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Nevada Nuclear Waste Storage Investigations Project

# Reference Nuclear Waste Descriptions for a Geologic Repository at Yucca Mountain, Nevada

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Prepared by
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# REFERENCE NUCLEAR WASTE DESCRIPTIONS FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA

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## ABSTRACT

This report describes the reference wastes to be used as a basis for the conceptual design of a geologic repository being considered for location in the tuff formations at Yucca Mountain, in Nye County, Nevada. Waste characteristics and production rates are taken from a DOE guidance document (OGR/B-2) entitled "Generic Requirements for a Mined Geologic Disposal System;" this information is recast as waste receival and emplacement schedules to be used in the design of repository facilities and equipment and as input to the timetable for underground development.

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# 1. INTRODUCTION

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project, managed by the Nevada Operations Office of the U.S. Department of Energy (DOE), is supporting a feasibility study for a high-level radioactive waste repository being considered for location in the tuff formations at Yucca Mountain, in Nye County, Nevada. As a participant in this project, Sandia National Laboratories (SNL) has responsibilities that include the conceptual design of the repository surface facilities and the underground waste disposal area.

This report describes the "reference" wastes for which the repository is to be designed. In the following chapters, DOE waste definitions and requirements for repository design are summarized, and site-specific assumptions for the Yucca Mountain repository are discussed. Year-by-year waste receival and emplacement schedules are presented for use in the design of repository facilities and equipment and as an input to the schedule for underground development. Areas in which additional information and data are required are discussed briefly and, finally, alternative disposal scenarios and their impacts on repository design and operation are described.

# 2. DOE GUIDANCE

The basis for this report is Appendix B of a DOE guidance document (OGR/B-2) entitled "Generic Requirements for a Mined Geologic Disposal System,"[1] which was "baselined" in September 1984. That appendix is reproduced as Appendix B of this report. The essential elements of Appendix B are summarized here.

(1) The first repository will be designed for the disposal of spent power reactor fuel and solidified West Valley high-level waste (WVHLW) from the West Valley Demonstration Project in New York. The second repository will be designed for spent power reactor fuel only. Both repositories must be capable of accepting defense high-level waste (DHLW), which may, at the President's discretion, be disposed of in the "civilian" repositories. [Under the terms of the Nuclear Waste Policy Act (NWPA) of 1982,[2] DHLW will be disposed of in a licensed civilian repository unless the President decides that a separate repository is required.]

(2) The design capacity of each of the first two repositories is 70,000 metric tons uranium (MTU) -- i.e., each repository must accept the wastes derived from 70,000 metric tons of uranium initially loaded in civilian power reactors. If either repository accepts DHLW, the DHLW will replace an equivalent amount (calculated on an MTU basis) of civilian waste.

(3) Both repositories will be designed to accept infrequent shipments of spent fuel with burnups as high as 60 GWd/MTU and with cooling times as short as 5 years.

(4) The waste receiving plant of the first repository will incorporate a Stage I facility and a Stage II facility. The Stage I facility will begin operation in 1998 and will accept spent fuel and occasional shipments of WVHLW (and, possibly, DHLW) at the rate of 400 MTU/year through the year 2002. Although Appendix B specifies that operation of the Stage I facility will be discontinued after 2002, it is assumed in this report that the Stage I facility continues in use for receiving WVHLW and DHLW (as suggested on pages 2-3 of the April 1984 draft of the Mission Plan for the Civilian Radioactive Waste Management Program[3]). If the repository accepts DHLW, it is assumed that the throughput of the Stage I facility remains at 400 MTU/year in 2003, 2004 and 2005. In 2006, the throughput is increased to 600 MTU/year by changing from two- to three-shift operation (with weekends reserved for maintenance). With this schedule, the repository is filled to its 70,000 MTU capacity in 2021, when both the Stage I and Stage II facilities cease operation.

(5) The Stage II facility will begin operation in 2001 and will accept 500 MTU of spent fuel in 2001, 1,400 MTU in 2002, and 3,000 MTU/year thereafter. The total equivalent waste receiving capacity of the first repository is, therefore, 400 MTU/year during 1998 through 2000, 900 MTU/year in 2001, and 1,800 MTU/year in 2002. From 2003 through 2005, the capacity is either 3,000 or 3,400 MTU/year, depending on whether WVHLW or DHLW is received simultaneously with spent fuel. Beginning in 2006, the capacity is 3,000 MTU/year for spent fuel only, or 3,600 MTU/year for spent fuel plus DHLW.

(6) The total amount of spent fuel to be discharged from civilian power reactors through the year 2027 is 133,900 MTU, based on an Energy Information Agency (EIA) mid-case projection of 130 GW(e) (gigawatts electric) installed nuclear generating capacity in the year 2000, and 230 GW(e) in the year 2020, as shown in Appendix B, Table B-6. Spent fuel discharge rates, for an "oldest-fuel-first" schedule, are as projected in Appendix B, Table B-6.

(7) The fuel rods from 40 percent of the spent fuel delivered to the first repository in 1998 will have been consolidated at-reactor -- i.e., prior to shipment to the repository. This percentage will decrease at the rate of 4 percent per year so that, beginning in 2008, all the spent fuel will be delivered to the repositories as intact fuel assemblies. Consolidated fuel rods will be shipped in metal cans having the approximate dimensions of the fuel assemblies from which the fuel rods were removed. Each can will contain the rods from two fuel assemblies.

(8) A fuel rod consolidation facility will become operational in the Stage II facility of the first repository in 2001. The intent of Appendix B is that all spent fuel will be consolidated after that time but, as noted in Chapter 3 (Assumption 7), it is assumed here that high-burnup fuel will <u>not</u> be consolidated at the repository.

(9) The second repository will begin operation in 2005. It will accept spent fuel (but no WVHLW) at the rate of 1,800 MTU/year in the years from 2005 through 2009, and at the rate of 3,000 MTU/year thereafter. As noted in Guideline 1, the design of the second repository must not preclude a future decision to dispose of DHLW.

(10) The total amount of WVHLW available for disposal in the first repository is 650 MTU. It will be packaged in 61-cm-diameter by 300-cm-long, 304L stainless-steel canisters, each containing the equivalent of 2.1 MTU of vitrified high-level waste.

(11) The year-2020 inventory of DHLW that may be disposed of in a civilian repository (or repositories) is the equivalent of 10,000 MTU. This waste, too, will be packaged in 61-cm-diameter by 300-cm-long, 304L stainless-steel canisters. While the WVHLW and DHLW canisters differ in some details of mechanical design, their external dimensions are similar, and most of the handling equipment designed for WVHLW canisters can be used for DHLW. The number of DHLW containers to be disposed of is 20,000; it can be inferred, therefore, that each container will accommodate only 0.5 MTU of vitrified high-level waste like that which will be produced at the Savannah River Defense Waste Processing Facility (DWPF).

## 3. SITE-SPECIFIC ASSUMPTIONS

To formulate the waste receipt and emplacement schedules required for repository design, certain assumptions must be made regarding the disposal scenario for the Yucca Mountain repository. These assumptions are discussed below:

(1) For the purpose of calculating waste age, fuel burnup, etc., it is assumed that the Yucca Mountain repository is the <u>first</u> civilian radioactive waste repository.

(2) On the basis of preliminary spent fuel canister designs for the Yucca Mountain repository, it is assumed that a 66-cm-diameter canister will accommodate up to 3 intact or 6 consolidated pressurized water reactor (PWR) assemblies, or up to 6 intact or 12 consolidated boiling water reactor (BWR) assemblies. All the "hardware" waste produced in the at-repository consolidation operation will fit in the void spaces of the same canisters, so that no separate containers or boxes will be required. Canister lengths remain to be determined, but it is likely that four standard lengths will be required to accommodate the many fuel assembly designs in the projected inventory of spent fuel.

(3) On the basis of heat transfer calculations by Lawrence Livermore National Laboratory (LLNL), the thermal loading of a single spent fuel canister is limited to 3,400 watts. This restriction limits internal temperatures and minimizes the potential for corrosion of the Zircaloy cladding material on the fuel rods.

(4) At present, LLNL anticipates specifying an austenitic stainless steel as the reference material for spent fuel canisters and overpacks for WVHLW and DHLW pour canisters.[4] ("Pour" refers to the fact that, for vitrified waste forms like WVHLW and DHLW, molten glass is poured directly into the 304L stainless steel canisters described in Chapter 2, Guideline 10. There is a concern that the thermal cycling associated with the glass pour and subsequent cool-down may make the canister material susceptible to corrosion.) Although detailed design of the WVHLW and DHLW overpack has not yet been started, it can be assumed that the outside diameter will be about 66 cm and that the length will be about 325 cm.

(5) In calculating the number of spent fuel assemblies and, therefore, the number of spent fuel containers to be emplaced, it is assumed that each PWR assembly contains 0.4614 MTU and that each BWR assembly contains 0.1833 MTU. These are the values used by Oak Ridge National Laboratory (ORNL) in recent ORIGEN2 decay calculations that will be published and baselined later as an addendum to Appendix B of the Generic Requirements Document.[1]

(6) There is negligible delay between the delivery of waste to a repository and its emplacement in the underground disposal area; thus, all waste is emplaced during the year in which it is delivered to the repository.

(7) No PWR fuel whose burnup exceeds 40 GWd/MTU and no BWR fuel whose burnup exceeds 35 GWd/MTU will be consolidated at the repository. (In this report, spent fuel with higher values of burnup is considered to be "high-burnup" fuel.) The rationale for this assumption is that the

design of high-burnup fuel is likely to be completely different from that of the fuel for which the consolidation equipment is designed.

Even if it were possible to extend the burnup of standard fuel, the physical changes associated with higher burnup might well lead to an unacceptably high incidence of cladding failure during the disassembly operation.

The above definitions of high-burnup fuel are arbitrary; the burnup limits for normal-burnup fuel are about 7 GWd/MTU above the nominal values for both PWR and BWR fuel. By these definitions, and according to the spent fuel discharge schedule in Table B-6 of Appendix B, there will be no high-burnup BWR fuel in either of the first two repositories.

(8) All spent fuel not disqualified for consolidation under Assumption 7 is consolidated. This ignores the possibility that the repository operator will probably choose not to disassemble fuel whose mechanical integrity is suspect. Also, it may not be economically advantageous to disassemble fuel delivered to the repository complete with the non-fuel "hardware" (control rods, instrument tubes, etc.) discharged with the fuel. Finally, it may not be cost effective to build special tooling to disassemble fuel types that are produced only in small quantity.

(9) The thermal power decay of normal-burnup PWR and BWR fuel and of high-burnup PWR fuel is as shown in Figure 1. The normal-burnup curves are plotted from the ORNL ORIGEN2 data referred to in Assumption 5 above. The high-burnup PWR curve is an estimate obtained by averaging data for normal-burnup and 50-GWd/MTU fuel. (Data for 50-GWd/MTU are from a private communication from T. I. McSweeney, Office of Crystalline Rock Development (OCRD), to P. D. O'Brien (SNL).[5] Such averaging is

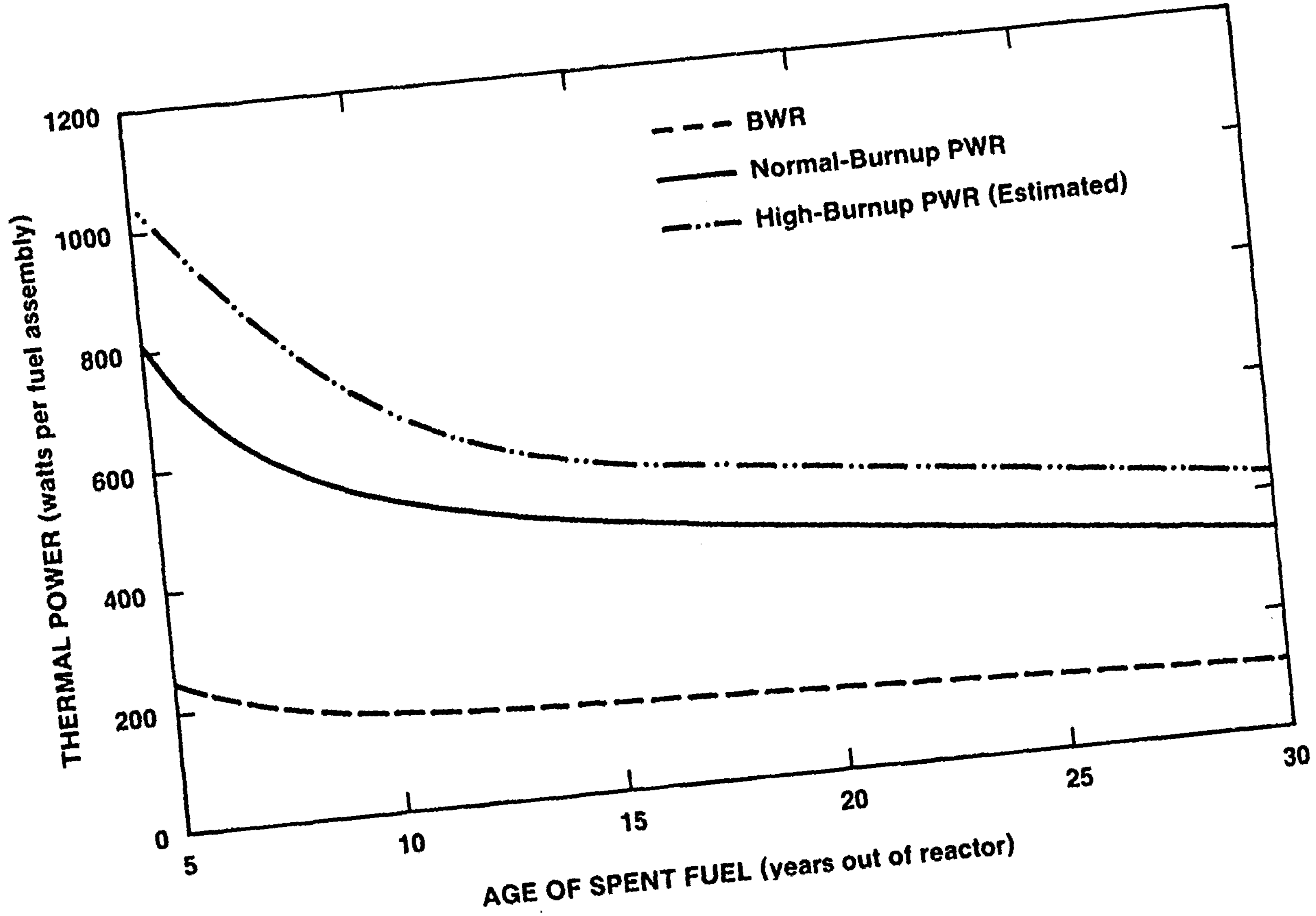


Figure 1 Thermal Power Decay of Spent Fuel

not really proper because the "spectrum" of actinides produced during irradiation is highly burnup-dependent; averaging is justified in this case only because no ORIGEN2 data are available for the 42.5-GWd/MTU average burnup of the high-burnup PWR fuel. The high-burnup curve in Figure 1 probably underestimates thermal power for short cooling times.

