CHAPTER 11: RADIATION PROTECTION†

11.0 INTRODUCTION

This chapter discusses the design considerations and operational features that are incorporated in the HI-STORM FW system design to protect plant personnel and the public from exposure to radioactive contamination and ionizing radiation during canister loading, closure, transfer, and on-site dry storage. Occupational exposure estimates for typical canister loading, closure, transfer operations, and ISFSI inspections are provided. An off-site dose assessment for a typical ISFSI is also presented. Since the determination of off-site doses is necessarily site-specific, similar dose assessments shall be prepared by the licensee, as part of implementing the HI-STORM FW system in accordance with 10CFR72.212 [11.0.1]. The information provided in this chapter meets the requirements of NUREG-1536 [11.0.3].

11.1 ENSURING THAT OCCUPATIONAL RADIATION EXPOSURES ARE AS-LOW-AS-REASONABLY-ACHIEVABLE (ALARA)

11.1.1 Policy Considerations

The HI-STORM FW has been designed in accordance with 10CFR72 [11.0.1] and maintains radiation exposures ALARA consistent with 10CFR20 [11.1.1] and the guidance provided in Regulatory Guides 8.8 [11.1.2] and 8.10 [11.1.3]. Licensees using the HI-STORM FW system will utilize and apply their existing site ALARA policies, procedures and practices for ISFSI activities to ensure that personnel exposure requirements of 10CFR20 [11.1.1] are met. Personnel performing ISFSI operations shall be trained on the operation of the HI-STORM FW system, and be familiarized with the expected dose rates around the MPC, HI-STORM overpack and HI-TRAC VW during all phases of loading, storage, and unloading operations. Chapter 13 provides dose rate limits at the HI-TRAC VW and HI-STORM overpack surfaces to ensure that the HI-STORM FW system is operated within design basis conditions and that ALARA goals will be met. Pre-job ALARA briefings will be held with workers and radiological protection personnel prior to work on or around the system. Worker dose rate monitoring, in conjunction with trained personnel and well-planned activities will significantly reduce the overall dose received by the workers. When preparing or making changes to site-specific procedures for ISFSI activities, users shall ensure that ALARA practices are implemented and the 10CFR20 [11.1.1] standards for radiation protection are met in accordance with the site's written commitments.

† This chapter has been prepared in the format and section organization set forth in Regulatory Guide 3.61[11.0.2]. However, the material content of this chapter also fulfills the requirements of NUREG 1536[11.0.3]. Pagination and numbering of sections, figures, and tables are consistent with the convention set down in Chapter 1 in this SAR. Finally, all terms-of-art used in this chapter are consistent with the terminology of the Glossary.

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It is noted that although Loading Pattern B for the MPC-37 allows assemblies with higher heat loads and therefore higher source terms in the outer region (Region 3) of the MPC, the guiding principle in selecting fuel loading should still be to preferentially place assemblies with higher source terms in the inner regions of the basket as far as reasonably possible.

11.1.2 Radiation Exposure Criteria

The radiological protection criteria that limit exposure to radioactive effluents and direct radiation from an ISFSI using the HI-STORM FW system are as follows:

1. 10CFR72.104 [11.0.1] requires that for normal operation and anticipated occurrences, the annual dose equivalent to any real individual located beyond the owner-controlled area boundary must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other critical organ. This dose would be a result of planned discharges, direct radiation from the ISFSI, and any other radiation from uranium fuel cycle operations in the area. The licensee is responsible for demonstrating site-specific compliance with these requirements. As discussed below, the design features of the HI-STORM FW system components are configured to meeting this and other criteria cited below without undue burden to the user (discussed in Subsection 11.1.2).

2. 10CFR72.106 [11.0.1] requires that any individual located on or beyond the nearest owner-controlled area boundary may not receive from any design basis accident the more limiting of a total effective dose equivalent of 5 rem, or the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) of 50 rem. The lens dose equivalent shall not exceed 15 rem and the shallow dose equivalent to skin or to any extremity shall not exceed 50 rem. The licensee is responsible for demonstrating site-specific compliance with this requirement.

