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WHITE PAPER: MULTI-PURPOSE CANISTER (MPC) FOR DOE-OWNED SPENT NUCLEAR FUEL (SNF)

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ABSTRACT

The White Paper, Multi-Purposed Canister (MPC) for DOE-Owned Spent Nuclear Fuel (SNF) examines the issue, "What are the advantages, disadvantages, and other considerations for using the MPC concept as part of the strategy for interim storage and disposal of DOE-owned SNF?" The Paper is based in part on the results of an evaluation made for the DOE National Spent Fuel Program by the Waste Form Barrier/Canister Team, which is composed of knowledgeable DOE and DOE-contractor personnel. The Paper reviews the MPC and DOE SNF status, provides criteria and other considerations applicable to the issue, and presents an evaluation, conclusions, and recommendations. The primary conclusion is that while most of DOE SNF is not currently sufficiently characterized to be sealed into an MPC, the advantages of standardized packages in handling, reduced radiation exposure, and improved human factors should be considered in DOE SNF program planning. While the design of MPCs for DOE SNF are likely premature at this time, the use of canisters should be considered which are consistent with interim storage options and the MPC design envelope.

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Statement of Issue

This White Paper examines the issue: "What are the advantages, disadvantages and other considerations of using the multi-purpose canister (MPC) concept as part of the strategy for interim storage and disposal of DOE-owned spent nuclear fuel (SNF)?" An evaluation of this issue was made for the DOE SNF National Program by the Waste Form Barrier/Canister Team composed of knowledgeable DOE and DOE-contractor personnel (see Appendix A for list of members), and the results, conclusions and recommendations are presented herein.

Background

The Department of Energy Office of Civilian Radioactive Waste Management (DOE-OCRWM) is evaluating the use of an MPC for the interim storage, transportation, and disposal of commercial spent nuclear fuel,[1] and, according to a 2/24/94 DOE news release, Secretary O'Leary "has directed OCRWM to proceed with the next phase of the development program for ... MPCs, including the acquisition of designs for submission to the ... Nuclear Regulatory Commission (NRC) for certification and appropriate environmental review." Following the change in DOE mission to terminate reprocessing of DOE-owned SNF, DOE is developing a program for management of the DOE-owned SNF for interim storage and ultimate disposal with emphasis on using as much commercial technology as possible. Because DOE SNF is quite varied in composition and characteristics, and generally significantly different from commercial SNF, additional characterization and conditioning may be required before disposal. In addition, an immediate need to solve current storage vulnerabilities has been identified by DOE Spent Fuel Working Group.[2] The resulting actions which may be required to solve storage vulnerabilities could result in placement of some of the SNF into interim dry storage before adequate characterization and detailed repository acceptance criteria have been established. This White Paper considers the MPC and DOE SNF characteristics and special needs in an evaluation of the use of an MPC for interim storage, transportation and disposal of DOE SNF.

Multi-Purpose Canister (MPC). As described in a January, 1994, brochure issued by DOE Office of Civilian Radioactive Waste Management (OCRWM), "A multi-purpose canister is a metal container holding spent fuel... Together with appropriate outer containers, or overpacks, it would be used for temporary storage at reactor sites, transportation from reactor sites to the Monitored Retrieval Storage (MRS) facility, temporary storage at the MRS facility, transportation to the repository, and disposal in the repository."[1] The MPC would be designed to provide dry storage, containment, acceptable fuel cladding temperatures, high strength and subcriticality during storage, transportation, and disposal. The MPC concept assumes that it is welded shut and does not have to be opened, which results in advantages, including minimized handling of individual SNF assemblies and compatibility between the dry storage devices used at storage sites and DOE facilities.[1] The storage of MPCs at the reactor will require licensing of the utility under 10 CFR 72 by the NRC. Transportation of the MPC and cask must be certified by the NRC under 10 CFR 71, including a demonstration that the MPC-cask system can withstand hypothetical accident conditions without losing integrity, releasing excessive radioactive materials, or experiencing a criticality. The MPC disposal at the repository will be licensed by the NRC under 10 CFR 60, which includes specifications on the long-term performance of the waste package. The waste package is the

engineered barrier to the release of radionuclides and consists of the waste or SNF, the outer disposal container, or overpack, and an internal container such as the MPC. Thus, the MPC does not have to meet the 300-1000 yr containment requirements of 10 CFR 60.113 by itself, but must be compatible with the highly durable outer disposal overpack to be developed after the repository has been characterized. As part of the schedule for development of the MPC, a Request for Proposal (RFP), including performance specifications, will be issued by DOE-OCRWM in May, 1994.

A conceptual design has recently been issued by DOE-OCRWM and includes the conceptual design of the various components, draft requests for the proposal and design specifications, and results of supporting studies.[3] A feasibility study was issued in which preconceptual MPC designs were completed for the DOE SNF types of N-Reactor, aluminum Advanced Test Reactor (ATR) and Materials Test Reactor (MTR), Three Mile Island (TMI) commercial fuel canisters, and Fort St. Vrain graphite block assemblies.[4] Some of the key points of the DOE-OCRWM conceptual design are described in the following:[3]

Two sizes of the MPC under consideration are a large canister with a capacity of 21 pressurized water reactor (PWR) or 40 boiling water reactor (BWR) assemblies which would weigh nominally 125 tons, including the transport cask, and an intermediate canister with a capacity of 12 PWR or 24 BWR assemblies with a nominal weight of 75 tons, including the cask. A 25-ton transport cask would be used to move fuel from reactors which have access by truck but not by rail for transportation to a facility, such as an MRS, for reloading the fuel into one of the MPCs. The 125-ton MPC concept is only compatible with a high heat-loading strategy at the repository and requires an assumption of burn-up credit for PWR fuel to meet the sub-criticality specifications, otherwise the 75-ton MPC must be used. The conceptual maximum temperature of commercial-fuel zircaloy cladding (10-yr cooled for 20-yr storage) is limited to 340° C by using aluminum sheets to conduct and remove the excess heat. Criticality is controlled by using borated aluminum or stainless-steel alloy in the MPC fuel basket.[3]

An alternative concept, which was also investigated in the conceptual design to provide a basis for evaluating the MPC, includes the transportable storage cask (TSC) system. The TSC is a container which satisfies the interim storage and transportation functions of an MPC, but not the disposal function. Such a dual function concept may be required for some of the DOE SNF in which more uncertainties exist concerning the need for additional stabilization or characterization before disposal.[3]

DOE Spent Nuclear Fuel (SNF). The DOE owns and is currently storing approximately 4506 metric tons total mass or 2675 metric tons mass of heavy metal (MTHM) of SNF and other reactor irradiated nuclear materials, herein referred to as DOE SNF. The SNF includes the following: a variety of reactor irradiated target materials for production of plutonium; fuels irradiated in commercial power reactors with title transferred to DOE for further testing; fuel irradiated for production of plutonium within the fuel itself (Hanford N-Reactor, Single Pass reactor); driver fuel irradiated in reactors containing special targets for isotope production (Savannah River Site (SRS) reactors); fuel irradiated in several types of research and experimental reactors (High Flux Isotope Reactor at Oak Ridge - HFIR, High Flux Beam Reactor at Brookhaven - HFBR, Fast Flux Test Facility at Hanford - FFTF, Advanced Test

Reactor (ATR) and Naval Reactors ship propulsion program at Idaho and others as described in Table 1 and Appendix B.

DOE SNF is made up of over 100 fuel types with a wide range of characteristics, including both low and high enrichment of U-235, high Pu-239 content, metallic and oxide composition, and cladding of zircaloy, aluminum, stainless steel, graphite, and other metal alloys. Table 1 provides an overall summary of selected characteristics of DOE SNF as grouped into eight different categories, and Appendix B gives a more detailed listing. The quantities[5] of SNF in Appendix B and Table 1 are projected for June 1, 1995, the date of the final Environmental Impact Statement (EIS), and are based on the current data base. Each category has a large variety of fuel types, in contrast with the small variety of commercial fuels.

Most DOE SNF is stored at DOE sites, including Hanford for primarily production reactor irradiated materials (approximately 80% of total mass of initial heavy metal-IHM); Idaho for naval reactor, commercial, and research reactor fuel (approximately 11% of IHM); and Savannah River for production reactor fuel and targets, commercial fuel, and research reactor fuel (approximately 7% of IHM). Other sites, including West Valley for commercial fuel, store approximately 2% of IHM of DOE fuels. Figure 1 shows graphically the distribution of DOE fuels for different bases, including total mass, volume, number of storage units, uranium mass, fissile mass, and initial heavy metal mass.

The DOE Order 5820.2A is being revised to include DOE SNF management. The order will include details on some of the issues described in this White Paper, including fuel characterization.

