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CAPABILITIES FOR PROCESSING SHIPPING CASKS
AT SPENT FUEL STORAGE FACILITIES

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by

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ABSTRACT

Spent fuel is received at a storage facility in heavily shielded casks transported either by rail or truck. The casks are inspected, cooled, emptied, decontaminated, and reshipped. The spent fuel is transferred to storage. The number of locations or space inside the building provided to perform each function in cask processing will determine the rate at which the facility can process shipping casks and transfer spent fuel to storage. Because of the high cost of construction of licensed spent fuel handling and storage facilities and the difficulty in retrofitting, it is desirable to correctly specify the space required. In this paper, the size of the cask handling facilities is specified as a function of rate at which spent fuel is received for storage.

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The minimum number of handling locations to achieve a given throughput of shipping casks has been determined by computer simulation of the process. The simulation program uses a Monte Carlo technique in which a large number of casks are received at a facility with a fixed number of handling locations in each process area. As a cask enters a handling location, the time to process the cask at that location is selected at random from the distribution of process time. Shipping cask handling times are based on experience at the General Electric Storage Facility, Morris, Illinois. Shipping cask capacity is based on the most recent survey available of the expected capability of reactors to handle existing rail or truck casks.

INTRODUCTION

The Du Pont Company, at the request of the Department of Energy, is assisting in studies related to the back end of the LWR fuel cycle. Several of these studies have been concerned with the receipt and storage of spent LWR fuel. Initial studies were for a handling and lag storage facility at a reprocessing complex as part of the Alternate Fuel Cycle Technology (AFCT) program. Recent studies have been concerned with implementation of the DOE policy to take title to spent fuel. In each of the studies, under water handling and storage of the spent fuel was selected.

At a storage facility, several specific operations are performed on the shipping cask before fuel assemblies are placed in storage. These operations generally take place inside a building which must be constructed to meet the Nuclear Regulatory Commission's licensing requirements.

The number of locations or space inside the building provided to perform each function in cask processing will determine the rate at which the facility can process shipping casks and transfer spent fuel to storage. Because of the high cost of construction of licensed spent fuel handling and storage facilities and the difficulty in retrofitting this type construction, it is desirable to correctly specify the space required. A study has been made to specify the size of cask handling facilities required as a function of the rate at which spent fuel is received for storage.

DISCUSSION

Underwater Handling and Storage

Underwater handling and storage of spent LWR fuel was selected for the Du Pont studies because it is a proven concept that is acceptable to the NRC. The technology of water-cooled storage is well developed, and water pools have been successfully used for receiving and storing spent nuclear fuel for more than 30 years. Spent fuel has been stored without any significant incident or detriment to the surrounding environment or population. Further, the storage has been accomplished without any serious deterioration of the fuel cladding.

Use of water as the storage medium offers the following benefits:

- It is an excellent heat transfer medium for removing decay heat from the fuel, and it provides a substantial heat sink.
- It is a transparent radiation shield that allows visual inspection and direct manipulation of the fuel.
- It provides partial containment of some fission product gases and essentially full containment of any particulate radioactive material that may escape from a fuel assembly.

Cask Process Operations

At a spent fuel handling and storage facility several specific operations (Figure 1) are required on the shipping cask-carrier before fuel assemblies are removed and placed in storage. These operations each of which require a specific area within the fuel handling and storage building are:

- *Preparation* — peripheral equipment is removed from the cask and carrier and stored
- *Cask Loading and Offloading* — casks containing spent fuel are removed from the carrier and empty casks are loaded on the carrier
- *Cooling and Washdown* — loaded casks undergo exterior washdown and interior flushing and cooling
- *Decontamination* — casks are decontaminated as required after removal from the carrier or from the fuel unloading pool
- *Fuel Unloading* — fuel assemblies are removed from the casks and placed in storage baskets

The design capacity for receiving and placing spent fuel in storage is achieved by supplying a sufficient number of each type of location to perform the individual handling operation.* The number of each type location required is determined by 1) the time required to accomplish each handling operation and 2) the capacity of the casks handled.

