR authorized storage capacities will be filled, 5 facility dates have increased by at least a year, 12 have earlier dates by at least one year, and six remain unchanged.

Table A-4 At-Reactor Capacity for With and Without Full Core Reserve Modeled For a Low Growth Rate of Nuclear Power [1]

Year	Installed Capacity, GWe	Maximum Basin Storage Capacity, MTHM	
		Without FCR	With FCR
1983	85	38,000	31,000
1984	92	40,000	33,000
1985	100	43,000	35,000
1986	108	46,000	38,000
1987	116	50,000	41,000
1988	124	52,000	44,000
1989	132	56,000	47,000
1990	140	59,000	50,000
1991	149	62,000	53,000
1992	158	65,000	55,000
1993	167	68,000	58,000
1994	176	71,000	60,000
1995	186	76,000	64,000
1996	194	78,000	67,000
1997	203	81,000	69,000
1998	212	84,000	71,000
1999	221	87,000	74,000
2000	230	91,000	77,000

FCR = Full Core Reserve

References

[1] U.S. Nuclear Regulatory Commission, "Handling and Storage of Spent Light Water Power Reactor Fuel," NRC Report NUREG-0575, August 1979. Available from the National Technical Information Service, Springfield, VA 22161.

[2] U.S. Nuclear Regulatory Commission, "Licensed Operating Reactors, Status Summary Report," Vol. 8, No. 1, NRC Report NUREG-0020, January 1984. Available from the National Technical Information Service, Springfield, VA 22161.

[3] U.S. Nuclear Regulatory Commission, "Summary Information Report," Vol. 2, No. 3, NRC Report NUREG-0871, August 1984. Available from the National Technical Information Service, Springfield, VA 22161.

[4] U.S. Department of Energy, "Spent Fuel Storage Requirements," January 1983 DOE Report DOE/RL-83-1. Available from the National Technical Information Service, Springfield, VA 22161.

APPENDIX B

HIGH-LEVEL WASTE STORAGE REQUIREMENTS

The design of facilities that store high-level waste (HLW) are affected by the quantities of wastes and waste properties such as heat generation rates and radioactivity. Commercial power reactors of the size typically in use in the United States generate spent fuel at a rate equivalent to about 35 metric tons of heavy metal per GWe-year of electrical energy production. If estimates of commercial electrical generating capacity are accurate this capacity could reach 202 GWe per annum by the year 2000, depending on the rate at which new plants become operable. At this rate of spent fuel production, spent fuel inventories for the industry are estimated to be 77,000 MTHM by the year 2000 [1].

Waste Characteristics

As nuclear fuel is irradiated in a reactor, fission products are formed. Actinides are formed from non-fission neutron absorption by uranium. Actinides have atomic numbers greater than 88 and typically have greater radiotoxicities and half-lives than fission products. Fission products result from the fission of uranium and plutonium isotopes. They are by comparison to actinides, characterized by relatively short half-lives and lower radiotoxicity. Small quantities of activition products are formed by neutron absorption by structural materials which support and blanket reactor fuel.

Recovery and purification of uranium can be accomplished using solvent extraction where impurities are preferentially extracted. Once separated, the waste stream which contains in excess of 99% of spent fuel fission products and only about 0.5% of uranium and plutonium is solidified.* Substantial quantities of a variety of transuranic wastes will also be present.

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*In the uranium recycle fuel cycle, it has been assumed that 99.5% of the plutonium in spent fuel is recovered and placed in storage, while the recovered uranium is returned to the fuel cycle.

Figure B-1 presents the radioactivity of pressurized water reactor (PWR) spent fuel as a function of time after removal from a reactor, and Figure B-2 present the same information for the wastes which would result from reprocessing PWR spent fuel from the uranium recycle. Figures B-1 and B-2 as well as subsequent figures and tables in this section are all normalized on the basis of one metric ton of heavy metal initially charged to a reactor. The figures for HLW thermal contents and radioactivity assume time zero begins with completion of reprocessing. Reprocessing begins after 0.5 years have elapsed since the fuel was removed from the reactor.

A comparison of the first two figures of this section shows that radioactivity from spent nuclear fuel decreases by over four orders of magnitude during the first 100 years whereas HLW decreases by just more than two orders of magnitude for the same period. Much of this change occurs primarily because of decay of Sr-90, Cs-137 and other short-lived fission products. Some of the shorter-lived actinides such as Pu-238 also decay significantly during the first few hundred years.