DOE SNF Environmental Safety and Health (ES&H) Vulnerability Assessment

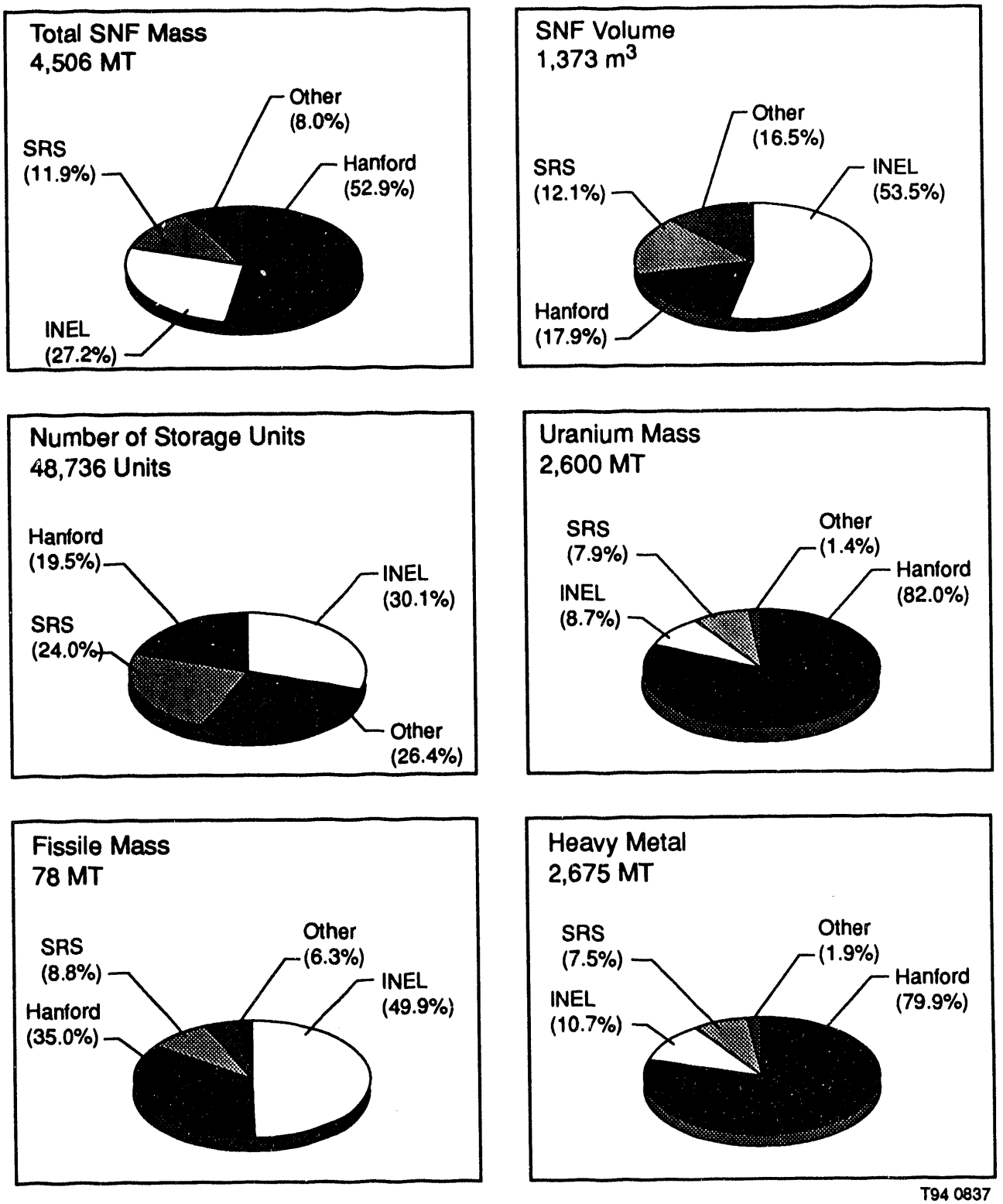
The Spent Fuel Working Group was formed by DOE Office of Environmental Health and Safety (EH) in September, 1993, to provide an itemized inventory of spent fuel and other reactor irradiated nuclear materials and an initial assessment of the ES&H vulnerabilities associated with the current storage and handling of these materials. After a series of meetings and assessments, the Spent Fuel Working Group Report[2] was issued, and five fuel storage facilities were identified that warrant priority management attention to avoid unnecessary increase in worker radiation exposure and cost during clean up. These are the Hanford 105-K East Basin, Idaho Chemical Processing Plant (ICPP) 603 Underwater Fuel Storage Facility, Savannah River L- and K-Reactor Disassembly Basins, and Hanford PUREX Canyon. A draft Phase I action plan has been issued to address the vulnerabilities at these facilities and will likely involve removal of spent fuel into dry storage as soon as possible, generally by 2002, with a minimal amount of fuel characterization.[6] Phase II and III reports are expected to be issued in April and September, 1994, respectively, at which time the following policy issues are expected to be resolved:[6] a) path forward for geologic disposal of SNF, b) licensing of new interim storage by NRC, c) storage of Hanford N-Reactor fuel in a dry configuration, and d) contingency plans if some DOE SNF is deemed unsuitable for extended interim, dry storage or direct geologic disposal.

Table 1. Summary Characteristics of DOE SNF

Type	Fuel Material	Cladding	Enrichment	Burnup	MTHM[a]
1. Naval	Classified	Zr	high	Classified	**9.9**
2. Aluminum-clad	UAl_x UAl_x U metal UO_2	Al Al Al Al	high high depleted high	low high high high	17.7 33.7 138.2 0.6 **190.2** **Sub-Total**
3. Hanford Production	U metal U metal	Zr Al	low low	low low	2100 3.4 **2103.4** **Sub-Total**
4. Graphite	U carbide	Si carbide Graphite	high	medium	**27.6** **Sub-Total**
5. Commercial	UO_2-Intact UO_2-Damaged Other	Zr Zr SS	low low low	high high high	74.3 82 2.5 **158.8** **Sub-Total**
6a. SS Test	U metal PuO_2 UO_2or alloy Other Other	SS SS SS SS SS	high high low high low	high high high various various	48.4 9.5 47.9 0.09 1.05 **106.9** **Sub-Total**
6b. Zr Test	U-Mo alloy UO_2 UO_2 Other	Zr Zr Zr Zr	high low low high	low unknown high various	4 43 18 12 **77.0** **Sub-Total**
6c. Other	U-F salts	none	low	low	**0.04** **Sub-Total**

2675 Total

[a] Projected to June 1, 1995, the proposed issue date of the DOE SNF EIS.



MT - Metric tons (1000 kg or 2,205 lb)
INEL - Defined here as the physical location and includes DOE-ID facilities, NRF and ANL-W
Other - Includes other DOE sites, non-DOE domestic reactor fuel, and research reactor fuel that will be owned and managed by DOE

Figure 1. Distribution of DOE SNF throughout all DOE Sites. Comparison based on mass, volume, number of storage units, U mass, mass of fissile material, and mass of heavy metal

DOE SNF National Program

The DOE SNF National Program has been set up under DOE Office of Environmental Management (EM) EM-37 to coordinate the assessment and dispositioning of all DOE SNF. Major activities to date include an SNF Strategic Plan, an SNF Database, an assessment of facilities, and a development of an Interim Storage Plan, Characterization Plan and Technology Integration Plan. A Systems Engineering program is being undertaken to develop a comprehensive schedule of work required for the duration of the DOE SNF program.

DOE Spent Fuel Strategic Plan. A draft Strategic Plan has been developed, which recommends the following:

- Place SNF in 40-year safe interim storage as soon as possible
- Shut down inadequate existing storage facilities
- Minimize immediate characterization to support only dry storage needs
- Complete necessary characterization prior to disposal
- Condition the SNF for disposal based on the repository waste acceptance criteria
- Place SNF eventually in the first geologic repository

DOE Spent Fuel Interim Storage Plan Issues. Preparation of an Interim Storage Plan has been started with the goal to achieve safe, cost-effective interim storage of all DOE SNF pending repository disposal. Topics which will be addressed include the consolidation of DOE fuel storage locations, fuel conditioning strategies, facility upgrades and replacements, transportation, schedules and cost estimates. Some of the technical issues which have been identified include dry vs wet storage, conditioning requirements, storage condition envelope, storage of degraded fuel, location of storage facilities, fuel shipments, and interface and consistency with DOE-OCRWM fuel storage, transportation and disposal. A draft report describes technical issues for possible dry storage of DOE-owned fuel.[7] Recently, DOE EM-37 has announced the possibility of constructing new interim storage facilities under NRC licensing oversight,[8] which may also help to meet waste acceptance requirements for disposal in a repository.

Team Criteria and Related Considerations for the Evaluation of Use of an MPC for DOE SNF

The Waste Form Barrier/Canister Team met in Idaho Falls on February 23, 1994. The objective of this Team meeting was to review existing DOE SNF information and provide a preliminary assessment whether or not the MPC should be included as part of the strategy for interim storage and eventual disposal. The list of Team members and meeting attendees is shown in Appendix A.

The Team developed criteria which were considered to be important for the use of an MPC for the storage, transportation, and disposal of DOE SNF. The criteria and related considerations include fuel durability, hazardous waste potential, temperature limits, criticality safety, special nuclear materials (SNM) issues, waste package design requirements, fuel acceptance specifications, similarity with commercial fuel, timing, segregation of SNF categories, and programmatic issues. These are described in the following:

Fuel Durability, Dimensions, and Composition. The DOE SNF has such varied physical dimensions, compositions and cladding materials, generally with higher cladding failure rate than commercial fuel. For example, the N-Reactor fuel has a large number of elements with failed zircaloy cladding which was caused as part of normal operations, when the elements were pushed through the lined graphite channels and dropped onto a trampoline during removal from the reactor. Other fuels such as the aluminum-clad fuels have experienced high corrosion rates from storage in basins with poor water chemistry or which are beyond the expected storage life. The degree of radiation embrittlement and corrosion product (crud) need to be determined for handling and contamination potential. Standard sized fuel canisters might provide a benefit in allowing for standardized handling and contamination control while being sized to fit into the storage configuration for interim storage as well as an MPC. Spent fuel dimensions and composition must be characterized for storage and transportation requirements, including radiation shielding, decay heat removal and criticality control. In addition, DOE SNF must be further characterized for repository disposal performance assessment in support of licensing requirements which have not yet been finalized. Compatibility of DOE SNF canister materials with the disposal container materials must be determined to protect against galvanic corrosion in an MPC or disposal package.

Potential for Designation as a Hazardous Waste. The Resource Conservation and Recovery Act (RCRA) applies to management and disposal of mixed radioactive and hazardous waste. Some of the DOE SNF contains potentially hazardous materials such as hydrides, carbides, sodium and cadmium. A RCRA compliance study is currently under way as part of the DOE national SNF program to determine how the DOE SNF categories would fit under a hazardous waste category. This could have a significant impact on interim storage and disposal and on the appropriate regulatory courses of action. There is currently no provision for emplacing RCRA waste in the repository.

Temperature Limits of DOE SNF. Commercial fuels which consist of heavy metal oxides and zircaloy cladding have been thoroughly evaluated and determined to be able to withstand a cladding temperature of 340 °C. DOE SNF compositions range from heavy metal oxides to metal alloys and in cladding from zircaloy to aluminum and other metals. Maximum allowable cladding temperatures for aluminum fuels may be significantly lower than for commercial fuels, possibly as low as 150 °C. If a "hot" thermal loading strategy is adopted for the repository, the expected host rock temperatures will be higher than 150 °C. Depending on the cladding conditions, some of the other materials may also have lower temperature limits. Significant research is still needed to develop the technical criteria and accepted thermal performance of the DOE SNF in dry storage.

