RADIOLOGICAL ANALYSIS FOR DRY CASK STORAGE OF SPENT FUELS

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ABSTRACT

A study to evaluate the radiological implementation requirements for dry cask storage of spent fuel at the Monticello and Prairie Island plant sites has been conducted by Stone and Webster Engineering Corporation (SWEC) at the request of Northern States Power Company (NSP). Based on the simulation of the spent fuel loading and cask transfer operations, the dose calculations including accident and operational exposures were performed, and the anticipated manpower requirements, occupancy times, and assumptions for handling operations of spent fuel dry casks were evaluated.

GENERAL TECHNICAL CONSIDERATIONS

For licensing purposes, the onsite storage facility used for the temporary storage of power reactor spent fuel aged for at least one year is classified as an Independent Spent Fuel Storage Installation (ISFSI), since it is to be located away and separate from existing spent fuel pools. The provisions of 10CFR Part 72 establishes the requirements, procedures, and criteria for the issuance of licenses to process power reactor spent fuel and other radioactive materials associated with spent fuel storage in an ISFSI, and the terms and conditions under which the Nuclear Regulatory Commission will issue licenses.

The storage facility consists of an ISFSI and a Controlled Area. As defined by 10CFR72.3, the ISFSI is the complex which is specifically designed and constructed for the storage of spent fuel and other radioactive materials associated with spent fuel storage. The Controlled Area is the area immediately surrounding an ISFSI over which the licensee exercises authority and within which the ISFSI operations are performed.

The complexity of the ISFSI can vary from a sophisticated structure to a simple concrete slab on grade. The storage of spent fuel at the ISFSI is accomplished by the use of a dry storage cask, which is self-sufficient providing storage, protection, and shielding of the spent fuel. The cask is the single safety system providing radiation material retention, heat transfer, shielding, and criticality control for the spent fuel.

CASK STORAGE PAD CONFIGURATION AND CONCEPT

The purpose of this section is to depict the cask array configuration, to define the design basis assumptions, and to describe the storage pad requirements including its location and orientation, cask orientation in arrays on pad placement, and to estimate the radiation fields and dose assessments.

Dry Storage Cask Array Configuration

The REA 2023 dry storage cask[1] is designed for storage in either the vertical or horizontal orientation. SWEC concurs with REA's recommendation that the horizontal orientation be utilized in lieu of the vertical orientation for the following reasons: (1) the handling of the cask is simplified and the onsite transfer equipment requirements can be minimized, (2) crane handling of cask can be eliminated after cask leaves the rail bay area, (3) allows easy access to monitoring parts, and (4) the stability of the cask is increased, thereby eliminating the possibility of cask tip over during the transfer and storage of the cask or any accident situation resulting from design basis external natural and man-induced events.

An evaluation of the cask storage array packing density has been performed by REA which includes such factors as radiation dose rates, nuclear criticality potential, heat dissipation, static loads on storage pad and handling requirements. Based on these factors, the storage array recommended by REA in the horizontal position requires a minimum distance between adjacent casks of not less than 1.8 m with a preferred distance of 2.4 m as illustrated in Fig. 1.

The ends of the cask in adjacent rows can be placed as close together as the skids will allow.

Design Basis Assumptions

The design basis for any dry storage cask must be approved by the Nuclear Regulatory Commission (NRC) to ensure interim safe storage of aged spent fuel in the type of facility being considered. The features of the dry storage cask and other design basis assumptions relevant to Monticello and Prairie Island ISFSIs are as follows:

1. Dry type, helium filled after loading to provide for cask leakage detection;
2. Passively air-cooled after loading to

adequately dissipate a design basis 1.0 kW of thermal energy generated per assembly;
3. Maximum fuel rod surface temperature is approximately 250°C;
4. Each cask can hold up to 32 BWR fuel assemblies and up to 24 PWR fuel assemblies;
5. Reference spent fuel is 3.5 percent enriched, has 33 MWD/KgU and has decayed five years;
6. Maximum dose rate 1.8 m from cask surface for either a BWR or PWR cask is approximately 10 mrem/hr due to combined neutrons and gammas;
7. Service life of each cask is at least five years;
8. The storage pads are to provide for BWR spent fuel 1.03×10^5 KgU (seventeen 7.9×10^4 Kg casks) for Monticello and PWR spent fuel 2.85×10^5 KgU (twenty-six 1.05×10^5 Kg casks) for Prairie Island.

