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

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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FACSIM/MRS-2: STORAGE AND SHIPPING PERFORMANCE ASSESSMENT

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Richland, Washington 99352

SUMMARY

The Pacific Northwest Laboratory (PNL) has completed an evaluation of the Monitored Retrievable Storage (MRS) Facility. This performance assessment was conducted as part of PNL's Monitored Retrievable Storage Program sponsored by the U.S. Department of Energy (DOE).

This report provides a performance assessment of the design for the storage and shipping operations of the MRS facility. These activities, referred to as back-end operations, include handling canistered spent fuel and secondary waste in the shielded canyon cell, in onsite yard storage, and in repository shipping cask loading areas. The model used to obtain the performance assessment (FACSIM/MRS-2) is one of the FACSIM models developed by PNL's nuclear waste handling facility simulation effort. A performance assessment of MRS receiving and handling of arriving spent fuel and of consolidating and canistering activities (the front-end operations) is presented in FACSIM/MRS-1: Cask Receiving and Consolidation Performance Assessment (Lotz and Shay 1987). This report verified the adequacy of MRS front-end operations and estimated that throughput requirements could be achieved with equipment utilization rates of 70% or lower. The simulation model used to complete the analysis of MRS storage and shipping operations is described in FACSIM/MRS-2: Storage and Shipping Documentation and User's Guide (Huber et al. 1987).

The two major types of material flow through the shielded canyon cells are 1) canistered spent fuel, and 2) secondary waste. Canistered spent fuel consists of spent fuel that has been disassembled and consolidated in the four shielded process cells in the front end of the facility. Secondary waste consists of nonfuel-bearing spent fuel assembly components remaining from disassembly, and onsite-generated high activity waste.

This analysis verified that the MRS facility back-end operations as designed are capable of handling 3,600 metric tons of uranium (MTU) per year if the facility operates seven days per week (24-hour days). The cask cart utilization rate is highest, in use about 50% of the operating year. Cask cart utilization refers to the utilization of the shielded canyon cell repository shipping cask loadout port (also referred to as the exit port) and the cask

cart that serves that port. The receiving and handling facility design specifies two loadout ports, one for each side of the facility. This analysis also determined that a throughput rate of 3,000 MTU per year could be achieved with five-day week facility operation.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

This report provides a performance assessment of the design for the storage and shipping operations of the MRS facility. These activities, referred to as back-end operations, include handling canistered spent fuel and secondary waste in the shielded canyon cell, in onsite yard storage, and in repository shipping cask loading areas. The model used to obtain the performance assessment (FACSIM/MRS-2) is one of the FACSIM models developed as part of PNL's[(a)] nuclear waste handling facility simulation effort. The simulation model used to complete the analysis of MRS storage and shipping operations is described in FACSIM/MRS-2: Storage and Shipping Documentation and User's Guide (Huber et al. 1986). Additional MRS facility performance issues not related to storage and shipping operations are included in FACSIM/MRS-1: Cask Receiving and Consolidation Performance Assessment (Lotz and Shay 1987).

1.1 PERFORMANCE ASSESSMENT OBJECTIVE

The objective of this performance assessment was to verify that the design for the storage and shipping functions is adequate to meet the requirements specified in the Functional Design Criteria for an Integral MRS Facility (PNL 1986). The design criteria for the MRS specify that it must be capable of receiving, handling, and shipping 3,600 metric tons of uranium (MTU) per year based on 7 days per week, 24 hours per day operation. This analysis sought to verify that, given expected equipment reliability, the MRS would be capable of handling this throughput requirement without excessive equipment utilization rates or repository shipping cask turnaround times, and without exceeding in-building lag storage capacities.

The review of equipment utilization rates concentrated on the 35-ton cranes servicing the in-building lag storage and loadout area and the cask carts used for repository shipping cask loading. Utilization rates measure the capability of equipment to handle fluctuations in throughput and provide a measure of the equipment's ability to recover from unscheduled downtime.

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute.

Repository shipping cask turnaround time provides a measure of the efficiency of the MRS/repository transportation system interface. Smooth functioning of this interface (i.e., minimal unnecessary cask delays) would result in minimum requirements for the repository's shipping cask fleet.

Adequate process-cell lag storage would compensate for fluctuations in the arrival of spent fuel and ensure the smooth flow of material through the facility. The adequacy of in-building lag storage was evaluated using a variety of operating scenarios and throughput rates.

1.2 ANALYSIS OVERVIEW

This performance assessment of MRS facility back-end operations was performed by simulating facility operations using commercially-available simulation software. The software used, called SIMAN, is a SIMulation ANalysis language for modeling general systems (Pegden 1985). The modeling approach and user guide is described in FACSIM/MRS-2: Storage and Shipping Model Documentation and User's Guide (Huber et al. 1987).

Using the facility design drawings and material flow descriptions from the Conceptual Design Report (Parsons 1985), a simulation model was developed that represented all major equipment components of MRS back-end operations. Process times for these operations are based on Parsons' estimates and were modeled using a triangular distribution. The triangular distribution represents the minimum, most likely, and maximum time estimates for each processing activity.

Failures of overhead cranes were included in the simulation-based performance evaluation to determine their impact on receiving and handling operations. These failures were modeled as occurring randomly, and the time between failures was assumed to be exponentially distributed.

A description of back-end facility operations is presented in Chapter 2.0, and the performance assessment for MRS back-end operations is presented in Chapter 3.0.

2.0 DESCRIPTION OF BACK-END MRS FACILITY OPERATIONS

Back-end MRS facility operations handle spent fuel from the point after canister welding to emplacement of the canister in a lag storage vault cell or within a storage cask or a repository shipping cask. Interactions between the facility yard storage and the receiving and handling (R&H) building are also included as part of back-end operations. The major areas of the facility included in the analysis are shown in Figure 2.1, which shows one half of the R&H building.

The R&H building is composed of two halves, which are essentially mirror images of each other. One half handles spent fuel from pressurized water reactors (PWRs) and the other handles spent fuel from boiling water reactors (BWRs). Areas One through Four, shown in Figure 2.1, were included in the MRS front-end performance assessment report (Lotz and Shay 1987). The following sections describe MRS spent-fuel handling activities following canister welding in Area Four through repository shipment preparation in Area Eight.

2.1 BACK-END CANISTERING AND LAG STORAGE

After disassembly and consolidation in one of the four process cells, spent fuel is canistered and the canister is welded, inerted, decontaminated and inspected. The average PWR and BWR spent-fuel assemblies are assumed to contain 0.462 MTU and 0.186 MTU, respectively. Three consolidated PWR spent-fuel assemblies are placed in a canister, resulting in 1.386 MTU/canister. Seven consolidated BWR spent-fuel assemblies are placed in a canister, resulting in 1.302 MTU/canister.

The canister loading and welding area in the shielded canyon cells consists of a welding, decontamination, and inspection system, as shown in Figure 2.2. One welding machine services two shielded process cells. Following welding and decontamination, a helium leak test is performed to test the weld seal, a swipe for contamination is completed, and the canister is then transferred to an ultrasonic test station to test the integrity of the weld.