Criticality Safety. Some of the DOE SNF contains high-enriched uranium (HEU) or plutonium, and criticality control must be developed for storage, transportation and disposal in

accordance with 10 CFR 71, 10 CFR 72, and 10 CFR 60. Calculations have shown that HEU present in some of the DOE SNF could achieve a criticality with as little as 0.7 kg in one package during disposal, assuming that the optimal configuration can be attained.[9] Thus, if the licensing requirements specify that criticality must be avoided even after closure of the repository, large MPCs containing over 100 kg of HEU would likely not be allowed. A special DOE SNF program task team is currently evaluating the consequences and performance assessment of a criticality event after closure of the repository.[10]

Special Nuclear Materials (SNM) Protection - Safeguards and Accountability. If the disposal of DOE SNM occurs in conjunction with the DOE-OCRWM programs, as is planned, it may be subject to International Atomic Energy Authority (IAEA) safeguards. For example, SNM in commercial fuels is well quantified, clearly marked with alphanumeric identifiers, and plans for tracking throughout the DOE-OCRWM program are being developed. Similar methodology must be developed for DOE SNM, including those materials which are classified for security. The degree of safeguards depends on the amount of SNM present in the fuel and would be expected to be very stringent for HEU or large amounts of plutonium. Commercial fuel and vitrified HLW are assumed to have low enough fissile content and high radiation fields to consider that diversion for production of nuclear weapons is not likely. The safeguards, once the fuel has been placed in a repository, could range from extensive in-place monitoring of fuel containers to simple monitoring of the storage facility for intrusion. If some of the DOE SNF is placed in large MPCs, significantly large quantities of HEU would be located in one canister and conceivably could be accessible through direct contact mining hundreds of years after disposal, when most of the shorter-lived fission products have decayed.

Repository Waste Package Design Requirements (10 CFR 60.135). Geologic disposal design requirements specified by 10 CFR 60.135 applicable for all waste packages and their components include provisions such as avoiding explosive, pyrophoric and chemically reactive materials, and free liquids; designs with a unique identification which maintain waste containment during transportation, emplacement, and retrieval; waste form criteria that include solidification in a sealed container and consolidation of particulates in an encapsulation matrix; and conversion of combustibles to a non-combustible form. Extensive characterization and/or assessment is required to ascertain whether the expected condition of most DOE fuels at the end of the dry storage period could satisfy these requirements unless significant conditioning were performed prior to placement into dry storage.

Fuel Acceptance Specifications. Current specifications for fuel acceptance at the repository are given generally in 10 CFR 961 and in the Waste Acceptance System Requirements Document (WASRD).[11] 10 CFR 961.5 requires Federal agencies or departments requiring disposal services to sign a suitable agreement reflecting the terms and conditions of 10 CFR 961.11. The commercial fuel acceptance specifications in the WASRD include information on chemical and radionuclide composition, burn-up, heat loading, and criticality control. Adequate quality assurance must be provided in the supporting fuel information to meet DOE-OCRWM and NRC requirements. Some performance assessments have been completed or are under way to evaluate the impacts of some of the DOE SNF disposal scenarios. The Team members agreed that while these specifications and the commercial fuel comparisons

can provide indicators for DOE SNF acceptance, this may not be resolved until actual licensing of the repository takes place.

Degree of Similarity of DOE Fuels with Commercial Fuel Storage/Disposal. DOE fuels with a higher degree of similarity to commercial fuel may be more likely to meet the storage, transportation, and disposal requirements assumed for commercial fuel in an MPC. Some DOE-owned fuels, such as the intact commercial fuels, have similar dimensions, enrichment, cladding, burn-up, and other characteristics to commercial fuels which would be placed in MPCs and would not be expected to require additional acceptance requirements. Other DOE-owned fuels, such as high-enriched aluminum test reactor fuels have significantly different dimensions and characteristics from commercial fuels and could require additional characterization and waste qualification effort for repository disposal. N-Reactor fuels use low enrichment and zircaloy cladding which are similar characteristics to commercial fuel, but have different dimensions, use a uranium metal alloy rather than uranium oxide, and exhibit a higher percentage of damaged cladding compared to commercial fuel. Standardized canister designs for each DOE fuel type which are compatible with interim storage vaults and commercial MPC designs would be beneficial from systems safety and human factor considerations.

Timing. The timing for removal and interim storage of DOE SNF will be determined by facility vulnerabilities,[2] state agreements, and licensing or certification of shipping casks and interim storage. The schedule for moving DOE SNF out of some of the old facilities with identified ES&H vulnerabilities to alternative storage is approximately 8-10 years.[6] The MPC schedule for commercial fuels includes design specifications for the bid package completed by May, 1994, and fabrication of the first models would be completed by 1998. If the MPC concept is desired for DOE SNF dry storage, the schedule which is determined by facility vulnerability may require detailed MPC design information before it is available. Significant additional characterization and design effort, resulting in a signed acceptance agreement, similar to 10 CFR 961 for commercial fuels, would likely be required for DOE SNF before sealing the fuel in an MPC with sufficient confidence for repository acceptance as compared to the commercial fuel and HLW glass cases.

Segregation of DOE SNF Categories. Because of the different types of DOE SNF and their characteristics, such as low or high enrichment of fissile materials, one criterion proposed by the team is to keep DOE SNF categories or dissimilar fuel types segregated during interim storage and do not combine with other categories. This would allow conditioning of some categories if deemed necessary with minimum disruption of interim storage of the other categories.

Other Programmatic Issues Impacting Repository Disposal. Programmatic issues which need to be addressed and resolved for DOE SNF disposal in a repository include development of metric tons heavy metal equivalence, declassification of information, repository schedule impacts and consequences, transportation cask and system design and licensing, waste acceptance planning, including completion of a Memorandum of Agreement between DOE-EM and -OCRWM, projections of future production, and quality assurance.

Evaluation of MPC Use for DOE SNF

The following reviews the bases and drivers which impact DOE SNF interim management and presents the advantages and disadvantages of MPC use. A detailed evaluation of the above criteria as applied to each fuel type is given in Appendix C.

Bases. In order to have common bases for the evaluation, the Team agreed that the MPC consists of a tri-purpose canister used for storage, transportation, and disposal, which is sealed by welding after loading with fuel and then remains closed throughout interim storage, transportation and emplacement in a repository. The MPC would be considered as part of the waste form during disposal and would be placed in a long-lived overpack at the repository. It would thus not be required to take credit for the complete containment requirement during 300-1000 years given in 10 CFR 60.113. The fuel inside the MPC would have to be sufficiently characterized to meet DOE-OCRWM waste acceptance requirements and NRC licensing. While DOE SNF waste acceptance requirements have not yet been finalized, requirements for any waste in the repository exist in 10 CFR 60, and commercial SNF requirements exist in 10 CFR 961 and the WASRD document.[11] Such requirements include the fuel, cladding and basket material characterization for chemical and radionuclide composition, operating history including burnup, thermal output, and criticality control. The waste form qualification information may be required only to the extent that it will be possible to obtain the characteristics which will bound that particular fuel type. In addition, the MPC and SNF would have to meet transportation requirements, such as limits to hydrogen generation. The DOE SNF National Program has not yet reached a decision concerning the proposed extent of dry versus wet interim storage. Since MPCs are planned for dry commercial SNF storage, in the following evaluations of this White Paper, it was assumed that any interim storage of DOE SNF would use dry storage for comparison.

Drivers. The major drivers which will impact the use and timing of MPCs for DOE SNF include (1) the ES&H vulnerabilities as identified in the Spent Fuel Working Group,[2] and resulting action plans,[6] (2) programmatic dry storage plans with minimum characterization to meet NRC disposal criteria as described in the DOE Spent Fuel Strategic Plan, (3) the DOE program for development of MPCs for commercial fuels, (4) lead time required to secure NRC licensing for storage and transportation casks, MRS, and (5) lead time to provide sufficient DOE SNF testing for characterization and repository performance to secure NRC repository licensing. These drivers have potentially conflicting goals, such as the degree of characterization needed for dry storage compared to repository disposal, and the timing for fuel removal from storage basins considered to have ES&H vulnerabilities compared to the timing required for sufficient characterization for MPC use.

Advantages of MPCs for DOE SNF. The Team generally agreed that the advantages cited for MPC use for commercial fuel also applied to DOE SNF. These include common handling of standard packages, reduced radiation exposure to the public, containment of contamination, improved human factors and operation efficiency. A common design for all fuel and waste should reduce the overall handling, transportation and repository emplacement costs in a simpler, more integrated operation, thus requiring fewer modifications for DOE-OCRWM to accept DOE SNF. Based on the decision to continue development of an MPC for commercial SNF, any concepts for DOE fuel disposal would have to be compatible with the MPC designs

at a minimum in handling, transportation and disposal operations. There may be an advantage if the designs for interim storage were within the design envelope for an MPC even if further characterization and stabilization were required prior to disposal.

Disadvantages of MPCs for DOE SNF. Most of the Team members' evaluation focused on the question of feasibility and uncertainty which would drive the development needs and costs and might offset the advantages. The greatest uncertainty focused on repository waste acceptance criteria and if the different DOE fuels would meet the criteria compared to commercial SNF. Waste characterization sufficient to meet similar criteria as for commercial fuel might have to be carried out earlier than previously planned in the DOE SNF National Program and interfere with the desired timing to remove fuel stored in vulnerable basins. If fuel requires further characterization, testing or stabilization to resolve waste acceptance concerns, this would also impact the National Plan timing. The design criteria for the MPC are expected in 5/94. The schedule for detailed design needs to be evaluated to determine if sufficient time is available to be incorporated in DOE SNF interim storage facilities. Much of the DOE fuel should be in interim storage by 2002, which may not leave sufficient time to determine acceptability for repository disposal. Available fuel records and QA levels need to be evaluated to determine if sufficient fuel characterization information is available to meet waste acceptance specifications.