The all welded cask sealing method and passive heat dissipation mode are advantageous to dry storage. During the storage mode of operation, maintenance, and surveillance requirements are minimized. Remote monitoring of the cask interval pressure by a pressure transducer is all that is required to ensure maintenance of cask seal integrity.

Each design basis cask has dimensions, shielding properties and materials similar to those identified in the REA topical reports. Assuming the horizontal cask positioning shown in Fig. 1, the pad minimal dimensions would be 9.1 m x 62.5 m and 9.1 m x 97.5 m for Monticello and Prairie Island respectively.

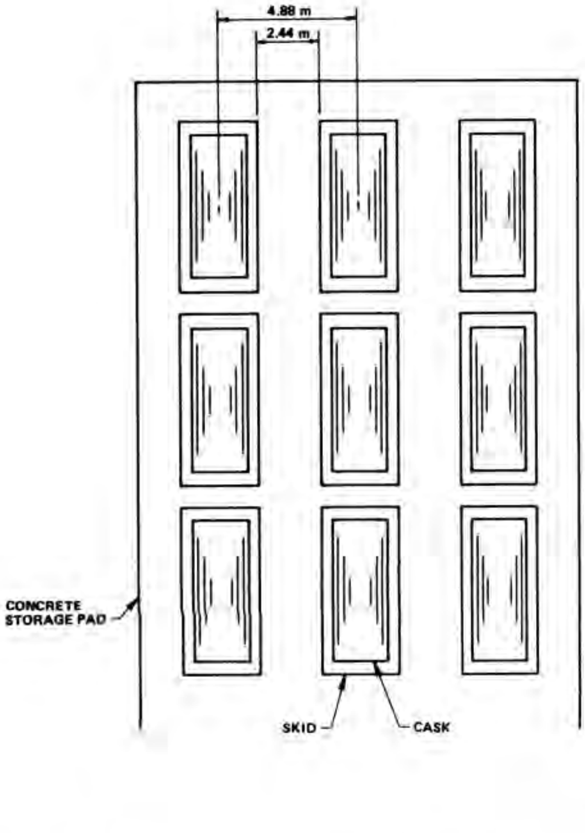

Fig. 1. Recommended Spacing for Cask Arrays in the Horizontal Position.

General Site Storage Pad Location and Orientation

Applying the ALARA (as low as reasonably achievable) radiation protection principle to both offsite and onsite personnel, the spent fuel dry cask storage pad should be located and orientated such that all direct radiation exposures are minimized within regulatory and other site constraints. Minimizing exposure should include transportation of cask to an ISFSI. For example, there may be a clear ALARA advantage to orientating the casks at a preselected angle to the plant i.e., assuming no intermediate shielding to minimize construction cost. Figure 2 illustrates consideration of the application of exposure reduction by finding the minimum exposure location and orientation.

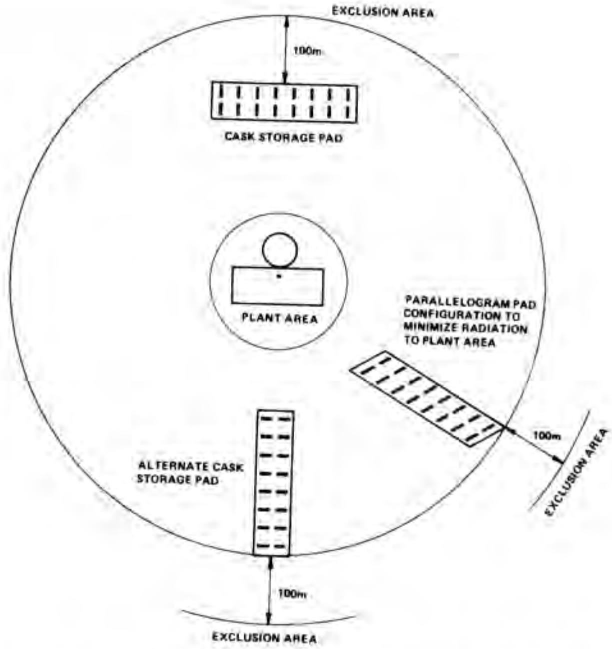

Fig. 2. ALARA Design Considerations for Cask Storage Pad Location and Orientation.

Estimating Dose Assessment

To determine in an approximate manner whether the cask storage pad configuration concept meets the necessary regulatory requirements and standards, dose rates and integrated doses are estimated. The neutron and gamma radiation dose rates and time (integrated annual and cumulative doses) were estimated for the design basis storage cask containing 10^4 KgU design basis spent fuel. Figures 3 and 4 show this information for a single design basis cask. Radiation contributions included air skyshine and ground scattering, decay gamma, fixed neutron, subcritical multiplication and secondary gamma, and storage time decay of these radiation sources.

