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Your ref: Docket No. 52-006
Our ref: DCP/NRC1727

December 8, 2005

SUBJECT: Westinghouse AP1000 Design Control Document Revision 15 Errata

Enclosed please find an updated Revision 15 of the AP1000 Design Control Document (DCD) including Errata in support of our application for Design Certification of the AP1000 standard plant design. The Revision 15 AP1000 DCD was provided with Westinghouse letter DCP/NRC1725 dated November 14, 2005.

The Errata included with this update includes two paragraphs added in Section 9.2 and Table of Contents Changes resulting from pagination changes.

Enclosure 2 contains the updated AP1000 Design Control Document with sensitive, unclassified information protected under 10 CFR 2.390 redacted. The information provided in Enclosure 1 does not include sensitive unclassified information. Enclosure 2 supersedes Enclosure 3 of letter DCP/NRC1725. Enclosure 3 of DCP/NRC1725 was included with the submittal of Revision 15 to provide a public version of the AP1000 Design Control Document with the sensitive, unclassified information redacted as provided in 10 CFR 2.390.

Pursuant to 10 CFR 50.30(b), an Oath of Affirmation for Revision 15 was provided with Westinghouse letter DCP/NRC1725.

There is no information proprietary to Westinghouse included in this application. The Westinghouse Electric Company copyright notice is included within the document.

Please contact me if you have any questions concerning this transmittal.

Very truly yours,

R. P. Vijuk

R. P. Vijuk, Manager
Passive Plant Engineering
AP600 & AP1000 Projects

D063

/Enclosures

1. APP-GW-GL-700, Revision 15, "AP1000 Design Control Document - Errata"
2. APP-GW-GL-700, Revision 15, Public View "AP1000 Design Control Document" (cd-rom)

			DCD
cc:	C. B. Brinkman	- Westinghouse, Rockville, MD	1
	W. E. Cummins*	- Westinghouse, Pittsburgh, PA, EC E3	
	Doc Control Desk	- U.S. NRC, Rockville, MD	1 hardcopy 1 public version
	E. Kennedy	- Westinghouse, Windsor, CT	1
	Y. Taik Lee	- KOPEC, Gyeonggi-do, Korea	1 cd-rom
	B. F. Maurer*	- Westinghouse, Pittsburgh, PA, EC E4-07A	
	G. Saiu	- Ansaldo	1
	R. P. Vijuk	- Westinghouse, Pittsburgh, PA, EC E3-05	1
	J. N. Wilson	- U.S. NRC, Rockville, MD	3 hardcopy 10 cd-rom 1 public version
	J. W. Winters	- Westinghouse, Pittsburgh, PA, EC E3-08	1

* Letter only

DCP/NRC1727
Docket No. 52-006

December 8, 2005

Enclosure 1

APP-GW-GL-700, Revision 15

"AP1000 Design Control Document - Errata"

December 8, 2005

Enclosure 2

APP-GW-GL-700, Revision 15

"AP1000 Design Control Document – Public View"

AP1000 Design Control Document

Instructions for Inserting Revision 15 (Updated) Change Pages

(December 5, 2005)

Tier 2 Material
Volume 2

After the "Tier 2 List of Effective Pages" tab, remove the following page within this tab and insert the corresponding updated page:

Page
15 (Rev. 15)/16 (Rev. 15)

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and
cxix (Rev. 15)/cxx (Rev. 15)

Volume 3

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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cxix (Rev. 15)/cxx (Rev. 15)

Volume 4

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Volume 5

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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and
cxix (Rev. 15)/cxx (Rev. 15)

Volume 6

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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and
cxix (Rev. 15)/cxx (Rev. 15)

Volume 7

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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and
cxix (Rev. 15)/cxx (Rev. 15)

After Tab 9 "Auxiliary Systems," remove all of the pages within this tab and insert the Revision 15 updated pages:

Remove Pages	Insert Pages
i (Rev. 9)/ii (Rev. 9) through xi (Rev. 9)/xii (Rev. 9)	i (Rev. 15)/ii (Rev. 15) through xi (Rev. 15)/xii (Rev. 15)

After Tab 9.1 "Fuel Storage and Handling," remove the following pages within this tab and insert the corresponding updated pages:

Pages
9.1-19 (Rev. 15)/9.1-20 (Rev. 15) through 9.1-63 (Rev. 15)/Blank

Volume 8

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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and
cxix (Rev. 15)/cxx (Rev. 15)

Volume 9

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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Volume 10

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

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and
cxix (Rev. 15)/cxx (Rev. 15)

Volume 11

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

Pages
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and
cxix (Rev. 15)/cxx (Rev. 15)

Volume 12

After the "Tier 2 Master Table of Contents" tab, remove the following pages within this tab and insert the corresponding updated pages:

Pages
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and
cxix (Rev. 15)/cxx (Rev. 15)

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- When the decay heat level in the reactor is greater than 9 MW, the water in the passive containment cooling water storage tank is reserved for containment cooling. Safety related spent fuel pool cooling is provided for at least 72 hours from the pool itself and makeup water from the cask washdown pit. After 72 hours, non-safety related makeup can be provided from the passive containment cooling ancillary water storage tank.

- Minimum volume in the passive containment cooling water storage tank for spent fuel pool makeup is 756,700 gallons. Availability of this makeup source for the first 72 hours is controlled by technical specifications. Minimum volume in the passive containment ancillary water storage tank for spent fuel pool makeup is 175,000 gallons.

Table 9.1-4 provides the calculated timing and spent fuel pool water levels for several limiting event scenarios which would require makeup to the spent fuel pool.

Alignment of the cask washdown pit is accomplished by positioning manual valves located in the waste monitor tank room B (12365) in the auxiliary building. Alignment of the passive containment cooling water storage tank is accomplished by positioning manual valves located in the mid annulus access room (12345) and in the passive containment cooling valve room in the upper shield building. Because these alignments are made by positioning manual valves, they are not susceptible to active failures.

Gravity driven flow from the cask washdown pit to the spent fuel pool is provided as the cask washdown pit water level will follow the spent fuel pool level. Figures 9.1-5 and 9.1-6 show the connection of the cask washdown pit to the spent fuel pool.

Gravity driven flow from the passive containment cooling water storage tank is controlled by a manual throttle valve with local flow indication which is set to achieve the desired flow when the makeup is initiated. Figure 6.2.2-1 shows the flow path from the passive containment cooling water storage tank leading to the spent fuel pool and the tie-in to the spent fuel pool is also shown in Figure 9.1-6.