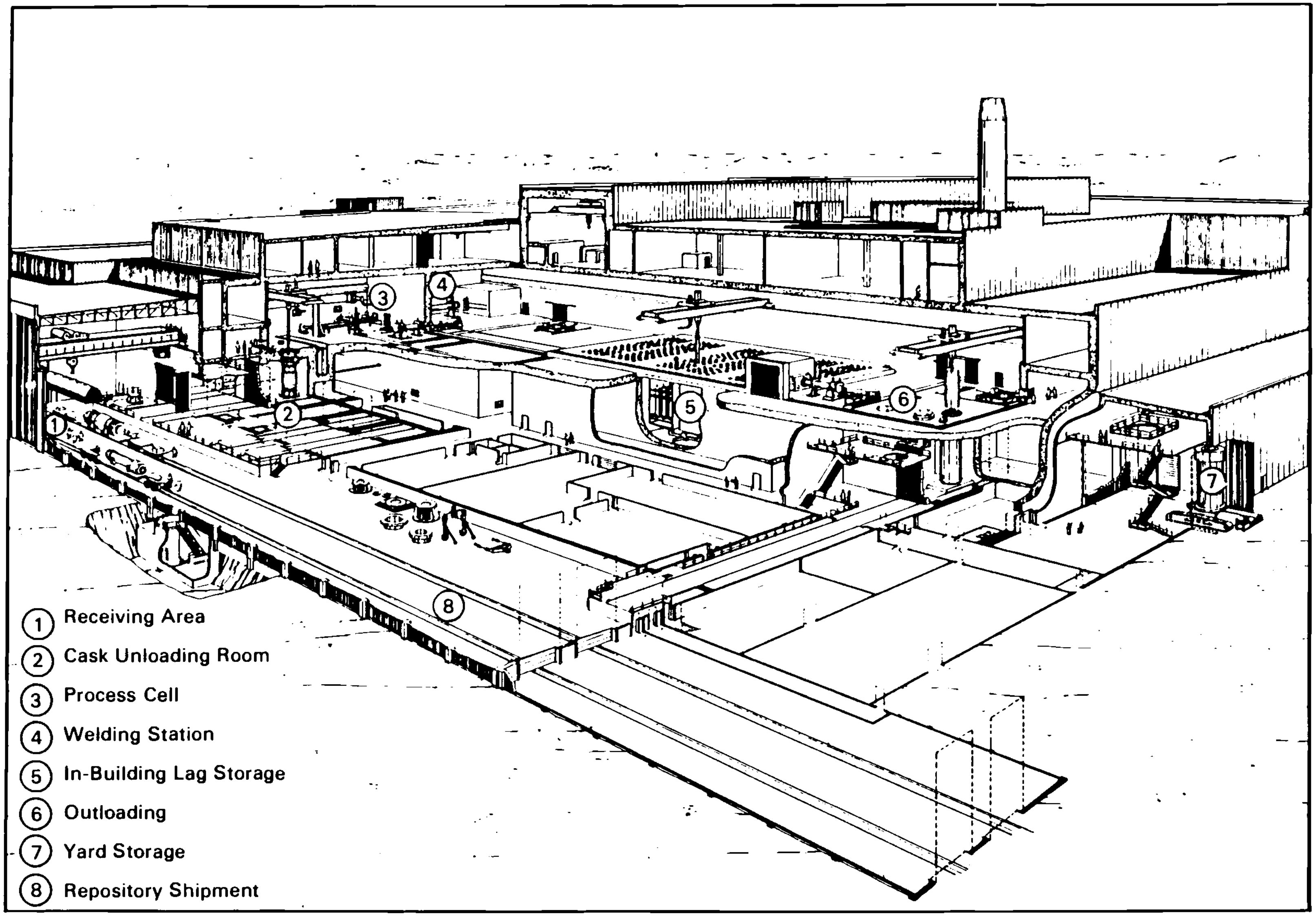
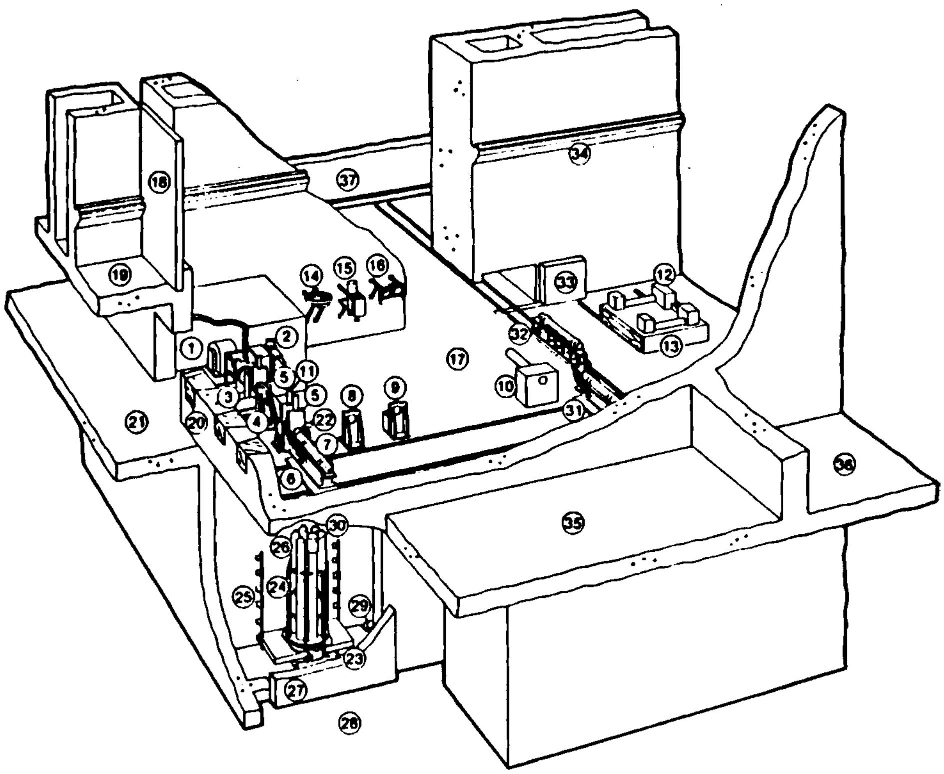


FIGURE 2.1. MRS Receiving and Handling Building (Parsons 1985)



1 Welding Power Generator/Equipment Room
2 Canister Lid Supply System
3 Canister Welding Station
4 Canister Decon/Helium Leak Test Chamber
5 Chamber Isolation Valves
6 Canister Upender No. 1
7 Storage Canister
8 Ultrasonic Test Station
9 Canister Cutting Station
10 Fuel Rod Bundle Push Rod System
11 Forge Press Restraint
12 Maintenance Hatch Jacking Mechanism
13 Maintenance Hatch
14 Plug Grapple
15 Pintle Grapple
16 Equipment Lifting Yoke
17 Shielded Canyon Cell #6
18 Maintenance Area Shield Door
19 Crane Maintenance Room
20 Observation Window
21 Operating Gallery
22 Clean Canister and Lid Supply Port
23 Carousel Lift Mechanism
24 Carousel Canister Rack
25 Guide Rail Lift Mechanism
26 Clean Canisters
27 Shield Door
28 Access Corridor
29 Lift Mechanism Hydraulic Pump System
30 Canister Lid Supply Support Tube
31 Canister Upender No. 2
32 Canister Pass-Thru Cart
33 Canister Pass-Thru Shield Door
34 35 ton Crane Rails
35 Shielded Process Cell #2
36 Decon Cell
37 Shielded Canyon Cell #5

FIGURE 2.2. Canister Loading and Welding Area

If the weld on the storage canister is unacceptable, the canister is sent to a cutting station for lid removal, and the welding process is repeated. A canister cutting station consists of a fully automatic pipe lathe located near the welding station. If one of the welding stations malfunctions, a canyon cell canister pass-through cart is provided to transfer spent-fuel canisters between the shielded canyon cells.

Following successful completion of the weld, the canister is placed into in-building vault lag storage, field storage, or directly into a repository shipping cask or into a scaled storage cask. Both in-building lag storage vaults have a total capacity of 748 canisters or about 1,000 MTU of spent fuel. The top of the storage vault is covered with a concrete floor with holes on 3-foot centers. Each hole has a removable shielding plug with a lifting pintle identical to the one on the canister. Each in-building lag storage/loadout area is serviced by two 35-ton overhead cranes. Placing a canister into in-building lag storage requires removing a shielding plug with the 35-ton crane, emplacing the canister into storage, and replacing the shielding plug. Time estimates for back-end canistering and lag storage emplacement are provided in Table 2.1.

Maintenance of the 35-ton cranes is performed in shielded maintenance bays. If one 35-ton crane is out of service, the other 35-ton crane is available to perform all operations. In practice, either crane can perform all shielded canyon cell lifts at a reduced pace. However, this'alternative was not modeled because of its minor impact on average crane utilization.