From Appendix B, Table B-6, it can be determined that the weighted average burnup of normal-burnup PWR fuel discharged through the year 2020 is 32.5 GWd/MTU. The normal-burnup PWR curve in Figure 1 and the calculations upon which this report is based are for a burnup of 33 GWd/MTU. Averaged over the life of the repository, then, the reported values of thermal power per container are reasonably accurate. However, because average burnup varies from year to year (in general, increasing over the life of the repository), thermal power values for a specific year are less accurate.

The weighted average burnup of BWR fuel discharged through the year 2020 is 26.4 GWd/MTU. The BWR curve in Figure 1 and the calculations for this report are for a burnup of 27.5 GWd/MTU. Therefore, the preceding comments on the accuracy of thermal power calculations for normal-burnup PWR fuel apply equally well to BWR fuel.

As noted above, the reported values of thermal power for high-burnup PWR fuel are not very accurate. Except for near-field heat transfer calculations, this is probably unimportant because high-burnup PWR fuel constitutes only 6.5 percent of the PWR fuel and only 3.9 percent of all the fuel (PWR plus BWR) emplaced in the repository.

(10) The 3400-watt limit from Assumption 3 would be exceeded only for containers loaded with short-cooled, consolidated, nominal-burnup PWR fuel rods (Assumption 7 states that no high-burnup PWR fuel rods will be consolidated). When normal loading would lead to a thermal power in excess of 3400 watts, it is assumed (without regard for whether or not

uneven heating of the waste package is acceptable) that an intact fuel assembly can be substituted for a canister containing the fuel rods from two assemblies. Thus, a container of "consolidated" PWR fuel rods might actually contain one intact fuel assembly and two canisters containing the consolidated fuel rods from four assemblies, or even two intact assemblies and one canister of consolidated fuel rods.

(11) If civilian repositories are used for the disposal of DHLW, it is assumed that the entire 10,000 MTU inventory will be disposed of in the first repository. The rationale for this assumption is that the handling equipment for WVHLW and DHLW is the same, and Appendix B requires that the first--but not the second--repository be designed to accept WVHLW.

As noted in the discussion of Guideline 4, it is assumed that DHLW (as well as WVHLW) will be received through the Stage I facility. This scenario is advantageous from the standpoint of operational convenience, and it facilitates the logistical separation of the commercial and defense waste disposal operations.

## 4. WASTE RECEIVAL AND EMPLACEMENT SCHEDULES

In this chapter, the DOE guidance from Chapter 2 and the site-specific assumptions from Chapter 3 are interpreted as waste receival and emplacement schedules for the first civilian repository. Appendix A of this report summarizes "intermediate" calculations of waste age, fuel burnup, etc., used in generating the waste receival and emplacement schedules described below.

Table 1 tabulates waste receival rates for each year of repository operation beginning in 1998. Two cases are considered: Case 1 is the reference case in which no DHLW is emplaced in the first repository, and Case 2 is based on Assumption 11, which is that 10,000 MTU (20,000 containers) of DHLW is disposed of in the first repository, beginning in 2004. Spent fuel receipts

TABLE 1
WASTE RECEIVAL SCHEDULE FOR FIRST REPOSITORY

Case 1: 650 MTU WVHLW Received in 2003 and 2004, No DHLW

Stage I Facility Used for WVHLW

| Year | WVHLW Canisters Received This Year | DHLW Canisters Received This Year | Spent Fuel Assemblies Received This Year: PWR Intact | PWR Consolidated* | BWR Intact | BWR Consolidated* |
|---|---|---|---|---|---|---|
| 1998 | 0 | 0 | 259 | 173 | 656 | 438 |
| 1999 | 0 | 0 | 228 | 128 | 822 | 463 |
| 2000 | 0 | 0 | 308 | 145 | 709 | 334 |
| 2001 | 0 | 0 | 809 | 315 | 1498 | 583 |
| 2002 | 0 | 0 | 1753 | 554 | 3050 | 963 |
| 2003 | 190 | 0 | 3079 | 770 | 5342 | 1336 |
| 2004 | 120 | 0 | 3434 | 654 | 5104 | 972 |
| 2005 | 0 | 0 | 3673 | 501 | 5156 | 703 |
| 2006 | 0 | 0 | 3655 | 318 | 5857 | 509 |
| 2007 | 0 | 0 | 3720 | 155 | 6348 | 264 |
| 2008 | 0 | 0 | 4018 | 0 | 6252 | 0 |
| 2009 | 0 | 0 | 4057 | 0 | 6154 | 0 |
| 2010 | 0 | 0 | 3966 | 0 | 6383 | 0 |
| 2011 | 0 | 0 | 4005 | 0 | 6285 | 0 |
| 2012 | 0 | 0 | 4038 | 0 | 6203 | 0 |
| 2013 | 0 | 0 | 3940 | 0 | 6448 | 0 |
| 2014 | 0 | 0 | 4012 | 0 | 6268 | 0 |
| 2015 | 0 | 0 | 4025 | 0 | 6236 | 0 |
| 2016 | 0 | 0 | 3869 | 0 | 6628 | 0 |
| 2017 | 0 | 0 | 4012 | 0 | 6268 | 0 |
| 2018 | 0 | 0 | 3973 | 0 | 6367 | 0 |
| 2019 | 0 | 0 | 3960 | 0 | 6399 | 0 |
| 2020 | 0 | 0 | 3537 | 0 | 7463 | 0 |
| 2021 | 0 | 0 | 3544 | 0 | 7447 | 0 |
| 2022 | 0 | 0 | 3706 | 0 | 7038 | 0 |
| 2023 | 0 | 0 | 3700 | 0 | 7054 | 0 |
| 2024 | 0 | 0 | 3366 | 0 | 4892 | 0 |
| TOTALS | 310 | 0 | 86,646 | 3,713 | 144,327 | 6,565 |

*Consolidated At-Reactor

TABLE 1 (Continued)
WASTE RECEIVAL SCHEDULE FOR FIRST REPOSITORY

Case 2: 650 MTU WVHLW Received in 2003 and 2004
10,000 MTU DHLW Received in 2004 through 2021

Stage I Facility Used for WVHLW and DHLW

| | | | Spent Fuel Assemblies Received This Year | | | |
|---|---|---|---|---|---|---|
| | | | PWR | | BWR | |
| Year | WVHLW Canisters Received This Year | DHLW Canisters Received This Year | Intact | Consolidated* | Intact | Consolidated* |
| 1998 | 0 | 0 | 259 | 173 | 656 | 438 |
| 1999 | 0 | 0 | 228 | 128 | 822 | 463 |
| 2000 | 0 | 0 | 308 | 145 | 709 | 334 |
| 2001 | 0 | 0 | 809 | 315 | 1498 | 583 |
| 2002 | 0 | 0 | 1753 | 554 | 3050 | 963 |
| 2003 | 190 | 0 | 3079 | 770 | 5342 | 1336 |
| 2004 | 120 | 300 | 3434 | 654 | 5104 | 972 |
| 2005 | 0 | 800 | 3673 | 501 | 5156 | 703 |
| 2006 | 0 | 1200 | 3655 | 318 | 5857 | 509 |
| 2007 | 0 | 1200 | 3720 | 155 | 6348 | 264 |
| 2008 | 0 | 1200 | 4018 | 0 | 6252 | 0 |
| 2009 | 0 | 1200 | 4057 | 0 | 6154 | 0 |
| 2010 | 0 | 1200 | 3966 | 0 | 6383 | 0 |
| 2011 | 0 | 1200 | 4005 | 0 | 6285 | 0 |
| 2012 | 0 | 1200 | 4038 | 0 | 6203 | 0 |
| 2013 | 0 | 1200 | 3940 | 0 | 6448 | 0 |
| 2014 | 0 | 1200 | 4012 | 0 | 6268 | 0 |
| 2015 | 0 | 1200 | 4025 | 0 | 6236 | 0 |
| 2016 | 0 | 1200 | 3869 | 0 | 6628 | 0 |
| 2017 | 0 | 1200 | 4012 | 0 | 6268 | 0 |
| 2018 | 0 | 1200 | 3973 | 0 | 6367 | 0 |
| 2019 | 0 | 1200 | 3960 | 0 | 6399 | 0 |
| 2020 | 0 | 1200 | 3537 | 0 | 7463 | 0 |
| 2021 | 0 | 900 | 1672 | 0 | 3702 | 0 |
| TOTALS | 310 | 20,000 | 74,002 | 3,713 | 121,598 | 6,565 |

*Consolidated at-reactor

are separated by reactor type, and into "intact" and "consolidated" categories -- the consolidated fuel being that which was disassembled and consolidated at-reactor, prior to shipment to the repository.

As guidance for calculating the number of waste shipments to be received, it may be assumed that up to 80 percent of the spent fuel received at the repository will be shipped in 100-ton rail casks containing 12 intact PWR assemblies or 32 intact BWR assemblies, and that up to 70 percent will be shipped in truck casks containing two intact PWR assemblies or five intact BWR assemblies.[6] For spent fuel consolidated at-reactor, the cask capacities will be somewhat greater than for intact assemblies, but the actual capacities have not yet been determined. For WVHLW and DHLW, the only shipping cask now under development is a truck cask with a capacity of one waste canister. By the year 2000, it is expected that a rail cask with a capacity of five to seven canisters will have been developed.

Table 2 indicates the number of waste containers of each type to be emplaced during each year of repository operation. Again, two cases -- one for no DHLW and one for 10,000 MTU of DHLW -- are considered. For each year of emplacement, the thermal power of each type of spent fuel container (intact PWR, consolidated PWR, etc.) was calculated on the basis of the data in Appendix A and in Figure 1, and the total number of kilowatts (spent fuel only) emplaced each year was estimated. It is seen that for Case 1, 30,189 containers of spent fuel will be emplaced between 1998 and 2024, and 310 containers of WVHLW will be emplaced in 2003 and 2004. For Case 2, 25,341 containers of spent fuel will be emplaced between 1998 and 2021, 310 containers of WVHLW will be emplaced in 2003 and 2004, and 20,000 containers of DHLW will be emplaced between 2004 and 2021.

From Appendix B, Table B-2, it can be seen that each container of WVHLW emplaced in 2003 and 2004 will have a thermal power of about 200 watts. The total thermal power at the time of emplacement for all 310 containers is, therefore, only about 60 kW. Aside from its mere existence as a second waste type with unique requirements for handling and disposal, WVHLW should cause few operational problems for the repository.

# TABLE 2
## Waste Emplacement Schedule for First Repository
## Case 1: 650 MTU WVHLW Emplaced in 2003 and 2004, No DHLW

### Stage I Facility Used for WVHLW

| Year | Canisters of WVHLW Emplaced This Year | Canisters of DHLW Emplaced This Year | Spent Fuel Emplaced This Year: PWR Intact Canisters | PWR Intact Watts Per Canister | PWR Consolidated** Canisters | PWR Consolidated** Watts Per Canister | BWR Intact Canisters | BWR Intact Watts Per Canister | BWR Consolidated** Canisters | BWR Consolidated** Watts Per Canister | Total Spent Fuel Canisters Emplaced This Year | Total Spent Fuel kW Emplaced This Year | Total Canisters Emplaced This Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 0 | 0 | 86 | 1042 | 29 | 2085 | 109 | 684 | 36 | 1368 | 260 | 274 | 260 |
| 1999 | 0 | 0 | 76 | 1081 | 21 | 2163 | 137 | 708 | 39 | 1416 | 273 | 280 | 273 |
| 2000 | 0 | 0 | 103 | 1083 | 24 | 2167 | 118 | 709 | 28 | 1419 | 273 | 287 | 273 |
| 2001 | 0 | 0 | 0 | - | 187 | 2175 | 0 | - | 173 | 1424 | 360 | 653 | 360 |
| 2002 | 0 | 0 | 0 | - | 384 | 2207 | 0 | - | 334 | 1444 | 718 | 1330 | 718 |
| 2003 | 190 | 0 | 0 | - | 641 | 2253 | 0 | - | 557 | 1473 | 1198 | 2265 | 1388 |
| 2004 | 120 | 0 | 0 | - | 681 | 2319 | 0 | - | 506 | 1513 | 1187 | 2345 | 1307 |
| 2005 | 0 | 0 | 31 | 1523 | 680 | 2431 | 0 | - | 488 | 1582 | 1199 | 2472 | 1199 |
| 2006 | 0 | 0 | 91 | 1569 | 616 | 2528 | 0 | - | 531 | 1640 | 1238 | 2571 | 1238 |
| 2007 | 0 | 0 | 136 | 1598 | 578 | 2594 | 0 | - | 551 | 1680 | 1265 | 2642 | 1265 |
| 2008 | 0 | 0 | 117 | 1620 | 611 | 2647 | 0 | - | 521 | 1712 | 1249 | 2699 | 1249 |
| 2009 | 0 | 0 | 122 | 1644 | 615 | 2703 | 0 | - | 513 | 1745 | 1250 | 2758 | 1250 |
| 2010 | 0 | 0 | 122 | 1683 | 600 | 2764 | 0 | - | 532 | 1781 | 1254 | 2811 | 1254 |
| 2011 | 0 | 0 | 127 | 1750 | 604 | 2848 | 0 | - | 524 | 1830 | 1255 | 2901 | 1255 |
| 2012 | 0 | 0 | 125 | 1842 | 610 | 2947 | 0 | - | 517 | 1887 | 1252 | 3003 | 1252 |
| 2013 | 0 | 0 | 126 | 1940 | 594 | 3044 | 0 | - | 537 | 1942 | 1257 | 3095 | 1257 |
| 2014 | 0 | 0 | 124 | 2033 | 606 | 3134 | 0 | - | 522 | 1993 | 1252 | 3192 | 1252 |
| 2015 | 0 | 0 | 118 | 2123 | 612 | 3224 | 0 | - | 520 | 2044 | 1250 | 3286 | 1250 |
| 2016 | 0 | 0 | 104 | 2243 | 593 | 3350 | 0 | - | 552 | 2115 | 1249 | 3387 | 1249 |
| 2017 | 0 | 0 | 111 | 2318 | 736* | 2862 | 0 | - | 522 | 2162 | 1369 | 3492 | 1369 |
| 2018 | 0 | 0 | 82 | 2440 | 745* | 2986 | 0 | - | 531 | 2246 | 1358 | 3617 | 1358 |
| 2019 | 0 | 0 | 82 | 2528 | 743* | 3083 | 0 | - | 533 | 2311 | 1358 | 3730 | 1358 |
| 2020 | 0 | 0 | 83 | 2621 | 658* | 3194 | 0 | - | 622 | 2387 | 1363 | 3804 | 1363 |
| 2021 | 0 | 0 | 57 | 2719 | 675* | 3322 | 0 | - | 621 | 2474 | 1353 | 3934 | 1353 |
| 2022 | 0 | 0 | 73 | 2744 | 697* | 3358 | 0 | - | 586 | 2498 | 1356 | 4005 | 1356 |
| 2023 | 0 | 0 | 54 | 2795 | 884* | 2745 | 0 | - | 588 | 2549 | 1526 | 4076 | 1526 |
| 2024 | 0 | 0 | 70 | 2848 | 789* | 2809 | 0 | - | 408 | 2603 | 1267 | 3478 | 1267 |
| TOTALS | 310 | 0 | 2,220 | | 15,213* | | 364 | | 12,392 | | 30,189 | 72,387 | 30,499 |

