9.7 FUEL AND REACTOR COMPONENT HANDLING EQUIPMENT

9.7.1 NEW FUEL STORAGE

New fuel is removed from its shipping container by the auxiliary hook of the Spent Fuel Cask Handling Crane and is transferred to the new fuel storage racks. These dry storage racks are for both units and are constructed to provide storage for two-thirds of a core (144 assemblies). New fuel, with a maximum enrichment of 5.0 wt% U-235, may be stored in the new fuel storage racks. For the Westinghouse standard fuel design, this results in a maximum effective multiplication factor of 0.89 at a water density of 1.0 gm/cc (full flood), and a multiplication factor of less than 0.89 for aqueous foam. Due to the large available margin, an uncertainty analysis was not performed since typical uncertainty analyses result in uncertainties of less than 3.0%. For the Westinghouse value added pellet (VAP) fuel design and AREVA/Framatome fuel assemblies, this results in a maximum effective multiplication factor of less than 0.95, including all biases and uncertainties for full flood and aqueous foam conditions. If there is space in the SFP, new fuel may be stored in the Unit 1 SFP provided its wt% U-235 does not exceed the maximum enrichment allowed in the Unit 1 SFP. New fuel may be stored in the Unit 2 SFP provided that the enrichment-burnup and checkerboarding restrictions of Limiting Condition for Operation 3.7.17 are met.

Unless specified, the reactivity of any SFP or refueling pool system completely filled with VAP assemblies with axial blankets and with or without a Zirc Diboride (ZrB_2) coating is always less reactive than the design-basis VAP configuration. Thus, VAP assemblies with enrichment up to 5.0 w/o, with axial blankets, and with or without ZrB_2 can be safety stored in the new fuel storage racks.

9.7.2 SPENT FUEL STORAGE

9.7.2.1 Spent Fuel Pool Racks

The SFP is located outside the containment in the Auxiliary Building and provides underwater storage of spent fuel assemblies after their removal from the reactor vessel. The pool, designed in two halves, can accommodate 1830 assemblies and one spent fuel shipping cask. The Unit 1 half of the SFP contains storage racks in six 10x10, two 8x10, and one 7x10 array. The Unit 2 half of the SFP contains racks in ten 10x10 arrays. Control element assemblies removed from the core can be stored in the guide tubes within the fuel assemblies. The pool is constructed of reinforced concrete and lined with stainless steel. The pool was designed in accordance with Safety Guide No. 13, published March 10, 1971.

The spent fuel assemblies are placed in stainless steel storage racks consisting of vertical cells grouped in parallel rows with a center-to-center distance of 10-3/32" in both Units. Sandwiched between the inner and outer walls of each storage cell is a 6.5" wide sheet of B_4C poison material. Unit 1 storage racks use a B_4C composite material, carborundum, and Unit 2 racks use Boraflex. There is a coupon surveillance program to monitor the condition of the carborundum material. Boraflex is no longer credited as a neutron absorber due to degradation calculations (License Amendment No. 246); therefore, testing the Boraflex coupons is no longer necessary and has been eliminated. The top opening of the racks has angled lead-in guides which effectively block the spaces between the cavities, as well as guide the fuel assembly into the open tube.

Per Title 10 Code of Federal Regulations (CFR) 50.68, if no credit for soluble boron is taken, the k_{eff} of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95% probability, 95% confidence level, if flooded with unborated water. If credit it taken for soluble boron, the k_{eff} of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95% probability, 95% confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical) at a 95% probability, 95% confidence level, if flooded with unborated water. In addition, the maximum nominal U-235 enrichment of the fresh fuel assemblies is limited to 5 wt%.

For an infinite axial and radial array of Unit 1 storage cells of nominal dimensions with credit for the carborundum poison sheets and containing the maximum enrichment of 5.0 w/o Westinghouse VAP fuel at the worst case temperature of 40°F, the maximum unborated k_{eff} value of 0.986 is calculated with all biases and uncertainties, which is less than the 10 CFR 50.68 regulatory value of 1.0. The maximum k_{eff} value of 0.947 at a moderator boron concentration of 350 ppm with all biases and uncertainties is less than the 10 CFR 50.68 regulatory value of 0.95. Note that Westinghouse VAP fuel is more reactive than similarly enriched Westinghouse standard fuel and AREVA fuel, thus any analysis performed for Westinghouse VAP fuel conservatively bounds that for Westinghouse standard fuel and AREVA/Framatome fuel.