2.2 CONCRETE CASK YARD STORAGE

The yard storage area is designed to temporarily store spent-fuel canisters in sealed storage casks containing 12 canisters in an open field above ground. A diagram of the storage yard in relation to the R&H building is shown in Figure 2.3. Total storage yard capacity is about 15,000 MTU. However, no more than a total of 15,000 MTU can be stored onsite.

Storage casks are fabricated at the MRS cask manufacturing facility and transported to the R&H building when needed. Empty storage casks are prepared for loading in an area adjacent to and below the outloading area.

TABLE 2.1. Back-End Canistering and Lag Storage Emplacement Time Estimates (Parsons 1985)

Operation Description	Operation Time (in minutes)
I. Activities Included in Front-End Performance Model	
Index clean canister carousel, raise rack, lift port plug, set down plug, lift canister, place on Upender No. 1, replace plug	30
Downend Upender No. 1 (with canister), rotate, translate, and position to receive fuel bundle	15
Receive fuel bundle from consolidation process Cell 1	15
Retract from position, rotate canister, and translate to welder centerline	15
Insert canister into chamber, evacuate canister and chamber, backfill with inert gas and weld	20
Transfer canister in decontamination chamber, decontaminate, drain chamber and evacuate chamber for leak check	35
Open air lock, swipe canister while transferring to upender	15
Transfer welded canister to ultrasonic station, inspect and verify weld	45
II. Activities Included in Back-End Performance Model	
Retract canister, translate to open position, upend canister and place canister into vault lag storage or repository shipping cask	15

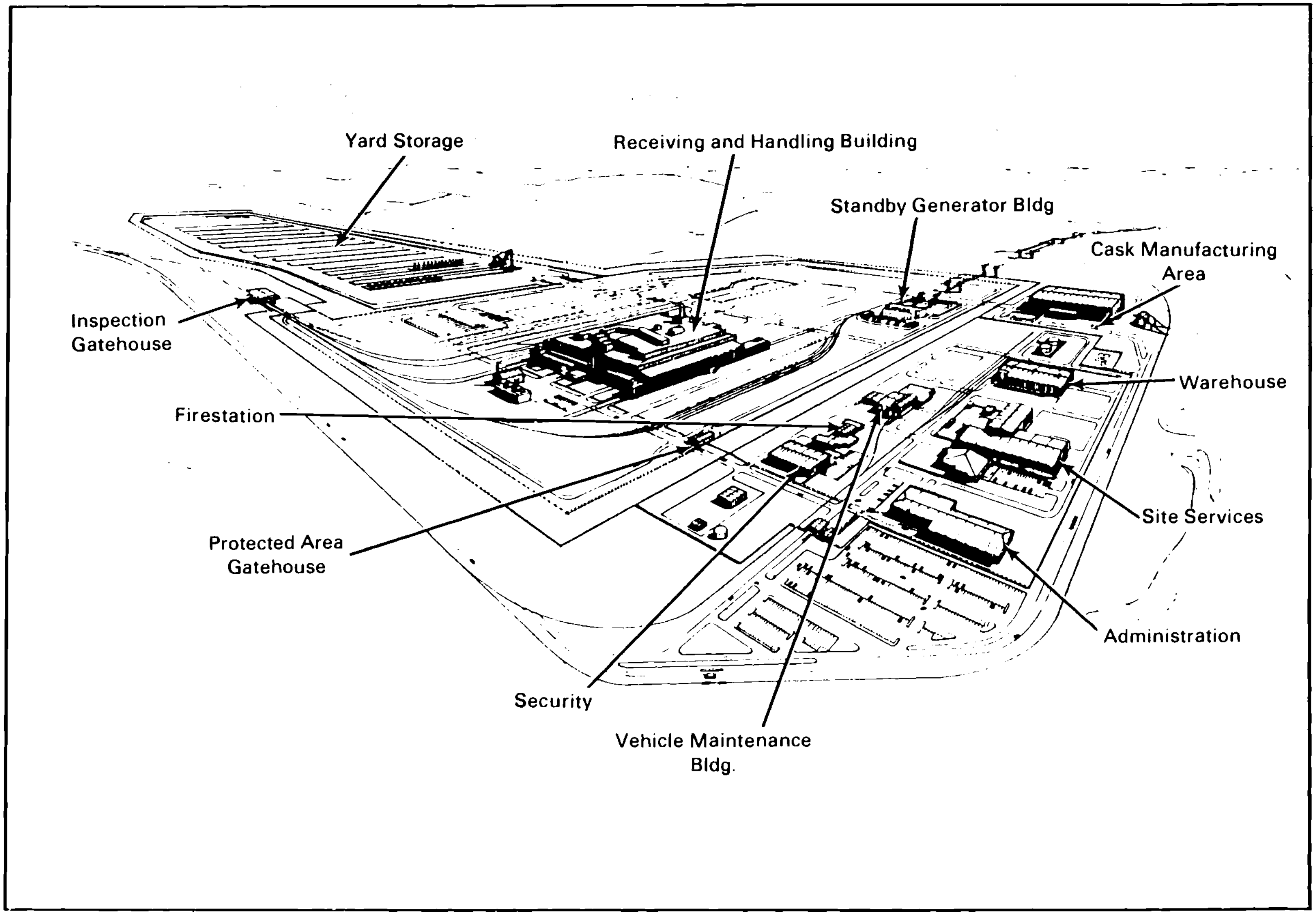


FIGURE 2.3 Storage Yard Location in Relation to the R&H Building (Parsons 1985)

After preparation for loading, the storage cask is moved into a loadout room located beneath the loadout area, and a contamination barrier is installed between the cask and loadout area port. The loadout area port plug and the cask shield plug are removed, and canisters are loaded into the storage cask using one of the 35-ton overhead cranes.

Once loading is completed, the loadout area port plug and the cask shield plug are replaced, and the storage cask is moved into an adjacent area where a contamination survey of the cask top is performed. A metal cask lid is installed, sealed, welded, and inspected. The transporter then moves the cask to the storage yard where the cask-handling crane removes the cask from the transporter. Time estimates for storage cask handling are provided in Table 2.2.

Storage cask retrieval and unloading back into the R&H building are, for the most part, the reverse of loading operations.

2.3 REPOSITORY SHIPPING CASK RECEIVING AND HANDLING

In addition to the storage cask loadout ports, the loadout area also contains repository shipping cask loadout ports. The loadout area also includes space for equipment to overpack canisters for shipment to the repository, which may or may not be used in actual operation. Time estimates for repository shipping cask R&H activities are provided in Table 2.3.

A detailed diagram of the repository shipping cask loading area is shown in Figure 2.4. If overpacks are used, the repository overpack arrives at the R&H building and is placed on the cask cart servicing the repository shipping cask area. The overpack is fitted with a contamination control adapter to reduce airborne contamination during the transfer of the repository overpack into the loadout area.

Once the loadout area port plug is removed, the 35-ton crane is used to place the overpack into the repository overpack welding station pit. The loadout area plug is replaced, and the overpack containment control adapter and cask cart is returned to the repository shipment area where the containment control adapter is removed from the cart. The overpack is loaded with four

TABLE 2.2. Concrete Cask Yard Storage Time Estimates (Parsons 1985)

Operation Description	Operation Time (in minutes)
Emplacement:	
Move cask into unloading room	15
Install contamination barrier and shield ring, move into corridor	15
Remove shield plug, .install canisters, install shield plug	300
Remove contamination barrier and shield ring, move into corridor	20
Perform contamination survey of cask top	10
Remove plug lifting eyes, install cover and welder, set up welder	20
Make weld	60
Remove welder	5
Visually inspect weld	10
Perform magnetic particle weld inspection	30
Pressure check cask interior	40
Clean weld area and coat	15
Move cask to storage area	30
Position lifting fixture and lift cask	10
Emplace cask and disengage lifting fixture	15
Complete thermocouple instrumentation connections	30
Return cask transporter to Cask Manufacturing Facility	30
Set new cask on transporter and move to R&H Area	30
Retrieval:	
Load cask onto transporter	35
Move cask to R&H Building	30
Prepare cask for unloading	120
Position cask under exit port	20
Remove shield plugs	20
Unload and decontaminate canisters as necessary	500
Replace shield plugs	20
Remove cask from unloading room	15
Prepare cask for temporary storage prior to decommissioning	60
Transport cask to temporary storage area, remove lifting yoke	30
Place cask on storage pad	35