The flow from the passive containment cooling water storage tank (PCCWST) to the spent fuel pool, required to provide sufficient makeup to the spent fuel pool to keep the fuel covered as the pool water boils off, is 118 gpm. This is the maximum flow required at the initiation of makeup flow from the PCCWST during the worst case conditions in the pool, which is a full core offload. The makeup flow rate required decreases with time as the decay heat decreases.

After 72 hours, makeup water from the passive containment cooling ancillary water storage tank can either be pumped (with the passive containment cooling recirculation pumps) to the passive containment cooling water storage tank and then gravity fed to the spent fuel pool as discussed above, or the water can be pumped directly to the spent fuel pool. When the makeup water is pumped directly to the pool, the flow rate is controlled by the same manual throttle valve which is used to set the flow rate when providing gravity driven flow from the passive containment cooling water storage tank.

The flow provided from the passive containment cooling auxiliary water storage tank (PCCAWST) to the spent fuel pool by the recirculation pumps, required to provide sufficient

makeup to the spent fuel pool to keep the fuel covered as the pool water boils off, is 35 gpm. The plant condition associated with this flow is a loss of power combined with a seismic event when the plant is operating at full power, shortly after startup from a refueling outage. This condition results in the maximum flow required from the PCCAWST because cooling water must be supplied to both the PCCWST and the spent fuel pool to provide both containment and spent fuel cooling for a period of four days following the initial three days of passive systems operation.

Spent fuel pool level instrumentation is discussed in Subsection 9.1.3.7.

9.1.3.4.3.1 Failure of a Spent Fuel Pool Cooling System Pump

If a spent fuel pool cooling system pump fails when only one pump is operating, an alarm is actuated. Due to the heat capacity of the water in the spent fuel pool, sufficient time exists for the operators to manually align the standby spent fuel pool cooling system train of equipment (pump/heat exchanger) to cool the spent fuel pool.

9.1.3.4.3.2 Leakage from the Spent Fuel Pool Cooling System

The connections from the spent fuel pool cooling system to the pool are such that leakage in the spent fuel pool cooling system will not result in the pool water level falling to unacceptable levels. The heat capacity of the water in the pool is sufficient to allow the operators enough time to locate the leak and repair it. In the most probable scenario, cooling will be maintained by operation of the standby train of equipment. However, if spent fuel pool cooling must be terminated, sufficient time exists to allow for repairs of a leak in the system.

9.1.3.4.3.3 Loss of Offsite Power

The spent fuel pool cooling system pumps can be manually loaded on the respective onsite standby diesel generator in the event of a loss of offsite power. The spent fuel pool cooling system is capable of providing spent fuel pool cooling following this event.

9.1.3.4.3.4 Station Blackout

Following a loss of ac power (off-site power and both standby diesel generators), the heat capacity of the water in the pool is such that cooling of the fuel is maintained. Table 9.1-4 provides the times before boiling would occur in the pool following station blackout for various scenarios as well as the minimum levels of water that would be reached. Water vapor that evaporates from the surface of the spent fuel pool is vented to the outside environment through an engineered relief panel. This vent path maintains the fuel handling area at near atmospheric pressure conditions. The doses resulting from spent fuel pool boiling have been calculated and are included in Chapter 15. The release concentrations at the site boundary are small fractions of the limits specified in 10 CFR 20, Appendix B with no credit for removal of activity by building ventilation systems (which are not available during loss of ac power situations). The equipment in the fuel handling area, rail car bay\filter storage area, and spent resin equipment and piping areas exposed to elevated temperature and humidity conditions as a result of pool boiling does not provide safety-related mitigation of the effects of spent fuel pool boiling or station blackout. The fuel handling area, rail car bay, and spent resin area do not have connecting ductwork with other areas of the radioactively controlled area of the auxiliary building and connecting floor drains have a

water seal which prevents steam migration. The environment in these other areas during spent fuel pool steaming is mild with respect to safety-related equipment qualification and affords access for post-accident actions.

Spent fuel pool makeup for long term station blackout can be provided through seismically qualified safety-related makeup connections from the passive containment cooling system. These connections are located in an area of the auxiliary building that can be accessed without exposing operating personnel to excessive levels of radiation or adverse environmental conditions during boiling of the pool. Operating personnel are not required to enter the fuel handling area when normal cooling is not available, and are not required to enter the area to recover normal cooling.

9.1.3.4.3.5 Reactor Coolant System Makeup

During an event in which the reactor coolant system pressure and inventory decrease the normal residual heat removal system pumps are started to provide makeup water to the reactor coolant system when the primary system pressure is sufficiently reduced for injection to start. The AP1000 procedure for post-accident operation of the normal residual heat removal pumps is that the operators align the pumps to the cask loading pit. This is accomplished by the operator opening a motor operated isolation valve (see subsection 5.4.7.3.3.5) between the cask loading pit and the normal residual heat removal pump suction line. When the water in this pit nears empty, the pump suction is re-aligned to the IRWST/containment recirculation connection so that the pumps can continue to provide injection to the reactor coolant system. The refueling water from the cask loading pit provides additional water into containment (and thus additional driving head) for the post accident containment recirculation. The AP1000 emergency operating procedures will include a restriction on use of this injection method if the gate between the spent fuel pool and the cask loading pit is open at the initiation of the event. In this case the operators will be instructed to close the gate, if possible, before initiating the makeup flow with the normal residual heat removal pumps. Injection from the cask loading pit will only be initiated if the gate can be closed. The gate is normally in the closed position unless cask loading operations are in progress.

9.1.3.5 Safety Evaluation

The only spent fuel pool cooling system safety-related functions are containment isolation and emergency makeup connections to the spent fuel pool. Containment isolation evaluation is described in subsection 6.2.3. The following provides the evaluation of the design of the spent fuel pool as well as the spent fuel pool cooling system:

- The spent fuel pool is designed such that a water level is maintained above the spent fuel assemblies for at least 7 days following a loss of the spent fuel pool cooling system, using only onsite makeup water (see Table 9.1-4). The minimum water level to achieve sufficient cooling is the subcooled, collapsed level (without vapor voids) required to cover the top of the fuel assemblies.