Possible boraflex degradation in the Unit 2 SFP was documented based on calculations using the Racklife software package. Crediting burnup in lieu of boraflex assures that the 10 CFR 50.68 regulatory k_{eff} limit is maintained. The CCNPP SFP Rack Criticality Methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than the 10 CFR 50.68 regulatory limit with Westinghouse VAP and standard fuel and AREVA/Framatome fuel ranging in enrichment from 2.0 to 5.0 w/o with burnup credit and with partial credit for soluble boron in the Unit 2 SFP. The soluble boron credit will be limited to 350 ppm per the restrictions of the Unit 1 criticality analysis including all biases and uncertainties.

The burnups required to store fuel in the Unit 2 SFP crediting 350 pm of soluble boron including all biases and uncertainties are the following:

Enrichment (w/o)	Burnup (GWD/MTU)
2.0	6.00
2.5	13.75
3.0	20.50
3.5	27.00
4.0	32.75
4.5	38.25
5.0	43.75

Each assembly offloaded from either reactor or from an Independent Spent Fuel Storage Installation dry shielded canister must be evaluated against the above burnup restrictions to determine if it can be safely stored in the Unit 2 SFP. No similar restrictions exist on the Unit 1 SFP.

Several checkboard patterns were modeled in an effort to store more reactive fuel in the Unit 2 SFP. Note that only one pattern meets the requirements of 10 CFR 50.68. If credit is taken for soluble boron, that fuel assembly must be surrounded on all four adjacent faces by empty rack cells or other nonreactive materials (e.g., wall, water, …).

The SCALE 4.4 CSAS25 code module with the 44 group ENDF/B-V cross-section library was utilized to perform the KENO-Va Monte Carlo criticality calculations. The neutron adsorption of the stainless steel rack cells was credited in the criticality calculations. However, no credit for the U-234 and U-236 fuel was taken.

The analysis methods and neutron cross-section data are benchmarked by comparison with critical experiment data for similar configurations. The benchmarking process establishes a calculational bias and uncertainty of the mean with a one-sided tolerance factor of 95% probability at a 95% confidence level. The maximum k_{eff} value for the SFP is obtained by summing the calculated value, the calculational bias, the total uncertainty defined as a statistical combination of the calculational and mechanical uncertainties, and the burnup axial distribution bias. Mechanical and material uncertainties may be treated by assuming worst case conditions or by performing sensitivity studies and obtaining worst case uncertainties. Uncertainties may be combined statistically provided that they are independent variations.

The fuel design uncertainty analysis of the Unit 1 SFP consists of the following:

	Westinghouse	AREVA/ Framatome
Delta k_{eff} for 95/95 calculational uncertainty	0.00760	0.00760
Delta k_{eff} for stack height density	0.00417	0.00267
Delta k_{eff} for storage cell pitch	0.00575	0.00571
Delta k_{eff} for steel thickness	0.00569	0.00462
Delta k_{eff} for poison loading	0.00607	0.00513
Delta k_{eff} for eccentric positioning	0.00249	0.00243
Delta k_{eff} for fuel pellet diameter	0.00000	0.00148
Delta k_{eff} for water in gap	0.00000	0.00574
Total Delta k_{eff}	0.01355	0.01365

The Unit 1 SFP Biases included:

Delta k_{eff} for calculational methodology	0.00080	0.00080
Delta k_{eff} for poison loading	0.00466	0.00000
Total Delta k_{eff}	0.00546	0.00080

The Unit 1 SFP worst-case assumptions are the following:

Temperature	4°C (39.2°F)	4°C (39.2°F)
Fuel Clad Composition	Optin	M5®
Fuel Enrichment	5 wt%	5 wt%

A total Unit 1 bias and uncertainty value of 0.01901 was included in all Unit 1 SFP reactivity results for Westinghouse fuel, and a value of 0.01445 was included in all Unit 1 SFP reactivity results for AREVA/Framatome fuel.