* Canister capacity limited by thermal power
** Consolidated either at-reactor or at the repository

# TABLE 2
## Waste Emplacement Schedule for First Repository
## Case 2: 650 MTU WVHLW Emplaced in 2003 and 2004, 10,000 MTU DHLW Emplaced in 2004 through 2021

### Stage I Facility Used for WVHLW and DHLW

| | | | Spent Fuel Emplaced This Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PWR | | | | BWR | | | | | | |
| | | | Intact | | Consolidated** | | Intact | | Consolidated** | | | | |
| Year | Canisters of WVHLW Emplaced This Year | Canisters of DHLW Emplaced This Year | Canisters | Watts Per Canister | Canisters | Watts Per Canister | Canisters | Watts Per Canister | Canisters | Watts Per Canister | Total Spent Fuel Canisters Emplaced This Year | Total Spent Fuel kW Emplaced This Year | Total Canisters Emplaced This Year |
| 1998 | 0 | 0 | 86 | 1042 | 29 | 2085 | 109 | 684 | 36 | 1368 | 260 | 274 | 260 |
| 1999 | 0 | 0 | 76 | 1081 | 21 | 2163 | 137 | 708 | 39 | 1416 | 273 | 280 | 273 |
| 2000 | 0 | 0 | 103 | 1083 | 24 | 2167 | 118 | 709 | 28 | 1419 | 273 | 287 | 273 |
| 2001 | 0 | 0 | 0 | - | 187 | 2175 | 0 | - | 173 | 1424 | 360 | 653 | 360 |
| 2002 | 0 | 0 | 0 | - | 384 | 2207 | 0 | - | 334 | 1444 | 718 | 1330 | 718 |
| 2003 | 190 | 0 | 0 | - | 641 | 2253 | 0 | - | 557 | 1473 | 1198 | 2265 | 1388 |
| 2004 | 120 | 300 | 0 | - | 681 | 2319 | 0 | - | 506 | 1513 | 1187 | 2345 | 1307 |
| 2005 | 0 | 800 | 31 | 1523 | 680 | 2431 | 0 | - | 488 | 1582 | 1199 | 2472 | 1199 |
| 2006 | 0 | 1200 | 91 | 1569 | 616 | 2528 | 0 | - | 531 | 1640 | 1238 | 2571 | 1238 |
| 2007 | 0 | 1200 | 136 | 1598 | 578 | 2594 | 0 | - | 551 | 1680 | 1265 | 2642 | 1265 |
| 2008 | 0 | 1200 | 117 | 1620 | 611 | 2647 | 0 | - | 521 | 1712 | 1249 | 2699 | 1249 |
| 2009 | 0 | 1200 | 122 | 1644 | 615 | 2703 | 0 | - | 513 | 1745 | 1250 | 2758 | 1250 |
| 2010 | 0 | 1200 | 122 | 1683 | 600 | 2764 | 0 | - | 532 | 1781 | 1254 | 2811 | 1254 |
| 2011 | 0 | 1200 | 127 | 1750 | 604 | 2848 | 0 | - | 524 | 1830 | 1255 | 2901 | 1255 |
| 2012 | 0 | 1200 | 125 | 1842 | 610 | 2947 | 0 | - | 517 | 1887 | 1252 | 3003 | 1252 |
| 2013 | 0 | 1200 | 126 | 1940 | 594 | 3044 | 0 | - | 537 | 1942 | 1257 | 3095 | 1257 |
| 2014 | 0 | 1200 | 124 | 2033 | 606 | 3134 | 0 | - | 522 | 1993 | 1252 | 3192 | 1252 |
| 2015 | 0 | 1200 | 118 | 2123 | 612 | 3224 | 0 | - | 520 | 2044 | 1250 | 3286 | 1250 |
| 2016 | 0 | 1200 | 104 | 2243 | 593 | 3350 | 0 | - | 552 | 2115 | 1249 | 3387 | 1249 |
| 2017 | 0 | 1200 | 111 | 2318 | 736* | 2862 | 0 | - | 522 | 2162 | 1369 | 3492 | 1369 |
| 2018 | 0 | 1200 | 82 | 2440 | 745* | 2986 | 0 | - | 531 | 2246 | 1358 | 3617 | 1358 |
| 2019 | 0 | 1200 | 82 | 2528 | 743* | 3083 | 0 | - | 533 | 2311 | 1358 | 3730 | 1358 |
| 2020 | 0 | 1200 | 83 | 2621 | 658* | 3194 | 0 | - | 622 | 2387 | 1363 | 3804 | 1363 |
| 2021 | 0 | 900 | 27 | 2669 | 318* | 3256 | 0 | - | 309 | 2429 | 654 | 1858 | 1454 |
| TOTALS | 310 | 20,000 | 1,993 | | 12,486* | | 364 | | 10,498 | | 25,341 | 58,752 | 45,651 |

* Canister capacity limited by thermal power

** Consolidated either at-reactor or at the repository

No obvious repository interface problems have been identified if a decision is made to dispose of DHLW in the first civilian repository. On the average, the thermal power per container would be comparable with the 200 watts cited above for WVHLW. (Table B-4 of Appendix B shows the thermal power decay of equilibrium DHLW, which will be produced only late in the operating history of the DWPF.) The total thermal power of the eight hundred 200-watt containers emplaced each year is only 160 kW, and the effect of the DHLW on the thermomechanical stability of the repository would be small compared with the effect produced by the spent fuel. The logistical impact of the DHLW, on the other hand, would be substantial because of the very large number of containers (20,000, received at the rate of 800 to 1,200 per year).

## 5. OTHER WASTE TYPES

Although Appendix B emphasizes spent fuel, WVHLW and DHLW, a number of other waste types will or may be disposed of in the first repository. These are discussed qualitatively below:

(1) Site-Generated Wastes: Site-generated wastes include discarded air and water filters, evaporator residues, and decontamination materials. Under normal operating conditions, and even under credible abnormal conditions, these will probably be in the "low-level" (non-transuranic, or non-TRU) radioactive waste category -- i.e., they will contain less than 100 nanocuries of transuranic radionuclides per gram of waste; they would, therefore, qualify for disposal in a surface burial facility. No such facility will be available at the Yucca Mountain repository, however, and the site-generated wastes will be disposed of in the same manner as TRU wastes. They will be packaged in metal boxes and drums -- perhaps after mechanical compaction, but without incineration -- and emplaced in a remote and relatively cool part of the underground disposal area. Bechtel National, Inc., (BNI) is characterizing and quantifying site-generated wastes under its repository design contract with Sandia.

(2) "Hardware" Waste: Hardware waste is the highly radioactive (but non-TRU) metal scrap -- end fittings, spacers, etc., -- remaining after the fuel rod consolidation operation. As noted in Chapter 3, Assumption 2, all the hardware waste produced in the repository consolidation operation will be disposed of in the spent fuel containers themselves; no additional containers of any kind will be required. The question of how to dispose of the hardware waste generated at-reactor has not yet been addressed by DOE.

(3) "Non-Fuel" Waste: Under 10 CFR 961, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste," utilities are permitted to transfer such non-fuel core components as control rods, instrument tubes, etc., to the DOE for disposal. This waste is being characterized and quantified by Fluor Corporation under a contract supporting the salt repository project. Sandia is monitoring this activity and will provide appropriate inputs to the design of the Yucca Mountain repository when information becomes available.

(4) CHLW and Commercial TRU Waste: Appendix B states that the first and second civilian repositories need not include provisions for the disposal of commercial high-level waste (CHLW) or commercial TRU (CTRU) waste, but specifies that the designs of the repositories should not preclude a future decision to dispose of such wastes. The description of the reference CHLW provided in Appendix B, Table B-3, indicates that no serious technical problems would be encountered in converting to a CHLW-based disposal scenario: the number of high-level waste containers to be emplaced is approximately the same for an all-CHLW repository as for an all-spent-fuel repository, and elimination of the fuel rod consolidation operation would actually simplify and accelerate the process of preparing waste containers for disposal. The radiation levels associated with a CHLW container would be somewhat higher than for a spent fuel container; this should be considered in the design of permanent facilities such as hot cells.

CTRU waste is not characterized in Appendix B, but it can be seen from an earlier study[7] that TRU (and other) wastes from reprocessing would pose a serious logistical problem in a repository designed for a once-through fuel cycle. The secondary wastes produced in reprocessing 3,000 MTU of spent fuel, for example, would include some 1200 55-gallon drums of low-activity ("contact-handled") compacted TRU waste, 900 canisters (61-cm diameter by 300 cm) of high-activity ("remote-handled") compacted TRU waste, and 1,000 canisters (61-cm diameter by 300 cm) of compacted cladding hulls. In addition, mixed-oxide (MOX) fuel fabrication (without which there is no real incentive to reprocess spent fuel in the first place) would produce another 4700 55-gallon drums of low-activity compacted TRU waste. These numbers represent the annual <u>increment</u> in the number of waste containers to be disposed of, if reprocessing were to be resumed. These secondary wastes are of relatively low activity, and their disposal introduces no new technical problems. The potential logistical problem, on the other hand, demands careful consideration in the design of the repository.

(5) <u>Other Wastes</u>: Regardless of how carefully the repository design parameters are formulated, there should be reasonable flexibility for handling and disposing of one-of-a-kind waste packages that are significantly different from those received (or generated on-site). Among the most important waste categories are those that will result from decommissioning the repository itself.

## 6. RADIATION LEVELS

The radiation levels associated with the various types of waste containers are important in the design of hot cells and transfer casks and in the assessment of radiation doses to operating personnel and the general public. These radiation levels will be calculated on the basis of the new ORIGEN2 data referred to in Chapter 3, Assumption 5. For the present, only order-of-magnitude estimates can be made for the surface dose rates associated with spent fuel and CHLW containers: spent fuel containers will exhibit peak gamma dose rates of about $10^5$ rem/hr and neutron dose rates of about $10^2$ rem/hr; the corresponding values for CHLW are less than $10^6$ rem/hr (gamma) and $10^2$ rem/hr (neutron).

From earlier work[7], it is estimated that WVHLW and DHLW containers will exhibit gamma dose rates of approximately $10^3$ rem/hr, and near-negligible neutron dose rates. Other waste types are not well characterized, but it can be estimated that the non-fuel waste shipped directly from reactors and the cladding waste from spent fuel reprocessing will exhibit gamma dose rates on the order of thousands of rem/hr (but near-negligible neutron dose rates). Design inputs related to all the waste types will be updated as information becomes available.

## 7. SUMMARY

In this report, the waste descriptions and generation rates baselined by DOE (and reproduced in Appendix B) have been recast as waste receival and waste emplacement schedules for a geologic repository at Yucca Mountain, Nevada. The data presented provide a basis for determining the land area and equipment requirements for the surface and underground facilities, and for formulating a timetable for mining the waste disposal area.

The reference disposal scenario is for a repository that accepts only spent power reactor fuel and solidified high-level waste from the West Valley Demonstration Project. It is seen that major logistical problems (but no serious technical problems) can arise from alternative waste management plans in which the repository accepts defense high-level waste, or in which commercial high-level waste is shipped to the repository along with the secondary wastes produced from reprocessing spent fuel. Both contingencies should be considered in the basic design of the waste handling facilities.

Appendix B specifies that the repository must be designed to accept occasional shipments of short-cooled, high-burnup fuel. Radiation source terms for this fuel will be defined on the basis of recently updated ORIGEN2 decay calculations, and will serve as an input for the design of repository hot cells and on-site waste transfer casks.

This report will be updated as necessary when new design information becomes available.

## REFERENCES


1. U.S. Department of Energy, "Generic Requirements for a Mined Geologic Disposal System" (draft), September 1984.

2. Nuclear Waste Policy Act of 1982, Public Law 97-425.

3. U.S. Department of Energy, "Mission Plan for the Civilian Radioactive Waste Management Program," DOE/RW-0005 Draft, Washington, D.C.

4. Letter from L. Ramspott, Lawrence Livermore National Laboratory, to D. L. Vieth, U.S. Department of Energy, Waste Management Project Office, June 6, 1984, on the subject of "Changes to Waste Package Reference Designs for Site Characterization Plan Revision."

5. Private communication from T. I. McSweeney, Office of Crystalline Rock Development, to Paul D. O'Brien, Sandia National Laboratories, May 10, 1984.

6. E. L. Wilmot, M. M. Madsen, J. W. Cashwell, D. S. Joy, "A Preliminary Analysis of the Cost and Risk of Transporting Nuclear Waste to Potential Candidate Commercial Repository Sites," SAND83-0867, Sandia National Laboratories, Albuquerque, New Mexico, June 1983.

7. P. D. O'Brien, "Preliminary Reference Waste Descriptions for a Repository at Yucca Mountain, Nevada," SAND83-1805, Sandia National Laboratories, Albuquerque, New Mexico, July 1984.