Cask Process Time

Cask process experience has been obtained from Nuclear Fuel Services, General Electric (Morris), and the Receiving Basin for Offsite Fuel (RBOF) at the Savannah River Plant.

RBOF experience varied widely because of the range of different types of casks handled at the facility, many of which are not suitable for LWR fuel. Minimum cask process times reported were by the Nuclear Fuel Services receiving facility; however, the most complete data were available from the GE Morris facility.

Nuclear Fuel Services made a special effort to reduce turn-around time, which had initially been much higher than the currently reported 4-8 hours.[1,2] For example, a protective shroud to minimize cask contamination in the Fuel Unloading Pool and a decontamination station that enclosed the cask and used high pressure water sprays to aid in decontamination were added. Contact with current and

* A simpler but more expensive concept consists of parallel paths with locations for all of the above operations. In this study the crane arrangement is such that casks can be transferred to any available handling location.

and former NFS personnel confirm that the 4-8 hour turnaround was routinely achieved.

General Electric made studies at Morris of the time required to process the NAC-1 type (or NFS-4) cask. Table 1 shows the best estimate of the time required to perform each major function at Morris. The 18-hour total time is conservative based on NFS reports of processing the same cask in an average of 4 to 8 hours. The Morris times are judged to be long because the measurements were made early in their program and because they had little incentive to speed up processing. Morris has not, for example, used a protective shroud such as that devised by NFS to minimize cask contamination in the Fuel Unloading Pool or developed special equipment to assist in decontamination.

Information on experience with handling large rail casks is limited to the GE IF 300 cask at the Morris facility as shown in Table 1.* As with truck casks, the process time is expected to decrease as handling experience is gained.

The GE process times were used in the determination of the number of process areas because:

1. Enlargement of the process area, once constructed will be difficult and the GE process times are expected to be conservative.

* The NLI 10/24 cask, which is licensed, has a capacity $\sim$40% higher than the IF 300 cask. The process times for this cask are expected to be greater than the IF 300 cask because of the higher transport temperatures (dry cavity), double head, and heavily finned outer surface.

2. A breakdown of time for each operation was available.
3. Sufficient data were available to indicate the range of process times.
4. The effect of increased cask throughput on process times cannot be evaluated so that use of conservative times is justified.
5. No other process times were available for rail casks.

As experience is gained at AFR storage facilities it is expected that these process times will be reduced. Studies are currently in progress at the AGNS facility at Barnwell, South Carolina to evaluate some of the parameters associated with cask processing.

Expected Mixture of Rail and Truck Casks

Three types (sizes) of fuel casks have been designed for shipment of spent LWR fuel (Table 2). The small legal weight truck (LWT) cask holds 1 PWR or 2 BWR assemblies. Slightly larger casks hold 2 PWR or 4 BWR assemblies, but require overweight trucks (OWT). The very large casks contain 7 to 10 PWR or 18 to 24 BWR assemblies, but must be transported by rail or barge. At the present time only the LWT casks and the smaller of the two rail casks (the GE IF 300) are being used in this country.

The number of casks to be handled at a receiving basin depends on the amount of fuel to be received as well as the mix of the type of cask (rail or LWT) handled.

The types of casks used will probably be determined by what the reactors are capable of handling. All reactors can ship by truck cask, but not all reactors have access to railroads or barges. Three projections of reactors either with rail facilities or the capability to ship by rail type cask have been made:

Year	*Reactors with Rail Facilities, %*
1980[3]	56
1987[4]	73
1975-2020[5]	90[a]

a. Estimated percent of fuel shipped by rail type cask.

The 1987 projection was made by Nuclear Assurance Corporation (NAC) at DOE's request for use in conceptual design studies. The reactors with rail access constituted 75.2% of the fuel weight and were distributed as shown:

Section	*Reactors with Rail Access, %*
Midwest	92.0
West	85.0
South	76.1
Northeast	47.3

The trend was for the larger (newer) reactors to have rail access.