Figures B-3 and B-4 display the decay heat generation for spent fuel and reprocessed wastes. From these figures it is evident that the fission product decay heat generation rate makes up the largest fraction of the total heat generation and this accounts for the over two orders of magnitude difference between spent fuel and reprocessed waste decay heats during the first 100 years. About a 50% reduction in heat generation rate is achieved within the first 100 years for either of the waste types.

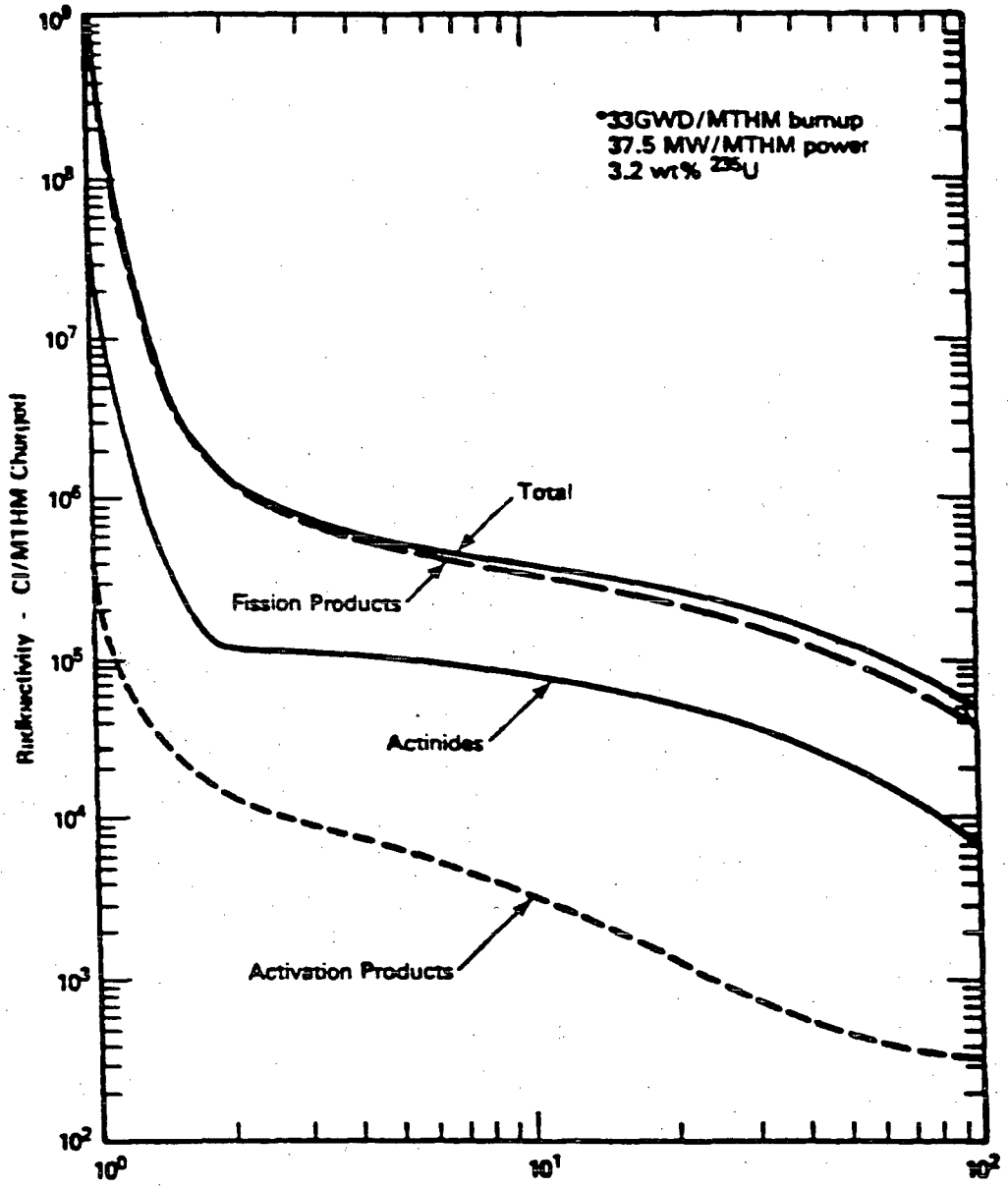

Figure B-1 PWR SPENT FUEL* -- RADIOACTIVITY [4]