Appendix A

First Repository Emplacement Schedule
(Case 1: 650 MTU WVHLW Emplaced in 2003 and 2004, No DHLW)

Stage I Facility Used for WVHLW

| Year | MTU WVHLW Emplaced This Year | Cumulative MTU WVHLW Emplaced at End of Year | MTU DHLW Emplaced This Year | Cumulative MTU DHLW Emplaced at End of Year | MTU PWR Spent Fuel Emplaced This Year | MTU BWR Spent Fuel Emplaced This Year | Total MTU Spent Fuel Emplaced This Year | Cumulative MTU Spent Fuel in First Repository at End of Year | Cumulative MTU Spent Fuel in Second Repository at End of Year | Cumulative MTU Spent Fuel in Both Repositories at End of Year | Percent (MTU Basis) of Spent Fuel Emplaced This Year That is PWR | Percent of Spent Fuel Emplaced This Year After Consolidation-at-Reactor | Percent of PWR Spent Fuel Emplaced This Year With Burnup >40 GWd/MTU | Average Age (Years Out-of-Reactor) of Spent Fuel Emplaced This Year | Average Burnup (GWd/MTU) of Normal-Burnup PWR SF Emplaced This Year | Average Burnup (GWd/MTU) of High-Burnup PWR SF Emplaced This Year | Average Burnup (GWd/MTU) of BWR SF Emplaced This Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 0 | 0 | 0 | 0 | 199.5 | 200.5 | 400 | 400 | 0 | 400 | 49.9 | 40 | 0 | 27.8 | - | - | - |
| 1999 | 0 | 0 | 0 | 0 | 164.5 | 235.5 | 400 | 800 | 0 | 800 | 41.1 | 36 | 0 | 25.8 | 21.4 | - | 10.2 |
| 2000 | 0 | 0 | 0 | 0 | 208.9 | 191.1 | 400 | 1200 | 0 | 1200 | 52.2 | 32 | 0 | 25.7 | 18.6 | - | 12.1 |
| 2001 | 0 | 0 | 0 | 0 | 518.6 | 381.4 | 900 | 2100 | 0 | 2100 | 57.6 | 28 | 0 | 25.5 | 19.9 | - | 15.4 |
| 2002 | 0 | 0 | 0 | 0 | 1064.3 | 735.7 | 1800 | 3900 | 0 | 3900 | 59.1 | 24 | 0 | 24.7 | 25.1 | - | 18.1 |
| 2003 | 400 | 400 | 0 | 0 | 1775.9 | 1224.1 | 3000 | 6900 | 0 | 6900 | 59.2 | 20 | 0 | 23.6 | 27.9 | - | 22.5 |
| 2004 | 250 | 650 | 0 | 0 | 1886.2 | 1113.8 | 3000 | 9900 | 0 | 9900 | 62.9 | 16 | 0 | 22.1 | 29.1 | - | 24.8 |
| 2005 | 0 | 650 | 0 | 0 | 1926.0 | 1074.0 | 3000 | 12900 | 1800 | 14700 | 64.2 | 12 | 2.2 | 19.7 | 30.2 | 42.5 | 23.1 |
| 2006 | 0 | 650 | 0 | 0 | 1833.0 | 1167.0 | 3000 | 15900 | 3600 | 19500 | 61.1 | 8 | 6.9 | 17.8 | 32.2 | 42.5 | 23.8 |
| 2007 | 0 | 650 | 0 | 0 | 1788.0 | 1212.0 | 3000 | 18900 | 5400 | 24300 | 59.6 | 4 | 10.5 | 16.6 | 33.7 | 42.5 | 27.3 |
| 2008 | 0 | 650 | 0 | 0 | 1854.0 | 1146.0 | 3000 | 21900 | 7200 | 29100 | 61.8 | 0 | 8.7 | 15.7 | 34.1 | 42.5 | 28.1 |
| 2009 | 0 | 650 | 0 | 0 | 1872.0 | 1128.0 | 3000 | 24900 | 9000 | 33900 | 62.4 | 0 | 9.0 | 14.8 | 34.1 | 42.5 | 28.4 |
| 2010 | 0 | 650 | 0 | 0 | 1830.0 | 1170.0 | 3000 | 27900 | 12000 | 39900 | 61.0 | 0 | 9.2 | 13.9 | 34.5 | 42.5 | 28.8 |
| 2011 | 0 | 650 | 0 | 0 | 1848.0 | 1152.0 | 3000 | 30900 | 15000 | 45900 | 61.6 | 0 | 9.5 | 12.8 | 34.2 | 42.5 | 28.5 |
| 2012 | 0 | 650 | 0 | 0 | 1863.0 | 1137.0 | 3000 | 33900 | 18000 | 51900 | 62.1 | 0 | 9.3 | 11.7 | 34.3 | 42.5 | 28.7 |
| 2013 | 0 | 650 | 0 | 0 | 1818.0 | 1182.0 | 3000 | 36900 | 21000 | 57900 | 60.6 | 0 | 9.6 | 10.8 | 34.5 | 42.5 | 28.8 |
| 2014 | 0 | 650 | 0 | 0 | 1851.0 | 1149.0 | 3000 | 39900 | 24000 | 63900 | 61.7 | 0 | 9.3 | 10.1 | 34.1 | 42.5 | 28.1 |
| 2015 | 0 | 650 | 0 | 0 | 1857.0 | 1143.0 | 3000 | 42900 | 27000 | 69900 | 61.9 | 0 | 8.8 | 9.5 | 33.8 | 42.5 | 28.8 |
| 2016 | 0 | 650 | 0 | 0 | 1785.0 | 1215.0 | 3000 | 45900 | 30000 | 75900 | 59.5 | 0 | 8.1 | 8.8 | 31.5 | 42.5 | 25.8 |
| 2017 | 0 | 650 | 0 | 0 | 1851.0 | 1149.0 | 3000 | 48900 | 33000 | 81900 | 61.7 | 0 | 8.3 | 8.4 | 31.2 | 42.5 | 25.9 |
| 2018 | 0 | 650 | 0 | 0 | 1833.0 | 1167.0 | 3000 | 51900 | 36000 | 87900 | 61.1 | 0 | 6.2 | 7.8 | 31.4 | 42.5 | 27.4 |
| 2019 | 0 | 650 | 0 | 0 | 1827.0 | 1173.0 | 3000 | 54900 | 39000 | 93900 | 60.9 | 0 | 6.2 | 7.4 | 32.2 | 42.5 | 28.5 |
| 2020 | 0 | 650 | 0 | 0 | 1632.0 | 1368.0 | 3000 | 57900 | 42000 | 99900 | 54.4 | 0 | 7.0 | 7.0 | 33.1 | 42.5 | 25.7 |
| 2021 | 0 | 650 | 0 | 0 | 1635.0 | 1365.0 | 3000 | 60900 | 45000 | 105900 | 54.5 | 0 | 4.8 | 6.6 | 32.2 | 42.5 | 25.7 |
| 2022 | 0 | 650 | 0 | 0 | 1710.0 | 1290.0 | 3000 | 63900 | 48000 | 111900 | 57.0 | 0 | 5.9 | 6.5 | 31.8 | 42.5 | 24.8 |
| 2023 | 0 | 650 | 0 | 0 | 1707.0 | 1293.0 | 3000 | 66900 | 51000 | 117900 | 56.9 | 0 | 4.4 | 6.3 | 32.6 | 42.5 | 25.6 |
| 2024 | 0 | 650 | 0 | 0 | 1553.3 | 896.7 | 2450 | 69350 | 54000 | 123350 | 63.4 | 0 | 6.2 | 6.1 | 33.8 | 42.5 | 28.5 |
| 2025 | | | | | | | | | 57000 | 126350 | | | | | | | |
| 2026 | | | | | | | | | 60000 | 129350 | | | | | | | |
| 2027 | | | | | | | | | 63000 | 132350 | | | | | | | |
| 2028 | | | | | | | | | 64450 | 133900 | | | | | | | |

## Appendix A

First Repository Emplacement Schedule
(Case 2: 650 MTU WVHLW Emplaced in 2003 and 2004
10,000 MTU DHLW From 2004 through 2021

| Year | MTU WVHLW Emplaced This Year | Cumulative MTU WVHLW Emplaced at End of Year | MTU DHLW Emplaced This Year | Cumulative MTU DHLW Emplaced at End of Year | MTU PWR Spent Fuel Emplaced This Year | MTU BWR Spent Fuel Emplaced This Year | Total MTU Spent Fuel Emplaced This Year | Cumulative MTU Spent Fuel in First Repository at End of Year | Cumulative MTU Spent Fuel in Second Repository at End of Year | Cumulative MTU Spent Fuel in Both Repositories at End of Year | Percent (MTU Basis) of Spent Fuel Emplaced This Year That is PWR | Percent of Spent Fuel Emplaced This Year After Consolidation-at-Reactor | Percent of PWR Spent Fuel Emplaced This Year With Burnup >40 GWd/MTU | Average Age (Years Out-of-Reactor) of Spent Fuel Emplaced This Year | Average Burnup (GWd/MTU) of Normal-Burnup PWR SF Emplaced This Year | Average Burnup (GWd/MTU) of High-Burnup PWR SF Emplaced This Year | Average Burnup (GWd/MTU) of BWR SF Emplaced This Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 0 | 0 | 0 | 0 | 199.5 | 200.5 | 400 | 400 | 0 | 400 | 49.9 | 40 | 0 | 27.8 | - | - | - |
| 1999 | 0 | 0 | 0 | 0 | 164.5 | 235.5 | 400 | 800 | 0 | 800 | 41.1 | 36 | 0 | 25.8 | 21.4 | - | 10.2 |
| 2000 | 0 | 0 | 0 | 0 | 208.9 | 191.1 | 400 | 1200 | 0 | 1200 | 52.2 | 32 | 0 | 25.7 | 18.6 | - | 12.1 |
| 2001 | 0 | 0 | 0 | 0 | 518.6 | 381.4 | 900 | 2100 | 0 | 2100 | 57.6 | 28 | 0 | 25.5 | 19.9 | - | 15.4 |
| 2002 | 0 | 0 | 0 | 0 | 1064.3 | 735.7 | 1800 | 3900 | 0 | 3900 | 59.1 | 24 | 0 | 24.7 | 25.1 | - | 18.1 |
| 2003 | 400 | 400 | 0 | 0 | 1775.9 | 1224.1 | 3000 | 6900 | 0 | 6900 | 59.2 | 20 | 0 | 23.6 | 27.9 | - | 22.5 |
| 2004 | 250 | 650 | 150 | 150 | 1886.2 | 1113.8 | 3000 | 9900 | 0 | 9900 | 62.9 | 16 | 0 | 22.1 | 29.1 | - | 24.8 |
| 2005 | 0 | 650 | 400 | 550 | 1926.0 | 1074.0 | 3000 | 12900 | 1800 | 14700 | 64.2 | 12 | 2.2 | 19.7 | 30.2 | 42.5 | 23.1 |
| 2006 | 0 | 650 | 600 | 1150 | 1833.0 | 1167.0 | 3000 | 15900 | 3600 | 19500 | 61.1 | 8 | 6.9 | 17.8 | 32.2 | 42.5 | 23.8 |
| 2007 | 0 | 650 | 600 | 1750 | 1788.0 | 1212.0 | 3000 | 18900 | 5400 | 24300 | 59.6 | 4 | 10.5 | 16.6 | 33.7 | 42.5 | 27.3 |
| 2008 | 0 | 650 | 600 | 2350 | 1854.0 | 1146.0 | 3000 | 21900 | 7200 | 29100 | 61.8 | 0 | 8.7 | 15.7 | 34.1 | 42.5 | 28.1 |
| 2009 | 0 | 650 | 600 | 2950 | 1872.0 | 1128.0 | 3000 | 24900 | 9000 | 33900 | 62.4 | 0 | 9.0 | 14.8 | 34.1 | 42.5 | 28.4 |
| 2010 | 0 | 650 | 600 | 3550 | 1830.0 | 1170.0 | 3000 | 27900 | 12000 | 39900 | 61.0 | 0 | 9.2 | 13.9 | 34.5 | 42.5 | 28.8 |
| 2011 | 0 | 650 | 600 | 4150 | 1848.0 | 1152.0 | 3000 | 30900 | 15000 | 45900 | 61.6 | 0 | 9.5 | 12.8 | 34.2 | 42.5 | 28.5 |
| 2012 | 0 | 650 | 600 | 4750 | 1863.0 | 1137.0 | 3000 | 33900 | 18000 | 51900 | 62.1 | 0 | 9.3 | 11.7 | 34.3 | 42.5 | 28.7 |
| 2013 | 0 | 650 | 600 | 5350 | 1818.0 | 1182.0 | 3000 | 36900 | 21000 | 57900 | 60.6 | 0 | 9.6 | 10.8 | 34.5 | 42.5 | 28.8 |
| 2014 | 0 | 650 | 600 | 5960 | 1851.0 | 1149.0 | 3000 | 39900 | 24000 | 63900 | 61.7 | 0 | 9.3 | 10.1 | 34.1 | 42.5 | 28.1 |
| 2015 | 0 | 650 | 600 | 6550 | 1857.0 | 1143.0 | 3000 | 42900 | 27000 | 69900 | 61.9 | 0 | 8.8 | 9.5 | 33.8 | 42.5 | 28.8 |
| 2016 | 0 | 650 | 600 | 7150 | 1785.0 | 1215.0 | 3000 | 45900 | 30000 | 75900 | 59.5 | 0 | 8.1 | 8.8 | 31.5 | 42.5 | 25.8 |
| 2017 | 0 | 650 | 600 | 7750 | 1851.0 | 1149.0 | 3000 | 48900 | 33000 | 81900 | 61.7 | 0 | 8.3 | 8.4 | 31.2 | 42.5 | 25.9 |
| 2018 | 0 | 650 | 600 | 8350 | 1833.0 | 1167.0 | 3000 | 51900 | 36000 | 87900 | 61.1 | 0 | 6.2 | 7.8 | 31.4 | 42.5 | 27.4 |
| 2019 | 0 | 650 | 600 | 8950 | 1827.0 | 1173.0 | 3000 | 54900 | 39000 | 93900 | 60.9 | 0 | 6.2 | 7.4 | 32.2 | 42.5 | 28.5 |
| 2020 | 0 | 650 | 600 | 9550 | 1632.0 | 1368.0 | 3000 | 57900 | 42000 | 99900 | 54.4 | 0 | 7.0 | 7.0 | 33.1 | 42.5 | 25.7 |
| 2021 | 0 | 650 | 450 | 10000 | 771.4 | 678.6 | 1450 | 59350 | 45000 | 104350 | 53.2 | 0 | 4.8 | 6.8 | 32.3 | 42.5 | 26.5 |
| 2022 | | | | | | | | | 48000 | 107350 | | | | | | | |
| 2023 | | | | | | | | | 51000 | 110350 | | | | | | | |
| 2024 | | | | | | | | | 54000 | 113350 | | | | | | | |
| 2025 | | | | | | | | | 57000 | 116350 | | | | | | | |
| 2026 | | | | | | | | | 60000 | 119350 | | | | | | | |
| 2027 | | | | | | | | | 63000 | 122350 | | | | | | | |
| 2028 | | | | | | | | | 66000 | 125350 | | | | | | | |
| 2029 | | | | | | | | | 69000 | 128350 | | | | | | | |
| 2030 | | | | | | | | | 70000 | 129350 | | | | | | | |

# APPENDIX B

# EXTERNAL SYSTEM INTERFACES

SECTION B.1  WASTE SOURCE SYSTEM INTERFACE

SECTION B.2  TRANSPORTATION SYSTEM INTERFACE

## SECTION B.1

## WASTE SOURCE SYSTEM INTERFACE

This section describes the baseline for wastes to be received at the MGDS. In order to design the MGDS, its capacity and waste receipt rate must be specified, and the characteristics of the received waste forms must be known. Since the first MGDS will not begin receiving waste until 1998 per the present schedule, the planning data base must incorporate projections and assumptions as to the nuclear power generation and commercial reprocessing activities over an extensive period of time. The assumptions in this section are keyed as closely as possible to the Civilian Radioactive Waste Management Program Mission Plan and the "Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics" documents produced annually by the DOE (see DOE/NE-0017/2, 1983). This latter series of inventory documents bases its projections on the DOE Energy Information Agency's (EIA) annual projections. Changes in these official projections will be periodically incorporated into this baseline document as necessary.