Handling Locations

A cask handling facility includes all the different cask processing locations required to achieve the desired throughput.

The minimum number of each type of handling location to achieve a given throughput of shipping casks has been determined by computer simulation of the several process operations (Table 3). As previously discussed, shipping cask handling times are based on experience at the General Electric Storage Facility, Morris, Illinois. A log normal distribution is used to describe the variation in cask handling time. Shipping cask capacity is based on a survey by NAC[4] of the expected capability of reactors to handle existing rail or truck casks. However, for purposes of this study it was conservatively assumed that only 70% of the reactors will ship spent fuel by rail casks (vs. ~75% in Reference 4), and the remaining reactors will likely ship by legal weight truck casks (LWT). The computer program uses a Monte Carlo technique to simulate processing of shipping casks at a facility with a fixed number of handling locations in each process area. As a cask enters a handling location, the time to process the cask at that location is selected at random from the distribution of process time. The handling locations can process either LWT or rail casks. If any location were limited to only rail or LWT casks, additional handling locations would be required. Providing extra handling locations (e.g., Fuel Unloading Pool or Decontamination Area) may be desirable if a location has a high potential for gross contamination.

As the cask throughput is increased for a given number of handling locations, the throughput will eventually become limited by one of the handling locations. The addition of a handling location of the limiting type may then increase throughput significantly as shown in Table 3. However, the random addition of a handling location other than the limiting one will have little or no effect on throughput as shown in Table 4.

A conceptual layout of a cask handling facility is shown in Figure 2. A facility arranged as shown would have the capability to process about 2 rail casks and 7 LWT casks each day for an annual receiving rate of 2500 MTU. A similar layout was used as the basis for the generic environmental impact statement for storage of spent LWR fuel.[6]

The limiting size for a single handling facility is judged to be about 3000 MTU/year for the assumed cask mixture. Larger facilities are believed to be hampered by limitations on movements of cranes handling both casks and fuel baskets and by difficulty in achieving layout of handling locations for the higher material flow. For throughputs larger than 3000 MTU/year, parallel or multiple facilities would be constructed, i.e., for 4000 MTU/year throughput, two 2000 MTU/year facilities would be provided.

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TABLE 1

Cask Process Times

	Time, hr			
	LWT Cask[a] *(Truck)*		*GE IF-300 Cask (Rail)*	
Area	*Expected*	*Upper Limit*[b]	*Expected*	*Upper Limit*[b]
Preparation-Offload	4.0	8.0	4.9	9.1
Cooldown	4.0	8.0	4.9	9.1
Fuel Unloading	2.8	7.2	7.0	11.4
Decontamination	3.3	11.0	14.0	22.4
Reload-Delay (Preparation-Offload)	4.0	10.5	6.1	13.3
Turnaround Time	18.0	45.0	37.0	65.0

a. NAC-1, NFS-4, NLI 1/2.

b. Upper limit includes 95% of all values.

TABLE 2

Licensed and Available United States Shipping Casks for Current Generation LWR Spent Fuel

Cask Designation	*Number of Assemblies* *PWR*	*BWR*	*Approximate Loaded Cask Weight, Tonnes*	*Usual Transport Mode*	*Maximum Heat Removal, kW*
NFS-4 (NAC-1)	1	2	23	Truck	11.5
NFS-5	2	3	25	Truck	24.7
NLI 1/2	1	2	22	Truck	10.6
TN-8	3	-	36	Truck[a]	35.5
TN-9	-	7	36	Truck[a]	24.5
IF-300	7	18	63	Rail[b]	76.0[c]
NLI 10/24	10	24	88	Rail	97.0[d]

a. Overweight permit required.

b. Truck shipment for short distances with overweight permit.

c. Licensed decay heat load is 62 kW

d. Licensed decay heat load is 70 kW.