3. 10CFR20 [11.1.1], Subparts C and D, limit occupational exposure and exposure to individual members of the public. The licensee is responsible for demonstrating site-specific compliance with this requirement.

4. Regulatory Position 2 of Regulatory Guide 8.8 [11.1.2] provides guidance regarding facility and equipment design features. This guidance has been followed in the design of the HI-STORM FW storage system as described below:

    - Regulatory Position 2a, regarding access control, is met by locating the ISFSI in a Protected Area in accordance with 10CFR72.212(b)(5)(ii) [11.0.1]. Depending on the site-specific ISFSI design, other equivalent measures may be used. Unauthorized access is prevented once a loaded HI-STORM FW overpack is placed in an ISFSI. Due to the passive nature of the system, only limited monitoring is required, thus reducing occupational exposure and supporting ALARA considerations. The licensee is responsible for site-specific compliance with these criteria.

- Regulatory Position 2b, regarding radiation shielding, is met by the storage cask and transfer cask biological shielding that minimizes personnel exposure, as described in Chapter 5 and in this chapter. Fundamental design considerations that most directly influence occupational exposures with dry storage systems in general and which have been incorporated into the HI-STORM FW system design include:
  - system designs that reduce or minimize the number of handling and transfer operations for each spent fuel assembly;
  - system designs that reduce or minimize the number of handling and transfer operations for each MPC loading;
  - system designs that maximize fuel capacity, thereby taking advantage of the self-shielding characteristics of the fuel and the reduction in the number of MPCs that must be loaded and handled;
  - system designs that minimize planned maintenance requirements;
  - system designs that minimize decontamination requirements at ISFSI decommissioning;
  - system designs that optimize the placement of shielding with respect to anticipated worker locations and fuel placement;
  - thick walled overpack that provides gamma and neutron shielding;
  - thick MPC lid which provides effective shielding for operators during MPC loading and unloading operations;
  - multiple welded barriers to confine radionuclides;
  - smooth surfaces (that come in contact with pool water) to reduce decontamination time;
  - minimization of potential crud traps on the handling equipment to reduce decontamination requirements;
  - capability of maintaining uncontaminated water in the MPC during welding to reduce dose rates;
  - capability of maintaining water in the transfer cask annulus space and water jacket to reduce dose rates during closure operations;
  - MPC penetrations located and configured to reduce neutron streaming paths;
  - elimination of trunnions in the HI-TRAC VW, which serve as streaming paths;
  - streaming paths in the HI-STORM FW overpack are limited to the air vent passages.

- MPC vent and drain ports with resealable caps to prevent the release of radionuclides during loading and unloading operations and facilitate draining, drying, and backfill operations;
- use of a bottom lid, annulus seal, and Annulus Overpressure System to prevent contamination of the MPC shell outer surfaces during in-pool activities;
- maximization of shielding around the top region of HI-TRAC VW where the most human activities occur during loading operations; and
- low-maintenance design to reduce occupational dose during long-term storage.

- Regulatory Position 2c, regarding process instrumentation and controls, is met since there are no radioactive systems at an ISFSI.
- Regulatory Position 2d, regarding control of airborne contaminants, is met since the HI-STORM FW storage system is designed to withstand all design basis conditions without loss of confinement function, as described in Chapter 7 of this SAR, and no gaseous releases are anticipated. No significant surface contamination is expected since the exterior of the MPC is kept clean by using clean water in the HI-TRAC VW-MPC annulus and by using a proven inflatable annulus seal design.
- Regulatory Position 2e, regarding crud control, is not applicable to a HI-STORM FW system ISFSI since there are no radioactive systems at an ISFSI that could transport crud.
- Regulatory Position 2f, regarding decontamination, is met since the exterior of the loaded transfer cask is decontaminated prior to being removed from the plant's fuel building. The exterior surface of the HI-TRAC VW transfer cask is designed for ease of decontamination. In addition, an inflatable annulus seal is used to prevent fuel pool water from contacting and contaminating the exterior surface of the MPC.
- Regulatory Position 2g, regarding monitoring of airborne radioactivity, is met since the MPC provides confinement for all design basis conditions. There is no need for monitoring since no airborne radioactivity is anticipated to be released from the casks at an ISFSI.
- Regulatory Position 2h, regarding resin treatment systems, is not applicable to an ISFSI since there are no treatment systems containing radioactive resins.
- Regulatory Position 2i, regarding other miscellaneous ALARA items, is met since stainless steel is used in the MPC Enclosure Vessel. This material is resistant to the damaging effects of radiation and is well proven in the SNF cask service. Use of this material quantitatively reduces or eliminates the need to perform maintenance (or replacement) on the primary confinement system.