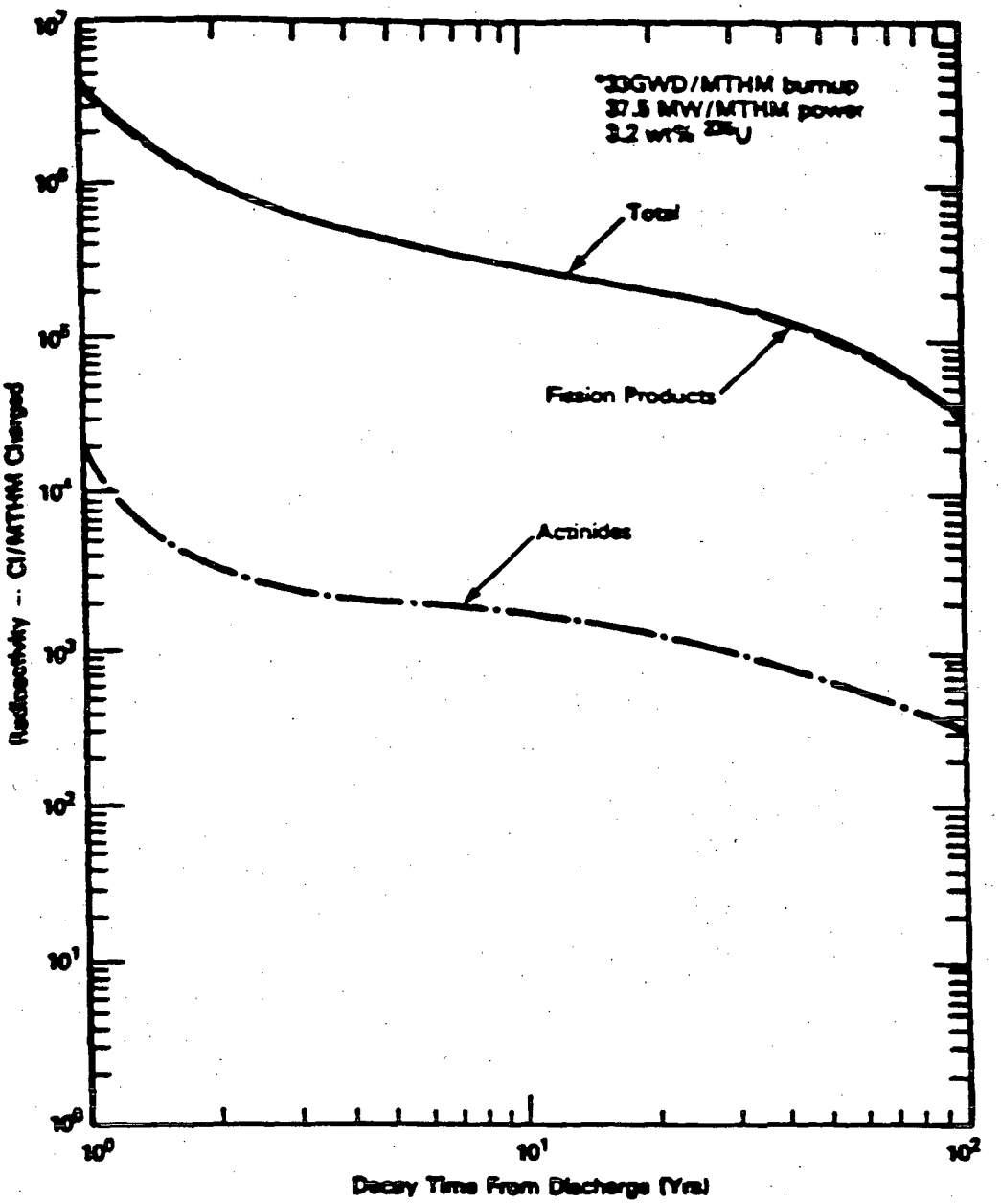

FIGURE B-2* URANIUM RECYCLE REPROCESSING WASTE -- RADIOACTIVITY [4]