The dose rate and dose at a given distance from the storage pad (array of casks) was then estimated by multiplying single cask contributed dose rate, or doses, by the number of casks in the front row of the array which the selected dose location faces. This approximation assumes self-shielding of the casks in the rows behind the front row of the array. The dose location is assumed sufficiently removed from the external face of the array such that the subtended solid angle of the cask array by the dose location is small.

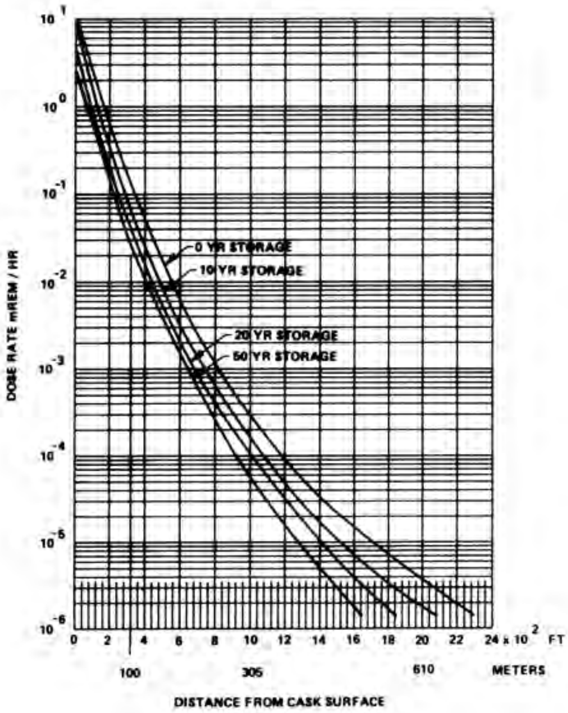

Fig. 3. Dose Rate vs Distance from Single Cask Containing 10,000 KgU Design Basis Spent Fuel Decayed 5 Years.

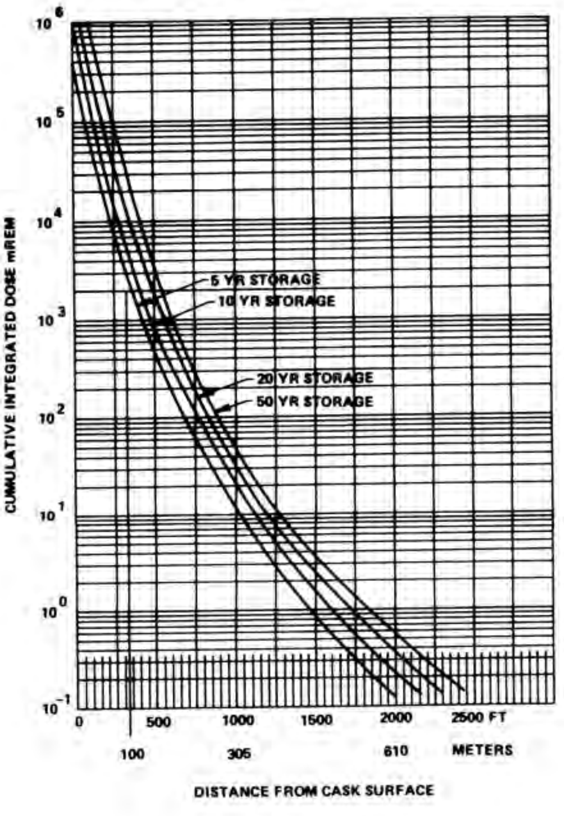

Fig. 4. Cumulative Integrated Dose vs Distance From Single Cask Comparing Effects on Storage Time.

At the dry cask storage boundary (100 meters) for both Monticello and Prairie Island, the calculated dose rates are estimated to be less than 2.5 mrem/hr. Therefore, no radiation shield wall is anticipated for either storage pad facility. Utilizing the data from Fig. 3 and Fig. 4, the cask array multiplying factors and other information as referenced in the REA topical reports, the annual and cumulative doses are shown in TABLE I for Monticello and in TABLE II for Prairie Island. Maximum dose rates in the storage pad cask array are estimated to not exceed 40 mrem/hr for each facility.

The criteria in 10CFR20.105 for unrestricted area personnel dose rates and doses should be used in combination with the information in this section to estimate the minimum distance to the pad area exclusion boundary.