11.1.3 Operational Considerations

Operational considerations that most directly influence occupational exposures with dry storage systems in general and that have been incorporated into the design of the HI-STORM FW system include:

- totally-passive design requiring minimal maintenance and monitoring (other than security monitoring) during storage;
- remotely operated welding system, lift yoke, mating device and moisture removal systems to reduce time operators spend in the vicinity of the loaded MPC;
- use of a well-shielded base for staging the welding system;
- maintaining water in the MPC and the annulus region during MPC closure activities to reduce dose rates;
- low fuel assembly lift-over height over the HI-TRAC VW maximizes water coverage over assemblies during fuel assembly loading;
- a water-filled neutron shield jacket allows filling after removal of the HI-TRAC VW from the spent fuel pool. This maximizes the shielding on the HI-TRAC VW without exceeding the crane capacity;
- descriptive operating procedures that provide guidance to reduce equipment contamination, obtain survey information, minimize dose and alert workers to possible changing radiological conditions;
- preparation and inspection of the HI-STORM FW overpack and HI-TRAC VW in low-dose areas;
- MPC lid fit tests and inspections prior to actual loading to ensure smooth operation during loading;
- gas sampling of the MPC and HI-STAR 100 annulus (receiving from transport) to assess the condition of the cladding and MPC Confinement Boundary;
- HI-STORM FW overpack temperature monitoring equipment allows remote monitoring of the vent operability surveillance;
- Use of proven ALARA measures such as wetting of component surfaces prior to placement in the spent fuel pool to reduce the need for decontamination;
- decontamination practices which consider the effects of weeping during HI-TRAC VW transfer cask heat up and surveying of HI-TRAC VW prior to removal from the fuel handling building;

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- Use of non-porous neutron absorber (Metamic-HT) to preclude waterlogging of the neutron absorber to minimize basket drying time. Specifically, Boral (a sandwich of aluminum sheets containing a mixture of boron carbide and aluminum powder which tends to hold the pool water in the porous space of the mixture extending canister drying times) is prohibited from use in HI-STORM FW MPCs);
- a sequence of short-term operations based on ALARA considerations; and
- use of mock-ups and dry run training to prepare personnel for actual work situations

11.1.4 Auxiliary/Temporary Shielding

In addition to the design and operational features built into the HI-STORM FW system components, a number of ancillary shielding devices can be deployed to mitigate occupational dose. Ancillaries are developed on a site-specific basis that further reduce radiation at key work locations and/or allow for operations to be performed faster to reduce the time personnel spend in close proximity in the radiation field. Licensees are encouraged to use such ALARA-friendly ancillaries and practices.

11.2 RADIATION PROTECTION FEATURES IN THE SYSTEM DESIGN

The design of the HI-STORM FW components has been principally focused on maximizing ALARA during the short-term operations as well as during long-term storage. Some of the key design features engineered in the system components to minimize occupational dose and site boundary dose are summarized in Table 11.2.1. The design measures listed in Table 11.2.1 have been incorporated in the HI-STORM FW system to effectively reduce dose in fuel storage applications.