The fuel design uncertainty analysis of the Unit 2 SFP consists of the following:

	Westinghouse	AREVA/ Framatome
Delta k_{eff} for 95/95 calculational uncertainty	0.00760	0.00760
Delta k_{eff} for stack height density	0.00090	0.00394
Delta k_{eff} for storage cell pitch	0.00358	0.00711
Delta k_{eff} for fuel enrichment	0.00155	0.00696
Delta k_{eff} for steel thickness	0.01346	0.01353
Delta k_{eff} for eccentric positioning	0.00961	0.01380
Delta k_{eff} for fuel depletion	0.02089	0.01956
Delta k_{eff} for fuel pellet diameter	0.00000	0.00185
Delta k_{eff} for water in gap	0.00000	0.00269
Delta k_{eff} for clad composition	0.00000	0.00252

	Westinghouse	AREVA/ Framatome
Total Delta k_{eff}	0.02799	0.03075

The Unit 2 SFP Biases included:

Delta k_{eff} for calculational methodology	0.00080	0.00080
Delta k_{eff} for axial burnup distribution	0.03250	0.03030
Total Delta k_{eff}	0.03330	0.03110

The Unit 2 SFP worst-case assumptions are the following:

Temperature	68.33°C (155°F)	68°C
Fuel Clad Composition	Zirc4	M5®
Poison Loading	0.000 gm/cm^2	0.000 gm/cm^2

A total Unit 2 bias and uncertainty value of 0.06129 for Westinghouse fuel and 0.06185 for AREVA/Framatomre fuel was included in all Unit 2 SFP reactivity results, where burnup credit was assumed. If no burnup or burnup credit is assumed, a total Unit 2 bias and uncertainty value of 0.01944 for Westinghouse fuel and 0.02452 for AREVA/Framatome fuel may be assumed.

A finite radial and axial model of the Unit 1 SFP of nominal dimensions containing the maximum enrichment of 5.0 w/o fuel at the worst case temperature of 40°F at a soluble boron concentration of 350 ppm including all biases and uncertainties was modeled with alternate and sequential assemblies in the row closest to the SFP wall on spacers to simulate the reconstitution/inspection process. Sufficient margin exists in going from a two to three dimensional model to counteract any increase in reactivity from raising a row of assemblies on spacers. In addition, there is no reactivity penalty between reconstituting an entire row of assemblies or alternate assemblies in a row. Since the boraflex is no longer credited in the Unit 2 SFP, raising assemblies on spacers has no reactivity effect.

Dropping an assembly of 5.0 w/o fuel onto the SFP racks was analyzed, even though it is not a credible accident. The double contingency principle was applied, which required two unlikely, independent, concurrent events to produce a criticality accident. The double contingency principle means that realistic conditions may be assumed. For example, if soluble boron is normally present in the SFP water, the loss of soluble boron is considered as one accident condition and a second concurrent accident need not be assumed. Therefore, total credit for the presence of soluble boron may be assumed in evaluating this accident condition. Per Technical Specifications, the normal SFP boron concentration is conservatively assumed to be 2000 ppm. Taking credit for 2000 ppm per the double contingency principle drops the k_{eff} value for this accident to well below the regulatory requirement.

The racks are designed to withstand all anticipated loadings. Structural deformations are limited to preclude any possibility of criticality. The racks are supported in such a manner as to preclude a reduction in separation space under either the Operating Basis or Safe Shutdown Earthquake. The racks themselves are designed not to collapse or bow under the force of a fuel assembly dropped into an empty cavity, or dropped horizontally across the top of the racks assuming no drag resistance from the water. The structure is fabricated of stainless steel and boron carbide sheets in both units and meets the requirements of Seismic Category I.

Spent fuel decay heat is removed by the fuel pool cooling system described in Section 9.4. The design of the racks allows for adequate convective cooling of stored fuel assemblies by natural circulation.

Monitoring and alarm instrumentation are provided at appropriate locations to assure that the decay heat from the spent fuel elements is being removed and to assure that proper radiation levels are maintained. Means will be provided to control unauthorized entry and to account for the flow of tools in and out of the area.

9.7.2.2 ICI Trash Container Rack

A four-cell ICI trash container rack is located in the lower portion of the refueling canal adjacent to the upender machine. The rack is positioned such that assemblies or cans are submerged to the same elevation as when vertically in place in the upender. Incore instrumentation trash containers or new/spent fuel assemblies may be temporarily placed in the rack to facilitate handling during refueling. The reactor vessel closure head guide studs are stored in the rack during normal plant operation. The guide studs align the reactor vessel head during refueling outages and do not interfere with the temporary handling of fuel assemblies or the ICI trash containers. The rack is stainless steel with four vertical storage positions on 24” centers. The ICI storage rack is designed to withstand all anticipated loadings and meets the requirements of Seismic Category I. Open frame construction allows for natural convective cooling.