Conclusions

DOE-OCRWM is now proceeding with the next phase of developing the MPC for interim storage, transportation, and disposal of commercial fuel. If the MPC concept is successful for commercial fuel, DOE-owned SNF will eventually have to be interfaced within the MPC design envelope for transportation and disposal to meet the logistics requirements. This White Paper has presented many of the issues, criteria, and other considerations, including facility vulnerabilities, DOE SNF characterization, timing, and waste form qualifications and acceptance, which will have to be considered in determining the timing for adopting the MPC design envelope. The Barrier/Canister Team determined that the degree of characterization of DOE SNF may not be sufficient to meet repository waste acceptance requirements and thus that most of DOE SNF is currently not ready to be sealed into an MPC for final disposal. However, the advantages of standardized package handling, reduced radiation exposure, reduced potential of spread of contamination, improved human factors and reduced operation costs would benefit the DOE SNF program planning for interim storage and transportation and should be included as much as possible. While designs of MPCs for DOE SNF are likely premature at this time, the possibility of designing and using fuel canisters which will be consistent with the interim storage options and MPC design envelope should be pursued. The DOE MPC and DOE SNF programs need to be coordinated through internal agreements to allow for optimum interchange of design information in support of developing DOE interim storage and of eventual interfacing with the MPC design envelope.

Recommendations

Specific recommendations can be made involving program coordination, systems engineering, fuel characterization, quality assurance, testing, and design of interim storage for DOE SNF:

- The MPC design and development activities under DOE-OCRWM and the DOE SNF interim storage activities under DOE-EM should include a mechanism for inter-program coordination in order that DOE SNF interim storage can be designed with sufficient flexibility for future MPC use, should the MPC become the accepted method for commercial fuel dispositioning.

- As part of the DOE SNF National Program systems engineering study, the use of standard canisters for DOE SNF should be evaluated, including tradeoffs on canister size, existing facility capabilities, and adaptability to proposed interim storage configuration and MPC design dimensions.

- The characteristics of MPCs, including optimum packaging compatible with internal MPC dimensions, reduced radiation exposure, containment of contamination, and improved human factors should be incorporated as much as possible into the designs for interim storage packages of DOE SNF.

- The fuel characterization effort should include compiling records to assess those fuels with well-qualified data, fuels with possible RCRA hazardous materials, and fuels with possible waste-form problems as described in 10 CFR 60.135, with a goal of determining waste qualification needs for DOE SNF.

- DOE SNF needs to be evaluated for materials characterization needs, and test programs should be developed to evaluate the material performance in interim storage, transportation and disposal.

- The existing quality assurance programs should be upgraded to meet DOE-OCRWM and applicable NRC standards in completing the fuel characterization and eventually meeting waste qualification standards.

- Impacts of criticality and SNM requirements for HEU and other applicable fuels should be continued to be evaluated in coordination with DOE-OCRWM and its M&O contractors.

References

1. U. S. DOE, OCRWM, Conceptual Design for a Waste-Management System that Uses Multipurpose Canisters, DOE/RW-0432 (January 1994).

2. U. S. DOE, Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and their Environmental, Safety and Health Vulnerabilities, Vol. 1 (November 1993).

3. CRWM M&O Contractor, MPC Implementation Program Conceptual Design Phase, Volume I - MPC Conceptual Design Summary Report, Revision 0, A20000000-00811-5705-00001, TRW Environmental Safety Systems Inc., 2650 Park Tower Drive, Suite 800, Vienna, VA 22180 (September 30, 1993).

4. D. A. Lopez and D. G. Abbott, Feasibility Study for a DOE Research and Production Fuel Multipurpose Canister, EGG-WM-11011 (February 1994).

5. A. P. Hoskins, Personal Communication, "Projected Spent Nuclear Fuel Inventory for EIS Preparation," (April 12, 1994).

6. U. S. DOE, Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities, Phase I, Vols. I and II (February 1994).

7. M. Louthan, R. Einziger, and M. McKinnon, Technical Issues for Possible Dry Storage of DOE Owned Spent Nuclear Fuels (to be published, 1994)

8. J. Jicha, "The Department of Energy Spent Fuel Program," INMM Spent Fuel Workshop, Washington, D.C. (January 25-28, 1994)

9. H. C. Paxton and N. L. Pruvosp, Critical Dimensions of Systems Containing U-235, Pu-239, and U-233, LA-10860-MS (1968).

10. R. P. Rechard, Editor, Performance Assessment of the Disposal of Spent Nuclear Fuel and High-Level Waste Stored at Idaho National Engineering Laboratory, Appendix on Criticality Modeling (to be published, December 1994).

11. U. S. DOE, OCRWM, Waste Acceptance System Requirements Document (WASRD) Revision 1, DOE/RW-0351P (March 1994).

APPENDIX A. LIST OF ATTENDEES OF 2/23/94 TEAM MEETING AND WASTE FORM BARRIER/CANISTER TEAM MEMBERS

Attendees of 2/23/94 Meeting

NAME	ORGANIZATION	PHONE	FAX
Dave Abbott*	EG&G Idaho	208-526-0037	208-526-8878
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Alan P. Hoskins	WINCO	208-526-4620	208-526-3505
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Wally Keltner	WINCO	208-526-3537	208-526-4741
Ron Klingler	WINCO	208-526-0183	208-526-7392
Dieter A. Knecht*	WINCO	208-526-3627	208-526-3499
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Ron E. Mizia*	WINCO	208-526-3352	208-526-6517
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David Ostby	WINCO	208-525-0015	208-525-0029
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APPENDIX B. DETAILED DESCRIPTION OF DOE SNF CHARACTERISTICS AND QUANTITIES

The DOE SNF is grouped into 8 categories. The categories are labeled "Jicha Cat. 1, 2, 3, 4, 5, 6a, 6b, and 6c" and are an attempt to group similar fuel types.

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
Naval Fuel											
1	INEL	CPP-603	Naval	50000	15	200		950		900	0.947
1	INEL	CPP-666	Naval	300000	80	600		5900		5800	5.9
1	INEL Subtotal			350000	95	800		6850		6700	6.847
1	NRF	ECF	Naval	150000	37	240		2500		2500	2.5
1	NRF	Prototype	Naval	39000	11	48		570		570	0.6
1	NRF Subtotal			189000	48	288	0	3070	0	3070	3.1
1	Other Navy										
1	Other Navy Subtotal										
1	TOTAL			539000	143	1088		9920		9770	9.947
SRS & Al Fuel											
2	Brookhave	BMRR	BMRR	6	0.03	36	assem	1.88	89.9	2.7	0.003
2	Brookhave	HFBR	HFBR	900	3.2	937	unit	250	93	203	0.252
2	Brookhaven Subtotal			906	3.23	973		251.88		205.7	0.255
2	INEL	TRA-660	ARMF/CFRMF	50	0.076	67	unit	14.1	93	12.5	0.014
2	INEL										
2	INEL	TRA-670	ATR recycle	584	6.2	591	elem	472	86	409	0.472
2	INEL	TRA-660	Core Filter	1000	0.003	1	unit	217	depleted	0.42	0.217
2	INEL	TRA-670	ATR spent	940	1.3	92	assem	94	82.6	78	0.094
2	INEL	ATR core	ATR	102.5	0.96	40	elem	46.1	83	40.8	0.046
2	INEL	CPP-666	ARMF	3.6	0.014	15	plate	0.2	90	0.18	0.0002
2	INEL	CPP-603	ATR	937.5	1	109	assem	90.5	82	74.82	0.099
2	INEL	CPP-603	HFBR	87.3	0.075	19	assm	5	79.9	4	0.005
2	INEL	CPP-603	MURR	158	0.24	25	assm	17	87.5	14.8	0.016
2	INEL	CPP-603	ORR	85	0.07	17	assm	3.3	80	2.6	0.0033
2	INEL	CPP-666	ATR	9000	9	1027	assm	821	82	673	0.83
2	INEL	CPP-666	HFBR	1013	0.865	221	assem	58.4	79.9	46.7	0.0584
2	INEL	CPP-666	MURR	198	0.3	31	assem	21	87.5	18.5	0.022
2	INEL	CPP-666	U of Wash	70	0.07	26	bund	4.1	93.6	3.6	0.0041
2	INEL Subtotal			14798.9	20.173	2281		1863.7		1378.92	1.881
2	LANL	CMR	OMEGA-W	40	0.4	61	elem	12.25	93	11.4	0.012
2	LANL	Pool	OMEGA-W	180	0.3	40	elem	9	93	8	0.009
2	LANL Subtotal			220	0.7	101		21.25		19.4	0.021
2	ORNL	Bld 3019	SRS U-233	100	1	144	can	70	100	70	0.07
2	ORNL	Bld 3019	Hanford U-233	50	0.3	41	can	23	100	23	0.023
2	ORNL	BSR	BSR	185	0.2	41	elem	3	93	2.4	0.003
2	ORNL	BSR	ORR	142.7	0.18	32	unit	3	19.8	0.6	0.003
2	ORNL	HIFR	HIFR	8800	7.5	60	assm	564	93	525	0.57
2	ORNL	TSR	TSR	182	0.1	1	assem	9.2	93	8.6	0.0092
2	ORNL Subtotal			9459.7	9.28	319		672.2		629.6	0.6782
2	SANDIA		CX	60	0.1	19	elem	23	93	20	0.02
2	SANDIA	SNM stor	SPR-II	20	0.1			12	93	10	0.01
2	SANDIA	SPR	SPR-II	200	0.1	6	elem	92	93	80	0.08