### A. Waste Types

A variety of wastes may ultimately be disposed of in the MGDS. To provide a consistent basis for repository design, the following baseline is established:

#### First Repository

Wastes to be received shall be spent fuel and canisters of solidified high-level waste from the West Valley Demonstration Project (WVHLW). Should the President decide to dispose of Defense High-Level Wastes (DHLW) in a commercial repository, receipt of DHLW may also be required. The repository design need not include specific provisions for disposal of DHLW, commercial high-level wastes (CHLW) (other than WVHLW) or commercial transuranic wastes (CTRU) from reprocessing or any other source, but the design should not preclude a later decision to dispose of such waste.

The current reference schedule for repository development, as described in the OCRWM Mission Plan (DOE/RW-0005 DRAFT), calls for the first repository to be constructed and operated in two stages. During Stage I repository operations, only spent fuel will be routinely received for disposal. Small amounts of WVHLW and of DHLW (should disposal of the latter in a commercial repository be decided) may also be received for emplacement during Stage I on a non-routine, special-handling basis. Quantities of WVHLW and DHLW will be small and will be handled and disposed of so as not to interfere with the normal flow of spent fuel.

Stage I will receive 400 MTU per year of spent fuel until Stage II comes fully on line. At that time, the Stage I surface facilities and operations will be discontinued. The Stage II facility will receive 500

MTU in the fourth year of the repository's operation and 1400 MTU in the fifth year (see Table B-5).

Second Repository

Waste to be received shall be spent fuel. Should the President decide to dispose of DHLW in a commercial repository, receipt of DHLW may be required. Repository design need not include specific provision for disposal of CHLW or CTRU from reprocessing or any other source, but the design should not preclude a later decision to dispose of such waste.

Currently, most high-level waste to be disposed of exists in the form of spent fuel assemblies at utility reactor sites. At present, the only CHLW requiring disposal is at the West Valley Demonstration Project.

The Nuclear Waste Policy Act of 1982 requires the President to evaluate the use of commercial disposal capacity for the disposal of DHLW. Pending completion of a DOE evaluation and a Presidential finding on DHLW disposal requirements, the Department is using the following principles as a planning basis relative to the potential receipt of defense wastes:

1. The repository design will not preclude the capability to dispose of defense waste. This capability will be maintained unless the President finds that a defense-only repository is required.

2. If civilian repositories accept defense wastes, these wastes will be received on a separate schedule such that the rate of receipt of commercial waste will not be altered. Such receipt will begin during the first year of operation of the first repository and will continue thereafter as required to work off the backlog of defense wastes. This option will be implemented after the full 3000 MTU per year receipt rate of the repository has been achieved.

B. Waste Forms

Spent Fuel

Spent fuel will be received at the repository as intact assemblies or as canisters of rods removed from assemblies for more efficient use of reactor pool storage space. As the backlog of fuel in the pools is drawn down, there will be decreasing need for consolidation. The repository should be designed to process up to 40 percent of the first year's receipt as consolidated fuel. This amount will decrease linearly to no consolidated fuel receipts after the first 10 years of operation.

Spent fuel will be shipped directly from the utility reactor sites to the repository or from other facilities, such as an MRS, if authorized by Congress. Spent fuel recieved from these facilities may be consolidated and possibly packaged for placement in the repository.

First Repository

During Stage I of repository operations, the repository rod consolidation facility will not be in operation. During this period, intact spent fuel assemblies or canisters of rods consolidated at-reactor will be packaged for disposal in the as-received condition (i.e., as intact assemblies or canisters of consolidated rods).

During Stage II of repository operations, spent fuel rods will be removed from intact assemblies, consolidated, and packaged for disposal. Rods received in canisters may be removed, reconsolidated, and repackaged for disposal, or the canistered rods may be further packed or processed for disposal, depending on site-specific considerations.

Second Repository

Spent fuel rods will be removed from intact assemblies, consolidated, and packaged for disposal. Rods received in canisters may be removed and repackaged for disposal, or the canistered rods may be further packaged or processed for disposal, depending on site-specific conditions.

Currently, spent fuel is stored as intact assemblies in reactor storage pools. Some utilities are considering disassembly of spent fuel bundles and storage of consolidated rods to more efficiently utilize the limited storage space available at reactor sites. The utility incentive to disassemble will be highest before the repository opens, and a large percentage of the early receipts are expected to be in disassembled form. As the waste disposal system begins to "draw down" the backlog of spent fuel at reactors, the incentive to disassemble will diminish. Thus, eventually 100 percent of the annual receipts may be expected to be intact assemblies.

Canisters of consolidated rods received at the repository are expected to contain the rods from two fuel assemblies and to have approximately the same exterior dimensions as the original fuel assemblies from which the rods were removed.

Consolidated rod waste packages are the configuration for disposal of spent fuel. Table B-1 presents some characteristics of spent fuel to be received at the MGDS. A more comprehensive listing of spent fuel characteristics, including decay heat rates, isotope inventories, photon and neutron spectra, etc., is being compiled and will be issued in the near future for reference.

Commercial High-Level Wastes

High-level radioactive wastes from the West Valley Demonstration Project will be received in solidified form. Radionuclides will be immobilized in borosilicate glass contained in a 304L stainless steel can similar* in design to that being used for solidification of wastes at the Defense Waste Processing Facility. WVHLW form characteristics are summarized in Table B-2. Containers will be processed and packaged at the MGDS as necessary to meet site-specific conditions during second stage repository operations.

No other CHLW from reprocessing exists as yet. However, if necessary for planning purposes, the CHLW waste form is assumed to be borosilicate glass in a canister with characteristics summarized in Table B-3. Each MGDS must be designed so that the capability of disposal of CHLW is not necessarily precluded, even though no specific design provision need be made. For additional details, consult "Reference Commercial High Level Waste Glass and Canister Definition," PNL 3838, dated September 1981.

Non-reprocessing CTRU is not presently part of the planning base, pending identification of a firmly-based inventory and characteristics of this waste type.

Should the President decide that DHLW is to be disposed of in a commercial repository, it is likely that from 6,700 containers by 2007 or 20,000 containers by 2020 will require disposal. For planning purposes, the DHLW form is assumed to be borosilicate glass in a canister with characteristics summarized in Table B-4. For additional details, consult "Description of Defense Waste Processing Facility Reference Waste Form and Canister", DP-1606, Rev 1 dated August 1983.

C. Repository Capacity

First and second repository design shall be based on a maximum capacity of 70,000 MTU of spent fuel or the equivalent in wastes (CHLW and CTRU) from the reprocessing of 70,000 MTU of spent fuel. The inventory of WVHLW (650 MTU) shall be included within this capacity for the first repository.

The NWPA establishes a maximum of 70,000 MTU on the amount of waste which can be disposed of in the first repository before a second repository is operational. In the Mission Plan, the DOE concludes that two repositories, each with about 70,000 MTU, will accommodate all wastes generated through 2020. This is the end of the period for which an estimate of repository

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*Handling arrangements and can external dimensions for the WVHLW can are identical to those for the DWPF can.

capacity is required by the NWPA, Section 301 (a)(9). This conclusion is based on the EIA Mid Case Projection (130 GWe in 2000 and 230GWe by 2020) which results in about 134,000 MTU of spent fuel requiring disposal by 2020. Several of the sites under consideration can accommodate repositories with capacities greater than 70,000 MTU. Several scenarios are possible where this additional capacity could be utilized. Among these are:

- Repository operations to dispose of waste generated after 2020.
- The selection of a site for the second repository with less than 70,000 MTU capacity.
- Use of two repositories on a regional basis as suggested by NWPA.

If DHLW are disposed of in a commercial repository, the quantities of DHLW shall be included within the 70,000 MTU capacity, displacing an MTU equivalent amount of spent fuel or CHLW. Current estimates indicate that the total amount of DHLW wastes generated from all sources through the year 2020 will be equivalent to about 10,000 MTU of commercial wastes.

D. <u>Receipt Rate</u>

<u>First Repository</u>

During Stage I of repository operations, spent fuel will be received at a rate of about 400 MTU/year for the first 5 years of repository operations. During the fourth and fifth years of repository operation, the second phase facility will accept waste at a rate of 500 and 1400 MTU/year, respectively (see Table B-5).

During Stage II repository operations, the average annual spent fuel receipt rate is to be 3000 MTU/year. The Phase I facility operations will be discontinued after 5 years.

In the Mission Plan, the DOE establishes a "Waste Acceptance Schedule" which specifies, in the aggregate, the quantities of spent fuel that the DOE will accept beginning in 1998. This schedule is the basis for the receipt rate requirements above.

No basis presently exists for specification of receipt rates for commercial reprocessing wastes (CHLW and CTRU). Commercial reprocessing wastes would replace an equivalent quantity of spent fuel and thus would be accommodated within the design capacity limit of 70,000 MTU.

Second Repository

During initial operation of the second repository, the receipt rate shall be at 1800 MTU/yr for the first 5 years. The receipt rate shall then be 3000 MTU/yr for the remainder of the repository life.

E. Waste Age

The "Standard Contract for Disposal of Spent Nuclear Fuel and/or High Level Radioactive Waste" (10 CFR 961) designates spent fuel aged as little as 5 years out of reactor as "standard spent fuel". Repository design should be capable of receiving standard spent fuel on a routine basis. Fuel cooled less than 5 years will remain the responsibility of the transportation and storage system. The Standard Contract and the Mission Plan both specify that the DOE will accept fuel for disposal on an "oldest first" basis. Figure B-6, which is based on the receipt rates shown in Table B-5 and the "oldest-first" assumption, shows that the average age of spent fuel received for disposal at both repositories is substantially higher than 5 years. For most of the first repository receiving and emplacement period, the average age is greater than 10 years. However, both first and second repository design shall be capable of receiving and disposing of infrequent shipments of spent fuel aged as little is 5 years out of reactor. Based on this, repository design is to be based on the spent fuel description and receipt schedule of Table B-6, including the capability to routinely accommodate infrequent shipments of fuel aged as little as 5 years. At-repository storage shall not be used for the purpose of aging spent fuel.

F. Spent Fuel Burnup

Fuel in pressurized water reactor assemblies and boiling water reactor assemblies is presently enriched to about 3.2 and 2.6 weight percent fissile $^{235}U$, respectively, and can be irradiated to achieve equilibrium burnups of 33,000 and 27,000 MWD/MTU, respectively. As nuclear power facilities mature, the average burnup of spent fuel assemblies is increasing toward this equilibrium value. The emerging economics of the nuclear power industry has produced an incentive to increase enrichments to allow higher equilibrium burnups. A recent survey of fuel vendors suggested that approximately two thirds of the present U.S. nuclear power plants have made commitments toward the purchase of fuels with higher enrichments to allow longer fuel residence times in reactor cores. This results in higher burnups. As the repository operation "draws down" the backlog of spent fuel at reactors, the average burnup of the annual receipts will tend to increase, since the lowest burnup fuel is also generally the oldest in storage (see Table B-6). Thus, the overall population average of spent fuel burnup received for disposal is expected to show a generally increasing trend over the life of the MGDS, and individual assemblies with burnups substantially exceeding the average may be anticipated. Table B-6 shows that beginning in approximately the year 2006 some reactors will discharge quantities of low burnup fuel as a consequence of the decommissioning of certain reactors. Such fuel must be accommodated in the design of the repository, but does not reverse the trend of generally higher population burnup averages.

Table B-6 shows the annual burnup of spent fuel received at the repositories based on the forecasts and receipt rates of Table B-5, normalized utility projections of burnup levels, and the "oldest first" principle discussed above. This figure shows a gradually increasing trend in average burnup for both PWR's and BWR's through 2020.

It is clear that, for an industry average burnup of 35,000 MWD/MTU in 2020, a number of cases in excess of the average would occur. Indeed, for a batch average discharge burnup of 42,000 MWD/MTU, a small number of assemblies would be expected to be as high as 60,000 MWD/MTU for PWRs.

Repository design is to be based on the receipt of spent fuel with the burnups and ages of Table B-6, including occasional receipt of individual assemblies with burnups as high as 60,000 MWD/MTU. Assemblies with higher burnups will be temporarily stored at a site other than the repository until repository operating limits are satisfied.