- The maximum heat load is assumed to be the heat load for a full core off load immediately following a refueling in which 44 percent of the fuel assemblies were replaced.

- Safety-related makeup water can be supplied to the fuel pool from the fuel transfer canal, cask washdown pit, and passive containment cooling water storage tank.
- The spent fuel pool cooling system includes safety-related connections from the passive containment cooling system water storage tank in the passive containment cooling system to establish safety-related makeup to the spent fuel pool following a design basis event including a seismic event.
- In addition to the safety-related water sources, makeup water is also obtained from the passive containment cooling system ancillary water storage tank. Water from this tank can be pumped by the passive containment cooling system recirculation pumps either to the passive containment cooling water storage tank (and then gravity fed to the spent fuel pool), or directly to the spent fuel pool.

Radiation shielding normally provided by the water above the fuel is not required when normal spent fuel pool cooling is not available. Personnel are not permitted in the area when the level in the pool is below the minimum level.

The acceptability of the design of the spent fuel pool cooling system is based on specific General Design Criteria (GDCs) and Regulatory Guides as described in Sections 3.1 and 1.9.

9.1.3.6 Inspection and Testing Requirements

9.1.3.6.1 Preoperational Testing, Analysis, and Inspection

9.1.3.6.1.1 Pump Flow Capability Testing

Each spent fuel pool cooling system pump will be tested. The flow paths will be aligned for normal spent fuel pool cooling by one train of spent fuel pool cooling system components. The flow delivered to each spent fuel pool cooling system heat exchanger will be measured by a flow instrument at the spent fuel pool cooling system pump discharge. The testing confirms that the pumped flow is equal to or greater than the minimum value shown in Table 9.1-3. This is the minimum value for the spent fuel pool cooling system to meet its functional requirement of normal spent fuel pool cooling. The flow delivered to each spent fuel pool cooling system heat exchanger will be measured by a flow instrument at the spent fuel pool cooling system pump discharge. The testing confirms that the pumped flow is equal to or greater than the minimum value shown in Table 9.1-3. This is the minimum value for the spent fuel pool cooling system to meet its functional requirement of normal spent fuel pool cooling.

9.1.3.6.1.2 Heat Transfer Capability Analysis

An analysis will be performed on the spent fuel pool cooling system heat exchangers during heat exchanger design. The analysis is to confirm that the product of the overall heat transfer coefficient and effective heat transfer area, UA, of each heat exchanger is equal to or greater than the minimum value shown in Table 9.1-3. This is the minimum value for the spent fuel pool cooling system to meet its functional requirement of normal spent fuel pool cooling.

9.1.3.6.1.3 Dimensional Inspections

The contained volumes of water in the spent fuel pool, fuel transfer canal and the cask washdown pit are used for cooling the spent fuel by boiling after a prolonged loss of normal spent fuel pool cooling. The inspections are to confirm that the contained volumes are equal to or greater than the minimum values shown in Table 9.1-2. These are the minimum values for the spent fuel pool cooling system to meet its safety-related requirement of spent fuel pool cooling for 3 days after loss of normal cooling.

9.1.3.6.2 Routine Testing

Active components of the spent fuel pool cooling system are either in continuous or intermittent use during normal system operation. Periodic visual inspection and preventive maintenance are conducted.

No specific equipment tests are required since system components are normally in operation when spent fuel is stored in the fuel pool. Sampling of the fuel pool water for gross activity, tritium and particulate matter is conducted periodically.

9.1.3.7 Instrumentation Requirements

The instrumentation provided for the spent fuel pool cooling system is discussed in the following paragraphs. Alarms and indications are provided as noted.

A. Temperature

Instrumentation is provided to measure the temperature of the water in the spent fuel pool and to give indication as well as annunciation in the main control room when normal temperatures are exceeded.

Instrumentation is also provided to give indication of the temperature of the spent fuel pool water as it leaves either heat exchanger.

B. Pressure

Instrumentation is provided to measure and give indication of the pressures in the spent fuel pool pump suction and discharge lines. Instrumentation is also provided at locations upstream and downstream from the spent fuel pool filter and demineralizer so that pressure differential across this equipment can be determined. High differential pressure across the spent fuel pool filter and demineralizer is annunciated in the main control room.

C. Flow

Instrumentation is provided to measure and give remote indication of the spent fuel pool cooling loop flow downstream of the spent fuel pool pumps. Purification flow is also continuously measured.

D. Level

Safety-related instrumentation is provided to give an alarm in the main control room when the water level in the spent fuel pool reaches either the high-level or low-level setpoint. This instrumentation is used for post-accident monitoring on the spent fuel pool level. (See Table 7.5-1)

Non-safety related instrumentation is provided to give an alarm in the main control room when the water level in the cask loading pit reaches either the high-level or low-level setpoint. This instrumentation is used to alert the operator to a low level in the cask loading pit when injecting water from the pit into the reactor coolant system with the normal residual heat removal pumps.

9.1.4 Light Load Handling System (Related to Refueling)

The fuel handling and refueling system consists of equipment and structures used for conducting the refueling operation. This system conforms to General Design Criteria as defined in Section 3.1. The light load handling system meets the guidelines of American Nuclear Society (ANS) 57.1 (Reference 6). Figures 1.2-9 and 1.2-14 indicate the relationship between the light load handling system and the fuel handling areas.

9.1.4.1 Design Basis

9.1.4.1.1 Safety Design Basis

The following safety design basis apply to the light load handling system:

A. Fuel handling devices have provisions to avoid dropping or jamming of fuel assemblies during transfer operation.

B. Handling equipment has provisions to avoid dropping of fuel handling devices during the fuel transfer operation.

C. Handling equipment used to raise and lower spent fuel has a limited maximum lift height so that the minimum required depth of water shielding is maintained.

D. The fuel transfer system, where it penetrates the containment, has provisions to preserve the integrity of the containment pressure boundary.

E. Criticality during fuel handling operations is prevented by the geometrically safe configuration of the fuel handling equipment.

F. In the event of a safe shutdown earthquake (SSE), handling equipment cannot fail in such a manner as to prevent required function of seismic Category 1 equipment.

G. The inertial loads imparted to the fuel assemblies or core components during handling operations are less than potential damage causing loads.

H. Physical safety features are provided for personnel who operate handling equipment.

9.1.4.1.2 Power Generation Design Basis

Design criteria for the light load handling system are as follows:

A. The primary design requirement of the equipment is reliability. A conservative design approach is used for load bearing parts.