PLANT AND ISFSI OPERATIONS FOR THE DRY STORAGE CASK

The final dry storage operation will require the development of detailed operating procedures incorporating the cask manufacturer's recommendations and site specific requirements. The plant and ISFSI dry storage cask operations discussed herein are limited in scope and only briefly highlight the significant operations generic to both Monticello and Prairie Island Nuclear Plants. Only areas which are not common to both sites are addressed separately. The operating sequence described was excerpted in part from the REA topical reports.[1]

Cask Arrival at the Reactor Site

The first step would be to perform a receipt through inspection using current QA/QC procedures before accepting the cask for use at either site. Personnel should inspect the cask for damage which may have occurred during shipment and verify that all documentation has accompanied the cask. If the cask has been previously used for nuclear fuel or radioactive waste, the cask radiation levels must be monitored and smear surveys taken. After the cask meets the NSP requirements for receipt inspection, the cask can be stored at the ISFSI or at a predetermined storage location.

If the cask is to be stored in the rail bay areas of Monticello or Prairie Island for immediate fuel transfer, the cask may have to be transferred to another vehicle. The length of the rail car between pulling faces is about 24.7 m. The significant size of this rail car creates operational problems for both Monticello and Prairie Island.

At Monticello the rail transporter cannot be positioned beneath the opening for lifting of the cask to the spent fuel pool using the reactor building crane. Consequently, the cask will have to be removed from the shipping transporter and transferred to another vehicle to facilitate lifting of the cask to the spent fuel pool.

At Prairie Island the situation is similar. The rail car will not clear the corner of the radwaste building because the distance between the rail and the radwaste building is approximately 0.3 m. Therefore, the cask will have to be transferred to a vehicle transporter for movement into the rail bay area.

Cask Movement to Plant Storage Area for Spent Fuel Loading

After cask inspection, the next step would be to wash the road dirt from the cask, skid, and transporter before entering the plant. Once this is accomplished, transport the cask to the lifting area in the rail bays, disengage all tie-down attachments and supports from the cask, skid, and transporter. Attach primary and redundant segments of the lifting yoke to the crane and slowly lift the cask in the horizontal orientation from the skid, and transport it to the recommended storage area.

After the cask arrives at the storage area, use the auxiliary crane or a chain hoist to lower the cask bottom so that it is vertically orientated before setting the cask down. Once the transfer operation begins, the rail bay areas at both Monticello and Prairie Island sites should be designated as restricted areas to insure that the transfer operation is not interrupted and to minimize the exposure of plant personnel to radiation.

Secondary and Primary Cover Removal

This phase of the operation consists of removing the secondary cover clamp ring and placing four eyebolts in the secondary cover. With the auxiliary crane, lift the secondary cover from the cask and transport the cover to a temporary storage location. Next, unscrew the bolts in the primary cover free of the threaded holes, but leave the bolts in the cover holes. Remove the primary cover from cask with the auxiliary crane and store in a protected area, using care to prevent damage to the o-ring grooves. A marked or deformed o-ring gasket must be replaced before the primary cover can be installed during later operations.

Cask Preparation for Fuel Loading Operations

After cover removal, inspect the cask cavity and basket to verify that it is clean and ready to accept fuel. Next, open the cask vent located near the top of the cask and both drain ports located near the bottom of the cask and attach an air hose to the vent port. Flush water through the drain posts to ensure that they are clean and open. Finally, inspect neutron shield cavity liquid level.

Cask Lowering Into the Spent Fuel Pool

In preparation for lowering of the cask, assemble primary and redundant sections of the lift yoke and attach them to the building crane. Next lift the cask, transferring the cask weight to the crane to clear the resting pad. Finally, clean the pool floor where the cask will later rest and lower the cask into the pool. It is necessary to record the crane location in all directions for reference to be used when the yoke is reattached for cask removal from the pool.

Inspection and Fuel Loading Operation

After the cask has been placed in the bottom of the spent fuel pool, the spent fuel pool crane will be used for transferring of the fuel assemblies to the cask. A visual inspection of the fuel assemblies is performed checking the fuel assemblies for dimensional and cladding integrity. The transfer of 32 BWR or 24 PWR fuel assemblies will be performed at this time.

Primary and Secondary Cover Replacements

After the cask is completely filled with fuel assemblies, wipe the gasket seal area of any debris which may have accumulated on it during the fuel loading operation. Retrieve the primary cover from its storage area and check the o-ring gaskets. Using the auxiliary crane, place the primary cover on the cask by mating it with the alignment pins on the cask bolt ring and then tighten the bolts. Place the secondary cover on the cask.