The ICI rack design includes members which are located on the tops and sides of the racks to prevent both the inadvertent insertion of an assembly between already stored assemblies and the transportation of an assembly to a position directly adjacent to already stored assemblies. Sufficient distance is provided between the top of the active fuel and the top deck of the storage rack to preclude criticality in the event that a fuel assembly is dropped and lands in a horizontal position on top of active fuel. Angled lead-ins guide an assembly or trash can into the rack and prevent inadvertent insertion of an assembly between already stored assemblies. The criticality analysis supports the Westinghouse standard and VAP design and the AREVA/Framatome design for 5.0 wt% U-235 enrichment for the ICI storage racks. Four fresh 5.0 wt% assemblies stored in the ICI racks with a fifth positioned at the minimum standoff distance, assuming no soluble boron, will maintain k_{eff} less than 0.95 including all biases and uncertainties. The k_{eff} will also remain less than 0.95, including all biases and uncertainties, after dropping a fresh 5.0 wt% assembly on an ICI storage rack filled with four fresh 5.0 wt% assemblies, assuming no soluble boron.

9.7.2.3 Spent Fuel Shipping Cask Pit

The spent fuel shipping cask pit is located on the Unit 1 side of the dividing wall in the pool. The floor of the pit is equipped with a stainless steel cask support platform upon which a shipping cask is set before being loaded with spent fuel bundles. Every cask used is designed such that spent fuel bundles can be placed in them while still maintaining the minimum water level above the fuel bundles. The cask cover is then placed on the cask and the unit is transferred to the cask wash down area by the Spent Fuel Cask Handling Crane. The wash down water is then piped to the MWPS. Means will be taken to assure that surface contamination is less than required by transportation regulations

.

A cask platform/energy absorbing device is located in the cask pit area and provides a second level of protection beyond that provided by the single-failure-proof crane in that the platform has the capability of absorbing the energy associated with a crane drive train failure.

The energy absorbing cask support platform, located inside the cask pit area, is comprised of a stainless steel shell Hexcel aluminum honeycomb material designed to meet the requirements of Seismic Category I and to protect the floor of the cask pit area by absorbing the impact of a cask due to drive train failure of the Spent Fuel Cask Handling Crane.

9.7.2.4 Spent Fuel Cask Handling Crane

Heavy loads (loads in excess of 1600 lbs) are prohibited from travel over spent fuel assemblies in the SFP unless such loads are handled by a single-failure proof device. The Spent Fuel Cask Handling Crane, which is designed in accordance with the "single-failure-proof" criteria of NUREG-0554 and NUREG-0612, is used to handle heavy loads in the SFP area. The maximum design rated load for the Spent Fuel Cask Handling Crane is 150/15 ton (150 ton for the main hoist and 15 ton for the auxiliary hoist). Its maximum critical load rating is 125/15 ton.

The Spent Fuel Cask Handling Crane is used to handle casks over the spent fuel pool and surrounding structures. The crane is single-failure-proof and has been designed in accordance with NUREG 0554.

9.7.2.5 SFP Purification

The SFP purification system consists of a demineralizer and filter. The demineralizer is not regenerated. When the demineralizer or filter is depleted, or as necessary, they are replaced. Additionally, cask movement meets all criteria of NUREG-0612.

The height of the filter transfer cask is 5'6" (including lifting rig). The monorail hoists' hook Elevation is 57'0", 12' above the floor. Therefore, there will be adequate clearance between a cask and the floor.

The filter transfer cask and the SFP purification filter together weigh 6.30 tons. The monorail and hoists are rated for 7.5 tons.

9.7.2.6 SFP Ventilation

The spent fuel handling area ventilation system, shown in Figure 9-21, contains charcoal filters, which remove iodine and other radioactive particulates. The Auxiliary Building air is discharged to the plant vent which is constantly monitored.

9.7.2.7 Spent Fuel Handling Machine and New Fuel Elevator

The spent fuel handling machine is located above the SFP. It is a bridge and trolley arrangement, similar to the refueling machine, which rides on rails set in the concrete on each side of the pool. The handling machine is designed to pass over the dividing wall (separating the two halves of the pool) and to serve both halves of the pool. Latitude and longitude motors on the bridge and trolley position the machine over the specified rack location in the SFP
.