G. Facility Operational (Emplacement) Lifetime

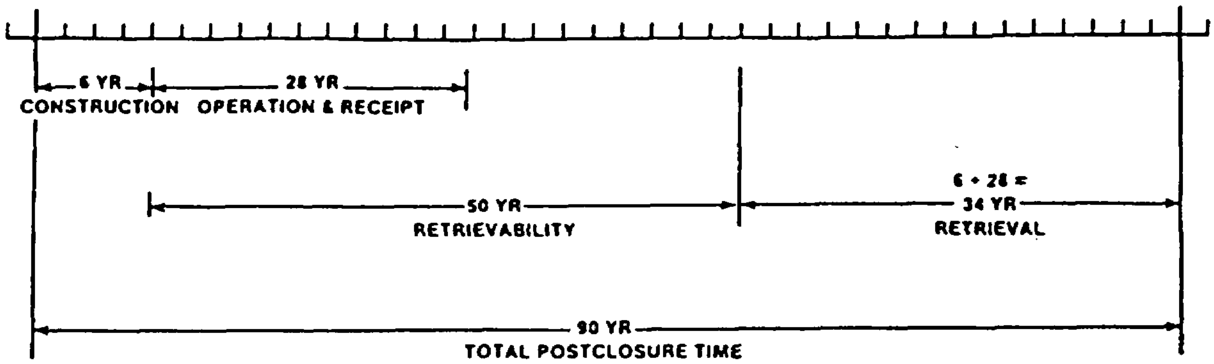
The MGDS shall be designed for an operating emplacement lifetime of 28 years. Facilities must be maintainable for approximately 90 years to accommodate possible retrieval operations.

Over the lifetime of the first repository, commercial nuclear power generation growth projections could be substantially lower than presently projected, higher burnups could reduce annual spent-fuel discharges, or commercial reprocessing could be re-introduced. The net effect of changes such as these will be reduced discharges of spent-fuel, or solidified high-level wastes that are generally cooler and require less disposal space per original MTU than spent fuel. In the case of higher burnup, it may be necessary to specify longer cooling times before disposal in the repository.

This uncertainty in receipt rates and inventories leads to uncertainty in the operational lifetime of the MGDS. At the expected receipt rate of 3,000 MTU/year after the first 5 years (see Table B-5), the operational (emplacement) lifetime of the first repository would be about 28 years. Lower receipt rates than those in the Waste Acceptance Schedule would extend the operational lifetime somewhat, but a 28-year operating lifetime is considered to be realistic.

The 90-year requirement for facility maintainability either in a dormant or active mode is based on the 10 CFR 60.111(b)(1) requirement for retaining a 50-year retrievability period following emplacement of the first wastes and a 34-year retrieval period for all emplaced wastes. The 34-year period is equal to the approximate 6-year Stage I construction period plus the 28-year operational period, as suggested by 10 CFR 60.111(b)(3).

The following "time line" depicts the yearly allocation for the 90-year total preclosure time.




H. <u>Waste Characteristics</u>

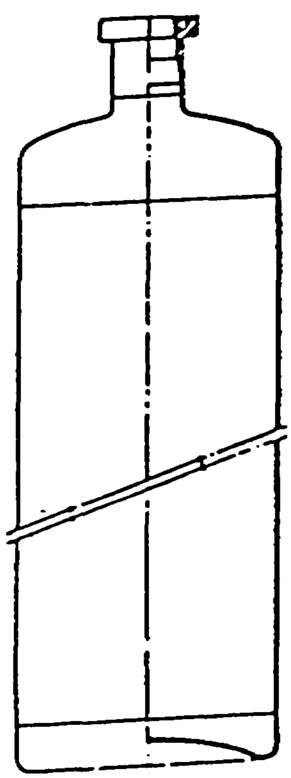
MGDS design and analysis requires a large volume of information on the characteristics of the various waste forms. This problem is compounded by the breadth and depth of the spectrum of the principal waste form, spent fuel. To ensure that repository designs proceed on a consistent and logical basis, the DOE is developing a computerized data base containing all the information necessary for the various design and analysis activities. This data base is designed to be directly accessible by each of the projects to allow selective retrieval of necessary data. It is anticipated that this data base will be fully operational in the near future, with early availability of the most essential information. To guide early design efforts, the information in Tables B-1 through B-6 is provided. The computerized data base will be made available when it is complete.

Table B-1 Characteristics of Spent Fuel Assemblies

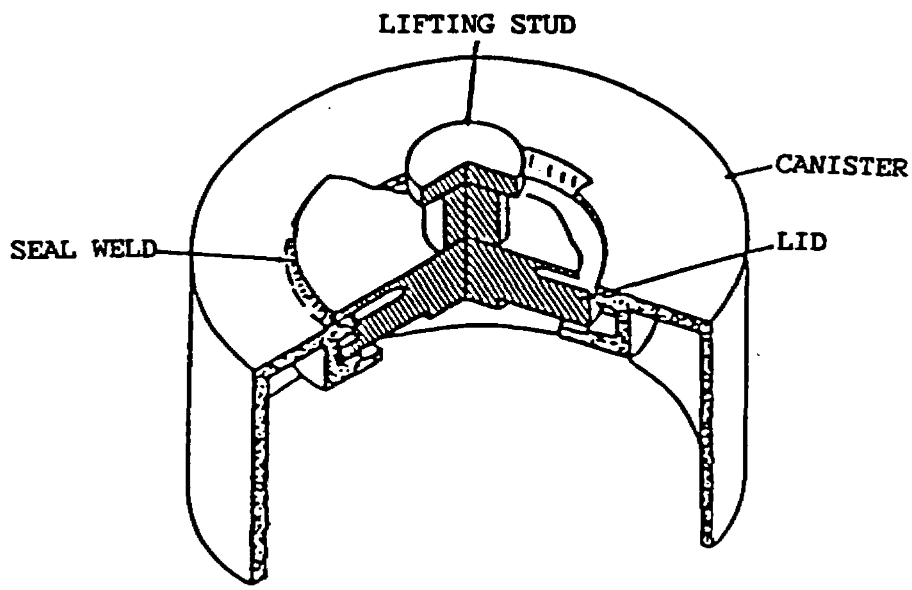
| Mechanical Characteristics | PWR | BWR |
|---|---|---|
| Overall Length-Range | 149" to 186" | 84" to 179" |
| Width (Square) | 8.1" to 8.5" | 4.3" to 6.5" |
| Fuel Rods/Assembly | 100 to 264 | 48 to 81 |
| Fuel Rod Diameter | .360" to .440" | .483" to .570" |
| Fuel Rod Length | 91.5" to 171" | 80.5" to 165" |
| Rod Pitch | .496" to .580" | .640" to .842" |
| MTU/Assembly | .11 to .52 | .19 to .20 |
| Assembly Weight (lb) | 1280 to 1450 | 600 |
| **Typical Characteristics as Received** | | |
| Age out of Reactor | 5 years | 5 years |
| Burnup (Average Conditions)MWD/MTU | 33,000 | 27,500 |
| Actinides and Daughters (Ci/MTU) | 104,000 | 93,000 |
| Fission Products (Ci/MTU) | 453,000 | 365,000 |
| Decay Heat (Watts/MTU) | 1800 | 1400 |
| Photon Release (Photons/Sec/MTU) | $1.3 \times 10^{16}$ | $1.0 \times 10^{16}$ |
| Photon Energy Release (Mev/Sec/MTU) | $4.8 \times 10^{15}$ | $3.6 \times 10^{15}$ |
| Burnup (High Condition) MWD/MTU | 50,000 | |
| Actinides and Daughters (Ci/MTU) | 155,000 | |
| Fission Products (Ci/MTU) | 640,000 | |
| Decay Heat (Watts/MTU) | 2,800 | |
| Photon Release (Photons/Sec/MTU) | $1.9 \times 10^{16}$ | |
| Photon Energy Release (Mev/Sec/MTU) | $7.3 \times 10^{15}$ | |
| Age out of Reactor | 10 years | 10 years |
| Burnup (Average Conditions) MWD/MTU | 33,000 | 27,500 |
| Actinides and Daughters (Ci/MTU) | 83,000 | 75,000 |
| Fission Products (Ci/MTU) | 302,000 | 249,000 |
| Decay Heat (Watts/MTU) | 1,100 | 900 |
| Photon Release (Photons/Sec/MTU) | $7.7 \times 10^{15}$ | $6.2 \times 10^{15}$ |
| Photon Energy Release (Mev/Sec/MTU) | $2.6 \times 10^{15}$ | $2.0 \times 10^{15}$ |
| Burnup (High Condition) MWD/MTU | 50,000 | |
| Actinides and Daughters (Ci/MTU) | 124,000 | |
| Fission Products (Ci/MTU) | 442,000 | |
| Decay Heat (Watts/MTU) | 1,800 | |
| Photon Release (Photons/Sec/MTU) | $1.1 \times 10^{16}$ | |
| Photon Energy Release (Mev/Sec/MTU) | $3.8 \times 10^{15}$ | |

Table B-2 West Valley High-Level Waste Form and Container

| | | |
|---|---|---|
| Overall Length | - | 9 ft. 10 in. ± .12 in. |
| Outside Diameter | - | 24 in. ± .12 in. |
| Wall Thickness | - | 0.375 nominal pipe tolerance |
| Bow | - | 1/4" maximum |
| Surface Finish | - | 125 rms |
| Inside Volume | - | 26.1 ft.$^3$ nominal |
| Weight Empty | - | 1000 lb ± 5% |
| Weight Full | - | 2 metric tons (approx.) |
| Material | - | 304L Stainless Steel |
| MTU/Can | - | 2.1 |



Reference WVHLW Canister




Canister Closure

Table B-2 (continued) Reference West Valley High-Level Waste Container

Source Terms

[Not available at present]+

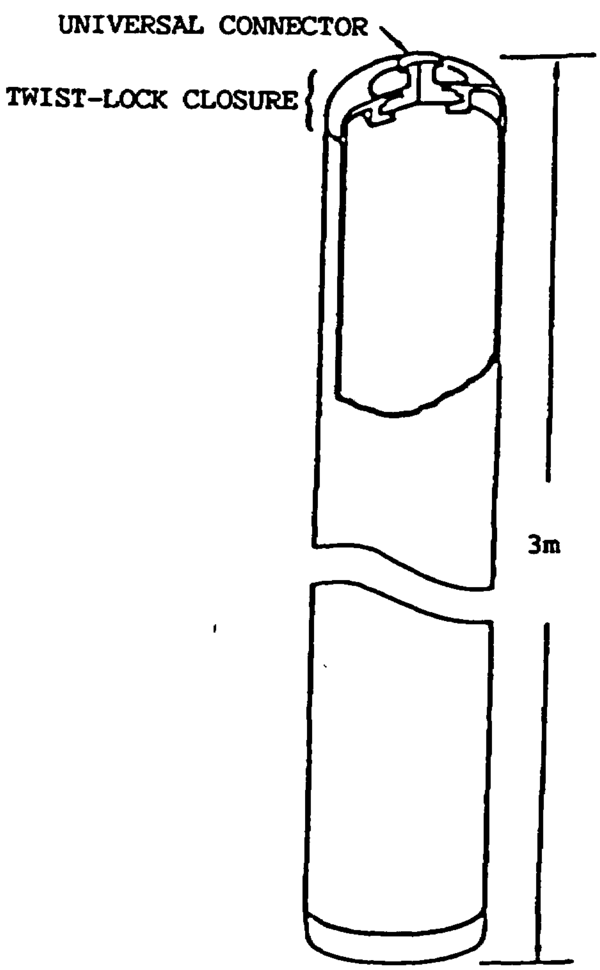
Canister Decay Heat and Activity*

| End of CY | Avg. Ci/Can | Avg. Watts/Can |
|---|---|---|
| 1990 | $9.77 \times 10^4$ | 289 |
| 1995 | $8.63 \times 10^4$ | 255 |
| 2000 | $7.63 \times 10^4$ | 225 |
| 2005 | $6.73 \times 10^4$ | 199 |
| 2010 | $5.93 \times 10^4$ | 175 |
| 2015 | $5.23 \times 10^4$ | 155 |
| 2020 | $4.63 \times 10^4$ | 137 |

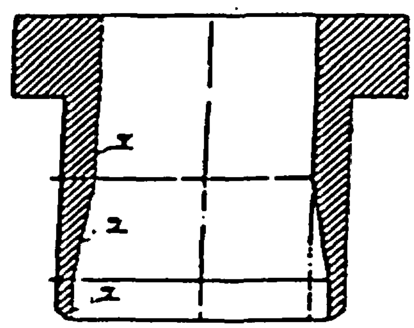
* Calculated from data in DOE/NE-0017/2, Table 2.18.
+ Representative chemical and radionuclide compositions of WVHLW are available in DOE/NE-0017/2, Table 2.11.

Table B-3 Reference Commercial High-Level Waste Canister
(From PNL-3838 - "Reference Commercial High-Level Waste Glass and Canister Definition", September 1981)

| | |
|---|---|
| Material | Stainless steel 304L |
| Dimensions | |
| • Outside diameter | 32.4 cm (12-in. Pipe) ± 2 mm |
| • Length | 3 m (10 ft) ± 2 mm |
| • Wall thickness | 0.64 cm (0.250-in. nominal pipe tolerance |
| Closure | PNL "twist-lock" (see sketch below) |
| Empty weight | 160 kg ± 5% |
| Volume when 90% filled | 192 Li ± 5% |
| Weight of glass (3.1 g/cm$^3$) | 595 kg |
| MTU of HLW per canister | 2.28 (@ 260.6 kg glass/MTU) |
| Activity | 1.02 x 10$^6$ Ci (at 5 yr after reactor discharge) |
| | 6.58 x 10$^5$ Ci (at 10 yr after reactor discharge) |




Typical CHLW Canister Outline



Typical Neck Detail

Table B-3 (continued) Reference Commercial High-Level Waste Canister

| Decay Period, Yr* | Canister Heat Generation Rate, W |
|---|---|
| 5 | 3690 |
| 10 | 2210 |
| 20 | 1600 |
| 50 | 798 |
| $10^2$ | 292 |
| $10^3$ | 20.1 |
| $10^4$ | 1.7 |
| $10^5$ | 0.264 |
| $10^6$ | 0.178 |

Gamma Source Term
(Mev/W-Sec/MTU)

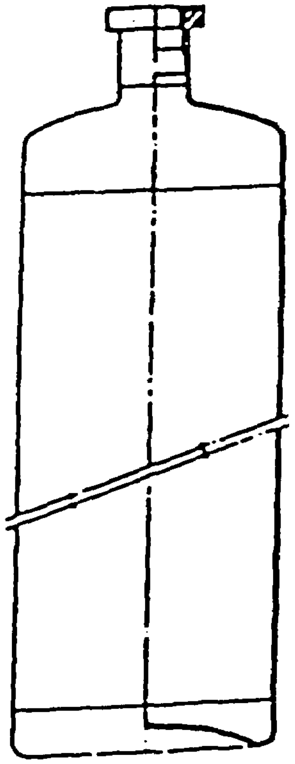
| Group | E (Mev) | Decay Time, yr* | | | |
|---|---|---|---|---|---|
| | | 5 | 10 | 50 | 100 |
| 1 | 0.085 | 1.3 + 6 | 8.6 + 5 | 3.0 + 5 | 9.4 + 4 |
| 2 | 0.125 | 1.7 + 6 | 1.0 + 6 | 3.0 + 5 | 9.0 + 4 |
| 3 | 0.225 | 3.0 + 6 | 1.9 + 6 | 7.0 + 5 | 2.1 + 5 |
| 4 | 0.375 | 2.7 + 6 | 1.5 + 6 | 5.0 + 5 | 1.5 + 5 |
| 5 | 0.575 | 7.5 + 7 | 4.9 + 7 | 1.8 + 7 | 5.6 + 6 |
| 6 | 0.85 | 2.4 + 7 | 6.1 + 6 | 2.6 + 5 | 5.8 + 4 |
| 7 | 1.25 | 7.5 + 6 | 3.6 + 6 | 2.1 + 5 | 3.0 + 4 |
| 8 | 1.75 | 3.9 + 5 | 1.6 + 5 | 1.5 + 4 | 3.1 + 3 |
| 9 | 2.25 | 2.7 + 5 | 4.3 + 3 | 1.4 + 0 | 0 |
| 10 | 2.75 | 1.0 + 4 | 3.3 + 2 | 0 | 0 |
| 11 | 3.5 | 1.7 + 3 | 5.4 + 1 | 0 | 0 |

*Following removal from reactor.
Note: Isotope inventories for various decay times and other useful information may be obtained from PNL-3838, September 1981.