B. The refueling machine and fuel handling machine are designed and constructed in accordance with applicable portions of the Crane Manufacturers Association of America, Inc. (CMAA), Specification 70 for Class A-1 service (Reference 7).

C. The static design loads for the crane structures and lifting components are normal dead and live loads plus the fuel assembly weight.

D. The allowable stresses for the refueling machine and fuel handling machine structures supporting the weight of a fuel assembly are as specified in the American Institute of Steel Construction (AISC) Manual.

E. The design load on the wire rope hoisting cables does not exceed 0.20 times the average breaking strength. Two independent cables are used, and each is assumed to carry one half the load.

F. Components critical to the operation of the equipment are assembled with the fasteners restrained from loosening under vibration.

9.1.4.2 System Description

The light load handling system consists of the equipment and structures needed for the refueling operation. This equipment is comprised of fuel assemblies, core component and reactor component hoisting equipment, handling equipment, and a dual basket fuel transfer system. The structures associated with the fuel handling equipment are the refueling cavity, the transfer canal, the fuel transfer tube, the spent fuel pool, the cask loading area, the new fuel storage area, and the new fuel receiving and inspection area.

9.1.4.2.1 Fuel Handling Description

The fuel handling equipment is designed to handle the spent fuel assemblies underwater from the time they leave the reactor vessel until they are placed in a container for shipment from the site. Underwater transfer of spent fuel assemblies provides an effective and transparent radiation shield, as well as a reliable cooling medium for removal of decay heat. The boric acid concentration in the water is sufficient to preclude criticality.

The associated fuel handling structures may be generally divided into two areas: the refueling cavity which is flooded only during plant shutdown for refueling, and the spent fuel pool and transfer canal, which is kept full of water. See subsection 9.1.1.3 for new fuel assembly storage. The new and spent fuel storage areas are accessible to operating personnel. The refueling cavity and the fuel storage area are connected by the fuel transfer tube which is fitted with a quick opening hatch on the canal end and a valve on the fuel storage area end. The hatch is in place except during refueling to provide containment integrity. Fuel is carried through the tube on an underwater transfer car.

Fuel is moved between the reactor vessel and the fuel transfer system by the refueling machine. The fuel transfer system is used to move up to two fuel assemblies at a time between the containment building and the auxiliary building fuel handling area. After a fuel assembly is placed in the fuel container, the lifting arm pivots the fuel assembly to the horizontal position for passage through the fuel transfer tube. After the transfer car transports the fuel assembly through the transfer tube, the lifting arm at that end of the tube pivots the assembly to a vertical position so that the assembly can be lifted out of the fuel container.

In the fuel handling area, fuel assemblies are moved about by the fuel handling machine. Initially, a short tool is used to handle new fuel assemblies, but the new fuel elevator must be used to lower the assembly to a depth at which the fuel handling machine can place the new fuel assemblies into or out of the spent fuel storage racks.

Decay heat, generated by the spent fuel assemblies in the fuel pool is removed by the spent fuel pool cooling and cleanup system. After a sufficient decay period, the spent fuel assemblies are removed from the fuel racks and loaded into a spent fuel shipping cask for removal from the site.

9.1.4.2.2 Refueling Procedure

New fuel assemblies received for refueling are removed one at a time from the shipping container and moved into the new fuel assembly inspection area. After inspection, the accepted new fuel assemblies are stored in the new fuel storage racks. For the initial core load, some new fuel assemblies may be stored in the spent fuel pool.

Prior to initiating the refueling operation, the reactor coolant system (RCS) is borated and cooled down to refueling shutdown conditions as specified in the Technical Specifications. Criticality protection for refueling operations is specified in the Technical Specifications. The following significant points are addressed by the refueling procedure:

- The refueling water and the reactor coolant contain approximately 2500 ppm boron. This concentration is sufficient to keep the core five percent $\Delta k/k$ subcritical during the refueling operations.

- The water level in the refueling cavity is high enough to keep the radiation levels within acceptable limits when the fuel assemblies are removed from the core. Radiation monitoring is described in Section 11.5.

- Continuous communications are established and maintained between the main control room and the personnel engaged in fuel handling operations. One or more of the systems described in subsection 9.5.2 are used for this communication.

The refueling operation is divided into four major phases: preparation, reactor disassembly, fuel handling, and reactor assembly. A general description of a typical refueling operation through these phases is provided below.

9.1.4.2.2.1 Phase I - Preparation

The reactor is shut down, borated, and cooled to refueling conditions (≤ 140°F) with a final k_{eff} less than 0.95 (all rods in). Following a radiation survey, the containment building is entered. At this time, the coolant level in the reactor vessel is lowered to a point slightly below the vessel flange. The refueling machine console is removed from storage and placed on the refueling machine and cables are connected. Then, the fuel transfer equipment and refueling machine are checked for operation (subsection 9.1.4.4).

9.1.4.2.2.2 Phase II - Reactor Disassembly

Head cables are disconnected at the integrated head package (IHP) connector plate to allow removal of the vessel head. See subsection 3.9.7 for a discussion of the integrated head package. The refueling cavity is prepared for flooding by checking the underwater lights, tools, and fuel transfer system; closing the refueling cavity drain lines; and removing the hatch from the fuel transfer tube. With the refueling cavity prepared for flooding, the vessel head is unseated and raised above the vessel flange using the containment polar crane. See subsection 9.1.5 for requirements for the polar crane. Water from the in-containment refueling water storage tank (IRWST) is transferred into the refueling cavity by gravity and the spent fuel pool cooling system (See subsection 9.1.3). The vessel head and the water level in the refueling cavity are raised, keeping the water level just below the vessel head. When the water reaches a safe shielding depth (subsection 9.1.4.3.7), the vessel head is taken to its storage pedestal. The control rod drive shafts are disconnected. The internals lift rig is installed and the upper internals are removed from the vessel. See subsection 9.1.5 for discussion of lifting rig requirements and design. The fuel assemblies are now free from obstructions, and the core is ready for refueling.

9.1.4.2.2.3 Phase III - Fuel Handling

The refueling sequence is started with the refueling machine. The positions of partially spent assemblies are changed, and new assemblies are added to the core.