The spent fuel handling machine serves several purposes, some of which are given here. One purpose is to transfer the spent fuel from the upending mechanism to a location in the SFP for decay, or to transfer new fuel to the upending machine. A second purpose is to take fuel from the new elevators and transfer it to a rack location in the SFP or to the fuel upending mechanism. A third function is to move fuel to and from the spent fuel inspection elevator, inspection/repair stations, and to move fuel between storage rack locations. A fourth function of the spent fuel handling machine is to transfer the decayed spent fuel to the shipping cask.

The spent fuel handling machine and new fuel elevators are designed to Seismic Category I requirements. The new fuel elevator is mounted on the west side of the Unit 1 SFP. The function of this elevator is to transport new fuel assemblies with a maximum enrichment of 5.0 wt% U-235 in the pool where the spent fuel handling machine is able to grapple and transfer the fuel to the desired location in the SFP. The fuel elevator on the west side of the Unit 2 SFP was modified to allow its use in inspection of fuel assemblies with a maximum enrichment of 5.0 wt% U-235. Two standoffs located on the new fuel elevator box assemblies ensure that a fuel assembly suspended from the spent fuel handling machine cannot be brought within eight inches of new fuel in the new fuel elevators. This is an added measure, along with existing interlocks and administrative controls, for the prevention of criticality. The spent fuel handling machine and fuel elevators are shown in Figures 1-9 and 1-13.

The Spent Fuel Handling Machine (SFHM) is capable of four modes of operation:

a. *Manual* mode allows movement of SFHM bridge, trolley, hoist, and grapple without system power available to the SFHM.
b. *Manual-Electric* mode allows SFHM bridge and/or trolley movements via joystick operations.
c. *Semi-Automatic* mode allows the operator to set "from" and "to" locations via the console, and the SFHM will automatically move the bridge and/or trolley per those settings.
d. *Automatic* mode allows SFHM bridge and/or trolley movements per a pre-determined file that contains a range of "from" and "to" locations.

Some of the safety features incorporated in this equipment are interlocks to prevent movement into the walls. These interlocks can be bypassed and restored in accordance with approved procedures. Additional safety features include limit switches to prevent the hoist from raising fuel above the point where adequate water for shielding is available. A redundant mechanical stop will prevent a fuel bundle from being raised above specified limits. This results in a maximum dose rate of 7 mrem/hr over the pool during refueling operations. The fuel grappling tool is designed so that the fuel bundle cannot be released accidentally. All motors are equipped with mechanical brakes or self-locking gears to prevent movement in case of a loss of power.

9.7.2.8 Spent Fuel Pool Platform

The SFP platform is a 16' long, 4' wide platform that fastens to the side of the SFP. It is designed such that when installed it will not interfere with the operation of the fuel handling machine. Removable railings are provided for personnel safety. The work platform is portable and can be located along the west wall of the north pool or the east wall of the south pool.

The original purpose of the work platform was to provide an efficient work site for the repairing of worn fuel assembly guide tubes (Section 3.6). The work platform overhang allows repairs to be made from a position directly over the fuel assemblies. The platform was first installed in the south pool in September 1978 in preparation for Unit 2's first refueling. It was moved to the north pool in March 1979 for Unit 1's third refueling. Since then the platform has been moved between the two pools as needed. Subsequently, its use has expanded to include eddy current tests, capsule exchanges, and fuel assembly reconstitutions.

9.7.2.9 Independent Spent Fuel Storage Installation

A detailed description of the Independent Spent Fuel Storage Installation and the transfer operations is discussed in the Independent Spent Fuel Storage Installation Safety Analysis Report.