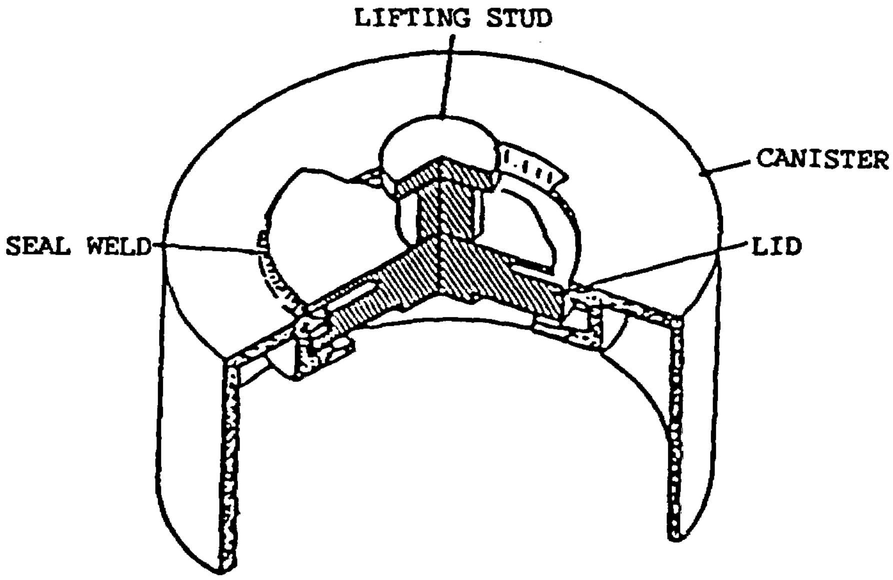
Table B-4 Defense High-Level Waste Container

(From DP 1606, Rev 1 - "Description of Defense Waste Processing Facility Reference Waste Form and Canister", August 1983)

| | | |
|---|---|---|
| Overall Length | - | 9 ft. 10 in. ± 0.12 in. |
| Outside Diameter | - | 24.00 in. ± 0.12 in. |
| Wall Thickness | - | 0.375 nominal pipe tolerance |
| Bow | - | 1/4 in. maximum |
| Surface Finish | - | 125 rms |
| Inside Volume | - | 26.1 $ft.^3$ nominal |
| Weight Empty | - | 1000 lb ± 5% |
| Weight Full | - | 4260 lb ± 5% (with Frit 131) |
| Material | - | 304L stainless steel |



Reference DHLW
Canister Outline




Canister Closure

Table B-4 (continued) Reference Defense High-Level Waste Container

Source Terms

| Energy, keV | Sludge Only *Cases I & II 0.625 m³ Glass Photons/sec | Sludge-Supernate *Cases III & IV 0.625 m³ Glass Photons/sec | Sludge-Supernate *Case V 0.734 m³ Glass Photons/sec |
|---|---|---|---|
| 100 | 1.165E14 | 1.723E14 | 2.533E14 |
| 125 | 6.988E13 | 5.678E13 | 8.346E13 |
| 225 | 4.618E12 | 3.756E12 | 5.520E12 |
| 375 | 1.462E13 | 1.189E13 | 1.747E13 |
| 575 | 1.328E14 | 1.350E15 | 1.985E13 |
| 850 | 2.210E13 | 2.441E13 | 3.589E13 |
| 1250 | 3.492E13 | 2.881E13 | 4.235E13 |
| 1750 | 7.145E11 | 5.808E11 | 8.537E11 |
| 2250 | 3.185E12 | 2.588E12 | 3.804E12 |
| 2750 | 1.095E10 | 8.900E09 | 1.308E10 |
| 3500 | 1.533E09 | 1.246E09 | 1.832E09 |

• Source Model: Cylinder volume source with self-absorption.

• Computations were made using the Shielding Design Calculation Code (SDC), ORNL - 3041, UC-32.

* For Case Details, see DP 1606, Rev. 1.

Table B-4 (continued) Reference Defense High-Level Waste Container

Canister Decay Heat & Activity*

| Year | Sludge-only Glass Curies/Can | Sludge-only Glass Watts/Can | Sludge-Supernate Glass Curies/Can | Sludge-Supernate Glass Watts/Can |
|---|---|---|---|---|
| 5 | 139,200 | 399 | 176,700 | 470 |
| 10 | 100,400 | 344 | 137,900 | 397 |
| 15 | 83,700 | 301 | 118,100 | 360 |
| 20 | 72,720 | 268 | 103,700 | 320 |
| 25 | 62,990 | 239 | 91,680 | 285 |
| 30 | 56,510 | 214 | 81,290 | 255 |
| 35 | 49,990 | 191 | 72,140 | 228 |
| 40 | 44,260 | 171 | 64,050 | 204 |
| 45 | 39,210 | 154 | 56,890 | 183 |
| 50 | 34,740 | 138 | 50,540 | 164 |
| 60 | 27,310 | 112 | 39,910 | 132 |

* For Case Details, see DP 1606, Rev. 1.

Table B-5. Projected Effects of First and Second Repository Receipt Rates on Total Spent Fuel Inventories Not at the Repository, 1998-2020, and on 10 Year and Older Spent Fuel Inventories Not at the Repository, 1998-2030.

| Year | Total Spent Fuel Accumulated (MTU)[A] | Total 5 yr. and Older Spent Fuel (MTU) | First Repository: Receipt and Disposal Rate (MTU/yr) | First Repository: Cumulative Disposal (MTU) | Second Repository: Receipt and Disposal Rate (MTU/yr) | Second Repository: Cumulative Disposal (MTU) | Total Repository Disposal (MTU)[C] | Remaining 5 yr and Older Spent Fuel (MTU)[C] | Total Remaining Spent Fuel (MTU)[C] |
|---|---|---|---|---|---|---|---|---|---|
| 1998 | 43,600 | 29,800 | 400 | 400 | - | - | 400 | 29,400 | 43,200 |
| 1999 | 46,500 | 32,400 | 400 | 800 | - | - | 800 | 32,000 | 45,700 |
| 2000 | 49,500 | 35,000 | 400 | 1,200 | - | - | 1,200 | 33,800 | 48,300 |
| 2001 | 52,700 | 38,000 | 900 | 2,100 | - | - | 2,100 | 35,900 | 50,600 |
| 2002 | 55,900 | 40,800 | 1,800 | 3,900 | - | - | 3,900 | 36,900 | 52,000 |
| 2003 | 59,400 | 43,600 | 3,000 | 6,900 | - | - | 6,900 | 36,700 | 52,500 |
| 2004 | 62,800 | 46,500 | 3,000 | 9,900 | - | - | 9,900 | 36,600 | 52,900 |
| 2005 | 66,700 | 49,500 | 3,000 | 12,900 | 1,800 | 1,800 | 14,700 | 34,800 | 52,000 |
| 2006 | 70,400 | 52,700 | 3,000 | 15,900 | 1,800 | 3,600 | 19,500 | 33,200 | 50,900 |
| 2007 | 74,400 | 55,900 | 3,000 | 18,900 | 1,800 | 5,400 | 24,300 | 31,600 | 50,100 |
| 2008 | 78,300 | 59,400 | 3,000 | 21,900 | 1,800 | 7,200 | 29,100 | 30,300 | 49,200 |
| 2009 | 82,300 | 62,800 | 3,000 | 24,900 | 1,800 | 9,000 | 33,900 | 28,900 | 48,400 |
| 2010 | 86,000 | 66,700 | 3,000 | 27,900 | 3,000 | 12,000 | 39,900 | 26,800 | 46,100 |
| 2011 | 90,500 | 70,400 | 3,000 | 30,900 | 3,000 | 15,000 | 45,900 | 24,500 | 44,600 |
| 2012 | 94,500 | 74,400 | 3,000 | 33,900 | 3,000 | 18,000 | 51,900 | 22,500 | 42,600 |
| 2013 | 99,000 | 78,300 | 3,000 | 36,900 | 3,000 | 21,000 | 57,900 | 20,400 | 41,100 |
| 2014 | 103,500 | 82,300 | 3,000 | 39,900 | 3,000 | 24,000 | 63,900 | 18,400 | 39,600 |
| 2015 | 108,600 | 86,000 | 3,000 | 42,900 | 3,000 | 22,000 | 69,900 | 16,100 | 38,700 |
| 2016 | 113,900 | 90,500 | 3,000 | 45,900 | 3,000 | 30,000 | 75,900 | 14,600 | 38,000 |
| 2017 | 118,400 | 94,500 | 3,000 | 48,900 | 3,000 | 33,000 | 81,900 | 12,000 | 36,500 |
| 2018 | 123,600 | 99,000 | 3,000 | 51,900 | 3,000 | 36,000 | 87,900 | 11,100 | 35,700 |
| 2019 | 128,900 | 103,500 | 3,000 | 54,900 | 3,000 | 39,000 | 93,900 | 9,600 | 35,000 |
| 2020 | 133,900 | 108,600 | 3,000 | 57,900 | 3,000 | 42,000 | 99,900 | 8,700 | 34,000 |
| 2021 | -[B] | 113,900 | 3,000 | 60,900 | 3,000 | 45,000 | 105,900 | 8,000 | 28,000[C] |
| 2022 | - | 118,400 | 3,000 | 63,900 | 3,000 | 48,000 | 111,900 | 6,500 | 22,000[C] |
| 2023 | - | 123,600 | 3,000 | 66,900 | 3,000 | 51,000 | 117,900 | 5,700 | 16,000[C] |
| 2024 | - | 128,900 | 3,000 | 69,900 | 3,000 | 54,000 | 123,900 | 5,000 | 10,000[C] |
| 2025 | - | 133,900 | 100 | 70,000 | 3,000 | 57,000 | 127,000 | 6,900 | 6,000[C] |
| 2026 | - | | | | 3,000[C] | 60,000[C] | 130,000 | 3,900[C] | 3,900[C] |
| 2027 | - | | | | 3,000[C] | 63,000[C] | 133,000 | 900[C] | 900[C] |
| | | | | | 900[C] | 63,900[C] | 133,900 | 0[C] | 0[C] |

[A]Source: EIA/EI-53, 1983 Mid-Case Projections
[B]1983 EIA projections stop at 2020
[C]Spent Fuel Generated Before 2020 only

Table B-6. Spent Fuel Burnups and Ages at Employment Normalized to EIA/EI, 1983 Mid Case Projections