Table 11.2.1

DESIGN MEASURES IN THE HI-STORM FW SYSTEM COMPONENTS THAT MITIGATE DOSE

	Component	Description of Design Feature	The Design Measure is Effective in Reducing the (A) Site Boundary Dose (B) Occupational Dose
1.	HI-STORM FW Overpack	Use of the steel weldment structure permits the density of concrete (set at a minimum of 150 lb/cubic feet) to be increased to as high as 200 lb/cubic feet.	A
2.	HI-STORM FW Overpack	The lid of the HI-STORM FW overpack contains the outlet ventilation ducts (Holtec Patent No. 6,064,710) in the overpack's closure lid. This eliminates the need for temporary shielding that will otherwise be needed if the ducts were located in the cask body for MPC transfer operations.	B
3.	HI-STORM FW Overpack	Use of multiple curved inlet ducts maximize radiation blockage (Holtec Patent No. 6,519,307B1).	B
4.	HI-STORM FW Overpack	Cask's vertical disposition and use of a thick lid (see drawing package in Section 1.5) and high density concrete minimizes skyshine.	B
5.	HI-TRAC VW/ MPC	The height of the MPC minimized for each site so that the height of HI-TRAC VW can be minimized and thus the maximum amount of lateral shielding in the cask can be incorporated consistent with the plant's crane capacity limits.	B
6.	HI-TRAC VW	Lifting trunnions located in the upper region of the transfer cask serve as neutron streaming paths in the space where human activity is necessary (welding, NDE, etc.). Eliminating trunnions and replacing them with TALs (see Glossary) eliminates steaming and aids ALARA during operations at the DAS.	B
7.	MPC	Use of Metamic-HT in the fuel basket reduces the weight of the fuel basket (in comparison to stainless steel). Thus additional shielding can be incorporated in the transfer cask whose total weight is limited by the plant's crane capacity.	B

Table 11.2.1 DESIGN MEASURES IN THE HI-STORM FW SYSTEM COMPONENTS THAT MITIGATE DOSE			
	Component	**Description of Design Feature**	**The Design Measure is Effective in Reducing the (A) Site Boundary Dose (B) Occupational Dose**
8.	HI-STORM FW overpack/MPC	The dose from a HI-STORM FW storage system is minimized because of the following advantages: a. Regionalized storage of fuel (cold fuel in the peripheral storage cells) possible because of the Metamic-HT fuel basket and the thermosiphon action-enabled MPC provides self-shielding. (Note that while loading hotter fuel in the inner cells is a requirement for some but not all loading configurations, it is preferred from an ALARA perspective.) b. Tight packing of overpacks on the ISFSI (that maximizes self-shielding) is possible because a large spacing between the modules is not necessary.	A,B
9.	MPC, HI-TRAC VW	The occupational dose from loading a HI-STORM FW overpack is minimized because of: a. A well-shielded HI-TRAC VW transfer cask. b. Regionalized fuel loading. (Note that while loading hotter fuel in the inner cells is a requirement for some but not all loading configurations, it is preferred from an ALARA perspective) c. A short water draining time (less than 2 hours) for the MPC. d. Reduced overall MPC welding time because the welding machine does not have to be removed and replaced to weld the secondary lid. e. Reduced time and personnel needed to install the MPC in the HI-STORM FW overpack due to vertical (gravity-aided) insertion. f. Reduced drying time because of use of porosity-free Metamic-HT.	B

Table 11.2.1

DESIGN MEASURES IN THE HI-STORM FW SYSTEM COMPONENTS THAT MITIGATE DOSE

	Component	Description of Design Feature	The Design Measure is Effective in Reducing the (A) Site Boundary Dose (B) Occupational Dose
10.	MPC	HI-STORM FW has been designed to accommodate high burnup and a maximum number of PWR or BWR fuel assemblies in each MPC to minimize the number of cask systems that must be handled and stored at the storage facility and later transported off-site.	A,B
11.	HI-STORM FW overpack	HI-STORM FW overpack structure is virtually maintenance free, especially over the years following its initial loading, because of the outer metal shell. The metal shell and its protective coating provide a high level of resistance degradation (e.g., corrosion).	A
12.	MPC	HI-STORM FW has been designed for redundant, multi-pass welded closures on the MPC; consequently, no monitoring of the Confinement Boundary is necessary and no gaseous or particulate releases occur for normal, off-normal or credible accident conditions.	A,B
13.	HI-TRAC VW	HI-TRAC VW transfer cask utilizes a mating device (Holtec Patent No. 6,625,246) which reduces streaming paths and simplifies operations.	B
14.	HI-TRAC VW	The HI-TRAC VW cask and mating device are designed for quick alignment with HI-STORM.	B
15.	HI-STORM FW overpack	HI-STORM FW has been designed to allow close positioning (pitch) on the ISFSI storage pad, thereby increasing the ISFSI self-shielding by decreasing the view factors and reducing exposures to on-site and off-site personnel (see Section 1.4).	A
16.	HI-STORM FW overpack	The HI-STORM FW overpack features narrow and tall optimized inlet duct shapes to minimize radiation streaming.	A