9.7.2.10 Storage of Failed Fuel Rods in Encapsulation Tubes

Encapsulation tubes are a standard Asea Brown Boveri/Combustion Engineering device for storing failed fuel rods and for containing solid fission products. They are easily identifiable and retrievable. Encapsulation tubes safely store individual irradiated failed fuel rods in the SFP in the peripheral guide tubes of empty grid cages. A single encapsulation tube containing a damaged fuel rod can be stored in an ICI trash can, can be stored in an empty SFP rack space that is inaccessible to both the SFHM and the Auxiliary Building cask handling crane, can be laid temporarily atop the spent fuel pool storage racks with administrative restrictions on fuel movement in the laydown area, or can be placed at the bottom of an upender trench with the associated upender tagged out. Failed fuel rods in encapsulation tubes cannot be stored in the center guide tube of an empty grid cage, since an encapsulation tube from the center guide tube of a grid cage can become wedged in the grapple of the SFHM. Encapsulated fuel rods stored within the guide tubes of empty grid cages or stored in an ICI trash can or empty SFP rack space, are prohibited from extending above the spent fuel pool racks to avoid interfering with the SFHM and its load.

Rod safety baskets are another device for storing failed fuel rods. Rod safety basket lids may be installed to encapsulate the rod. Rod safety baskets are stored in trays which are placed in an empty SFP rack space.

A criticality incident in the SFP will not occur. Storage of the encapsulation tubes in the peripheral guide tubes of empty grid cages or in an ICI trash can or empty SFP rack space will cause a decrease in maximum SFP reactivity due to a decrease in fissile inventory and will not create the possibility of inadvertent criticality. An encapsulated fuel rod placed temporarily atop the spent fuel pool storage racks or at the bottom of the upender trench will be decoupled in reactivity space from the assemblies stored within the rack. Undamaged fuel rods can only be stored in the encapsulation tubes in empty grid cages. This will ensure that the consequences of a fuel handling incident will be limited by the current analysis.

9.7.3 REACTOR COMPONENT HANDLING EQUIPMENT

The refueling equipment arrangement is shown in Figure 9-12.

9.7.3.1 Reactor Refueling Machine

The reactor refueling machine is shown in Figure 9-13.

The refueling machine is a traveling bridge and trolley which spans the refueling pool, and moves on rails located at Elevation 69'6" in the containment area. The bridge and trolley motions allow coordinate location of the fuel handling mast and hoist assembly over the fuel in the core. The hoist assembly contains a coupling device which, when rotated by the actuator mechanism, engages the fuel assembly to be removed. The hoist assembly is moved in a vertical direction by a cable that is attached to the swivel top of the hoist assembly, and runs over a sheave on the hoist cable support to the drum of the hoist winch. After the fuel assembly is raised into the hoist and the hoist into the refueling machine mast, the refueling machine transports the fuel bundle to another location or to the upender.

The controls for the refueling machine are mounted on a console which is located on the refueling machine trolley. Coordinate location of the bridge and trolley is indicated at the console by digital readout devices, which are driven by encoders coupled to the guide rails through rack and pinion gears. A system of pointers and scales is provided as a backup for the remote positioning readout equipment. Manually-operated handwheels are provided for bridge, trolley and winch motions in the event of a power loss.

The Refueling Machine is capable of three modes of operation:

a. *Manual-Electric* modes allow Refueling Machine bridge and/or trolley movements via joystick operation.
b. *Semi-Automatic* mode allows the operator to set “from” and “to” locations via the console, and the Refueling Machine will automatically move the bridge and/or trolley per those settings.
c. *Automatic* mode allows Refueling Machine bridge and/or trolley movements per a pre-determined file that contains a range of “from” and “to” locations.

During withdrawal or insertion of a fuel assembly, the load on the hoist cable is monitored at the control console to ensure that movement is not being restricted. Variations from normal loads in excess of 10% will automatically stop the motion of the hoist winch mechanism. A zoned, mechanical interlock is provided which prevents opening of the fuel grapple and protects against inadvertent dropping of the fuel. A piston-operated spreader device is provided which spreads adjacent fuel assemblies within the core to provide unrestricted removal and insertion. This spreader is part of the mast assembly and is operated after grappling of the fuel assembly. The safety features of the refueling machine are:

a. An anti-collision device on the refueling machine mast which stops bridge and trolley motion. This device consists of a hoop and limit switches to protect the mast from hitting the vessel guide studs, structures within the refueling cavity or the walls of the refueling cavity;
b. Interlocks which restrict simultaneous operation of either the bridge and trolley or the hoist winch drive mechanism;
c. An interlock which prevents bridge and trolley motion when spreader device is actuated;
d. Interlocks that prevent bridge and trolley motion until the hoisting operation is complete;
e. Over and under load switches which stop fuel hoist motion;
f. Automatic bridge and trolley speed restriction zones over the reactor core;
g. Fuel hoist programmed speed restriction while the fuel bundle is within the core and upending machine;

h. An interlock which prevents positioning of the refueling machine over the tilting machine unless the hoist is at the up limit and the spreader is retracted.