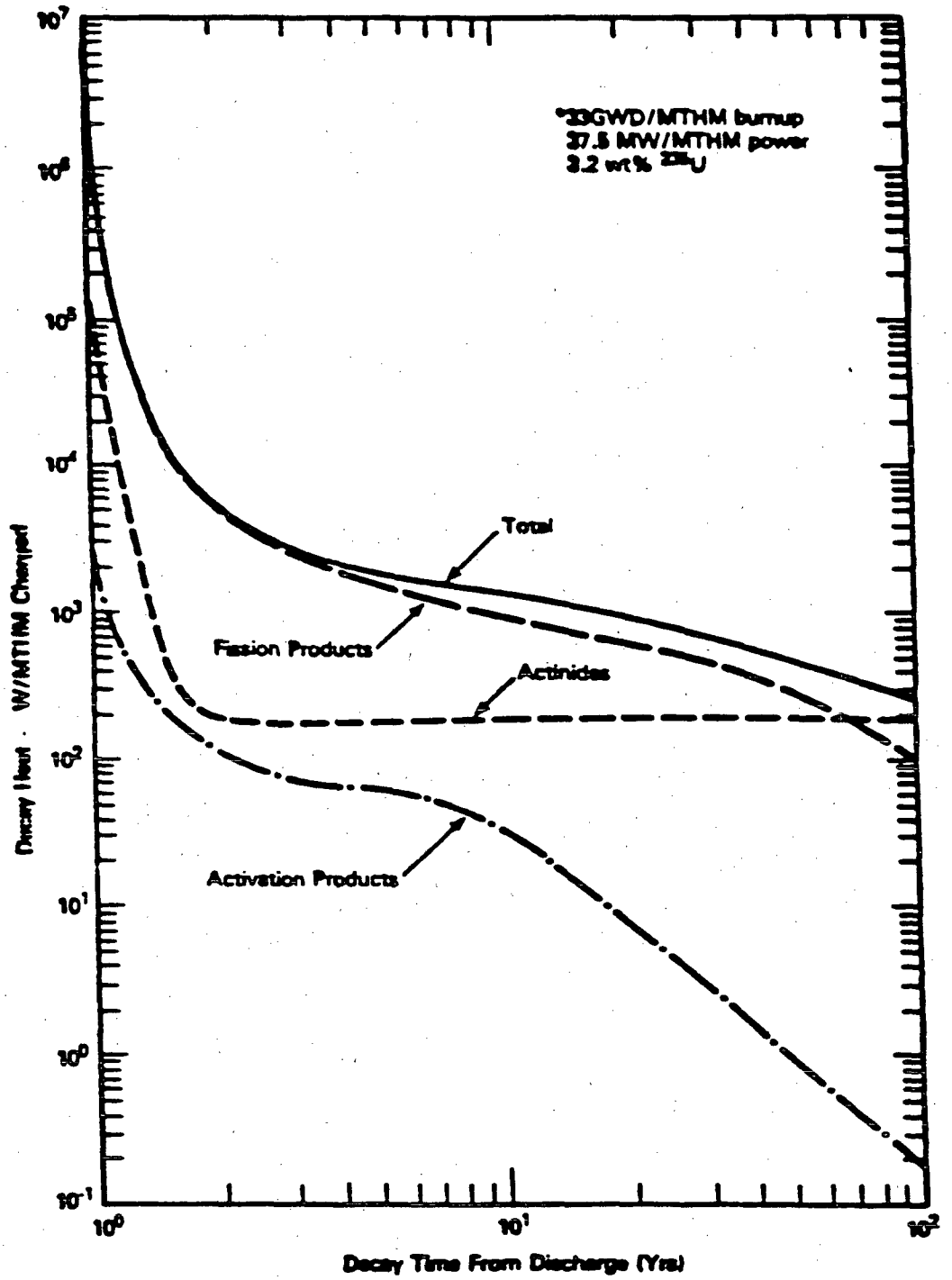

FIGURE B-3 PWR SPENT FUEL* -- DECAY HEAT GENERATION [4]