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
2	SANDIA	SPR	SPR-II&III	40	0.1			31	93	30	0.03
2	SANDIA	SPR	SPR-III	800	0.1	18	elem	227	93	220	0.22
2	SANDIA Subtotal			830	0.5	43		385		370	0.37
2	SRS	F-CANYO	Target	22200	5.2	1224	slug	22612	0.18	42	22.634
2	SRS	H-CANYO	Driver	130	0.42	13	asem	67.8	61	41.4	0.068
2	SRS	K-BASIN	Driver	30820	29	901	asem	3237	66	2113.5	3.256
2	SRS	KLP-BASI	non U Target	80	0.38	104	units	0.04	0	4.2	0.059
2	SRS	L-BASIN	Driver	15900	16.7	518	asem	2593	60	1546	2.613
2	SRS	L-BASIN	Target	115900	26.5	6246	slug pa	115383	0.18	211	115.498
2	SRS	P-BASIN	Driver	10200	14.8	449	asem	1391.2	66	921.3	1.408
2	SRS	RBOF	ANL Janus	20	0.1	4	bundle	2.79	93	2.59	0.003
2	SRS	RBOF	ASTR	60	0.1	4	bundle	3.22	93	3	0.003
2	SRS	RBOF	JMTR	200	20	71	assem	16.7	89	14.8	0.0167
2	SRS	RBOF	MIT	300	0.1	16	bundle	15.93	81	12.92	0.016
2	SRS	RBOF	MURR	2700	10	36	bundle	48.6	87	42.2	0.0486
2	SRS	RBOF	Nereide	900	0.4	8	bundle	35.42	19.8	7	0.035
2	SRS	RBOF	ORR-LEU	1000	0.5	14	can	95	15.7	15	0.0157
2	SRS	RBOF	ORR	1000	1	33	unit	116	27	31.9	0.115
2	SRS	RBOF	RHF	900	0.3		tube	25.5	81	20.78	0.0255
2	SRS	RBOF	RINC	30	0.1	6	bundle	3.7	89	3.3	0.0037
2	SRS	RBOF	Sterling Forest	900	4	932	can	123	91	112	0.123
2	SRS	RBOF	Taiwan RR	200000	3.4	143	can	20469	0.63	128	21
2	SRS	RBOF	U of Michigan	300	10	48	assem	33.85	15	4.96	0.0339
2	SRS	RBOF	U of Virginia	10	4	12	assem	1.9	89	1.7	0.0019
2	SRS	RBOF	EBR-II Target	50000	6	60	slugs	16983	0.25	194	17
2	SRS	RBOF	target samples	400	0.8		assem	369.3	0.2	0.67	0.37
2	SRS	RBOF	Foreign from relief	1000	0.2	448	elem	60	60	36	0.06
2	SRS Subtotal			418220	150.7	11290		183687		5510.22	184.407
2	Miscellaneous Facilities										
2	Pleasanton		GENTR	80	0.1	32	elem	8	93	7.2	0.008
2	Gaithersburg		NIS	200	0.2	186	elem	40	93	37	0.04
2	Miscellaneous Facilities Subtotal			280	0.3	218		48		44.2	0.048
2	University										
2	MIT		MTR type	290	0.1	63	elem	26.61	90	24	0.026
2	Cornell		ZPTR	3000	0.1	6	elem	1702	2.1	35.7	1.7
2	U of Florida		Argonaut	270	1	28	elem	23.68	93&19	12	0.024
2	Georgia		MTR type	290	0.1	25	elem	28.45	93&19	14	0.029
2	Iowa St.		MTR type	200	0.1	28	elem	20.18	19	4	0.02
2	U of Mass Lowell		MTR type	230	0.1	32	elem	23.18	93&19	12	0.023
2	Manhattan		ZPR	200		17	elem	19.6	19.8	4	0.019
2	U of Michigan		MTR type	500	0.1	72	elem	92.54	19.8	18	0.093
2	MURR Col.		MTR type	500	0.1	64	elem	46.83	93	45	0.047
2	MURR Rol.		RRR	200	0.1	56	elem	18.4	19.8	4.2	0.018
2	N. Carolina		PULSTAR	1000	0.1	34	pins	444.5	3.9	17.3	0.445
2	Ohio St.		OSR	200	0.3	24	elem	19.28	19.8	4	0.02
2	Purdue		MTR type	200	0.2	13	elem	14.03	93&19	7	0.014
2	Rhode Is.		MTR type	500	0.1	53	elem	30.28	19.8	7.5	0.03
2	U of Virginia		MTR type	500	0.1	32	elem	25.1	93&19	13	0.025
2	Worcester		MTR type	300	0.1	27	elem	17.98	19.8	9	0.018
2	University Subtotal			8310	2.7	574		2552.64		230.7	2.551
2	TOTAL			453024.6	187.58	15799		189481.6		8388.74	190.2112

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
Hanford Fuel											
3	Hanford	KE-BASIN	N Reactor	1234891	112	3667	canst	1143800	0.95	16142	1145.96
3	Hanford	KE-BASIN	SPR	408	0.04	4	canst	400	0.95	4	0.4
3	Hanford	KW-BASI	N Reactor	1027818	93	3815	canst	951900	1.08	14039	953.8
3	Hanford	KW-BASI	SPR	102	0.01	2	canst	100	1.15	1.15	0.1
3	Hanford	PUREX	N Reactor	291	0	20	elem	267	0.95	2.528	0.3
3	Hanford	PUREX	SPR	2927	0.2	779	elem	2870	0.064	1.837	2.87
3	TOTAL			2266437	205.25	8287		2099337		30190.5	2103.43
Graphite Fuel											
4	INEL	CPP-IFSF	Peachbottom core 1	730	0.82	18	elem	4.6	75.7	4.4	0.046
4	INEL	CPP-IFSF	Peachbottom core 2	33000	15.7	789	elem	126	53.3	119	1.3
4	INEL	CPP-749	Peachbottom core 1	32270	36.2	796	elem	202	75.7	194	1.654
4	INEL	CPP-IFSF	FSVR	95000	80	744	assm	308	54	189	8.6
4	INEL Subtotal			161000	132.72	2347		640.6		506.4	11.6
4	Pub. Ser. o	FSVR	FSVR	190000	160	1446	assem	616	54	333	16
4	Pub. Ser. Subtotal			190000	160	1446		616		333	16
4	ORNL	Bld 7829	Peachbottom	552	0.5			3	76	2	0.003
4	ORNL Subtotal			552	0.5	0	0	3	76	2	0.003
4	TOTAL			351552	293.22	3793		1259.6		841.4	27.603
Commercial Fuel											
5	ANL-E	Hot cell	Commercial	[redacted]		1	canst	19.5	4.7	0.9	0.019
5	ANL-E Subtotal			40	0	1		19.5		0.9	0.019
5	Hanford	Bld-324,5	LWR	100	4.1	10	cask	93	2	4	0.09
5	Hanford	Bld-324,5	Calvert Cliffs (PWR)	1000	0.37	2	assem	663	0.64	18	0.67
5	Hanford	Bld-324,5	Cooper (BWR)	500	0.17	2	assem	365	0.69	9	0.37
5	Hanford	Bld-324,5	HB Robinson (PWR)	50	0.005	14	rod	30	0.72	1	0.03
5	Hanford	Bld-324,5	Point Beach-1 (PWR)	1500	0.56	3	assm	1151	0.89	35	1.16
5	Hanford Subtotal			3150	5.205	31		2302		67	2.32
5	INEL	CPP-603	Pulstar Buffalo	332	0.1	24	can	251.4	4.8	13.5	0.252
5	INEL	TRA-603	OPTRAN	28	0.08	5	canst	19.7	2.5	0.63	0.0197
5	INEL	TRA-603	CANDU	19.4	0.03	2	canst	2.6	9.8	0.26	0.0026
5	INEL	TRA-603	Dresden SA-1	40.4	0.13	31	rod	18.6	2.1	0.54	0.0186
5	INEL	TRA-603	GAP CON	12.5	0.08	14	rod	8.94	10	0.89	0.0089
5	INEL	TRA-603	HALDEN IFA	3.3	0.07	5	rod	2.3	9.6	0.23	0.0023
5	INEL	TRA-603	HB Robinson	8.9	0.08	5	canst	6.3	0.75	0.13	0.0063
5	INEL	TRA-603	Halden	6.5	0.07	13	rod	4.55	depicted	0.46	0.0045
5	INEL	TRA-603	LOFT LEAD ROD	5	0.02	7	rod	3.5	9.3	0.33	0.0035
5	INEL	TRA-603	MAPI	31.8	0.96	49	rod	22.3	5.7	1.39	0.022
5	INEL	TRA-603	Peachbottom	13.4	0.08	5	canst	9.4	1.4	0.22	0.0094
5	INEL	TRA-603	RIA	8.6	0.08	8	canst	6.1	5.7	0.36	0.0061
5	INEL	TRA-603	Saxton	10.2	0.115	18	rod	7.1	8.9	0.66	0.0089
5	INEL	TRA-603	TC	3.6	0.03	6	rod	3.1	10	0.3	0.0031
5	INEL	TAN-607	BCD-LFRSB	441	0.19	1	assm	310	0.5	5.3	0.31
5	INEL	TAN-607	Con Yankee	540	0.19	1	assm	380	1.4	10.9	0.38
5	INEL	TAN-607	Peachbottom	234	0.17	1	assm	167	1.4	5.2	0.167
5	INEL	TAN-607	Peachbottom	271	0.17	1	assm	188	0.7	13	0.188