TABLE 2.3. Time Estimates for Repository Shipping Cask R&H Activities (Parsons 1985)

Operation Description	Operation Time (in minutes)
RO/SCFRO[a] inspection at gate	5
Move RO/SCFRO/vehicle to protected area	15
Check to determine contents	10
Survey SCFRO/vehicle for radiation	45
Move RO/SCFRO/vehicle to washdown area	15
Remove road dirt from RO/SCFRO/vehicle	45
Move RO/SCFRO/vehicle to cask-handling area	20
Remove personnel barriers from vehicle	30
Remove impact limiters and shipping restraints	30
Perform contamination survey on SCFRO	30
Place RO cask adapter on cask cart	20
Attach grapple and remove RO from transporter	15
Place RO on cask cart, and install restraints and RO lid	30
Move RO to cask-handling and decontamination room	10
Install contamination barrier adapter on RO cask cart adapter	10
Move RO into unloading room, engage contamination barrier, close shadow shield and close shield door	20
Remove cell entry port plug	20
Unload overpack with lid and place into weld/ decontamination station	20
Exchange grapple, remove RO lid, and place on floor	10
Exchange grapple and replace cell entry port plug to permit preparations for SCFRO	25
Load consolidated fuel canisters in RO, 20 min/SF canister	60
Insert RO lid in place and rotate welding head into position for weld	20

(a) Repository Overpack (RO)/Shipping Cask for Repository Overpack (SCFRO).

TABLE 2.3. (contd)

Operation Description	Operation Time (in minutes)
Weld RO lid via electron beam process and disengage weld head from RO	60
Perform visual inspection on welded RO	10
Open shadow shield and shield door, disengage contamination barrier, and move cask cart with empty RO cask adapter to cask-handling and decontamination room	20
Remove the contamination barrier adapter from the RO cask adapter	10
Survey for contamination and decontaminate if necessary	40
Move cask cart to receiving and inspection area	10
Remove RO cask adapter from cask cart and place in set-down area	15
Exchange 150-ton grapple for shipping cask yoke	5
Engage SCFRO, rotate to vertical, place on cask cart, and secure restraints	35
Move cask cart/SCFRO into cask-handling and decontamination room, close door, and install contamination control barrier adapter	20
Remove outer lid of SCFRO and remove all but four bolts of inner lid	30
Move SCFRO into unloading room, engage contamination barrier, close shadow shield and close shield doors	20
Remove cell entry port plugs, unbolt inner lid fasteners, and lift lid into cell	40
Engage RO pintle grapple and lift completed RO into SCFRO	25
Exchange grapple, replace inner lid of SCFRO, tighten bolts, and replace entry port plug	80
Open shadow shield, shield door, disengage contamination barrier and move cask cart with full SCFRO to cask-handling and decontamination room	20
Complete SCFRO closure installation, remove barrier adapter, survey for contamination, and decontaminate if necessary	150

TABLE 2.3. (contd)

Operation Description	Operation Time (in minutes)
Move cask cart to receiving and inspection area	10
Remove full SCFRO from cask cart, place SCFRO on transport vehicle, and remove lifting yoke	35
Install cask tiedown impact limiters, personnel barriers, etc.	60
Complete preparations for release of full SCFRO and transporter from R&H Building	30

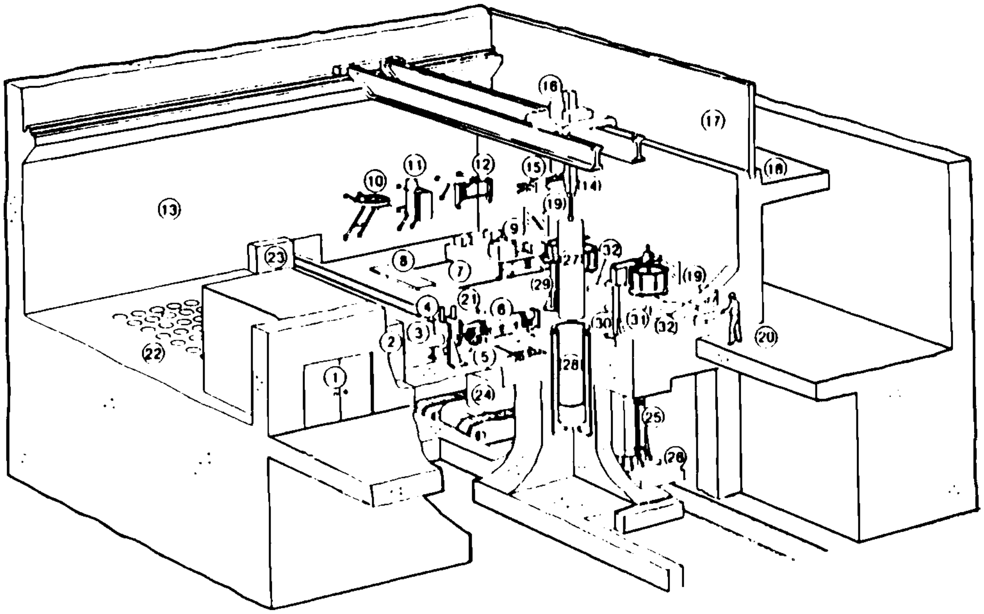
canisters using the 35-ton crane. An electron beam welder is used to secure a lid to the overpack, after which the overpack is inspected and decontaminated. If overpacks are not used, the canisters are loaded directly into a shipping cask.

The repository shipping cask is transported by rail to the repository shipment area of the R&H building, positioned in front of a cask cart, and prepared for unloading. The repository shipping cask is then transferred to the cask cart by the 150-ton crane. The cask cart transfers and mates the cask to the loadout area port. The required shielding is put into place and the loadout area plug is opened. The repository cask is loaded with an overpack or canisters, the port is closed, the outer lid is inspected, and the outer surface is decontaminated. Following decontamination, the repository shipping cask is removed from the cask cart and placed on the transport vehicle, and final preparations are made to release the shipping cask from the R&H building.

2.4 SECONDARY WASTE

Secondary waste refers to nonfuel material generated by disassembling spent-fuel assemblies and other waste that must be handled, packaged and shipped from the R&H building. Secondary waste is divided into two categories: nonfuel-bearing components and onsite-generated high-activity waste.

Nonfuel-bearing components (referred to as hardware) are the nozzles, grids, guidetubes, etc., remaining from spent-fuel disassembly for



1 Welding **Generator/Equipment** Room
2 Canister Welding Station
3 Canister **Decon/Helium** Leak Test Chamber
4 Chamber Isolation Valves
5 Canister Upender
6 Storage Canister
7 Exit Port
8 Lag Storage Cover
9 Exit Port Jacking Mechanism
10 Plug Grapple
11 Pintle Grapple
12 Equipment Lifting Yoke
13 Shielded Canyon Cell #6
14 Power Mast
15 Manipulator
16 35 Ton Cell Crane
17 Maintenance Area Shield Door
18 Crane Maintenance Room
19 Observation Window
20 Operating Gallery
21 Clean Canister and Lid Supply Port
22 Lag Storage Canyon Vault Area
23 Canister Pass-Thru Shield Door
24 Storage Cask and Transporter
25 Repository Overpack Cask Adapter
26 Cask Cart
27 Repository Overpack
28 Repository Overpack **Welding/Decon** Pit
29 Repository Overpack Welding Head and Jib Support Structure
30 Repository Overpack Decon Head and Jib Support Structure
31 Repository Overpack Port
32 Repository Overpack Port Plug (Outer & Inner)

FIGURE 2.4. Repository Shipping Cask Loading Area

consolidation. Onsite-generated high activity waste (HAW) consists of spent high-efficiency particulate air (HEPA) filters, spent cartridge filters, spent resins from radwaste systems, and evaporator slurry.