9.7.3.2 Fuel Transfer System

Upending Machines

Two upending machines are provided for each unit, one in the Containment Structure refueling pool and the other in the SFP. Each consists of a structural steel support base from which is pivoted an upending straddle frame, which engages the two-pocket fuel carrier. When the carriage with its fuel carrier is in position within the upending frame, the pivots for the fuel carrier and the upending frame are coincident. Hydraulic cylinders attached to both the upending frame and the support base rotate the fuel carrier between a vertical and horizontal position, as required by the fuel transfer procedure.

Interlocks are provided to ensure the safe operation of this equipment by prohibiting the lowering of a fuel assembly unless the fuel carrier is vertical, by preventing inadvertent rotation of the tilting cylinders while a fuel assembly is being lowered, and by deactivating the cable drive so that a premature attempt to move the carriage through the transfer tube cannot be initiated.

Fuel assemblies of 5.0 wt% U-235 can be inserted into the upenders. A k_{eff} less than or equal to 0.95 with biases and uncertainties can be maintained with two fuel assemblies of 5.0 wt% U-235 inserted into the upender.

Transfer Carriage

During refueling periods, the transfer carriage transports one or two fuel assemblies with a maximum enrichment of 5.0 wt% U-235 between the refueling pool and the fuel storage area. Ten large wheels, five on each side, support the carriage and allow it to roll on tracks within the transfer tube. Track sections at both ends of the transfer tube are supported from the pool floor and permit the carriage to be properly positioned to the upending mechanisms. The carriage is driven by steel cables connected to the carriage and through sheaves to its driving winches mounted below the operating floor level. The fuel carrier is mounted on the carriage and is pivoted for tilting by the upending machines.

Transfer Tube and Isolation Valve

The fuel transfer tube shown on Figure 9-14 connects the refueling pool with the SFP. During reactor operation, the transfer tube is closed by an isolation valve outside the containment and a blind flange inside the containment (Figure 9-14A). The flange is subject to local leak rate testing (Type B). The isolation valve is not local leak rate tested. The tube is supported by a larger diameter pipe which, in turn, is sealed to the containment envelope. The two concentric tubes are sealed to each other with a bellows-type expansion joint.

Transfer Rails

This assembly contains the rails on which the transfer carriage rides when moving between the reactor cavity and SFP area. The rail supports are welded to the 36" diameter transfer tube. The rail assemblies are fabricated to a length which will allow them to be lowered for installation in the transfer tube. A gap is left in the track at the valve on the fuel storage side of the transfer tube to allow closing of the valve.

9.7.3.3 CEA Handling Tool

Unit 1:

The refueling machine auxiliary hoist, used in conjunction with the CEA handling tool, is used to exchange CEAs within the reactor core under normal conditions. The auxiliary hoist has sufficient capacity to hoist a CEA.

Unit 2:

The refueling machine auxiliary hoists, used in conjunction with the CEA handling tool, are used to exchange CEAs within the reactor core under normal conditions. Each auxiliary hoist has sufficient capacity to hoist a CEA.

The CEA handling tool is visually aligned by a licensed operator to verify that the tool is correctly positioned above the fuel assembly prior to grappling. The CEA handling tool has a rotary grapple which rides in a vertical channel section so that inadvertent release of a CEA is not possible. A load cell is used with the CEA handling tool to verify loading (unloading) and prevent hoisting a bound CEA. Administrative controls prevent translation during hoisting or vice versa.

The CEA handling tool can also be used in the SFP, where it is lifted by the single failure proof crane.

9.7.3.4 Reactor Vessel Head Lifting Rig

The reactor vessel head lifting rig is shown in Figure 9-16.

This lifting rig is composed of a three-part lifting frame (tripod) and three lift links. The lift links are attached to the outer shroud, which is part of the CEDM air cooling structure. The outer shroud is attached to the reactor vessel head. The lift links support a service structure that includes three hoists for handling the hydraulic stud tensioners, reactor vessel studs, washers, and nuts. The lift links and service structure provide support for the CEDM, Reed Switch Position Transmitter, ICI, and Reactor Vessel Level Monitoring System electrical cables. The tripod is removed prior to plant operation.