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
5	INEL	TAN-607	Surry	20000	6.16	33	assm	14000	0.7	291	14
5	INEL	TAN-791	BCD B17	657	0.19	1	assm	410	0.8	8.2	0.41
5	INEL	TAN-607	Dresden	235	0.13	55	rod	165	depleted	0.7	0.165
5	INEL	TAN-791	EMAD	3084.6	0.94	5	assm	2200	0.7	41.8	2.2
5	INEL	TAN-607	HB Robinson	367	0.49	125	rod	257	0.7	5	0.257
5	INEL	TAN-607	LOFT	3600	1.3	14	assm	2200	4.1	90.2	2.2
5	INEL	TAN-607	LOFT fines	6.2	0.001	5	can	4.33	10.5	0.45	0.0105
5	INEL	TAN-607	TMI-2	120000	129	342	canst	82000	2.2	2100	82
5	INEL	TAN-791	DRCT	30000	4.54	24	can	21000	0.8	423	21
5	INEL Subtotal			179959.4	145.4	800		123647.2		3014.67	123.6554
5	Lynchburg		Arkansas-1	[redacted]	0.03	4	canst	11.76	0.4	0.05	0.015
5	Lynchburg		Con Edison								
5	Lynchburg		Oconee-1	[redacted]	0.03	4	canst	7.91	1.3	0.1	0.008
5	Lynchburg		Oconee-1								
5	Lynchburg		Oconee-2	[redacted]	0.05	7	canst	19.5	0.9	0.17	0.021
5	Lynchburg		TMI-2								
5	Lynchburg Subtotal			60	0.11	15		39.17		0.32	0.044
5	ORNL	BLD-3019	Con. Edison	[redacted]	1	405	can	1215	5	[redacted]	1.215
5	ORNL	BLD-4501	BR-3				rod				
5	ORNL	BLD-4501	GETR				cap				
5	ORNL	BLD-4501	HB Robinson (PWR)				rod				
5	ORNL	BLD-4501	Monticello (BWR)				rod				
5	ORNL	BLD-4501	Oconee-1 (PWR)				rod				
5	ORNL	BLD-4501	Peachbottom				rod				
5	ORNL	BLD-4501	Quad City-1 (BWR)				rod				
5	ORNL										
5	ORNL	Various	Various Commercial	[redacted]	[redacted]	40	Section	7	5	0.35	0.007
5	ORNL Subtotal			2010	2	445		1222		60.35	1.222
5	SRS	RBOF	CANDU	[redacted]	0.16	6	can	50.2	0.46	0.23	0.0502
5	SRS	RBOF	VBWR	[redacted]	0.003	4	bundle	11.9	10.4	1.24	0.012
5	SRS	RBOF	Dresden Power Rx	[redacted]	1.1	30	units	684	5.5	37.6	2.5
5	SRS	RBOF	EBWR	[redacted]	0.86	60	assm	9958	2	193	1.6
5	SRS	RBOF	HB Robinson	[redacted]	0.008	1	cans	0.5	0.72	0.004	5E-05
5	SRS	RBOF	LWR samples	[redacted]	0.03	5	cans	12.6	1.5	0.4	0.012
5	SRS	RBOF	Saxton Mo	[redacted]	0.48	9	cans	283	0.47	32.3	0.283
5	SRS	RBOF	Saxton UO	[redacted]	0.5	5	cans	89.2	7.7	7	0.089
5	SRS Subtotal			3616	3.141	120		11089.4		271.774	4.54625
5	WestValley	FRS	Big Rock (BWR)	19000	4.5	85	assem	11000	5	550	11.5
5	WestValley	FRS	Gina (PWR)	23000	0.3	40	assem	15000	3.5	525	15.5
5	WestValley Subtotal			42000	4.8	125		26000		1075	27
5	TOTAL			230835.4	160.65	1537		164319.3		4490.01	158.80665
Experimental SST Fuel											
6a	ANL-E	Hot cell	EBR-II FFTF	[redacted]		4	UNIT	54	66	46	0.06
6a	ANL-E Subtotal			70	0	4		54		46	0.06

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
6a	ANL-W	EBR-II	EBR-II	50000	100	225	assm	15000	66 & 2	1700	22.9
6a	ANL-W	HFEF	EBR-II	50000	50	90	assm	11000	66 & 2	900	11.89
6a	ANL-W	NRAD	NRAD	20	0.04	61	elem	11	64	7	0.011
6a	ANL-W	RSWF	EBR-II	15000	33	1500	units	11000		6000	11.33
6a											
6a	ANL-W	ZPPR	ZPPR	10000	20	1710	can	10000		6000	9.47
6a											
6a	ANL-W Subtotal			165020	203.04	3586		47011		17607	55.601
6a	Hanford	AREA 200	TRIGA AL OSU	216	2.7	90	assm	17.2	19	3	0.02
6a	Hanford	Area-200	EBR (LANL)	400	16.4	24	cask	200.5	0.336	151	0.2
6a	Hanford	Area-200	GETCF & SEFOR	300	5.3	22	cask	45.2	0.109	14	0.05
6a	Hanford	BLDG-30	TRIGA Al	80	0.02	35	assem	12.2	20	2	0.01
6a	Hanford	Bld-308	TRIGA SST	160	0.04	66	assem	6.7	20	1	0.01
6a	Hanford	Bld-327	EBR-II	100	0.2	1	cask	17	0.35	6	0.02
6a	Hanford	FFTF	FFTF	58000	16.5	341	assm	8400	0.7	52.58	11
6a	Hanford Subtotal			59256	41.16	579		8698.8		229.58	11.31
6a	INEL	CPP-603	Al	10	0.04	12	can	7.9	92.1	7.3	0.0079
6a	INEL	CPP-603	APPR (AGE-2)	2.3	0.012	1	can	0.2	90.9	0.18	2E-05
6a	INEL	CPP-603	BMI	22.5	0.017	3	can	1.9	65.9	1.22	0.0019
6a	INEL	CPP-603	BORAX V	150	0.3	36	assm	26	93.2	24	0.021
6a	INEL	CPP-603	EBR-II	1309	2.85	2163	can	1190	62.3	714	1.2
6a	INEL	CPP-603	EBR-II ANL-6	5	0.006	4	can	1.6	51.9	0.84	0.0016
6a	INEL	CPP-603	GCRE can	1.5	0.01	1	can	0.9	93	0.84	0.0009
6a	INEL	CPP-603	GCRE pellets	1	0.01	1	can	0.1	93	0.1	0.0001
6a	INEL	CPP-603	GETR Filters	50	0.19	10	bskt	4.4	92.3	4.1	0.0044
6a	INEL	CPP-603	Pathfinder	960	1.36	417	rod	53.41	92.1	49.2	0.0534
6a	INEL	CPP-603	SM-1A	786	1.2	93	assm	65.8	86.1	56.6	0.0658
6a	INEL	CPP-603	SNAP	50	0.1	19	can	21	93.3	19.6	0.029
6a	INEL	CPP-603	SPEC (Orme)	7.5	0.005	1	can	2.4	5	0.123	0.002
6a	INEL	CPP-603	SPSS (Spert)	5.5	0.012	1	can	0.6	92.9	0.546	0.001
6a	INEL	CPP-603	TRIGA Al	1700	0.45	578	rod	104.4	19.7	20.6	0.1
6a	INEL	CPP-603	TRIGA FLIP	22	0.01	2	can	1.2	67.8	0.8	0.0012
6a	INEL	CPP-603	TRIGA SST	84	0.21	263	elem	49.2	18.8	9.2	0.049
6a	INEL	CPP-603	Tory-IIA	2000	0.84	146	can	48.7	93.2	45.3	0.0487
6a	INEL	CPP-603	VBWR (Geneva)	24	0.07	4	can	12.4	21.1	2.6	0.012
6a	INEL	CPP-666	EBR-II	900	1.96	1492	can	820	62.3	492	0.83
6a	INEL	CPP-749	Fermi blanket	50000	18.7	14	can	34000	0.4	133	34.17
6a	INEL	CPP-IFSF	Tory-IIC	2500	3.5	655	tube	59.1	93.1	55	0.059
6a	INEL	PER-620	PBF Driver	12000	0.84	2425	rod	560	18.3	102.8	0.56
6a	INEL	CPP-IFSF	Ber-II Triga	254	0.24	21	elem	92	44	4	0.009
6a	INEL Subtotal			72844.3	32.932	8362		37123.21		1743.95	37.22792
6a											
6a	LANL Subtotal			0	0	0		0		0	0
6a	ORNL	TSR	JASPER	1000	0.3	116	units	868	4.8	46	0.868
6a	ORNL	Y-12	HPRR	200	0.1	31	pieces	204	93	190	0.204
6a	ORNL	Y-12	SNAP-10	10	0.04	36	rods	4.9	93	4.6	0.005
6a	ORNL Subtotal			1310	0.44	181		1076.9		239.6	1.077
6a	SANDIA	ACPR	FREC	50	0.1	182	elem	9.8	20	2	0.01
6a	SANDIA	ACRR	ACRR	100	1	256	elem	26	35	6	0.03
6a	SANDIA	ACRR	experiments	1	0.001			0.574		0.1	0.001