MRS handling of secondary waste consists of loading secondary waste into 55-gallon drums, followed by drum sealing and decontamination. The nonfuel-bearing waste drum processing and decontamination is accomplished in a cell located between adjacent shielded process cells. One nonfuel-bearing processing and decontamination cell is located in each half of the R&H building. Empty drums are brought into a process cell by a cart and placed at the shredder output for filling. Shredder loading is performed by a robot mounted on a powered transverse track that removes hardware from the disassembly consolidation station and places it in a shredder chute. The cart transfers the filled drum to a lid station, where the drum is sealed, and then into the decontamination cell where it is decontaminated and placed on a pallet. Process cell HEPA filters are boxed and removed to an adjacent area where they are compacted and placed into 55-gallon drums. The drums are then moved into the decontaniination cell and processed in the same manner as the nonfuel-bearing waste drums.

The loading, drum sealing, and drum decontamination of onsite-generated HAW resulting from radwaste treatment are completed in nearby rooms. These drums are then transferred directly to the loadout area.

Secondary waste is moved from the decontamination cell to the welding station area by a transfer cart carrying a pallet of five 55-gallon drums. The pallet is removed by a 35-ton crane and transferred to the outloading area. The outloading area contains a lag storage area assumed to be capable of containing 15 drums of nonfuel-bearing components and 45 drums of high-activity waste.

Drums are placed into drum baskets that hold five drums stacked in a vertical position. A maximum of nine drum baskets is assumed to be brought into the overpack area at a time through the repository shipping cask loadout port in a similar manner as repository overpacks. The bottom of the drum basket consists of a triangular base plate supporting three side supports for the basket. The top of the basket is formed by a triangular top plate with a lifting pintle that bolts to the side supports. Drum baskets are lifted by the 35-ton crane through the loadout port and into the overpack area, where the top plates are removed by 35-ton crane manipulators and guide pins are installed on the three support members. The operating strategy assumed for bringing in empty drum baskets is to have an empty basket ready for loading in each empty discharge lag storage basket cavity. The discharge lag storage is assumed to contain a total of 12 basket cavities.

Drum basket loading begins after the drum pallet is placed in the loadout area. A 35-ton crane secures a drum grapple attachment for individual drum lifts. After each drum is loaded into the basket, a triangular plate is placed on top of the drum. After the fifth drum is loaded into the basket, the top plate is installed and the drum grapple attachment is exchanged for a bolt manipulator and torque wrench. The top plate is then bolted to the three basket supports and loading is completed. The 35-ton crane then exchanges the bolt manipulator for a lifting attachment, and the drum pallet is returned to the transfer cart.

Shipping cask capacity for secondary waste is assumed to be three baskets of nonfuel-bearing components, or seven to nine baskets of high activity waste. Secondary waste loading is completed through the repository loadout port, similar to loading shipping casks with spent fuel. Secondary waste can also be stored onsite similar to spent-fuel canisters. However, for the purpose of this performance assessment, it was assumed that all secondary waste would be shipped offsite.

Activity times for secondary waste handling are provided in Table 2.4. Activity times not shown (e.g., preparing secondary waste shipping cask for loading) are assumed to be identical to activity times for similar spent-fuel handling activities.

Arrival rates of secondary waste to the shielded canyon cells are dependent on the MTU received by the MRS facility. Each MTU of spent fuel results in 0.4394 drums of nonfuel-bearing components and 0.3842 drums of high activity waste. At 3600 MTU per year, approximately 2965 drums of secondary waste must be handled.

TABLE 2.4. Activity Times for Secondary Waste Handling

Activity	Time (minutes)
Unload Drum Pallet:	
- 35-ton crane goes to pallet	10
- Secure pallet, move to discharge lag storage	15
- Replace lifting grapple with drum grapple	10
- Place drum 1 into basket	5
- Place spacer plate into basket	8
- Place drum 2	5
- Place plate 2	8
- Place drum 3	5
- Place plate 3	8
- Place drum 4	5
- Place plate 4	8
- Place drum 5	5
- Place plate 5	8
- Replace grapple for plate bolting manipulator	10
- Remove guide pins	5
- Bolt plate	15
- Replace manipulator with lifting device	10
- Return pallet	15
TOTAL	155 minutes
Load in Empty Drum Baskets:	
- Place basket cask adapter on cask cart	20
- Place nine baskets on cart (5 minutes each)	45
- Move to handling room, install contamination barrier adapter	20
- Move to unloading room, mate to port	20
- Remove port plugs with 35-ton crane	20
- Lift nine baskets into discharge lag storage (10 minutes each)	90
- Replace plugs	20
- 35-ton crane secures bolt manipulator	10
- Remove nine pintle plates and store (10 minutes each)	90
- Install nine sets of guide pins (5 minutes each set)	45
- Exchange bolt manipulator for lifting device	10
TOTAL	390 minutes
Return cask cart and remove adapters	80 minutes
Place loaded drum basket into shipping cask	20 minutes

2.5 EQUIPMENT RELIABILITY

MRS back-end equipment reliability was reviewed to determine the impact of equipment failure on facility throughput capability. The following five types of equipment were reviewed:

1. 150-ton bridge cranes
2. mobile 40-ton cranes
3. cask carts
4. yard cask transport vehicles
5. 35-ton bridge cranes.

The results of the reliability analysis formed the basis for modeling randomly occurring equipment failures during the simulation of MRS back-end operation. Failure rates for each equipment type and other reliability considerations are discussed in the following sections.

2.5.1 150-Ton Bridge Crane Reliability

The R&H building is served by one 150-ton crane in each of the two transport vehicle R&H areas. Failure of a 150-ton crane would result in the inability of one-half of the R&H building to handle rail casks and would disrupt repository shipping cask handling. To ensure maximum 150-ton bridge crane reliability, periodic preventive maintenance is assumed to be performed in such a manner as to minimize unplanned downtime. Expected 150-ton crane outage rates are provided in Table 2.5.

2.5.2 Mobile 40-Ton Crane/Cask Carts/Yard Cask Transfer Vehicle Reliability

Mobile 40-ton cranes are used in the cask R&H areas for smaller capacity lifts (i.e., lifts not requiring the use of the 150-ton bridge crane). Spare mobile cranes are expected to be available and no reduction in facility throughput is anticipated to be caused by failures associated with the crane.

The cask cart transports the upended repository shipping cask to the shipping cask loading room. Each half of the R&H building is served by one cask cart dedicated to material leaving the MRS site. A review of cask cart availability revealed that the equipment is expected to have a low maintenance requirement, and no cask cart failures were included in the simulation analysis.

TABLE 2.5. 150-Ton Bridge Crane Outages

	Potential Component Failure Rates	Time Between Occurrences	Repair Time Each Occurrence (hours)
1.	Planned overhaul (preventive maintenance)	5 yr	168
2.	Hook damaged - fails nondestructive testing (NDT)	5 yr	60
3.	Cable wear	2 yr	48
4.	Brake slips/locks	1 yr	12
5.	Control malfunction	6 mo	8
6.	Motor problems	5 yr	24
7.	Travel malfunction (bridge)	5 yr	48
8.	Drum wear	5 yr	48
9.	Power supply	5 yr	8
10.	Inspections: OSHA,[a] third party, other mandatory checks	1 yr	48
11.	Surveillance inspection each shift	8 hr	0.2

(a) OSHA - Occupational Safety and Health Administration.

Yard cask transfer vehicles transport concrete storage casks between the cask storage yard, cask manufacturing facility, and storage cask loading room. Similar to mobile 40-ton cranes, yard cask transfer vehicle failures are not expected to reduce facility throughput.

2.5.3 35-Ton Bridge Crane Reliability

Each shielded canyon cell is served by two 35-ton remotely operated bridge cranes that are used for handling canistered spent fuel and drummed secondary waste. Because failure of a 35-ton crane would reduce MRS back-end handling capability, the simulation model used the expected outages presented in Table 2.6 to account for less than 100% 35-ton crane reliability. If needed, the other 35-ton crane can be used when one is down.