Table 11.2.1 DESIGN MEASURES IN THE HI-STORM FW SYSTEM COMPONENTS THAT MITIGATE DOSE			
	Component	**Description of Design Feature**	**The Design Measure is Effective in Reducing the (A) Site Boundary Dose (B) Occupational Dose**
17.	HI-STORM FW overpack/MPC	The combination of a Metamic-HT (highly conductive) basket, a thermosiphon capable internal basket geometry, and a high profile inlet ducts enables the HI-STORM FW system to reject heat to the ambient to maintain the fuel cladding temperature below short-term limits in the scenario where the ISFSI is flooded and the floodwaters are just high enough to block off the ventilation airflow. This feature eliminates the need for human intervention to protect the fuel from damage from an adverse flood event and reduces occupational dose.	A,B
18.	HI-STORM FW overpack	The steel structure of the HI-STORM FW overpack gives it the fracture resistance properties that protect the overpack from developing streaming paths in the wake of the impact from a projectile such as a tornado missile strike or handling incident.	A,B

11.3 ESTIMATED ON-SITE CUMULATIVE DOSE ASSESSMENT

This section provides the estimates of the cumulative exposure to personnel performing loading, unloading and transfer operations using the HI-STORM FW system. This section uses the shielding analysis provided in Chapter 5, the operations procedures provided in Chapter 9 and the experience from the loading of many MPCs to develop a realistic estimate of the occupational dose.

The dose rates from the HI-STORM FW overpack, MPC lid, HI-TRAC VW, and HI-STAR 100 overpack are calculated to determine the dose to personnel during the fuel loading and unloading operations. No assessment is made with respect to background radiation since background radiation can vary significantly by site.

The estimated occupational dose is governed by three principal parameters, namely:

i. The dose rate emanating from the MPC.
ii. Average duration of human activity in the radiation elevated space.
iii. Relative proximity of humans to the radiation source.

The dose rate accreted by the MPC depends on its contents. Regionalized storage has been made mandatory in the HI-STORM FW MPC to reduce its net radiation output. The duration of required human activity and the required human proximity, on the other hand, are dependent on the training level of the personnel, and user friendliness of ancillary equipment and the quality of fit-up of parts that need to be assembled in the radiation field.

To provide a uniform basis for the dose estimates presented in this chapter, the reference MPC contents data, available HI-TRAC VW weight, etc., are set down in Table 11.3.1.

Using Table 11.3.1 data, the dose data for fuel loading (wet to dry storage) is provided in Table 11.3.2. The dose for the reverse operation (dry to wet storage) is summarized in Table 11.3.3.

For each step in Table 11.3.2, the task description, average number of personnel in direct radiation field, exposure duration in direct radiation field and average dose rate are identified. The relative locations refer to all HI-STORM FW overpacks. The dose rate location points around the transfer cask and overpack were selected based on actual experience in loading HI-STORM 100 Overpacks. Cask operators typically work with workers entering and exiting the immediate cask area. To account for this, an average number of workers and average dose rates are used. The tasks involved in each step presented in Table 11.3.2 are not provided in any specific order.

11.3.1 Estimated Exposures for Loading and Unloading Operations

Exposures estimates presented in Tables 11.3.2 is expected to bound those for unloading operations. This assessment is based on the similarity of many loading versus operations with the elimination of several of the more dose intensive operations (such as weld inspections and leakage testing). Therefore, loading estimates should be viewed as bounding values for the contents considered for unloading operations.