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
6a	SANDIA	HCF	PNL mixed	20	0.01			8.68		2	0.009
6a	SANDIA	Mansano	PNL mixed	80	0.1			24.78		5	0.025
6a	SANDIA Subtotal			221	1.211	438		69.834		14.1	0.075
6a	SRS	RBOF	B&W Scrap	0.1	0.0004	1	can	0.03	43	0.01	3E-06
6a	SRS	RBOF	EBR-II (ANL)	1	0.005	1	can	0.44	85	0.6	0.00044
6a	SRS	RBOF	EBR-II (HEDL)	1	0.005	1	can	2	79	2.9	0.00027
6a	SRS	RBOF	EBWR	5	0.01		assm	1.7	93.3	1.6	0.0017
6a	SRS	RBOF	EPR-1	0	0.008	1	can	0	0	0	2E-06
6a	SRS	RBOF	ERR	100	3.1	188	assm	224	83	215	0.224
6a	SRS	RBOF	GCRE	100	0.01	72	units	61.3	92.3	56	0.061
6a	SRS	RBOF	HTRE	10	0.1	13	cans	4	84	3.4	0.004
6a	SRS	RBOF	ML-1	100	1	68	assm	58.6	93	54	0.058
6a	SRS	RBOF	SRE	400	0.007		cans	154.9	93	144	0.155
6a	SRS	RBOF	SRE-UC	100	0.1	1	cans	44.32	10	4.34	0.044
6a	SRS	RBOF	CVTR	100	0.05	1	can	67.4	0.95	0.7	0.067
6a	SRS Subtotal			1321.1	4.3954	347		618.69		482.55	0.615415
6a	Miscellaneous Facilities										
6a	San Ramon		Areotest TRIGA	225	0.5	91	elem	14.89	19.9	2.96	0.015
6a	Armed Forces		AFRRI-TRIGA	300	0.5	110	elem	18.29	19.9	3.64	0.019
6a	Midland		DOW-TRIGA	200	0.5	78	elem	14.07	19.9	2.79	0.014
6a	San Diego		GA-TRIGA	660	0.8	263	elem	44.28	19.9	8.8	0.045
6a	Denver		US.Geol-TRIGA	300	0.5	161	elem	20.38	19.9	4	0.02
6a	Omaha		Veterans-TRIGA			0	elem				
6a	McLellan		TRIGA	200	0.5	90	elem	15	19.9	3	0.015
6a	Miscellaneous Facilities Subtotal			1885	3.3	793		126.91		25.19	0.128
6a	University										
6a	UC Irvine		TRIGA	200	0.1	113	elem	21.4	19.1	4.08	0.021
6a	U of Arizona		TRIGA	800	0.1	97	elem	18.1	18	3.2	0.081
6a	Cornell		TRIGA	200	0.1	6	elem	21.97	19.8	4.35	0.021
6a	Idaho St.		AGN	100	0.1	9	disc	11.03	19.8	1.5	0.011
6a	U of Illinois		TRIGA	400	0.1	193	elem	38.21	18.9	7.02	0.038
6a	Kansas		TRIGA	200	0.1	107	elem	24.89	19.8	3.57	0.025
6a	Maryland		TRIGA	200	0.1	93	elem	16.83	19.8	3.2	0.017
6a	U of New Mexico		AGN	30	0.1	9	elem	3.37	19.8	0.668	0.004
6a	Oregon St.		TRIGA FLIP	200	0.1	96	elem	17.4	68	10.5	0.017
6a	Penn St.		TRIGA	400	0.1	175	elem	36.22	18.3	6.56	0.036
6a	Reed		TRIGA	200	0.1	63	elem	12.56	19.7	2.48	0.013
6a	Rennesiaer		SPERT	4000	0.1	597	pin	387.54	4.8	18.6	0.388
6a	U of Texas		TRIGA	300	0.1	151	elem	29.14	19	5.57	0.029
6a	Texas AM		TRIGA FLIP	300	0.1	186	elem	27	69	11.5	0.027
6a	U of Utah		TRIGA	300	0.1	84	elem	25.58	19.5	4.99	0.026
6a	Washington		TRIGA FLIP	400	0.1	215	elem	36.64	17.9	3.7	0.037
6a	Wisconsin		TRIGA	400	0.1	228	elem	38.64	68.7	10.79	0.039
6a	University Subtotal			8630	1.7	2422		766.52		102.278	0.83
6a	TOTAL			310557.4	288.18	16712		95545.86		20490.2	106.92434
Experimental Zirconium Fuel											
6b	ANL-W	TREAT	TREAT	14.8	11	390	assm	10	93	10	0.01
6b	ANL-W Subtotal			14.8	11	390		10		10	0.01

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
6b											
6b	Hanford	T-plant	Shiport PWR blanket								
			Core 2 blanket	38500	9.6	72	assm	15660	0.7	252	15.78
6b	Hanford Subtotal			38500	9.6	72		15660		252	15.78
6b	INEL	CPP-666	Fermi core I & II	4600	1.2	214	can	4000	25.4	1000	3.9
6b	INEL	CPP-666	Shiport PWR C1-S4	2.9	0.19	4	subass	2	80.4	1.63	0.08
6b	INEL	CPP-666	Shiport PWR C2-S1	6800	1.8	19	clust	219.1	69.1	129	0.219
6b	INEL	CPP-666	Shiport PWR C2-S2	7100	1.8	20	clust	300.5	80.8	245	0.3
6b	INEL	CPP-749	Shiport LWBR	84000	31.1	48	can	576	13	1100	42.57
6b	INEL										
6b	INEL	MTR-603	Belgian	88.9	0.26	7	canst	62.4	4.7	3.2	0.06
6b	INEL	MTR-603	PCM - TRA	7.7	0.12	7	canst	5.4	28.6	1.55	0.028
6b	INEL Subtotal			102599.5	36.47	319		5165.4		2480.38	47.157
6b	NRF	ECF	Shiport PWR C1	25000	7	50	elem	500	70	350	0.5
6b	NRF	ECF	Shiport PWR C2	55000	16	110	elem	1100	70	770	1.1
6b	NRF Subtotal			80000	23	160		1600		1120	1.6
6b	SRS	RBOF	EBWR	6000	0.5	35	assm	918	0.23	2.1	0.918
6b	SRS	RBOF	EBWR	35000	3.9	280	assem	7438	0.99	74	7.44
6b	SRS	RBOF	EBWR	19000	0.86	60	assm	1600	6	96	1.6
6b	SRS	RBOF	EBWR	160	0.01	1	can	29	92	0.28	0.029
6b	SRS	RBOF	HWCT HEU	200	0.01	88	units	39.8	85	33.65	0.118
6b	SRS	RBOF	HWCT LEU	5000	0.5	88	units	1824	0.7	13.2	1.8
6b	SRS	RBOF	ORNL (S1W)	1	0.007	3	cans	0.18	93	0.17	0.00018
6b	SRS	RBOF	ORNL mixed oxide	2	0.002	1	can	0.38	0.79	0.56	0.00038
6b	SRS	RBOF	SPERT-3	50	0.01	3	can	9.7	4.8	0.5	0.005
6b	SRS	RBOF	shipingport	90	0.02	1	can	16.4	0.14	0.24	0.016
6b	SRS Subtotal			120483	5.819	538		11875.46		220.7	11.92656
6b	University										
6b	Buffalo		pins	2000	1	40	elem	493.19	5	27.81	0.493
6b	University Subtotal			2000	1	40		493.19	5	27.81	0.493
6b	TOTAL			343597.3	86.889	1519		34804.05		4110.89	76.96656
Other Fuel											
6c	ORNL	MSR	MSRE	12000	8.3	1	core	36.95	2.5	0.9	0.037
6c	ORNL Subtotal			12000	8.3	1		36.95		0.9	0.037
6c	TOTAL			12000	8.3	1		36.95		0.9	0.037
1	TOTAL			539000	143	1088		9920		9770	9.947
2	TOTAL			453024.6	187.58	15799		189481.6		8388.74	190.2112
3	TOTAL			2266437	205.25	8287		2099337		30190.5	2103.43
4	TOTAL			351000	292.72	3793		1256.6		839.4	27.603
5	TOTAL			230835.4	160.65	1537		164319.3		4490.01	158.80665
6a	TOTAL			310557.4	288.18	16712		95545.86		20490.2	106.92434
6b	TOTAL			343597.3	86.889	1519		34804.05		4110.89	76.96656

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M ton)
6c	TOTAL			12000	8.3	1		36.95		0.9	0.037
DOE	TOTAL			4506452	1372.6	48736		2594701		78280.7	2673.9257
1	INEL Subtotal			350000	95	800		6850		6700	6.847
1	NRF Subtotal			189000	48	288		3070		3070	3.1
1	TOTAL			539000	143	1088		9920		9770	9.947
2	Brookhaven Subtotal			906	3.23	973		251.88		205.7	0.255
2	INEL Subtotal			14798.9	20.173	2281		1863.7		1378.92	1.881
2	LANL Subtotal			220	0.7	101		21.25		19.4	0.021
2	ORNL Subtotal			9459.7	9.28	319	0	672.2		629.6	0.6782
2	SANDIA Subtotal			830	0.5	43		385		370	0.37
2	SRS Subtotal			418220	150.7	11290		183687		5510.22	184.407
2	Non-DOE Subtotal			280	0.3	218		48		44.2	0.048
2	University Subtotal			8310	2.7	574		2552.64		230.7	2.551
2	TOTAL			453024.6	187.58	15799	0	189481.6	0	8388.74	190.2112
3	TOTAL			2266437	205.25	8287		2099337		30190.5	2103.43
4	INEL Subtotal			161000	132.72	2347		640.6		506.4	11.6
4	Pub. Ser. Subtotal			190000	160	1446		616		333	16
4	ORNL Subtotal			552	0.5			3		2	0.003
4	TOTAL			161552	133.22	2347		643.6		508.4	11.603
5	ANL-E Subtotal			40	0	1		19.5		0.9	0.019
5	Hanford Subtotal			3150	5.205	31		2302		67	2.32
5	INEL Subtotal			179959.4	145.4	800		123647.2		3014.67	123.6554
5	Lynchburg Subtotal			60	0.11	15		39.17		0.32	0.044
5	ORNL Subtotal			2010	2	445		1222		60.35	1.222
5	SRS Subtotal			3616	3.141	120		11089.4		271.774	4.54625
5	WestValley Subtotal			42000	4.8	125		26000		1075	27
5	TOTAL			230835.4	160.65	1537		164319.3		4490.01	158.80665
6a	ANL-E Subtotal			70	0	4		54		46	0.06
6a	ANL-W Subtotal			165020	203.04	3586		47011		17607	55.601
6a	Hanford Subtotal			59256	41.16	579		8698.8		229.58	11.31
6a	INEL Subtotal			72844.3	32.932	8362		37123.21		1743.95	37.22792
6a	LANL Subtotal			0	0	0		0		0	0
6a	ORNL Subtotal			1310	0.44	181		1076.9		239.6	1.077
6a	SANDIA Subtotal			221	1.211	438		69.834		14.1	0.075
6a	SRS Subtotal			1321.1	4.3954	347		618.69		482.55	0.615415
6a	Non DOE Subtotal			1885	3.3	793		126.91		25.19	0.128
6a	University Subtotal			8630	1.7	2422		766.52		102.278	0.83
6a	TOTAL			310557.4	288.18	16712	0	95545.86	0	20490.2	106.92434
6b	ANL-W Subtotal			14.8	11	390		10		10	0.01
6b	Hanford Subtotal			38500	9.6	72		15660		252	15.78

SNF & ER/WM EIS Spent Nuclear Fuel Inventories Including Non-DOE locations - 6/1/ 1995 13-Jul-94

JICHA Cat.	Location	Facility	Fuel Name	Total Mass (kg)	Volume (m3)	No. Items	Units	Uranium Mass (kg)	Uranium Enrich. ( )	Fissile Mass (kg)	MTHM (M-ton)
6b	INEL Subtotal			102599.5	36.47	319		5165.4		2480.38	47.157
6b	NRF Subtotal			80000	23	160		1600		1120	1.6
6b	SRS Subtotal			120483	5.819	538		11875.46		220.7	11.92656
6b	University Subtotal			2000	1	40		493.19	5	27.81	0.493
6b	TOTAL			343597.3	86.889	1519	0	34804.05	5	4110.89	76.96656
6c	ONEL Subtotal			12000	8.3	1		36.95		0.9	0.037
6c	TOTAL			12000	8.3	1		36.95		0.9	0.037
DOE	TOTAL			4506452	1372.6	48736		2594701		78280.7	2673.9257