TABLE 2.6. 35-Ton Bridge Crane Outages

Potential Component Failure Rates	Time Between Occurrences	Repair Time Each Occurrence (hours)
1. Planned overhaul (preventive maintenance)	5 yr	168
2. Hook or mast-damaged, fails NDT	5 yr	120
3. Lift power package malfunction	2 yr	72
4. Brake slips/locks	1 yr	24
5. Control malfunction	6 mo	16
6. Motor problems	5 yr	48
7. Travel malfunction (bridge)	5 yr	168
10. Power supply	5 yr	8
11. Remote monitor installation	1 mo	4
12. TV-optics	1 mo	4
13. Audio	1 mo	4
14. Lights	1 mo	4
15. Inspections: OSHA, third party, other mandatory checks	1 yr	72
16. Surveillance inspection each shift,	8 hr	0.2

3.0 EXPECTED FACILITY PERFORMANCE

Using simulation analysis, MRS back-end facility performance was assessed for a variety of operating scenarios. For each scenario, the expected performance of the facility was reviewed for equipment utilization levels, impact of crane failures, throughput capability, lag storage adequacy, and repository shipping cask turnaround time.

The reference operating scenario is the set of conditions the MRS facility would experience based on the design throughput rate of 3,600 MTU per year. Additional operating scenarios include varied throughput requirements, cask capacities, and storage yard utilization rates. Each operating scenario and corresponding facility performance evaluation is described in the following sections.

3.1 REFERENCE SYSTEM PERFORMANCE

The reference system scenario assumes that the MRS facility would receive and handle 3,600 MTU per year. This results in a yearly total of about 1,560 canisters of consolidated PWR spent fuel and 1,110 canisters of consolidated BWR spent fuel and 2,965 fifty-five gallon drums being handled by the back-end shielded canyon cells. Fluctuations in these yearly totals were considered by incorporating random arrival patterns in the modeling analysis. Additional assumptions included in the reference system performance assessment are listed below:

- 25% of all canisters sent to yard storage
- 12 canisters stored in each concrete cask in yard storage
- 4 canisters placed into each repository shipping cask
- 5 repository shipping casks per train
- no overpack
- 7 days/week operation
- 400 canisters in lag storage during the first year of operation.

Expected facility performance is based on 11 years of simulated facility operation. The conclusion of this reference system performance assessment is that throughput would be met with acceptable equipment utilization rates and railcar turnaround times. In addition, lag storage would adequately handle surges in canister arrival and departure. It should be noted that at 3,600 MTU per year the front end of the MRS facility (i.e., cash receiving and consolidation operations) would adequately handle throughput with a disassembly station equipment utilization rate of about 70%.

Equipment utilization due to spent fuel handling is less than 50%. Table 3.1 summarizes utilization rates. It should be noted that crane utilization rates for all scenarios are less than 25%. The carts that carry the repository shipping casks between the railcar and the loading or exit ports are used most. However, cart utilization depends on the amount of time that casks wait at the loading port. The cart servicing the PWR side of the R&H building has a utilization rate of 37%, and the BWR-side cart has a utilization rate of 50%.

The turnaround (i.e., receiving, loading, and releasing) time for repository spent-fuel shipping casks at the MRS was estimated for both individual railcars/casks and multicar trains. Table 3.2 summarizes shipping cask turnaround times and confidence intervals on time estimates. Repository shipping casks containing three canisters of consolidated spent fuel (approximately 4.0 MTU total) are received, loaded, and released in about 20 hours.

TABLE 3.1. Reference System (3,600 MTU per year) Equipment Utilization Rates

Equipment	Utilization Rate (%)
PWR Side:	
35-Ton Cranes	23.5
Cask Cart	50.0
150-Ton Crane	20.0
BWR Side:	
35-Ton Cranes	19.0
Cask Cart	50.0
150-Ton Crane	20.0

TABLE 3.2. Repository Shipping Cask Turnaround Times for Spent Fuel

	Average Turnaround Time (hr)	95 Percent Confidence Interval Minimum Value (hr)	95 Percent Confidence Interval Maximum Value (hr)
PWR Cask	19	17	28
BWR Cask	19	18	36
Multicar Train (5 casks)	97	89	108

Multicar trains, consisting of five shipping casks each, can be received, loaded, and released from the MRS facility in approximately 97 hours or 4 days. The relative train turnaround times are shown in Figure 3.1. Figure 3.1 shows the two most likely train turnaround times to be 2.5 to 3.0 days and 4.5 to 5.0 days. The first most likely turnaround time of *2.5* to 3.0 days results from approximately 50% of the trains arriving at the MRS when the shipping facility is idle. The second most likely multicar train turnaround duration of 4.5 to 5.0 days is due to trains arriving at the MRS and having to wait for a previous train to be processed.

3.2 EVALUATION OF LAG STORAGE CAPACITY

The vault lag storage areas in the shielded canyon cells have a combined capacity of 1,000 MTU (approximately 748 canisters) and serve as a buffer between spent-fuel canistering, repository shipments, and yard storage. Lag storage levels are dependent on the equilibrium of spent-fuel arrival rates from reactors and shipment rates of canistered spent fuel to the repository. In addition, targeted lag storage levels (i.e., lag storage levels at which canisters are placed in yard storage to alleviate shielded canyon cell lag storage) also impact lag storage usage.

To address the impact of differences in spent-fuel arrival and departure rates on lag storage, an analysis was completed assuming that from 0 to 400 canisters are in lag storage when equilibrium in annual and departure rates is achieved. Furthermore, targeted lag storage levels were varied from 400 to 700. The results of this analysis in terms of average and maximum lag storage use are shown in Table 3.3 and Figures 3.2 and 3.3. It should be emphasized