11.3.2 Estimated Exposures for Surveillance and Maintenance

Table 11.3.3 provides an estimate of the occupational exposure required for security surveillance and maintenance of an ISFSI. Security surveillance time is based on a daily security patrol around the perimeter of the ISFSI security fence. Users may opt to utilize electronic temperature monitoring of the HI-STORM FW modules or remote viewing methods instead of performing direct visual observation of the modules. The security surveillances can be performed from outside the ISFSI, and the ISFSI fence is typically positioned such that the area outside the fence is not a radiation area. Although the HI-STORM FW system requires only minimal maintenance during storage (e.g., touch-up paint), maintenance will be required around the ISFSI for items such as security equipment maintenance, grass cutting, snow removal, vent system surveillance, drainage system maintenance, and lighting, telephone, and intercom repair, hence most of the maintenance is expected to occur outside the actual cask array.

Table 11.3.1 **ASSUMED PARAMETERS FOR DOSE ESTIMATE UNDER SHORT-TERM OPERATIONS AND UNDER LONG-TEM STORAGE**		
	Item	**Value**
1.	**MPC-Contents (MPC-37)[1]**	**45,000 MWD/MTU and 4.5 years**
2.	**Weight of HI-TRAC VW Full of Fuel and Water**	**125 tons**
3.	**HI-STORM Concrete Density**	**150 lb/cubic feet**

[1] The case of MPC-37 is used but similar results are expected for the MPC-89.

TABLE 11.3.2: ESTIMATED PERSON-MREM DOSE FOR LOADING THE HI-STORM FW SYSTEM				
Task Description (See Chapter 9 for detailed description of operations)	**Average Number of Personnel in Direct Radiation Field**	**Exposure Duration in Direct Radiation Field (mins)**	**Average Dose Rate at worker location (mrem/hr)**	**Exposure (mrem)**
Fuel loading and removal of the transfer cask and MPC from the spent fuel pool (includes: fuel loading, fuel assembly identification check, MPC lid installation, Lift Yoke attachment to the HI-TRAC VW, HI-TRAC VW removal from the spent fuel pool, preliminary decontamination, HI-TRAC VW movement to the DAS, Lift Yoke removal and decontamination. Background radiation of 1 mrem/hr assumed.	3	800	1.0	40.0
MPC preparation for closure (includes: HI-TRAC VW and MPC decontamination, radiation surveys, partial MPC pump down, annulus seal removal, partial lowering of annulus water level, annulus shield ring installation, weld system installation); workers assumed to be on scaffolding near the top of the HI-TRAC.	3	30	55.7	83.5
MPC Closure (includes MPC lid to shell welding, weld inspection). Assumes welding machine uses standard Holtec pedestal which provides additional shielding. Holtec auxiliary shielding methods and equipment assumed. Assumes operators are present for 10% of the total duration.	2	185	55.7	34.3

TABLE 11.3.2: ESTIMATED PERSON-MREM DOSE FOR LOADING THE HI-STORM FW SYSTEM				
Task Description (See Chapter 9 for detailed description of operations)	**Average Number of Personnel in Direct Radiation Field**	**Exposure Duration in Direct Radiation Field (mins)**	**Average Dose Rate at worker location (mrem/hr)**	**Exposure (mrem)**
MPC Preparation for Storage (includes: MPC hydrostatic testing, draining, drying and backfill, vent and drain port cover plate installation, welding, weld inspection and leakage testing). Holtec auxiliary shielding methods and equipment assumed. Assumes operators are present for 20% of the total duration.	2	170	175.4	198.7
MPC Closure Ring Installation (includes: closure ring to MPC shell welding, weld inspection and leakage testing of the MPC primary closure). Holtec auxiliary shielding methods and equipment assumed (lead blankets, water shields, etc.) Assumes operators are present for 10% of the total duration.	2	80	229.4	61.2
HI-STORM FW system preparation for receiving MPC (includes: HI-STORM FW overpack positioning at transfer location, HI-STORM lid removal, Mating Device installation on HI-STORM FW overpack).	3	160	0	0