The general fuel handling sequence is as follows:

1. The refueling machine is positioned over a fuel assembly in the core.

2. The refueling machine mast is lowered over a fuel assembly and engages it.

3. The refueling machine withdraws a spent fuel assembly from the core and raises it to a pre-determined height sufficient to clear the vessel flange and still leave sufficient water covering the fuel assembly.

4. The fuel transfer system car containing a new fuel assembly in the fuel basket (which contains up to two fuel assemblies) is moved into the refueling cavity from the fuel storage area, and the fuel basket is pivoted to the vertical position by the lifting arm.

5. The refueling machine is moved to line up the fuel assembly with the empty fuel basket.

6. The refueling machine loads the spent fuel assembly into the empty fuel basket of the transfer car.

7. The refueling machine then moves to the new fuel assembly (in the remaining fuel basket) and withdraws it from the fuel transfer system.

8. The refueling machine then moves back over the core area and inserts the fuel assembly into the open location in the core prepared in step 3.

9. The fuel basket is pivoted to the horizontal position and the fuel transfer system container is moved through the fuel transfer tube to the fuel handling area by the transfer car and pivoted to the vertical position.

10. A new fuel assembly is taken from a storage rack and loaded into the empty fuel basket by the fuel handling machine. Note that new fuel was put in spent fuel racks prior to the start of refueling (new fuel elevator).

11. The spent fuel assembly is then unloaded from the fuel basket by the fuel handling machine.

12. The spent fuel assembly is placed in the spent fuel storage rack.

13. The fuel basket is pivoted to the horizontal position, moved back into the containment building and pivoted to the vertical position.

14. The refueling machine, which was concurrently relocating partially spent fuel in the vessel engages a spent fuel assembly, which is to be discharged, and returns to the fuel transfer system.

15. This procedure is repeated until refueling is completed.

9.1.4.2.2.4 Phase IV - Reactor Reassembly

Reactor reassembly, following refueling, is achieved by reversing the operations given in Phase II - Reactor Disassembly.

During a reassembly of the reactor, the vessel head and the water are lowered simultaneously until the vessel head engages the guide studs. At this point of the reassembly, the water is lowered to the top of the reactor vessel flange.

9.1.4.2.3 Spent Fuel Cask Loading

The spent fuel assemblies are normally stored in the spent fuel pool, until fission product activity is low enough to permit shipment. The spent fuel assemblies are then transferred to a shipping cask which is designed to shield radiation. Provisions for handling the spent fuel cask are discussed in subsection 9.1.5.

The following procedure briefly outlines the typical steps of this operation, assuming that the cask loading pit has been previously filled with water and the gate between the cask loading pit and the spent fuel pool has been removed:

1. A clean, empty cask is brought into the cask washdown pit and washed with demineralized water. The cask lid is removed and stored while the remainder of the cask is washed.

2. The clean empty cask is then properly positioned in the flooded cask loading pit.

3. The fuel handling machine is positioned over the specific fuel assembly to be shipped out of the spent fuel storage rack. The fuel assembly is picked up and transported into the cask loading pit. During the transfer process the fuel assembly is always maintained with the top of the active fuel at least 10 feet below the water surface. This provides confidence that the direct radiation from the fuel at the surface of the water is minimal.

4. Once the fuel transfer process is complete, the lid is placed on top of the cask to provide the required shielding.

5. The cask is then moved to the washdown pit and cleaned with demineralized water. Decontamination procedures can be started at this time.

6. When the cask is satisfactorily decontaminated, it is lifted out of the cask washdown pit and prepared for shipping.

During the operations, sufficient water is maintained between plant personnel and fuel assemblies that are being moved to limit dose levels to those acceptable for continuous occupational exposure.

9.1.4.2.4 Component Description

A. Fuel Transfer Tube

The fuel transfer tube penetrates the containment and spent fuel area and provides a passageway for the conveyor car during refueling. During reactor operation, the fuel transfer tube is sealed at the containment end and acts as part of the containment pressure boundary. See subsection 3.8.2.1.5 for discussion of the fuel transfer penetration.

B. Fuel Handling Machine

The fuel handling machine performs fuel handling operations in the fuel handling area. It also provides a means of tool support and operator access for long tools used in various service and handling functions.

C. New Fuel Assembly Handling Tool

The new fuel assembly handling tool is used to lift and transfer new fuel assemblies from the new fuel shipping containers to the new fuel storage racks. The tool is also used to transfer new fuel assemblies from the new fuel storage racks to the new fuel elevator.

D. Spent Fuel Assembly Handling Tool

The spent fuel assembly handling tool is used to lift and transfer spent fuel assemblies from the fuel transfer system to the spent fuel racks.

E. New Fuel Elevator Hoist

The new fuel elevator lowers new fuel assemblies from the fuel handling area operating floor into the spent fuel pool where they can be picked up by the fuel handling machine.

F. New Rod Cluster Control Handling Tool

The new rod cluster control handling tool is used to lift and transfer new control rods from their shipping containers to the new fuel assemblies, and between new assemblies in their storage racks.

G. Refueling Machine

The refueling machine performs fuel handling operations in the containment building. It also provides a means of tool support and operator access for long tools used for service, control rod latching and unlatching, and for various handling functions.

H. Burnable Poison Rod Assembly Handling Tool

The burnable poison rod assembly handling tool is used to lift and transfer burnable poison rod assemblies between assemblies and/or storage fixtures.

I. Burnable Poison Rod Assembly Rack Insert

The burnable poison rod assembly rack insert is used to store burnable poison rod assemblies or control rods in the spent fuel storage racks.

J. Fuel Transfer System

The fuel transfer system conveys fuel assemblies between the containment building and the fuel handling area.

K. Rod Cluster Control Storage Station

The rod cluster control (RCC) storage station is mounted on the reactor cavity wall and provides storage space for one rod cluster control. The rod cluster control assembly can be rotated for inspection purposes by an operator standing on the operating floor.

L. Control Rod Drive Shaft Unlatching Tool

The control rod drive shaft unlatching tool is used to latch and unlatch the control rod drive shafts from the rod cluster control assemblies. It is operated from the refueling machine walkway.

M. Control Rod Drive Shaft Handling Tool

The control rod drive shaft handling tool is used to latch and unlatch the control rod drive shafts (CRDS) from the rod cluster control assemblies.

N. Irradiation Sample Handling Tool

The irradiation sample handling tool is used to remove irradiated reactor vessel surveillance capsules in the holders located in the reactor internals. It is also used for removing and installing the irradiation sample access plugs in the reactor internals.