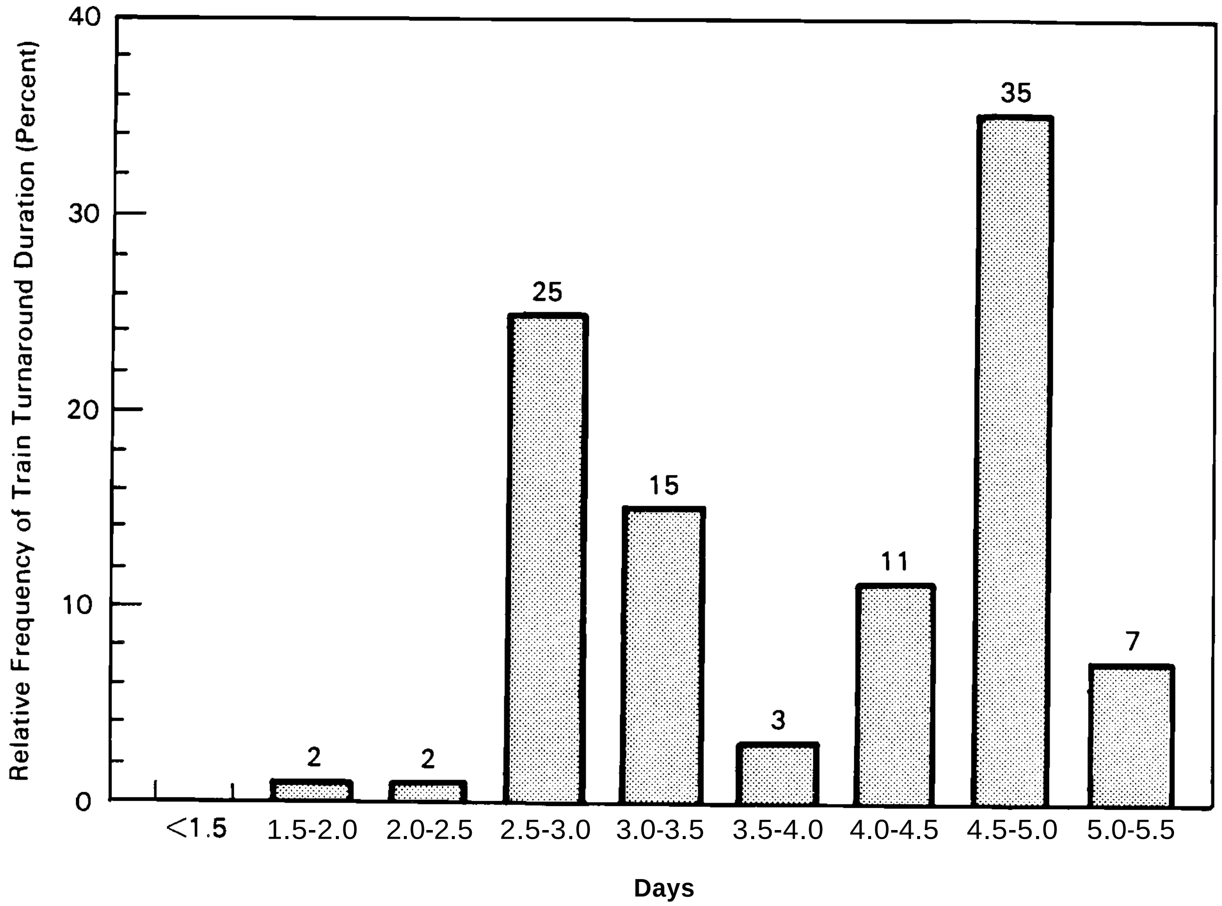


FIGURE 3.1. Relative Frequency of Train Turnaround Time

that the analysis was completed assuming that PWR and BWR canisters would not be mixed (i.e., dedicated shielded canyon cell lag storages). In practice, canisters could be transferred from one lag storage to another to permit maximum lag storage utilization. However, additional canister-handling requirements would be placed on the 35-ton cranes.

The results of the analysis is that sufficient lag storage capacity exists to handle expected surges resulting from random spent-fuel arrivals and departures. Lag storage capacity constraints occur when lag storage levels are more than 50% full before equilibrium is reached and the targeted lag storage level is high. At equilibrium, required surge capacity is approximately 200 to 250 canisters. Therefore, at the designed capacity of 748 canisters and assuming optimum lag storage utilization (ie., mixing PWR and BWR canisters),

TABLE 3.3. Analysis of Shielded Canyon Cell Lag Storage (maximum lag storage capacity = 748 canisters)

Number of Canisters Initially in Lag Storage	Average Number of Canisters in Lag Storage	Maximum Number of Canisters in Lag Storage	Difference Between Initial and Maximum Lag Storage
Targeted Lag Storage Level = 400 Canisters			
0	50	137	137
100	148	261	161
200	245	357	157
300	368	451	151
400	392	436	36
Targeted Lag Storage Level = 700 Canisters			
0	50	137	137
100	148	269	169
200	247	419	219
300	346	519	219
400[(a)]	420	578	178

(a) Simulation terminated prematurely because PWR lag storage capacity was exceeded.

approximately 500 canister storage locations can be used for long-term storage without affecting the shielded canyon cell's ability to handle expected lag storage surges or fluctuations.

3.3 IMPACT OF VARIED THROUGHPUT REQUIREMENTS

Throughput requirements from 3,000 to 3,600 MTU per year were used to assess back-end canister handling capability for the MRS facility. The functional design criteria state that the MRS facility must have adequate surge capacity to process 3,600 MTU per year. Excess processing capacity would enable the facility to handle fluctuations in the amount of spent fuel arriving yearly to the R&H building, and would also enable the facility to recover from an extended unscheduled outage.

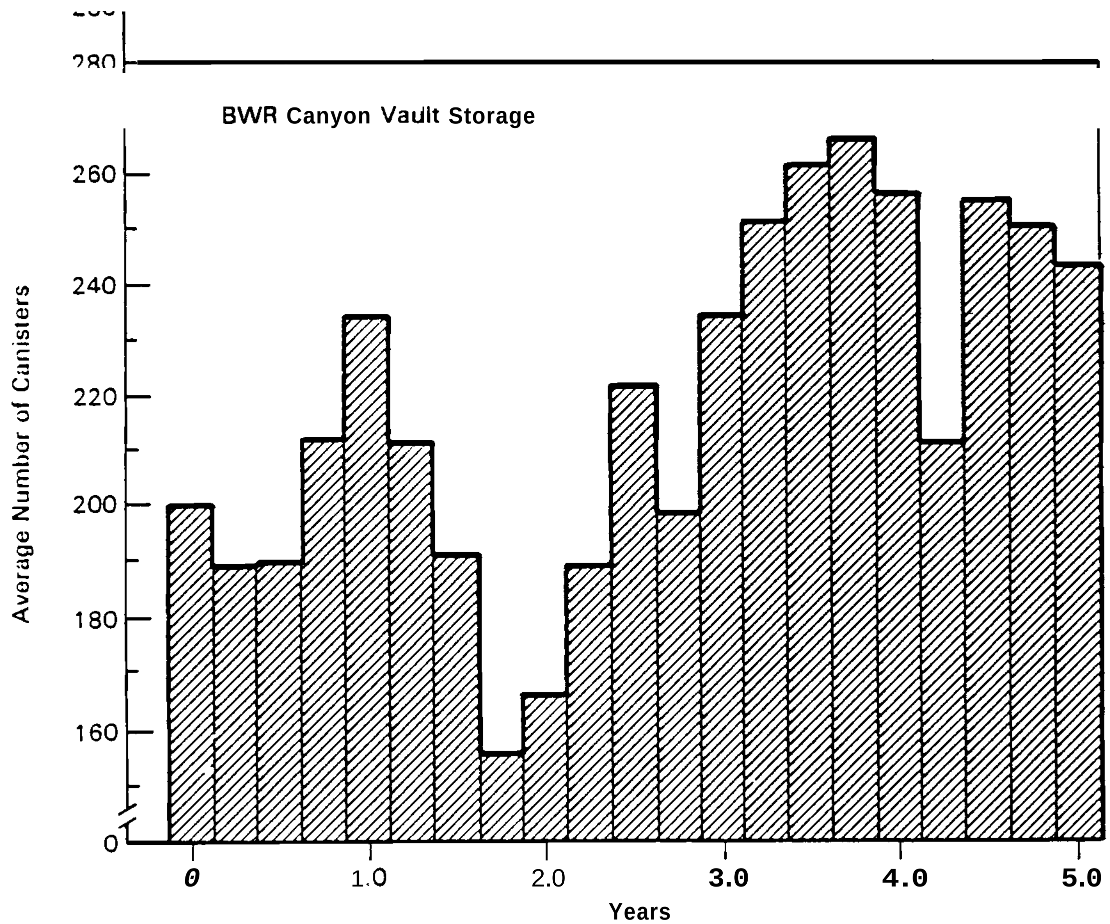


FIGURE 3.2. Average Number of BWR Canisters in Vault Storage

As noted in Section 3.1, the cart that transports the repository shipping cask from the railcar to the loading port has the highest utilization rate of any back-end facility equipment. Therefore, throughput capability would be limited by cart availability, which depends on the length of time that it takes to load casks at the loading port. The simulation-based estimate of cart utilization at 3,000 MTU per year throughput and 5-day week facility operation is less than 50%, indicating that throughput could be achieved.