TABLE 11.3.2: ESTIMATED PERSON-MREM DOSE FOR LOADING THE HI-STORM FW SYSTEM				
Task Description (See Chapter 9 for detailed description of operations)	**Average Number of Personnel in Direct Radiation Field**	**Exposure Duration in Direct Radiation Field (mins)**	**Average Dose Rate at worker location (mrem/hr)**	**Exposure (mrem)**
MPC Transfer (attachment of MPC lifting device, movement of HI-TRAC VW to transfer location, placement of HI-TRAC VW in Mating Device, bottom lid removal, MPC lowering, HI-TRAC VW removal, MPC lift device removal). Holtec auxiliary shielding methods and equipment assumed. Assumes operators are present for 10% of the total duration.	3	120	148	88.8
HI-STORM FW overpack movement to the ISFSI (will include: movement of the HI-STORM FW overpack from the fuel building to placement of the HI-STORM FW overpack on the ISFSI pad, disconnecting transporter, attachment of HI-STORM FW lid, attachment of thermal monitoring system). Holtec auxiliary shielding methods and equipment assumed. Assumes operators are present for 50% of the total duration.	3	220	37.3	205.2
TOTAL EXPOSURE (person-mrem)	711.6			

Table 11.3.3 ESTIMATED EXPOSURES FOR HI-STORM FW SURVEILLANCE AND MAINTENANCE				
ACTIVITY	**ESTIMATED PERSONNEL**	**ESTIMATED HOURS PER YEAR**	**ESTIMATED DOSE RATE (MREM/HR)**	**OCCUPATIONAL DOSE TO INDIVIDUAL (PERSON-MREM)**
SECURITY SURVEILLANCE	1	30	3	90
ANNUAL MAINTENANCE	2	15	10	300

Notes for Tables 11.3.2, 11.3.3, AND 11.3.4:

1. Refer to Chapter 9 for detailed description of activities.
2 Number of operators may be set to 1 to simplify calculations where the duration is indirectly proportional to the number of operators. The total dose is equivalent in both respects.

11.4 ESTIMATED CONTROLLED AREA BOUNDARY DOSE ASSESSMENT

11.4.1 Controlled Area Boundary Dose for Normal Operations

10CFR72.104 [11.0.1] limits the annual dose equivalent to any real individual at the controlled area boundary to a maximum of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem for any other critical organ. This includes contributions from all uranium fuel cycle operations in the region.

It is not feasible to predict bounding controlled area boundary dose rates on a generic basis since radiation from plant and other sources; the location and the layout of an ISFSI; and the number and configuration of casks are necessarily site-specific. In order to compare the performance of the HI-STORM FW system with the regulatory requirements, sample ISFSI arrays were analyzed in Chapter 5. These represent a full array of design basis fuel assemblies. Users are required to perform a site-specific dose analysis for their particular situation in accordance with 10CFR72.212 [11.0.1]. The analysis must account for the ISFSI (size, configuration, fuel assembly specifics) and any other radiation from uranium fuel cycle operations within the region.

Table 5.1.3 presents dose rates at various distances from sample ISFSI arrays for the design basis burnup and cooling time which results in the highest off-site dose for the combination of maximum burnup and minimum cooling times analyzed in Chapter 5. 10CFR72.106 [11.0.1] specifies that the minimum distance from the ISFSI to the controlled area boundary is 100 meters. Therefore this is the minimum distance analyzed in Chapter 5. One hundred percent (100%) occupancy (8760 hours) is conservatively assumed. In the calculation of the annual dose, the casks were positioned on an infinite slab of soil to account for earth-shine effects. Table 5.1.3 and Figure 5.1.3 in Chapter 5 show the annual dose rates for an array of HI-STORM FWs with MPC-37. These results are presented only as an illustration to demonstrate that the HI-STORM FW system is in compliance with 10CFR72.104 [11.0.1]. Neither the distances nor the array configurations become part of the Technical Specifications. Rather, users are required to perform a site-specific analyses to demonstrate compliance with 10CFR72.104 [11.0.1] contributors and 10CFR20 [11.1.1].