TABLE 3

Minimum Number of Cask-Handling Locations at Away-From-Reactor Fuel Storage Facility

Spent Fuel, MTU/year[a]	500	1000	1500	2000	2500	3000
Casks/24 hour day						
Rail	0.4	0.8	1.1	1.5	1.8	2.2
Legal Weight Truck	1.4	2.7	4.0	5.4	6.7	8.0
Handling Location	*Number*					
Preparation Area and Cask Offload-Load Area[b]	1	2	2	3	4	4
Cask Cool and Washdown Area	1	1	1	2	2	2
Fuel Unloading Pools	1	1	1	2	2	2
Cask Decontamination Area	1	1	2	2	2	3

a. Assumes 300 days operation of the facility at full capacity.

b. Preparation Area and Cask Offloading-Loading Areas are paired.

TABLE 4

Effect of Additional Cask-Handling Locations on Facility Throughtput

Fuel Receipt — 2500 MTU/year

Cask Receipt — 70% Rail
30% Truck

Site	*Minimum Required*	*Number of Sites*			
Preparation Area	4	5[a]	4	4	4
Cask Load-Offload Area	4	5[a]	4	4	4
Cask Cool and Wash Area	2	2	3[a]	2	2
Fuel Unloading Pool	2	2	2	3[a]	2
Cask Decontamination Arca	2	2	2	2	3[a]
Casks/Day	8.5	8.5	8.5	8.5	10.2

a. Indicates increase in number of sites by one. Other sites remain the same.