Cask Lifting From the Spent Fuel Pool

With a TV camera, verify the attachment of the yoke lift arms to all four top trunnions before lifting the cask. As the cask is raised from the water, attach the hose coming from the cask vent port to the helium supply. When the top of the cask reaches a point 0.6 m above the water, stop the vertical movement and pressurize the cask with helium and check for a gasket leak of the primary cover. If a leak exists, lower the cask back into the pool and replace the gasket. After the lid passes the gasket leak test, lift the cask from the pool, rinsing with clean water as the cask clears the pool water. Monitor and record the radiation levels outside of the cask. Transport the loaded cask to the decontamination area.

Cask Decontamination and Drying of the Cask Cavity

Decontamination of the cask will take place at the decontamination area using site specific decontamination procedures. After the decontamination process is completed, the cask cavity and the space between the cover plates is dried using one of the following cask manufacturer's recommended procedures: (1) vacuum; (2) forcing dry air or nitrogen through the cask cavity; or (3) permitting the cask time to reach 58^{o}C on the outer surface. The cask must be checked to ensure that the cavity and the space between the cover is dry.

Sealing of the Cask

The cask secondary lid is seal welded and checked for cracks using one of the following methods: (1) liquid penetrant, (2) ultrasonic inspection, and (3) magnetic particle. Next, the space between the lids is filled with helium to check the cask seal. If the cask is to be stored with helium in the cavity, the cavity is flushed with helium to remove air before pressurizing.

Cask Transfer to the ISFSI

After the yoke is attached, the cask is rotated to a horizontal orientation and set in the skid on the transporter. The cask tie-down devices are secured and the cask is transported to the ISFSI. The requirements of 10CFR73.37 regarding physical protection of spent fuel during transit must be complied with during the movement of the cask to the ISFSI.

Cask Storage Operation at the ISFSI

The cask is received at the ISFSI, tie-downs removed, and lifted to the designated storage position. After the cask is positioned, all monitoring equipment should be attached and tested to insure that it is functioning.

ESTIMATED OCCUPANCY DOSES FOR HANDLING OPERATIONS OF A SINGLE DRY STORAGE CASK

Based on the previously described operations of the spent fuel loading and cask transfer operations, the anticipated manpower requirements, occupancy times, and assumptions for the handling operations of a single dry storage cask are discussed herein. A

TABLE I

Monticello Estimated Annual and Cumulative Doses
In the Vicinity of the ISFSI

Horizontal Distance from Storage Pad	Annual and Cumulative Doses (MREM) at Various Storage Times(a)(b)(c)							
	5 year		10 year		20 year		50 year	
	annual	cum	annual	cum	annual	cum	annual	cum
Contact(d)	$2.6x10^5$	$1.5x10^6$	$1.9x10^5$	$2.6x10^6$	$1.4x10^5$	$4.0x10^6$	$6.3x10^4$	$6.8x10^6$
100m	$7.9x10^3$	$2.0x10^4$	$5.6x10^3$	$5.4x10^4$	$3.2x10^3$	$1.4x10^5$	$2.4x10^3$	$3.2x10^5$
305m	18	99	15	$1.7x10^2$	12	$2.9x10^2$	4.5	$4.9x10^2$
457m	1.2	6.3	0.81	11	0.63	19	0.29	31
610m	0.18	0.90	0.14	1.8	0.099	2.7	0.045	3.6

(a) Based on a 17 cask array.

(b) The dose rate per cask is based on 5 year old fuel (i.e. 5 year implies 10 year old fuel).

(c) The annual dose is the one year integrated dose at each specified storage time (around 5th, 10th, 20th, and 50th year). The cumulative dose is the time integrated dose from the beginning of storage to the specified storage time.

(d) Contact dose at surface of one cask located at the center of the cask array.

TABLE II

Prairie Island Estimated Annual and Cumulative Doses
In the Vicinity of the ISFSI

Horizontal Distance from Storage Pad	Annual and Cumulative Doses (MREM) at Various Storage Times(a)(b)(c)							
	5 year		10 year		20 year		50 year	
	annual	cum	annual	cum	annual	cum	annual	cum
Contact(d)	$2.6x10^5$	$1.5x10^6$	$1.9x10^5$	$2.6x10^6$	$1.4x10^5$	$4.0x10^6$	$6.3x10^4$	$6.8x10^6$
100m	$1.1x10^4$	$2.9x10^4$	$8.1x10^3$	$7.8x10^4$	$4.6x10^3$	$2.0x10^5$	$3.5x10^3$	$4.6x10^5$
305m	26	$1.4x10^2$	22	$2.5x10^2$	17	$4.2x10^2$	6.5	$7.1x10^2$
457m	1.7	9.1	1.2	16	0.91	27	0.42	44
610m	0.26	1.3	0.21	2.6	0.14	3.9	0.065	5.2

(a) Based on a 26 cask array.