O. Irradiation Tube End Plug Seating Jack

The irradiation tube end plug seating jack is used to push the irradiation samples into the specimen guides for the last few inches.

P. Control Rod Drive Shaft Storage Racks

The control rod drive shaft storage racks are located on the refueling cavity wall and are used to store spare control rod drive shafts and any ones that might be removed from the upper internals during refueling.

Q. Jib Crane

The new fuel jib crane is located in the fuel handling area. It is a standard commercial jib crane with an "L" shaped frame and an electric operated hoist. It is used to move the new fuel from the new fuel storage position to the new fuel elevator. The jib crane is positioned so that it cannot reach the spent fuel storage positions. The jib crane capacity is limited to 2000 pound load.

9.1.4.3 Safety Evaluation

9.1.4.3.1 Refueling Machine

The refueling machine design includes the following provisions to provide for safe handling of fuel assemblies:

A. Safety Interlocks

Operations which could endanger the operator or damage the fuel, designated below by an asterisk (*), are prevented by mechanical or failure tolerant electrical interlocks or by redundant electrical interlocks. Other interlocks are intended to provide equipment protection and may be implemented either mechanically or by electrical interlock and are not required to be fail safe.

Fail safe electrical design of a control system interlock is applied according to the following rules:

1. Fail safe operation of an electrically operated brake is such that the brake engages on loss of power.

2. Fail safe operation of a relay is such that the de-energized state of the relay inhibits unsafe operation.

3. Fail safe operation of a switch, termination, or wire is such that breakage or high resistance of the circuit inhibits unsafe operation. The dominant failure mode of the mechanical operation of a cam-operated limit switch is sticking of the plunger in its depressed position. Therefore, use of the plunger-extended position (on the lower part of the operating cam) to energize a relay is consistent with fail safe operation.

Those parts of a control system interlock which are not or cannot be operated in a fail safe mode as defined in the preceding rules are supplemented by a redundant component or components to provide the requisite protection. Required fail safe operations are:

*1. The refueling machine can only place a fuel assembly in the core or fuel transfer system.

*2. When the refueling machine gripper is engaged, the machine can not traverse unless the gripper is fully withdrawn into the mast.

*3. When the refueling machine gripper is disengaged, the machine can not traverse unless the gripper is withdrawn into the mast.

*4. Simultaneous traversing and hoisting operations are prevented.

*5. The refueling machine is restricted to raising a fuel assembly or core component to a height at which the water provides a safe radiation shield.

*6. When a fuel assembly is raised or lowered, interlocks provide confidence that the refueling machine can only apply loads which are within safe operating limits.

*7. The fuel gripper is monitored by devices to confirm operation to the fully engaged or fully disengaged position. Alarms are actuated if both engage and disengage switches are actuated at the same time or if neither is actuated.

8. Lowering of the gripper is not permitted if slack cable exists in the hoist.

9. The gripper tube is prevented from lowering completely out of the mast.

10. Before the fuel gripper can release a fuel assembly, the fuel gripper must be in its down position in the core or in the fuel transfer system.

*11. The weight of the fuel assembly must be off the gripper before the fuel gripper can release a fuel assembly.

12. The fuel transfer system container is prevented from moving unless the engaged gripper is in the full up position or the disengaged gripper is withdrawn into the mast or unless the refueling machine is out of the fuel transfer zone. An interlock is provided from the refueling machine to the fuel transfer system to accomplish this.

B. Bridge and Trolley Hold-Down Devices

Both refueling machine bridge and trolley are horizontally restrained on the rails by guide rollers on either side of the rail. Hold down devices are used to prevent the bridge or trolley from leaving the rails in the event of a seismic event.

C. Main Hoist Braking System

The main hoist is equipped with two independent braking systems. The winch has a mechanically-operated load brake to prevent overhauling, and a solenoid activated motor brake. Both brakes are rated at 125 percent of the hoist design load.

D. Fuel Assembly Support System.

The main hoist system is supplied with redundant paths of load support such that failure of any one component will not result in free fall of the fuel assembly. Two wire ropes are anchored to the winch drum and carried to a load equalizing mechanism on the top of the gripper tube.

The fuel assembly gripper has four fingers gripping the fuel, any two of which will support the fuel assembly weight.

During each refueling outage and prior to removing fuel, the gripper and hoist system are routinely load tested to 125 percent of the maximum setting on the hoist load limit switch.

9.1.4.3.2 Fuel Transfer System

The following personnel safety features are provided for in the fuel transfer system:

A. Transfer Car Permissive Switch

The transfer car controls are located in the fuel handling area, and conditions in the containment are therefore not visible to the operator. The transfer car permissive switch allows the fuel transfer system containment operator to exercise some control over car movement if conditions visible to him warrant such control.

B. Lifting Arm - Transfer Car Position

An interlock on the fuel transfer system prevents the upender from being moved from the horizontal to the vertical position if the transfer car has not reached the end of its travel.

C. Transfer Car - Valve Open

An interlock on the transfer tube valve permits transfer car operation only when the transfer tube valve position switch indicates the valve is fully open.

D. Fuel Container - Refueling Machine

The fuel transfer system is interlocked with the refueling machine. Whenever the transfer car is located in the refueling cavity, the fuel transfer system cannot be operated unless the refueling machine mast is in the fully retracted position, the refueling machine is over the core, or the gripper is released and inside the core.

E. Lifting Arm - Fuel Handling Machine

On the spent fuel pool side, the fuel transfer system is interlocked with the fuel handling machine. The fuel transfer system cannot be operated until the fuel handling machine is moved away from the fuel transfer system area.

9.1.4.3.3 Fuel Handling Machine

The fuel handling machine is the same design as the refueling machine and includes the same safety features.

9.1.4.3.4 Fuel Handling Tools and Equipment

Fuel handling tools and equipment handled over an open reactor vessel are designed to prevent inadvertent decoupling from machine hooks; i.e., lifting rigs are pinned to the machine hook, and safety latches are provided on hook supporting tools.

Tools required for handling internal reactor components are designed with fail safe features that prevent disengagement of the component in the event of operating mechanism malfunction.

These safety features apply to the following tools:

A. Control Rod Drive Shaft Unlatching Tool

The air cylinders actuating the gripper mechanism are equipped with backup springs which close the gripper in the event of loss of air to the cylinder. Air-operated valves are equipped with safety locking rings to prevent inadvertent actuation.