| Discharge Year | Burnup (MWD/MTU) vs. Year in MTU's: 0-5000 BWR | 0-5000 PWR | 5000-10000 BWR | 5000-10000 PWR | 10000-15000 BWR | 10000-15000 PWR | 15000-20000 BWR | 15000-20000 PWR | 20000-25000 BWR | 20000-25000 PWR | 25000-30000 BWR | 25000-30000 PWR | 30000-35000 BWR | 30000-35000 PWR | 35000-40000 BWR | 35000-40000 PWR | 40000-45000 BWR | 40000-45000 PWR | 45000-50000 BWR | 45000-50000 PWR | 50000-55000 BWR | 50000-55000 PWR | Age (yrs) at Emplacement (receipt yr) | Total BWR | MTU PWR | Total MTU BWR PWR | Cummulative MTU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961 | | | | | | | | | | | | | | | | | | | | | | | 37 (1998) | | | 4* | 4 |
| 1962 | | | | | | | | | | | | | | | | | | | | | | | 36 (1998) | | | 6* | 10 |
| 1963 | | | | | | | | | | | | | | | | | | | | | | | 35 (1998) | | | 10* | 20 |
| 1964 | | | | | | | | | | | | | | | | | | | | | | | 34 (1998) | | | 11* | 31 |
| 1965 | | | | | | | | | | | | | | | | | | | | | | | 33 (1998) | | | 11* | 42 |
| 1966 | | | | | | | | | | | | | | | | | | | | | | | 32 (1998) | | | 11* | 53 |
| 1967 | | | | | | | | | | | | | | | | | | | | | | | 31 (1998) | | | 11* | 64 |
| 1968 | | | | | | | | | | | | | | | | | | | | | | | 30 (1998) | | | 11* | 75 |
| 1969 | | | | | 1 | | 7 | | | | | 8 | | | | | | | | | | | 29 (1998) | 8 | 8 | 16 | 91 |
| 1970 | | | | | | | | 41 | | 8 | | | | | | | | | | | | | 28 (1998) | | 49 | 49 | 140 |
| 1971 | | | 14 | | 6 | 5 | | | | | | 40 | | | | | | | | | | | 27 (1998) | 20 | 45 | 65 | 205 |
| 1972 | 142 | | 12 | | 31 | 8 | 4 | 45 | | | | 9 | | 22 | | | | | | | | | 26 ('98-'99) | 189 | 84 | 273 | 478 |
| 1973 | 9 | | 16 | | 36 | | 40 | 24 | | | | 40 | | | | | | | | | | | 26 (1999) | 101 | 64 | 165 | 643 |
| 1974 | 60 | | 6 | 7 | 122 | 77 | 31 | 40 | 4 | 14 | | 74 | | | | | | | | | | | 25 ('99-'00) | 223 | 212 | 435 | 1078 |
| 1975 | | | 1 | 9 | 46 | 186 | 155 | 12 | 22 | 71 | | 41 | | 20 | | | | | | | | | 25 ('00-'01) | 224 | 339 | 563 | 1641 |
| 1976 | | | 49 | | 108 | 17 | 149 | 147 | | 84 | | 91 | | 37 | | | | | | | | | 25 ('01-'02) | 306 | 376 | 682 | 2323 |
| 1977 | | | 52 | | 34 | | 174 | 132 | 102 | 126 | | 134 | | 86 | | 18 | | | | | | | 25 (2002) | 362 | 496 | 858 | 3181 |
| 1978 | | | | 2 | 25 | 51 | 119 | 78 | 206 | 45 | 28 | 402 | | 73 | | 62 | | | | | | | 24 ('02-'03) | 438 | 713 | 1151 | 4332 |
| 1979 | | | | | 20 | 26 | 92 | 124 | 161 | 55 | 178 | 279 | | 239 | | 32 | | | | | | | 24 (2003) | 451 | 755 | 1206 | 5538 |
| 1980 | 15 | | | | 3 | 9 | 46 | | 352 | 55 | 110 | 304 | | 226 | | 29 | | | | | | | 23 (2003) | 526 | 623 | 1149 | 6687 |
| 1981 | | | | | | 26 | 73 | | 256 | | 162 | 304 | | 428 | | 16 | | | | | | | 22 ('03-'04) | 491 | 774 | 1265 | 7952 |
| 1982 | | | | | 15 | | 41 | 80 | 30 | 89 | 300 | 161 | | 361 | | 13 | | | | | | | 22 (2004) | 386 | 704 | 1090 | 9042 |
| 1983 | | | | | | | 36 | 49 | 42 | 48 | 292 | 296 | 16 | 220 | | 51 | | | | | | | 21 ('04-'05) | 394 | 664 | 1058 | 10100 |
| 1984 | 14 | | 9 | | 13 | 52 | 3 | 41 | 49 | 16 | 262 | 118 | 14 | 412 | | 94 | | 3 | | | | | 21 (2005) | 364 | 736 | 1100 | 11200 |
| 1985 | | | 55 | | 52 | 21 | 15 | 70 | 25 | 11 | 249 | 205 | | 380 | | 193 | | 24 | | | | | 20 (2005) | 396 | 904 | 1300 | 12500 |
| 1986 | 14 | | 62 | | 57 | 46 | 69 | 127 | 7 | 52 | 382 | 107 | 38 | 245 | | 266 | | 28 | | | | | 19 (2005) | 629 | 871 | 1500 | 14000 |
| 1987 | 29 | | 23 | | 34 | 59 | 102 | 48 | 127 | 27 | 255 | 123 | 13 | 379 | | 349 | | 32 | | | | | 18 (2005) | 583 | 1017 | 1600 | 15600 |
| 1988 | | | 33 | | 99 | 2 | 120 | 80 | 94 | 19 | 514 | 165 | 44 | 506 | | 417 | | 107 | | | | | 18 (2006) | 904 | 1296 | 2200 | 17800 |
| 1989 | | | 44 | | 24 | 27 | 41 | 27 | 159 | 64 | 399 | 165 | 118 | 501 | | 435 | | 95 | | | | 1 | 17 (2006) | 785 | 1315 | 2100 | 19900 |
| 1990 | | | 30 | | 15 | | 66 | 27 | 31 | 18 | 480 | 93 | 219 | 542 | | 460 | | 119 | | | | | 17 (2007) | 841 | 1259 | 2100 | 22000 |
| 1991 | | | 3 | | | | 47 | | 29 | 46 | 808 | 104 | 226 | 629 | | 618 | | 190 | | | | | 16 (2007) | 1113 | 1587 | 2700 | 24700 |
| 1992 | | | | | 3 | | 3 | | 152 | 1 | 470 | 100 | 272 | 771 | | 588 | | 139 | | 1 | | | 16 (2008) | 900 | 1600 | 2500 | 27200 |
| 1993 | | | | | | | 44 | 60 | 27 | 7 | 740 | 63 | 239 | 594 | | 703 | | 122 | | 1 | | | 15 (2008) | 1050 | 1550 | 2600 | 29800 |
| 1994 | | | | | | | | | 64 | 7 | 640 | 63 | 256 | 860 | | 553 | | 157 | | | | | 15 (2009) | 960 | 1640 | 2600 | 32400 |
| 1995 | | | | | | | | | 50 | | 699 | 73 | 225 | 825 | | 592 | | 135 | | 1 | | | 14 (2009) | 974 | 1626 | 2600 | 35000 |
| 1996 | | | | | | | | | 70 | 8 | 790 | 32 | 393 | 815 | | 731 | | 160 | | 1 | | | 14 (2010) | 1253 | 1747 | 3000 | 38000 |
| 1997 | | | | | | | | | 64 | 7 | 572 | 38 | 355 | 871 | | 717 | | 175 | | 1 | | | 13 (2010) | 991 | 1809 | 2800 | 40800 |
| 1998 | | | | | | | | | 56 | | 896 | 71 | 173 | 848 | | 586 | | 169 | | 1 | | | 13 (2011) | 1125 | 1675 | 2800 | 43600 |
| 1999 | | | | 21 | | | | | 68 | 30 | 638 | 31 | 379 | 849 | | 728 | | 155 | | 1 | | | 13 (2011) | 1085 | 1815 | 2900 | 46500 |
| 2000 | 1 | | | | | | 6 | | 31 | | 758 | 41 | 386 | 1022 | | 597 | | 158 | | | | | 12 (2012) | 1182 | 1818 | 3000 | 49500 |
| 2001 | | | | | | 11 | | | 117 | 10 | 743 | 87 | 300 | 882 | | 841 | | 208 | | 1 | | | 11 (2012) | 1160 | 2040 | 3200 | 52700 |
| 2002 | | | | | | | | | 71 | 8 | 916 | 33 | 403 | 853 | | 746 | | 169 | | 1 | | | 11 (2013) | 1390 | 1810 | 3200 | 55900 |
| 2003 | | | | | | | | | 33 | | 657 | 48 | 508 | 1167 | | 867 | | 219 | | 1 | | | 10 (2013) | 1198 | 2302 | 3500 | 59400 |
| 2004 | | | 36 | | | 27 | 45 | | 109 | 37 | 844 | 81 | 281 | 1029 | | 711 | | 199 | | 1 | | | 10 (2014) | 1315 | 2085 | 3400 | 62800 |
| 2005 | | | | | | | | | 38 | | 1120 | 42 | 515 | 1040 | | 966 | | 178 | | 1 | | | 9 (2014) | 1673 | 2227 | 3900 | 66700 |
| 2006 | | 4 | 32 | 50 | | 14 | 48 | 40 | 34 | 69 | 611 | 50 | 529 | 1127 | | 863 | | 228 | | 1 | | | 9 (2015) | 1254 | 2446 | 3700 | 70400 |
| 2007 | 14 | 17 | 87 | 56 | | 66 | 93 | 91 | 114 | 118 | 1009 | 121 | 285 | 982 | | 752 | | 194 | | 1 | | | 9 (2016) | 1602 | 2398 | 4000 | 74400 |
| 2008 | 20 | 5 | 177 | 49 | 49 | 128 | 204 | 28 | 119 | 68 | 715 | 157 | 427 | 820 | | 767 | | 166 | | 1 | | | 8 (2016) | 1711 | 2189 | 3900 | 78300 |
| 2009 | | 12 | 124 | 83 | | | | 132 | 41 | 271 | 788 | 2 | 428 | 1120 | | 773 | | 226 | | | | | 8 (2017) | 1381 | 2619 | 4000 | 82300 |
| 2010 | | 18 | | 61 | 37 | 67 | 144 | 73 | 80 | 142 | 910 | 45 | 273 | 1132 | | 575 | | 142 | | 1 | | | 8 (2018) | 1444 | 2256 | 3700 | 86000 |
| 2011 | | | | 42 | | 61 | | 103 | 58 | 105 | 1236 | 2 | 481 | 1381 | | 887 | | 142 | | 2 | | | 7 (2018) | 1775 | 2725 | 4500 | 90500 |
| 2012 | | 12 | 34 | 18 | 34 | 48 | | 131 | 83 | 79 | 810 | 22 | 590 | 1216 | | 754 | | 167 | | 2 | | | 7 (2019) | 1551 | 2449 | 4000 | 94500 |
| 2013 | 42 | | 160 | | | 59 | 160 | | 196 | 83 | 1095 | 2 | 417 | 1318 | | 787 | | 179 | | 2 | | | 6 (2020) | 2070 | 2430 | 4500 | 99000 |
| 2014 | 34 | 9 | | 43 | 188 | 99 | | 1 | 244 | 136 | 1122 | 31 | 569 | 1108 | | 804 | | 110 | | 2 | | | 6 (2020) | 2157 | 2343 | 4500 | 103500 |
| 2015 | | 3 | | 63 | 272 | | | 63 | 333 | 186 | 898 | 63 | 632 | 1606 | | 838 | | 143 | | | | | 6 (2021) | 2135 | 2965 | 5100 | 108600 |
| 2016 | | | 265 | 122 | 81 | 75 | 321 | | 156 | 181 | 1225 | 75 | 277 | 1627 | | 692 | | 203 | | | | | 5 (2021) | 2325 | 2975 | 5300 | 113900 |
| 2017 | 26 | | | 62 | 137 | | | 98 | 218 | | 1140 | | 404 | 1375 | | 958 | | 82 | | | | | 5 (2022) | 1925 | 2575 | 4500 | 118400 |
| 2018 | | | | | | | | | 107 | | 1214 | | 547 | 2271 | | 847 | | 214 | | | | | 5 (2023) | 1868 | 3332 | 5200 | 123600 |
| 2019 | | - | 109 | | 109 | | 111 | | 210 | | 1591 | | 198 | 1945 | | 838 | | 189 | | | | | 5-6 (24-25) | 2328 | 2972 | 5300 | 128900 |
| 2020 | | 27 | 111 | | | 129 | 164 | | 113 | 129 | 1204 | | 364 | 1613 | | 1053 | | 93 | | | | | 6-7 (25-27) | 1956 | 3044 | 5000 | 133900 |

*Detailed breakdown unavailable

Table B-6 (Cont'd)
Spent Fuel Burnups and Ages at Emplacement

- 1961-1968 data from "Spent Fuel Storage Requirements," DOE/RL83-1, January 1983.

- 1969-1983 data from "Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics," DOE/NE-0017/2, September 1983.

- 1984-2020 data normalized from PNL's Spent Fuel Data Base to correspond to EIA/EI 1983 Mid-Case Projections. These data are utility supplied. Since the normal utility planning horizon is 10 years, the accuracy becomes more uncertain as the projections are carried into the future. Some utilities have not projected fuel exposures. For those utilities that have projected fuel exposures, their projections do not correspond to EIA growth scenarios. Any transshipments or reinsertions to obtain additional exposure are not included unless the utility has indicated that such insertions are planned. Some utility data on reinsertions are not verifiable since the actual batch for reinserted fuel cannot be unambiguously traced.

- The waste ages at emplacement and the receipt years at the repository are based upon the waste acceptance schedule of Table B-5 and the Mission Plan for the Civilian Radioactive Waste Management Program.

# SECTION B.2

## TRANSPORTATION SYSTEM INTERFACE

GENERAL:

The waste transportation system - MGDS interface is that activity at which:

1. Wastes carried within transportation equipment are received at the repository, and

2. Transportation equipment is handled, unloaded, inspected, decontaminated, and return shipped.

This section outlines the requirements placed upon the MGDS by the transportation system, discusses the constraints under which the systems must operate, describes the functions of the receiving facility, and describes the components of the waste transportation system with which the repository must interface.

REQUIREMENTS AND CONSTRAINTS:

The Site will permit access to the repository by both truck and rail in keeping with the conditions outlined in 10 CFR 960.5-2-7(a), the Siting Guidelines. The Canistered Waste System will be designed in such a manner as to allow for transportation of the waste from the source to the repository in compliance with PL93-633 (Hazardous Materials Transportation Act), 49 CFR 101-178 (Hazardous Materials Transportation, Packaging and Containers), 10 CFR 71 (Packaging of Radioactive Materials for Transport and Transportation of Radioactive Materials Under Certain Conditions), and 10 CFR 73 (Physical Protection of Plants and Materials).

The repository receiving facility will be designed to handle both truck and rail deliveries of the waste forms described in Section B.1. Receipt rates will be based on the data also contained in Section B.1. While the actual rail-truck split cannot be determined at this time, 80 percent rail and 70 percent truck will be used as a reasonable planning factor[a]. The design should not preclude converting to 100 percent rail or 100 percent truck at some future date. The facility will be designed for dry unloading of casks. It will also have an unloading crane capacity of 125 tons. Transportation system components will be designed to facilitate quick-acting mechanized contact operations and/or remote handling wherever possible and to minimize exposure to the work force.

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[a]Although annual averages will result in a rail/truck delivery split that adds to 100%, receipt of either 80% rail or 70% truck shipments over shorter periods of time should be part of the receiving facility's designed capacity.

TRANSPORTATION SYSTEM COMPONENT REFERENCE DESCRIPTION

The following reference descriptions are generic in nature and are intended to aid in the design of the repository receiving facility. Data will be added or refined as they become available.

1. Shipping Casks.

   a. Truck Cask.

      (1) Dimensions
      (2) Gross Weight
      (3) Capacity
      (4) Handling Features
      (5) Closure Configuration
      (6) Dose Rate Map

   b. Rail Cask.

      (1) Dimensions
      (2) Gross Weight
      (3) Capacity
      (4) Handling Features
      (5) Closure Configuration
      (6) Dose Rate Map

2. Transportation Vehicles.

   a. Trucks.

      (1) Dimensions
      (2) Weight
         (a) Tractor
         (b) Trailer
         (c) Tie-downs and personnel barrier
      (3) Wheel loadings
      (4) Axle loadings
      (5) Turn radii
      (6) Arrangement of cask on vehicle
      (7) Tie-down features

   b. Rail Cars.

      (1) Number of trucks
      (2) Number of axles
      (3) Dimensions
         (a) Overall length
         (b) Spacing between truck centers
         (c) Width
         (d) Distance from top of rail to deck
      (4) Weight (including tie-downs and personnel barrier)
      (5) Axle loadings
      (6) Turn radii
      (7) Arrangement of cask on car
      (8) Tie-down features

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