9.7.3.5 Reactor Internals Lifting Rig

The reactor internals lifting rig consists of three major subassemblies: (1) upper guide structure lift rig which includes an ICI hoist, (2) a core support barrel lifting rig, and (3) an upper clevis (tripod) assembly. The upper clevis assembly is common to the upper guide structure lifting rig and the core support barrel lifting rig. The upper clevis assembly is a tripod-shaped structure connecting the lifting rigs to the containment crane lifting hook.

The upper guide structure lifting rig is shown in Figure 9-17. This lifting rig consists of a delta spreader beam which supports three columns providing attachment points to the upper guide structure. Attachment to the upper guide structure is accomplished manually from the working platform by means of lifting bolt torque tools. The integral ICI hoist connects to an adapter which is manually attached to the ICI structure by utilizing an adapter torque tool. The ICI is then lifted by the crane hook.

A core support barrel lifting rig, shown in Figure 9-18, is provided to withdraw the core barrel from the vessel for inspection purposes. The lifting rig includes a spreader beam providing three attachment points. Attachment is accomplished manually from the refueling machine bridge by means of a lift bolt torque tool.

Correct positioning of either the upper guide structure lifting rig or the core support barrel lifting rig is assured by guide bushings attached to the rigs which mate to the reactor vessel guide pins.

A separate upper guide structure lift rig is provided for each of the two reactors. The core support barrel lifting rig is shared by Unit 1 and Unit 2.

9.7.3.6 Surveillance Capsule Retrieval Tool

A retrieval tool is provided during the refueling shutdown for manual removal of the irradiated capsule assemblies of the reactor vessel materials surveillance program described in Section 4.1.5.4.

A diagram of the surveillance capsule retrieval tool is shown in Figure 9-19. The tool is operated from a position on the carriage walkway of the refueling machine. Access to the capsule assembly is achieved by inserting the tool through 3" diameter retrieval holes in the core support barrel flange provided in each capsule assembly location. A female acme thread at the end of the retrieval tool is mated to the surveillance capsule lock assembly (Figure 4-14) by turning the retrieval tool handle. A compressed spring in the lock assembly exerts a high frictional force at the retrieval tool-lock assembly interface to prevent disengagement during retrieval.

The overall length of the tool is 45.5'. The tool consists of two parts to facilitate storage. The upper portion is a 2" diameter tube and handle. The lower portion of the tool is also a 2" tube with a 1" outer diameter at the connector end. A 3/4" diameter hole in the upper end of the tool permits the containment crane to assist with the retrieval procedure and prevents inadvertent dropping of the tool. The tool is made of aluminum and has a dry weight of 40 lbs.

9.7.4 DESIGN EVALUATION AND SYSTEM RELIABILITY

Underwater transfer of spent fuel provides ease and safety in handling operations. Water is an effective, transparent radiation shield and an efficient cooling medium for removal of decay heat. Basic provisions to ensure the safety of refueling operations are:

a. Gamma radiation levels in the containment and fuel storage areas are continuously monitored and recorded (Section 11.2.3). These monitors provide an audible alarm at the initiating detector and in the Control Room, indicating an unsafe condition. Continuous monitoring of reactor neutron flux, with indication in the Control Room, provides immediate indication and alarm of an abnormal core flux level during fuel loading and unloading operations.

b. Whenever fuel is added to the reactor core, the source range neutron flux (count rate) is recorded to verify the subcriticality of the core.

c. The design of the equipment places physical limits on the extent of fuel movement, thereby avoiding any possibility of raising fuel beyond a safe limit. Fuel storage rack spacing provides positive protection against criticality in the event of inadvertent flooding of the fuel storage area with fresh water. The design of the spent fuel storage pool is such that water cannot drain out of the pool by gravity.

Manually-operated handwheels are provided to allow refueling bridge, trolley and winch motion in the event of a power loss.

The fuel transfer carriage is longer than the fuel transfer tube, assuring that one end of the carriage is accessible at all times during the transfer operation. Operability of the refueling system is assured by functional testing prior to each refueling operation.

At least 10" is provided between the top of the active fuel and the top deck of the storage rack to preclude criticality in the event of a fuel assembly is dropped and lands in the horizontal position on the top deck. The design of the racks assures adequate convective cooling to a fuel assembly lying horizontally across the top of the racks.