B. New Fuel Assembly Handling Tool

When the fingers are latched, the actuating handle is positively locked, preventing inadvertent actuations. The tool is preoperationally tested at 125 percent of the weight of one fuel assembly.

9.1.4.3.5 Seismic Considerations

The equipment classifications for fuel handling and storage equipment are listed in Section 3.2, which provides criteria for the seismic design of the various components.

For safety and non-safety equipment, design for the safe shutdown earthquake (SSE) is considered if failure might adversely affect safety-related equipment.

9.1.4.3.6 Containment Pressure Boundary Integrity

The fuel transfer tube which connects the refueling cavity (inside the containment) and the fuel storage area (outside the containment) is closed on the refueling cavity side by a hatch except during refueling operations. Two seals are located around the periphery of the hatch with leak-check provisions between them.

9.1.4.3.7 Radiation Shielding

During spent fuel transfer, the gamma dose rate at the surface of the water is 20 millirem/hour or less. This is accomplished by maintaining a minimum of 10 feet of water above the top of the active fuel height during handling operations.

The three fuel handling devices used to lift spent fuel assemblies are the refueling machine, fuel handling machine, and the spent fuel handling tool. Both the refueling machine and fuel handling machine contain positive stops which prevent the fuel assembly from being raised above a safe shielding height.

9.1.4.4 Inspection and Testing Requirements

The test and inspection requirements for the equipment in the light load handling system are as follows:

A. Fuel Handling Machine, Refueling Machine, and New Fuel Elevator

The minimum acceptable tests include the following:

- Hoist and cable are load tested at 125 percent of the rated load.
- The equipment is assembled and checked for function and operation.

The following maintenance and checkout tests are recommended to be performed prior to refueling:

- Visual inspection for loose or foreign parts; maintenance to keep free of dirt and grease.
- Lubrication of exposed gears with proper lubricant.
- Visual inspection of hoist cables for worn or broken strands.
- Visual inspection of limit switches and limit switch actuators for any sign of damaged or broken parts.
- Inspection of the equipment for function and operation.

B. New Fuel Assembly Handling Tool

The minimum acceptable tests are as follows:

- The tool shall be load tested to 125 percent of the rated load.
- The tool is assembled and checked for operation.

The following maintenance and checkout tests are recommended to be performed prior to use of the tools:

- Visual inspection of the tool for dirt and loose hardware and for any signs of damage such as nicks and burrs.
- Check of the tool for operation.

C. Fuel Transfer System

The minimum acceptable test is that the system is assembled and checked for function and operation.

The following maintenance and checkout tests are recommended to be performed prior to refueling:

- Visual inspection for loose or foreign parts; maintenance to keep free of dirt and grease.
- Lubrication of exposed gears.
- Visual inspection of limit switches and limit switch actuators for any sign of damaged or broken parts.
- Check of system for function and operation.

9.1.5 Overhead Heavy Load Handling Systems

Heavy load handling systems consist of equipment which lift loads whose weight is greater than the combined weight of a single spent fuel assembly and its handling device. This equipment is part of the mechanical handling system (MHS) and is located throughout the plant. The principal equipment is the containment polar crane and the spent fuel shipping cask crane. Other such equipment includes the reactor coolant pump handling machine, bridge cranes, miscellaneous monorail hoists and fixed hoists. Table 9.1-5 lists the heavy load handling systems located in the safety-related areas of the plant, specifically the nuclear island.

For AP1000, a heavy load is a load whose weight is greater than the combined weight of a fuel assembly with rod cluster control, and the associated handling device, consisting of the inner mast of the fuel handling machine and the fuel gripper assembly. This combined weight is about 3100 pounds. Thus, a heavy load is defined as a load weighing more than 3100 pounds.

9.1.5.1 Design Basis

9.1.5.1.1 Safety Design Basis

Section 3.2 identifies safety and seismic classifications for mechanical handling system equipment. Heavy load handling systems are generally classified as nonsafety-related, nonseismic systems. The components of single-failure-proof systems necessary to prevent uncontrolled lowering of a critical load are classified as safety-related.

The polar crane and the equipment hatch hoists are single-failure-proof systems and are classified as seismic Category I. They are designed to support a critical load during and after a safe shutdown earthquake. Although not single-failure-proof, the maintenance hatch hoist is classified as seismic Category I. The equipment and maintenance hatches are required to be operational after a safe shutdown earthquake.

A critical load is a heavy load that, if dropped, could cause unacceptable damage to reactor fuel elements, or loss of safe shutdown or decay heat removal capability. The consequences of a postulated load drop are considered to be acceptable when the four evaluation criteria of NUREG-0612 (Reference 8), Paragraph 5.1, are satisfied.

Heavy loads handled in safety-related areas of the plant are classified as critical loads unless the consequences of a load drop have been evaluated and found to be within acceptable limits. (See subsection 9.1.5.3.)

Plant arrangement and the design of heavy load handling systems are based on the following criteria:

- To the extent practicable, heavy loads are not carried over or near safety-related components, including irradiated fuel and safe shutdown components. Safe load paths are designated for heavy load handling in safety-related areas.
- The likelihood of a load drop is extremely small (that is, the handling system is single failure proof), or the consequences of a postulated load drop are within acceptable limits.
- Single-failure-proof systems can stop and hold a critical load following the credible failure of a single component.
- Single-failure-proof systems can support a critical load during and after a safe shutdown earthquake.

9.1.5.1.2 Codes and Standards

The mechanical handling system conforms to the applicable codes and standards listed in Section 3.2. Overhead cranes are designed according to ASME NOG-1 (Reference 12). Other cranes and hoists handling heavy loads are designed according to the applicable ANSI standard.

NUREG-0612 references ANSI B30.2 (Reference 9) and CMAA-70 (Reference 7) for the design of cranes in safety-related areas, and references NUREG-0554 (Reference 11) for the design of single-failure-proof cranes. The design of AP1000 cranes is based on ASME NOG-1 (Reference 12) and complies with the requirements of NUREG-0612. ASME NOG-1 also provides design guidance consistent with that provided by NUREG-0554 for the design of single-failure-proof cranes.