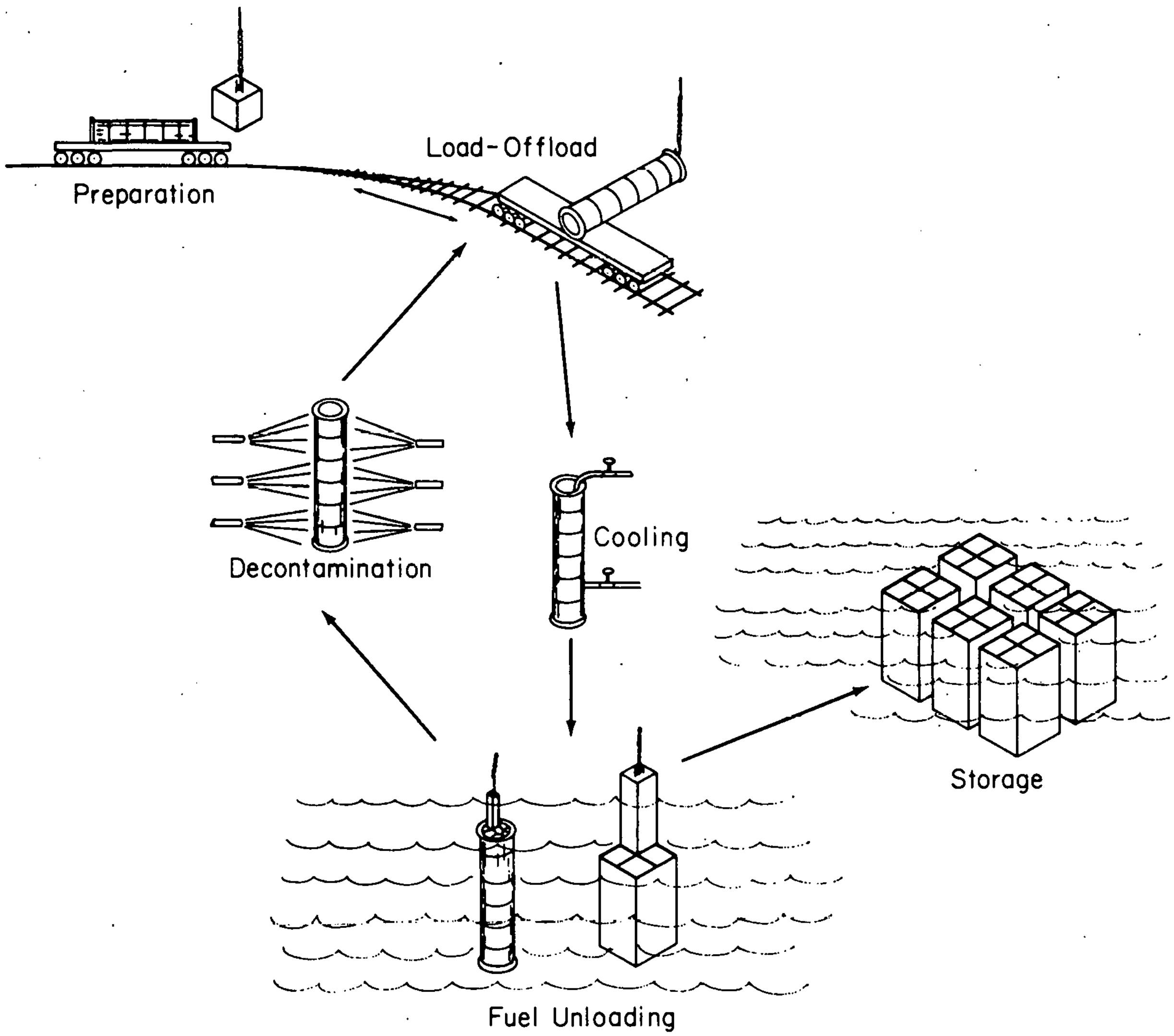

FIGURE 1. Process for Handling and Storing Spent LWR Fuel

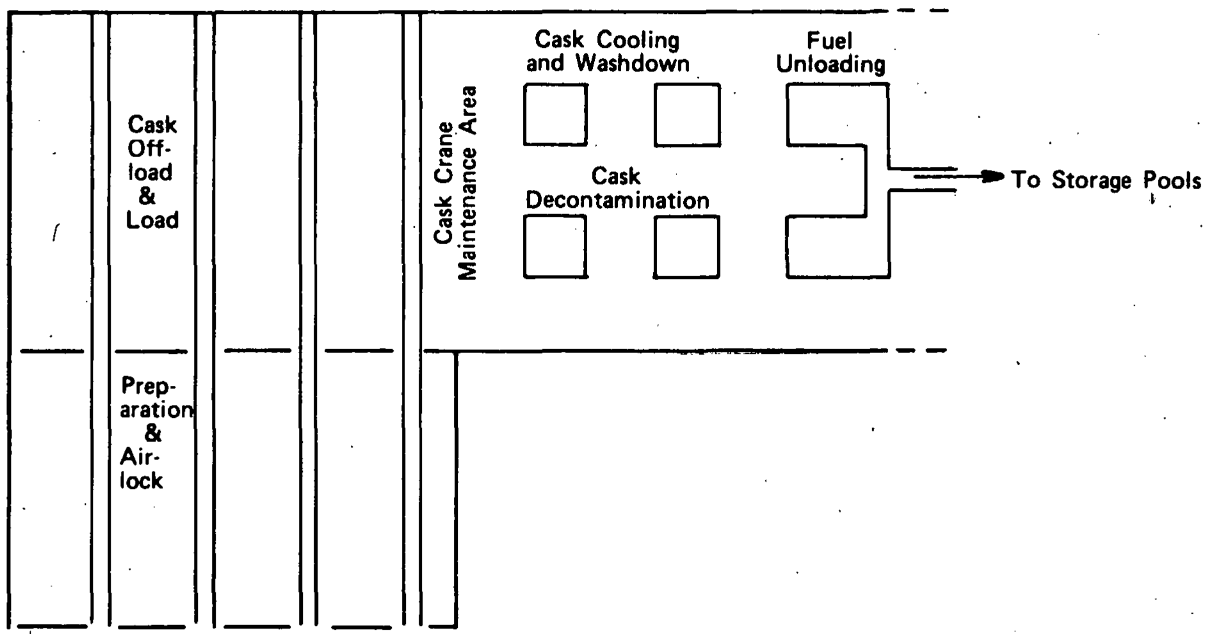

FIGURE 2. Cask and Fuel Handling Facility Layout