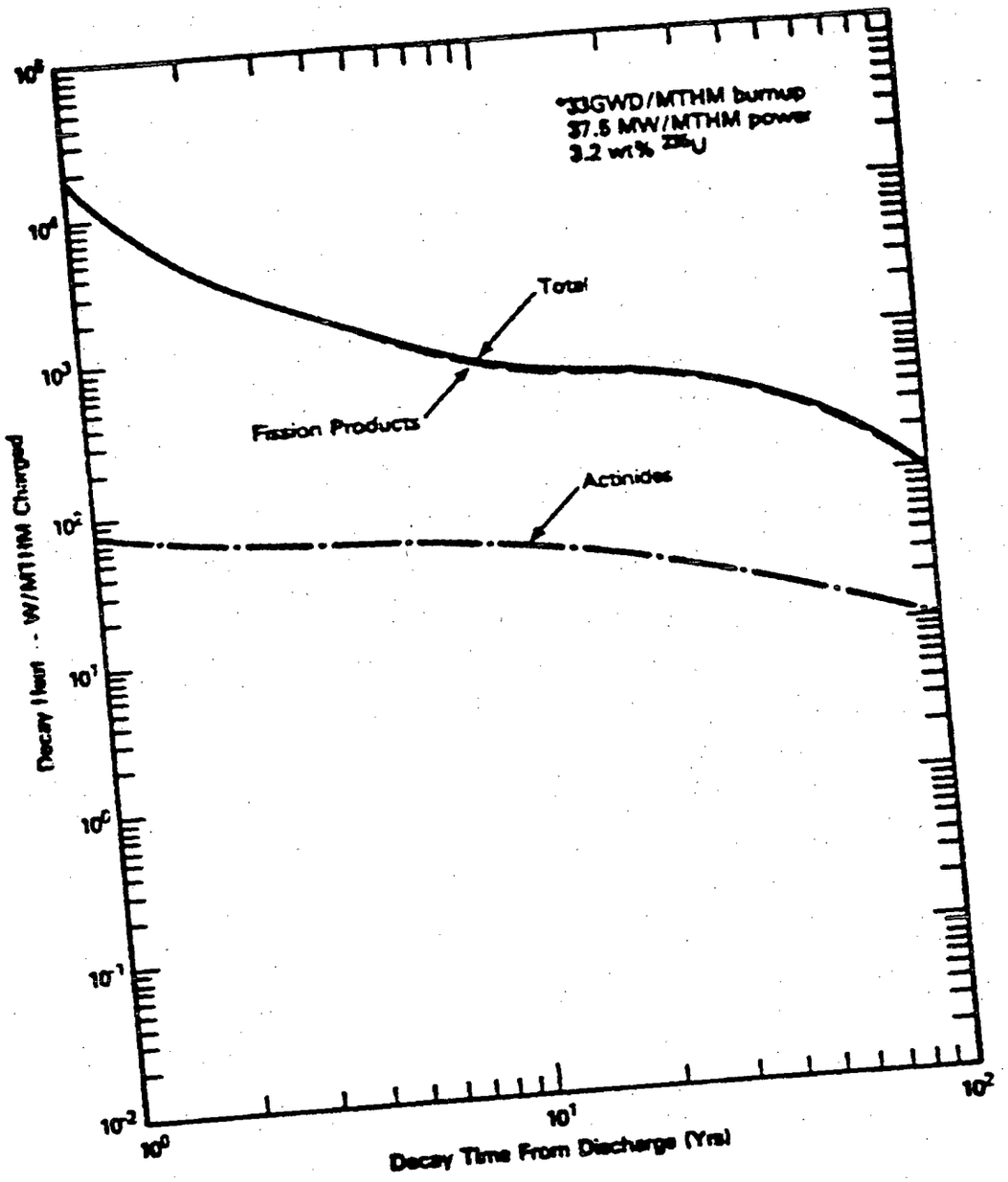

FIGURE B-4* URANIUM RECYCLE REPROCESSING WASTE -- DECAY HEAT GENERATION [4]

Solidified HLW

Table B-1 gives radioactivity content and thermal power in solidified high-level radioactive wastes for zero, 2 and 5 years following separation. Totals for waste are based on PWR fuel.

Table B-1 Radioactivity and Thermal Power in Solidified High-Level Radioactive Waste Per Metric Ton of Heavy Metal Processed [4]

Radionuclides	0 Years After Separation(a)	2 Years After Separation(a)	5 Years After Separation(a)
Fission Products, Ci/MTHM			
$^{90}Sr + ^{90}Y$	1.45×10^5	1.38×10^5	1.28×10^5
$^{106}Ru + ^{106}Rh$	8.61×10^5	2.18×10^5	2.77×10^4
$^{134}Cs + ^{137}Cs + ^{137m}Ba$	3.36×10^5	2.61×10^5	2.04×10^5
$^{144}Ce + ^{147}Pm$	9.75×10^5	2.16×10^5	4.27×10^4
All other FPs	2.28×10^6	1.69×10^5	2.54×10^4
Total FPs	4.60×10^6	1.00×10^6	4.28×10^5
Actinides Ci/MTHM			
^{241}Pu	6.18×10^2	5.60×10^2	4.85×10^2
^{241}Am	1.90×10^2	1.91×10^2	1.93×10^2
^{242}Cm	1.97×10^4	8.89×10^2	1.15×10^1
^{244}Cm	1.50×10^3	1.39×10^3	1.24×10^3
All other actinides	9.00×10^1	1.70×10^2	1.70×10^2
Total actinides	2.21×10^4	3.20×10^3	2.10×10^3
Heat Generation Rate, W/MTHM	1.92×10^4	4.04×10^3	1.48×10^3

[a] 0.5 years elapse between reactor discharges and chemical separation calculated with ORIGEN code PWR fuel data irradiated to 33,000 MWD/MTHM at a specific power of 37.5 MW/MTU.