(b) The dose rate per cask is based on 5 year old fuel (i.e. 5 year implies 10 year old fuel).

(c) The annual dose is the one year integrated dose at each specified storage time (around 5th, 10th, 20th, and 50th year). The cumulative dose is the time integrated dose from the beginning of storage to the specified storage time.

(d) Contact dose at surface of one cask located at the center of the cask array.

TABLE III

ESTIMATED OCCUPANCY DOSE ASSOCIATED
WITH HANDLING OPERATIONS OF A SINGLE DRY STORAGE CASK
LOADED WITH 32 DESIGN BWR SPENT FUEL ELEMENTS

MONTICELLO

OPERATION	AVERAGE DOSE RATE PER PERSON (MREM/HR)	AVERAGE NO. OF PERSONS	INDIVIDUAL		TOTAL PERSONNEL	
			HOURS	MREM	HOURS	MREM
1. Cask arrival at the reactor site						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
2. Cask movement to plant storage area for spent fuel loading						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
3. Secondary and primary cover removal						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
4. Cask preparation for fuel loading operation						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
5. Cask lowering into spent fuel pool						
QA/QC	2.5	0	0	0	0	0
Health Physics	2.5	1	0.25	0.6	0.25	0.6
Operations and Labor Force	2.5	3	1.0	2.5	3.0	7.5
6. Inspection and fuel loading operation						
QA/QC	2.5	1	8.0	20.0	8.0	20.0
Health Physics	2.5	1	1.0	2.5	1.0	2.5
Operations and Labor Force	2.5	4	8.0	20.0	32.0	80.0
7. Primary and secondary cover replacement (dry air space between covers)						
QA/QC	10.4	1	0.5	5.2	0.5	5.2
Health Physics	10.4	0	0	0	0	0
Operations and Labor Force	10.4	5	0.5	5.2	2.5	26.0
8. Cask lifting from spent fuel pool						
a. Rig, lift cask from pool and perform gasket leak test						
QA/QC	10.4	1	0.5	5.2	0.5	5.2
Health Physics	10.4	1	0.25	2.6	0.25	15.6
Operations and Labor Force	10.4	3	0.5	5.2	1.5	15.6
b. Initial cask rinse						
QA/QC	8.1	0	0	0	0	0
Health Physics	8.1	1	0.25	2.0	0.25	2.0
Operations and Labor Force	8.1	2	0.5	4.1	1.0	8.1
c. Place clamp ring on secondary cover						
QA/QC	10.4	0	0	0	0	0
Health Physics	10.4	1	0.25	2.6	0.25	2.6
Operations and Labor Force	10.4	4	0.5	5.2	2.0	20.8
d. Transport cask to decontamination area						
QA/QC	10.2	0	0	0	0	0
Health Physics	10.2	1	0.5	5.1	0.5	5.1
Operations and Labor Force	10.2	4	0.5	5.1	2.0	20.4

TABLE III (CONTINUED)

9. Cask decontamination and drying of cask cavity						
QA/QC	11.8	1	0.25	3.0	0.25	3.0
Health Physics	11.8	1	0.25	3.0	0.25	3.0
Operations and Labor Force	11.8	4	1.5	17.7	6.0	70.8
10. Sealing of cask						
a. Weld secondary cover						
QA/QC	10.4	0	0	0	0	0
Health Physics	10.4	0	0	0	0	0
Operations and Labor Force	10.4	2	6.0	62.4	12.0	124.8
b. Non-destructive testing of weld						
QA/QC	10.4	0	0	0	0	0
Health Physics	10.4	0	0	0	0	0
Operations and Labor Force	10.4	2	1.0	10.4	2.0	20.8
c. Leak test cover						
QA/QC	10.4	1	0.25	2.6	0.25	2.6
Health Physics	10.4	1	0.25	2.6	0.25	2.6
Operations and Labor Force	10.4	2	1.0	10.4	2.0	20.8
11. Cask transfer to the ISFSI						
a. Attach yoke and move cask to loading area and load on transporter						
QA/QC	10.4	1	0.5	5.2	0.5	5.2
Health Physics	10.4	1	0.5	5.2	0.5	5.2
Operations and Labor Force	10.4	3	1.0	10.4	3.0	31.2
b. Transport cask to ISFSI						
QA/QC	8.1	0	0	0	0	0
Health Physics	8.1	1	0.25	2.0	0.25	2.0
Operations and Labor Force	8.1	2	0.25	2.0	0.5	4.1
12. Cask storage operation at the ISFSI						
a. Set up transfer equipment						
QA/QC	10.2	0	0	0	0	0
Health Physics	10.2	0	0	0	0	0
Operations and Labor Force	10.2	5	0.5	5.1	2.5	25.5
b. Unload and store cask						
QA/QC	10.2	0	0	0	0	0
Health Physics	10.2	1	0.25	2.6	0.25	2.6
Operations and Labor Force	10.2	5	0.5	5.1	2.5	25.5
c. Attach and test instruments						
QA/QC	10.4	1	0.25	2.6	0.25	2.6
Health Physics	10.4	1	0.25	2.6	0.25	2.6
Operations and Labor Force	10.4	2	1.0	10.4	2.0	20.8
TOTAL						
QA/QC					10.25	43.8
HEALTH PHYSICS					4.25	33.4
OPERATIONS AND LABOR FORCE					76.50	522.7
TOTAL					91.00	599.9