APPENDIX C. APPLICATION OF MPCs TO EACH DOE SNF CATEGORY

The application of an MPC for each category of DOE SNF was compiled by the Team, based on the criteria presented in the report, and the evaluations are presented in the following (summarized in Table C-1):

DOE SNF Category 1 - Naval Fuel

The cladding is considered very stable compared to the other DOE SNF and commercial fuels, and is likely well characterized because of the high QA level of naval operations. The dimension and fuel composition information is well documented but classified as Confidential and would require clearance and need to know by the NRC and repository operating personnel. Some fuel may contain the control rods, and the resulting potential for designating the fuel as a hazardous waste needs to be resolved. The temperature limits are likely similar or higher than for commercial fuel. The fuel contains HEU, and the MPC would require fixed neutron poison material and possibly periodic verification of the material's stability for underwater loading and unloading and require a method for prevention of a criticality event during disposal according to 10 CFR 60.131(b)(7). The fuel would require strict safeguards after closure of the repository. The waste package design requirements in 10 CFR 60.135 would probably be met. Under the existing fuel acceptance specifications, the naval fuel would be considered nonstandard fuel based on physical dimensions and uranium enrichment. Characterization for MPC use in disposal may consist of qualification of the detailed records of fuel use, which are classified, assuming that the waste acceptance requirements could be met. The high uranium enrichment and dimensions would make this fuel dissimilar to commercial fuel. The naval fuel is very stable and can be stored underwater for a long time, and thus there does not seem to be a driver for immediate placement into interim storage because of ES&H vulnerabilities.

DOE SNF Category 2 - Aluminum-Clad Fuel

Most aluminum-clad DOE-owned fuel consists of cladding and fuel material that is not considered stable, and some of it has experienced severe corrosion and failure. Aluminum fuel does not appear to contain hazardous material. The maximum temperature in dry storage needs to be established and may be lower than for commercial fuel, possibly at 150 °C. The fuel contains HEU, and the MPC would require fixed neutron absorbing material for underwater loading and unloading and require a method for prevention of a criticality event during disposal according to 10 CFR 60.131(b)(7). The fuel would require strict safeguards after closure of the repository. The waste package design requirements in 10 CFR 60.135 may be met. Under the existing fuel-acceptance specifications, the aluminum fuel would be considered nonstandard fuel based on physical dimensions, cladding, cladding failure and uranium enrichment. There may be a short time to complete the characterization and/or stabilization to determine acceptability for repository disposal, and the canister may require re-opening to allow for the waste qualification activities before disposal. The generally high uranium enrichment and dimensions would make this fuel dissimilar to commercial fuel. The aluminum fuel is not very stable for underwater storage in most of the existing basins and may need to be placed in dry storage, assuming that this is successfully demonstrated, or further conditioned to eliminate the safety vulnerability.

Table C-1. Evaluation by Criteria of MPC for Each DOE SNF Category. Rating of Each Criterion to an MPC is (H) High Acceptability, (M) Medium Acceptability, (L) Low Acceptability

DOE SNF Category:

CRIT:	1-Navy	2-Al	3-Hanf[a]	4-Graf	5-Comm[b]	6a-SS	6b-Zr[c]	6c-Oth
1-Durab, Dimens	H	L	M	H	H	H	H	L
2-Hazard	M	M	M	L	H	L	M	L
3-Temp-erature	H	L	H	H	H	?	M	L
4-Critic	L	L	H	L	H	L	L	?
5-SNM	L	L	H	L	H	L	L	?
6-Pckg Reqmts	H	M	M	L	H	L	H	L
7-Accep-tability	H	L	M	L	H	L	M	L
8-Simi-larity	L	L	M	L	H	L	M	L
9-Timing	H	L	M	H	H	M	L	L

a. After stabilization to achieve minimum acceptable criteria for interim storage because this material is not suitable for dry storage in its present form.

b. Assuming intact commercial fuel; non-intact fuel may require stabilization to meet acceptable levels.

c. Shippingport PWR Core II fuel is expected to meet all criteria.

DOE SNF Category 3 - Hanford N-Reactor and Single Pass Reactor Fuel

The zircaloy cladding, which is also present in commercial fuel, has a significantly higher failure rate than commercial fuel. The cladding failure has resulted in undesired water reaction with the metal fuel for fuels not sealed in the N-Reactor canisters. Thus, fuel stabilization will be required prior to acceptance in a repository and is currently under evaluation. The fuel is potentially pyrophoric and gas generating and may be designated as hazardous waste.Temperature limits would have to be established for the final stabilized form. The plutonium level may not require some fixed neutron absorber material, unless the fuel configuration is changed significantly from the current N-Reactor canisters. The safeguards requirements should be similar to commercial fuel after closure of the repository, although many of the fuels may not be self-protecting after 50 years. Under the existing fuel acceptance specifications, the fuel would be considered nonstandard based on physical dimensions and cladding failure, and it may not meet waste package design requirements 10 CFR 60.135 without stabilization. The uranium enrichment of up to 1.25% is lower than in commercial fuel, but the fuel has different dimensions than commercial fuel is composed of uranium metal, rather than uranium dioxide. The fuel and existing storage canisters are stable in the existing basins but may need to be placed in dry storage after stabilization, assuming that this is successfully demonstrated. There may be a short time to complete the characterization and stabilization, which will likely be required to determine acceptability for repository disposal, and the canister may require re-opening before disposal.

DOE SNF Category 4 - Graphite Fuel

Although the fuel cladding is considered stable, the presence of carbides and potentially flammable graphite may require additional conditioning or stabilization prior to repository acceptance. The carbide and graphite may result in designating the fuel as a hazardous waste. The temperature limits are likely similar or higher than for commercial fuel. The fuel contains HEU, and the MPC would require fixed neutron poison material during handling and interim storage and require a method for prevention of a criticality event during disposal according to 10 CFR 60.131(b)(7). The fuel would require strict safeguards after closure of the repository. The waste package design requirements in 10 CFR 60.135 may not be met because of the flammable and potentially chemically reactive nature. Under the existing fuel acceptance specifications, the graphite fuel would be considered nonstandard based on composition, dimensions and uranium enrichment. The graphite and carbide composition, high uranium enrichment and dimensions would make this fuel dissimilar to commercial fuel. The graphite fuel has been in dry storage for nearly 20 yr in a facility which may have a seismic deficiency vulnerability, and it may require placement into different interim storage. As a result, there may not be sufficient time for characterization for MPC use in disposal.

DOE SNF Category 5 - Commercial Fuel

DOE-owned commercial fuels with stable cladding have similar dimensions as other commercial fuel owned by utilities. There may be little potential for designation as a hazardous waste, except for TMI fuel rubble which contains pieces of control rods, which might be hazardous. For intact elements, the temperature limits are the same as other commercial fuel. The plutonium level may require some fixed neutron poison material, but

presumably not require the strict safeguards of HEU after repository closure. The enrichment, composition, and characterization will likely meet the waste acceptance requirements as with other commercial fuel, assuming that the operating records are comparable. Waste package design requirements under 10 CFR 60.135 would presumably be met for intact fuel elements. Commercial fuel pieces may require stabilization before placement in an MPC. Some DOE commercial fuel may require removal from existing facilities in the near future; for example, LWR fuel in the Hanford 324 building may have to be removed in the next two years; West Valley fuel shipments are mandated by DOE agreements with the State of New York; and commercial fuel will need to be removed from the TAN storage basin.

DOE SNF Category 6a - Experimental Stainless-Steel Fuel

The durability of stainless-steel fuels are comparable to commercial fuel, although some cladding leaks have been observed. The components, sodium, carbides and hydrides, may result in a hazardous waste classification. The temperature limits need to be established. The MPC for high-enriched fuels would require fixed neutron material during handling and interim storage and require a method for prevention of a criticality event during disposal according to 10 CFR 60.131(b)(7). Strict safeguards would be required after closure of the repository. Waste package design requirements may not be met for some of the stainless-steel clad fuels due to the potentially hazardous components. The fuel may require additional characterization and possibly stabilization to determine acceptability for repository disposal. Most of the stainless-steel experimental fuels are dissimilar to commercial fuel in plutonium content or high uranium enrichment as well as different cladding material. Casks are being designed for FFTF fuels with fuel placement projected for FY 1996, subject to the outcome of the Environmental Assessment (EA). Stainless-steel clad fuels will have to be removed from the basins in CPP-603 and -666 to dry storage because of potential ES&H vulnerabilities from encapsulated sodium metal.

DOE SNF Category 6b - Experimental Zirconium Fuel

Some of the experimental zirconium fuel has a similar durability and dimensions as commercial fuel. There is probably no potential for designation as a hazardous waste. The temperature limits need to be determined. The MPC for high-enriched Zr-clad fuels would require fixed neutron poison material during handling and interim storage and require a method for prevention of a criticality event during disposal according to 10 CFR 60.131(b)(7). Strict safeguards would be required after closure of the repository. The waste package design requirements 10 CFR 60.135 are expected to be met. Some fuel may require additional characterization prior to acceptance for repository disposal. Some of the fuels have similar fuel material and enrichment as commercial fuel, such as the Shippingport PWR Core II. Fuels stored in the PBF basin will need to be transferred to CPP during 1996-8.

DOE SNF Category 6c - Other Fuel

This fuel includes mainly molten salt reactor fuels, consisting of sodium, calcium and uranium fluoride salts. It is expected to contain possible RCRA hazardous materials and the fuel has a potential for being designated as a hazardous waste. Temperature limitations, criticality concerns, and safeguards issues need to be established. The fuel must be conditioned and stabilized to meet waste package requirements. It would likely require additional stabilization and characterization prior to acceptance for repository disposal. There are no similarities with respect to durability, cladding and compositional characteristics with respect to commercial fuel. Timing for removal has to be determined.

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