Radioactivity and thermal power in spent light water reactor (LWR) fuel are reported in Table B-2. Values are reported for zero, 2 and 5 years from reactor discharge. Calculation of heat generation by solidified HLW and spent LWR fuel for storage in an interim spent fuel storage installation (ISFSI) or monitored retrievable storage installations (MRS) could be designed on a similar basis. At the present time, fuel reprocessing is not an alternative available to utilities for relieving them of their fuel storage space problems.

TABLE B-2

Radioactivity and Thermal Power in Spent LWR Fuel[a] per Metric Ton Uranium Charged to the Reactor [1]

	Years After Discharge		
	0	2	5
Radionuclide Content, curies			
Important Activation Products			
^{55}Fe	5.62×10^3	3.30×10^3	1.48×10^3
^{60}Co	7.87×10^3	6.05×10^3	4.08×10^3
^{63}Ni	6.62×10^2	6.53×10^2	6.38×10^2
^{125}Sb	1.60×10^3	9.83×10^2	4.64×10^2
^{125m}Te	3.35×10^2	2.40×10^2	1.13×10^2
All Other Activation Products	4.53×10^5	1.20×10^3	2.40×10^2
Total Activation Products	4.69×10^5	1.24×10^4	7.02×10^3
Important Actinides Products			
^{238}Pu	2.19×10^3	2.36×10^3	2.31×10^3
^{239}Pu	3.07×10^2	3.13×10^2	3.13×10^2
^{239}Np	2.21×10^7	1.71×10^1	1.71×10^1
^{241}Pu	1.26×10^5	1.14×10^5	9.91×10^4
^{241}Am	1.02×10^2	4.87×10^2	9.90×10^2
^{244}Cm	1.53×10^3	1.41×10^3	1.26×10^3
All Other Actinides	2.39×10^7	2.40×10^3	1.00×10^3
Total Actinides	4.62×10^7	1.21×10^5	1.05×10^5
Important Fission Products			
^{144}Pr	1.27×10^6	2.12×10^5	1.47×10^4
^{144}Ce	1.26×10^6	2.12×10^5	1.47×10^4
^{137}Cs	1.04×10^6	9.96×10^4	9.29×10^4
^{134}Cs	1.56×10^5	7.98×10^4	2.91×10^4
^{106}Rh	6.56×10^5	1.47×10^5	1.87×10^4
^{90}Y	7.71×10^4	6.98×10^4	6.50×10^4
All Other Fission Products	9.60×10^8	4.33×10^5	2.32×10^5
Total Fission Products	9.65×10^8	1.25×10^6	4.67×10^5
Thermal Power, Watts	7.26×10^6	5.34×10^3	1.82×10^3

[a] Calculated with the ORIGEN code for PWR fuel irradiated to 33,000 MWD/MTU at a specific power of 37.5 MW/MTU.

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13. ABSTRACT (200 words or less)

The Nuclear Waste Policy Act of 1982 (NWPA) addresses the need for development of monitored retrievable storage for spent fuel and high-level radioactive waste. The Commission has examined its regulations and determined that much of existing 10 CFR Part 72 regulations can be used during initial design development for a monitored retrievable storage installation (MRS), however, changes are needed to 10 CFR Part 72 to clarify specific issues which have been raised by the NWPA. The proposed revisions to 10 CFR Part 72 establish licensing requirements for a monitored retrievable storage installation. However, unless Congress authorizes construction of an MRS promulgation of these requirements would not result in construction or operation of such an installation. The issues identified as requiring resolution by the proposal amendments are (1) establishing license criteria for the long-term storage of spent fuel and high-level radioactive waste in an MRS, (2) inclusion of license requirements for the long-term storage of spent fuel and high-level radioactive waste in an MRS under 10 CFR Part 72, and (3) elimination of the current restrictions placed on fuel cladding integrity in the present Part 72 which require the fuel cladding be protected against degradation and gross ruptures, and substitution of restrictions on radioactive releases to the environment.

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