3.4 SHIPPING CASK VARIATIONS VERSUS FACILITY PERFORMANCE

An important measure of the effectiveness of the MRS facility design is the facility's ability to meet throughput requirements given potential variations in operating conditions. One area of potential variation is the

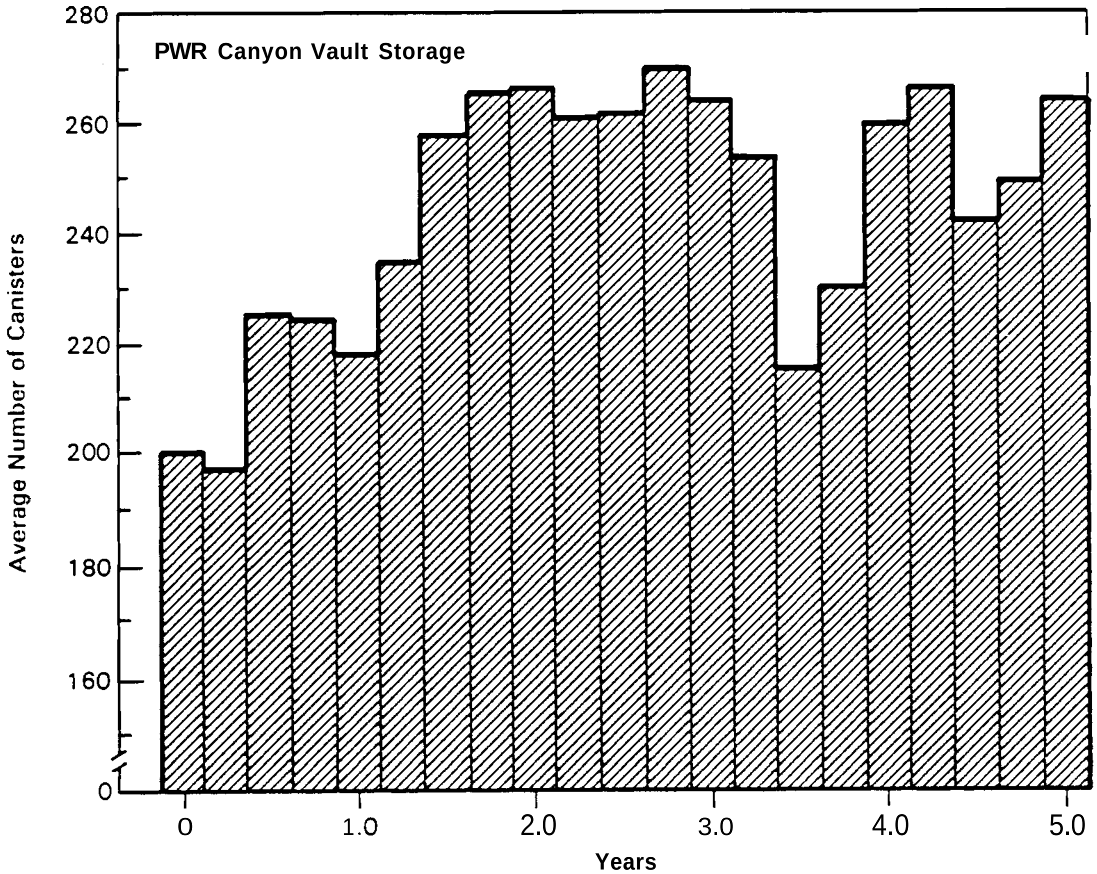


FIGURE 3.3. Average Number of PWR Canisters in Vault Storage

repository shipping cask and train transport. The simulation analysis of MRS facility operation was completed assuming the following scenarios:

- cask capacity increased from 3 to 4 MRS canisters
- multicar train increased from 5 cars to 10 cars
- a repository overpack operation was added at the MRS.

The impact of these scenarios on the performance of back-end MRS spent-fuel canister-handling operations is discussed in the following sections.

3.4.1 Impact of Shipping Cask Capacity

The shipping cask capacity for repository spent fuel affects the number of casks needed to meet shipping requirements. As cask capacities increase, the number of shipping casks the MRS facility must handle decreases. Although the actual repository shipping cask system may not use the MRS canister capacities of three PWR or seven BWR spent-fuel assembles per canister, these capacities were used to show the benefits of increasing cask capacity for MRS facility performance.

The reference operating scenario for the MRS assumes that three canisters of consolidated spent fuel would be placed into a repository shipping cask. Assuming that four canisters would be placed into a cask, a simulation analysis was completed to measure the resulting reduction in the utilization of the repository cask transfer cart. Cart utilization is a key performance measure because it has the highest utilization of any of the MRS back-end equipment. The analysis indicated that average cart utilization would be reduced by 7.3%. The net effect of reducing cart utilization by increasing shipping cask capacity would be an increase in yearly throughput capability for the MRS back-end facility.

3.4.2 Impact of Multicar Train Size

A simulation analysis of the size of multicar trains for the repository rail casks was completed to quantify the impact of train size on cask and train turnaround times. All operating assumptions in this analysis are identical to those for the reference scenario except train size.

A comparison of cask and train turnaround times is provided in Table 3.4 for 5-car and 10-car multicar trains. Both cask and train turnaround times increase due to casks waiting longer to be serviced. Repository shipping cask turnaround time increases from 19 hours per cask for 5-car trains to 27 hours per cask for 10-car trains. This represents more than a 40% increase in turnaround time.

TABLE 3.4. Comparison of Train Size and Cask/Train Turnaround Times

Number of Casks per Multicar Train	Cask Turnaround Time (hr)	Train Turnaround Time (hr)
5	19	97
10	27	206

3.4.3 Impact of Overpack Operations

Space for overpack equipment in the shielded canyon cells is included in the MRS facility design. The reference system scenario does not include overpacking because this operation is most likely to occur at the repository. A simulation model with MRS overpacking was developed to measure the impact of overpack operations on MRS equipment performance. All other assumptions (i.e., 3,600 MTU per year, etc.) were kept consistent with those assumptions presented in the reference system operating scenario in Section 3.1.

Overpack operations involve bringing in an overpack on the cask cart, after which a 35-ton hot-cell crane lifts the overpack into the shielded canyon cell. Overpacks are then loaded with canisters of consolidated spent fuel, welded, and inspected. Following inspection, overpacks are placed into a shipping cask for shipment to the repository. The addition of this overpack activity affects the utilization of the 35-ton shielded canyon cell cranes, the 150-ton receiving area cranes, and the cask carts. A comparison of equipment utilization rates for the reference system scenario and for the scenario that includes overpacking is presented in Table 3.5. As shown, cask cart utilization increases dramatically, from 50% to over 90%. The utilization of the 35-ton cranes increases from 21% to 39%, and the 150-ton crane utilization increases from 20% to 30%.

TABLE 3.5. Impact of Overpack Operations on Equipment Utilization (assuming 3,600 MTU per year throughput)

Equipment	Utilization Without Overpack (%)	Utilization With Overpack (%)
35-Ton Overhead Cranes	21.3	38.5
150-Ton Overhead Cranes	20.0	29.5
Carts	50.0	94.8

3.5 IMPACT OF VARIABLE YARD UTILIZATION

Routing material to the onsite MRS storage yard before shipment to the repository increases canister handling requirements for the back-end MRS equipment. A simulation model was completed that routed all of the canisters to the yard, and then retrieved the canisters back within the vault lag storage area for shipment to the repository.

The concrete storage cask with a 12-canister capacity was the onsite storage concept used for the simulation. These casks are brought into the back-end loading port via transport vehicles, loaded, sealed, and transported to yard storage and placed on a concrete pad. Retrieving canisters is the reverse of these operations. The 35-ton cranes are the most affected by increased yard utilization. The modeling results show that routing 100% of the canisters through the storage yard increases 35-ton crane utilization from 21.3% for the reference system to 26.7%. Because this increase is well within acceptable utilization levels, routing all canisters through the onsite storage yard does not significantly reduce back-end MRS throughput capability.

REFERENCES

Huber, H. D., et al. 1987. FACSIM/MRS-2: Storage and Shipping Model Documentation and User's Guide. PNL-6003, Pacific Northwest Laboratory, Richland, Washington.

Kaiser Engineers, Inc. 1984. Monitored Retrievable Storage Conceptual System Study: Dry Receiving and Handling Facility. KEHR-83-96, Kaiser Engineers Hanford Company, Richland, Washington.

Lotz, T. L. and M. R. Shay. 1987. FACSIM/MRS-1: Cask Receiving and Consolidation Performance Assessment. PNL-5989, Pacific Northwest Laboratory, Richland, Washington.

Pacific Northwest Laboratory (PNL). 1986. Functional Design Criteria for an Integral Monitored Retrievable Storage (MRS) Facility: Revision 4. PNL-5673, Pacific Northwest Laboratory, Richland, Washington.

Pegden, C. D. 1982. Introduction to SIMAN. Systems Modeling Corporation, State College, Pennsylvania.

Ralph M. Parsons Co. 1985. Conceptual Design Report. Ralph M. Parsons Co., Pasadena, California.

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