TABLE IV

ESTIMATED OCCUPANCY DOSE ASSOCIATED
WITH HANDLING OPERATIONS OF A SINGLE DRY STORAGE CASK
LOADED WITH 24 DESIGN PWR SPENT FUEL ELEMENTS

PRAIRIE ISLAND

OPERATION	AVERAGE DOSE RATE PER PERSON (MREM/HR)	AVERAGE NO. OF PERSONS	INDIVIDUAL HOURS	INDIVIDUAL MREM	TOTAL PERSONNEL HOURS	TOTAL PERSONNEL MREM
1. Cask arrival at the reactor site						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
2. Cask movement to plant storage area for spent fuel loading						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
3. Secondary and primary cover removal						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
4. Cask preparation for fuel loading operation						
QA/QC	0	0	0	0	0	0
Health Physics	0	0	0	0	0	0
Operations and Labor Force	0	0	0	0	0	0
5. Cask lowering into spent fuel pool						
QA/QC	2.5	0	0	0	0	0
Health Physics	2.5	1	0.25	0.6	0.25	0.6
Operations and Labor Force	2.5	3	1.0	2.5	3.0	7.5
6. Inspection and fuel loading operation						
QA/QC	2.5	1	6.0	15.0	6.0	16.0
Health Physics	2.5	1	1.0	2.5	1.0	2.5
Operations and Labor Force	2.5	4	6.0	15.0	24.0	60.0
7. Primary and secondary cover replacement (dry air space between covers)						
QA/QC	11.4	1	0.5	5.7	0.5	5.7
Health Physics	11.4	0	0	0	0	0
Operations and Labor Force	11.4	5	0.5	5.7	2.5	28.5
8. Cask lifting from spent fuel pool						
a. Rig, lift cask from pool and perform gasket leak test						
QA/QC	11.4	1	0.5	5.7	0.5	5.7
Health Physics	11.4	1	0.25	2.9	0.25	2.9
Operations and Labor Force	11.4	3	0.5	5.7	1.5	17.1
b. Initial cask rinse						
QA/QC	8.5	0	0	0	0	0
Health Physics	8.5	1	0.25	2.1	0.25	2.1
Operations and Labor Force	8.5	2	0.5	4.3	1.0	8.5
c. Place clamp ring on secondary cover						
QA/QC	11.4	0	0	0	0	0
Health Physics	11.4	1	0.25	2.9	0.25	2.9
Operations and Labor Force	11.4	4	0.5	5.7	2.0	22.8
d. Transport cask to decontamination area						
QA/QC	10.8	0	0	0	0	0
Health Physics	10.8	1	0.5	5.4	0.5	5.4
Operations and Labor Force	10.8	4	0.5	5.4	2.0	21.6

TABLE IV (CONTINUED)