Chapter 7 provides a discussion as to how the Holtec MPC design, welding, testing, and inspection requirements meet the guidance of ISG-18 such that leakage from the Confinement Boundary has been rendered non-credible. Therefore, there is no additional dose contribution due to leakage from the welded MPC. The site licensee is required to perform a site-specific dose evaluation of all dose contributors as part of the ISFSI design. This evaluation will account for the location of the controlled area boundary, the total number of casks on the ISFSI and the effects of the radiation from uranium fuel cycle operations within the region.

11.4.2 Controlled Area Boundary Dose for Off-Normal Conditions

As demonstrated in Chapter 12, the postulated off-normal conditions (off-normal pressure, off-normal environmental temperatures, leakage of one MPC weld, partial blockage of air inlets, and off-normal handling of HI-TRAC VW) do not result in the degradation of the HI-STORM FW system shielding effectiveness. Therefore, the dose at the controlled area boundary from direct radiation for off-normal conditions is equal to that of normal conditions.

11.4.3 Controlled Area Boundary Dose for Accident Conditions

10CFR72.106 [11.0.1] specifies the maximum doses allowed to any individual at the controlled area boundary from any design basis accident (See Subsection 11.1.2). In addition, it is specified that the minimum distance from the ISFSI to the controlled area boundary be at least 100 meters.

Chapter 12 presents the results of the evaluations performed to demonstrate that the HI-STORM FW system can withstand the effects of all accident conditions and natural phenomena without the corresponding radiation doses exceeding the requirements of 10CFR72.106 [11.0.1]. The accident events addressed in Chapter 12 include: handling accidents, tip-over, fire, tornado, flood, earthquake, 100 percent fuel rod rupture, Confinement Boundary leakage, explosion, lightning, burial under debris, extreme environmental temperature, and blockage of MPC basket air inlets.

The worst-case shielding consequence of the accidents evaluated in Chapter 12 for the loaded HI-STORM FW overpack assumes that as a result of a fire, the outer-most one inch of the concrete experiences temperatures above the concrete's design temperature. Therefore, the shielding effectiveness of this outer-most one inch of concrete is degraded. However, with the available concrete providing shielding, the loss of one inch will have a negligible effect on the dose at the controlled area boundary.

The worst case shielding consequence of the accidents evaluated in Chapter 12 for the loaded HI-TRAC VW transfer cask assumes that as a result of a fire, tornado missile, or handling accident, that all the water in the water jacket is lost. The shielding analysis of the HI-TRAC VW with complete loss of the water from the water jacket is discussed in Subsection 5.1.1. The results in that subsection show the resultant dose rate at the 100-meter controlled area boundary during the accident condition. At the calculated dose rate, Table 5.1.9 shows the calculated time to reach 5 rem. This length of time is sufficient to implement and complete the corrective actions outlined in Chapter 12. Therefore, the dose requirement of 10CFR72.106 [11.0.1] is satisfied. Users will need to perform site-specific analysis considering the actual site boundary distance and fuel characteristics.

Table 11.4.1
(Intentionally Deleted)

11.5 REFERENCES

[11.0.1] *U.S. Code of Federal Regulations,* Title 10, "Energy" Part 72 "Licensing Requirements for Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."

[11.0.2] Regulatory Guide 3.61 (Task CE306-4) "Standard Format for a Topical Safety Analysis Report for a Spent Fuel Storage Cask", USNRC, February 1989

[11.0.3] NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems", U.S. Nuclear Regulatory Commission, January 1997.

[11.1.1] *U.S. Code of Federal Regulations,* Title 10, "Energy" Part 20 "Standards for Protection Against Radiation."

[11.1.2] U.S. Nuclear Regulatory Commission "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power at Nuclear Power Stations will be As Low As Reasonably Achievable", Regulatory Guide 8.8, June 1978.

[11.1.3] U.S. Nuclear Regulatory Commission, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As is Reasonably Achievable", Regulatory Guide 8.10, Revision 1-R, May 1997.

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