9. Cask decontamination and drying of cask cavity						
QA/QC	11.9	1	0.25	3.0	0.25	3.0
Health Physics	11.9	1	0.25	0.25	0.25	3.0
Operations and Labor Force	11.9	4	2.0	23.8	8.0	95.2
10. Sealing of cask						
a. Weld secondary cover						
QA/QC	11.4	0	0	0	0	0
Health Physics	11.4	0	0	0	0	0
Operations and Labor Force	11.4	2	7.0	79.8	14.0	159.6
b. Non-destructive testing of weld						
QA/QC	11.4	0	0	0	0	0
Health Physics	11.4	0	0	0	0	0
Operations and Labor Force	11.4	2	1.0	11.4	2.0	22.8
c. Leak test cover						
QA/QC	10.4	1	0.25	2.6	0.25	2.6
Health Physics	10.4	1	0.25	2.6	0.25	2.6
Operations and Labor Force	10.4	2	1.0	10.4	2.0	20.8
11. Cask transfer to the ISFSI						
a. Attach yoke and move cask to loading area and load on transporter						
QA/QC	10.8	1	0.5	5.4	0.5	5.4
Health Physics	10.8	1	0.5	5.4	0.5	5.4
Operations and Labor Force	10.8	3	1.0	10.8	3.0	32.4
b. Transport cask to ISFSI						
QA/QC	8.5	0	0	0	0	0
Health Physics	8.5	1	0.25	2.1	0.25	2.1
Operations and Labor Force	8.5	2	0.25	2.1	0.5	4.3
12. Cask storage operation at the ISFSI						
a. Set up transfer equipment						
QA/QC	10.8	0	0	0	0	0
Health Physics	10.8	0	0	0	0	0
Operations and Labor Force	10.8	5	0.5	5.4	2.5	27.0
b. Unload and store cask						
QA/QC	10.8	0	0	0	0	0
Health Physics	10.8	1	0.25	2.7	0.25	2.7
Operations and Labor Force	10.8	5	0.5	5.4	2.5	27.0
c. Attach and test instruments						
QA/QC	10.8	1	0.25	2.7	0.25	2.7
Health Physics	10.8	1	0.25	2.7	0.25	2.7
Operations and Labor Force	10.8	2	1.0	10.8	2.0	21.6
TOTAL						
QA/QC					8.25	41.1
HEALTH PHYSICS					4.25	34.9
OPERATIONS AND LABOR FORCE					72.50	576.7
TOTAL					85.00	652.7

minimum cover of 2.4 m (Monticello) and 3.0 m (Prairie Island) of water above the fuel assembly is required to protect operating personnel during fuel loading and transfer operations. Under these conditions, the dose rate is less than 2.5 mrem/hr at the water surface. In TABLES III AND IV, the spent fuel loading for Monticello and Prairie Island is assumed to contribute no radiation hazard to operating personnel from the spent fuel since the spent fuel is submerged the required 2.4 m and 3.0 m from the water surface in the spent fuel pool during transfer operations. The submerged depths of 2.4 m and 3.0 m assume that an energy absorbing device is not attached to the bottom of the dry storage cask.

The anticipated manpower requirements and occupancy times for processing one cask are summarized in TABLES III and IV. The manpower requirements include an assumed 50 percent reduction in productivity for operating in a controlled area. The manpower requirements also include the estimated personnel required to perform the work and the corresponding time required to accomplish the described operation.

The occupancy times and doses were estimated for work performed in the immediate radiation areas around the dry storage cask during normal and anticipated operations. These include total occupancy hours and dose in millirem for an individual as well as total personnel in person-hours and person-millirem, respectively. The occupancy times and doses are based upon a single dry storage cask loaded with 32 design basis BWR and 24 design basis PWR spent fuel elements without radiation source decay for storage time. The dose estimates determined for the handling operations for the dry storage cask are based on the cask in air or water and the cask secondary cover removed. The total dose rates were estimated at average distances from cask to the operating personnel.

The estimated occupancy dose for both individual and total personnel for the handling operations of a single dry storage cask loaded with 32 design basis BWR and 24 design basis PWR five year old spent fuel elements are shown in TABLES III and IV.

The handling operations of a single dry storage cask is estimated to take about three days assuming three 8-hour shifts. The time starts when the cask is receipt inspected and stops when the cask is stored at the storage concrete pad and all instruments are operational. This time assumes that non-manual welding methods will be employed for sealing the cask. Based on the operational dose estimation using the QADMOD[2] and COHORT[3] computer codes, the estimated onsite collective dose assessment for both Monticello and Prairie Island complies with the licensing requirements of 10CFR Part 72 and 10CFR Part 20 and the guidelines of Regulatory Guide 3.28.

REFERENCES

1. Topical Reports for the REA 2023 Dry Storage Cask for BWR and PWR Spent Fuels, Revision 0, Ridihalgh, Eggers and Associates (REA), Columbus, Ohio, (1983).

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3. J. K. Warkentin, "The COHORT Monte Carlo Procedure," Radiation Research Associates, (March 1979).