The spent fuel shipping cask crane is designed according to the requirements of ASME NOG-1 for a Type III crane. The spent fuel shipping cask crane is also designed to meet the applicable requirements of ANSI/ANS-57.1 (Reference 6) and ANSI/ANS-57.2 (Reference 4), except as described in Table 9.1.5-1.

9.1.5.2 System Description

Table 9.1-5 lists heavy load handling systems in the nuclear island. The polar crane is designed according to the requirements of ASME NOG-1 for a Type I, single-failure-proof crane. A description of the polar crane is provided in this subsection. The equipment hatch hoist system incorporates single-failure-proof features based on NUREG-0612 guidelines. Based on the conservative design of these heavy load handling systems and associated special lifting devices, slings and load lift points (See subsection 9.1.5.2.3), a load drop of the critical loads handled by the polar crane or the equipment hatch hoist is unlikely. Except for the containment polar crane and the equipment hatch hoists, the heavy load handling systems are not single-failure-proof.

9.1.5.2.1 General Description

The containment polar crane is a bridge crane mounted on a circular runway rail supported by the containment structure. The bridge consists of two welded steel box girders held together with structural end beams. The two end beams are supported by wheeled trucks that travel on top of the runway rail.

The trolley is mounted on wheeled trucks which move by tractive power over rails secured to the crane girders. The trolley provides structural support for the crane hoisting machinery. Devices are installed to preclude derailment of the bridge or trolley under seismic loading.

Two electric-powered hoists are provided, a main hoist and an auxiliary hoist. Each hoist raises and lowers loads by reeving wire rope through upper and lower sheaves. The lower sheaves are an integral part of the load block. A hook is attached to each load block.

9.1.5.2.2 System Operation

The polar crane lifts a variety of loads for refueling and maintenance, such as the reactor vessel integrated head package, reactor internals, and the reactor coolant pump components. The crane is designed to withstand the containment environmental conditions during all modes of plant operation, including pressurization and depressurization of the containment. The crane is designed to operate only during shutdown periods.

Movements of the bridge, trolley, main, and auxiliary hoists can be controlled from the operator's cab or from a pendant suspended from the crane. Both the pendant and cab controls include a main power control switch. The pendant is equipped with a keylock switch that inhibits control from the cab. Motion control push buttons in the cab and on the pendant return to the OFF position when released.

Bridge, trolley, and hoist speeds, and speed controls are in accordance with ASME NOG-1. All speeds are variable. Speed controls permit precise positioning of the load.

The crane can be used for steam generator replacement. The structural design of the bridge is sufficient to support the steam generator, which is a noncritical load. A special hoist on a temporary trolley may be used for the steam generator replacement. Steam generator replacement is not intended to be accomplished with single-failure-proof equipment.

9.1.5.2.3 Component Descriptions

The polar crane is designed according to ASME NOG-1. Table 9.1.5-3 lists the design characteristics of these cranes. This subsection describes how the code requirements are implemented in the design of key safety-related components. Associated lifting devices and load lift points are also described.

Main Hoist Systems

The hoisting rope is wound around the drum in a single layer. If the rope becomes dislodged from its proper groove, the crane drives are automatically shut down and the brakes are set. Features are

also provided to contain the drum and prevent disengagement of the gearing in the event of drum shaft or bearing failure. A control brake and two redundant holding brakes are provided.

Two separate, redundant reeving systems are used, so that a single rope failure will not result in the dropping of the load. Two wire ropes are reeved side-by-side through the upper and lower sheaves. Each cable passes through an equalizer that adjusts for unequal cable length. The equalizer is also a load transfer safety system, eliminating sudden load displacement and shock to the crane in the unlikely event of a cable break. In the event of hook overtravel to the point where the load block contacts the crane structure, the ropes cannot be cut or crushed.

The load block provides two separate load attachment points; the main hook is a two-pronged, sister hook with safety latches.

Auxiliary Hoist System

The auxiliary hoist system is similar to that of the main hoist.

Special Lifting Devices

Special lifting devices for critical and non-critical loads are designed to meet the applicable requirements of ANSI N14.6 (Reference 14). The stress design safety factors are based on the combined maximum static and dynamic loads that could be imparted to the handling device, based on the characteristics of the crane. Special lifting devices used for the handling of critical loads are listed in Table 9.1.5-2.

Lifting Devices Not Specially Designed

Slings or other lifting devices not specially designed are selected in accordance with ANSI B30.9 (Reference 15), except that the load rating is based on the combined maximum static and dynamic loads that could be imparted to the sling.

For the handling of critical loads, dual or redundant slings are used, or a sling having a load rating twice that required for a non-critical load is used.

Load Lift Points

The design stress safety factors for heavy load lift points, such as lifting lugs or cask trunnions, are consistent with the safety factors used for special lifting devices. The design of lift points for critical loads is in accordance with NUREG-0612, Paragraph 5.1.6.(3).

9.1.5.2.4 Instrumentation Applications

Limit switches are used to initiate protective responses to:

- Hoist overtravel
- Hoist overspeed
- Hoist overload or unbalanced load

- Improper winding of hoist rope on the drum
- Bridge or trolley overtravel

Redundant limit switches are used with the main hoist and the auxiliary hoists to limit the extent of travel in both the hoisting and lowering directions. The primary protection for each hoist in each direction is a limit switch which interrupts power to the hoist motor via the control circuitry. Interruption of power to the hoist motor causes the hoist brakes to set. The hoist may be operated in the safe direction to back out of the overtravel condition.

The secondary protection for each hoist in the raising direction is a block-actuated limit switch which directly interrupts power to the hoist motor and the hoist brakes, causing the brakes to set. The secondary protection for each hoist in the lowering direction is a limit switch which is mechanically and electrically independent of the primary switch but also interrupts power to the hoist motor via the control circuitry. Actuation of the secondary limit switches prevents further hoisting or lowering until specific corrective action is taken.

A centrifugal-type limit switch, located on the drum shaft, provides overspeed protection for each hoist. Hoist speeds in excess of 115 percent of the rated lowering speed for a critical load cause the hoist motor to stop and the holding brakes to set.

A load-sensing system is used to detect overloading of the hoists. Hoisting motion is stopped when the overload setpoint is exceeded. Similarly, an unbalanced load is detected by a system that stops the hoist motion when there is excessive movement of the equalizer mechanism.

A level wind limit switch is provided to detect improper threading of the hoist rope in the drum grooves. This switch stops crane drive motors and sets the brakes. Further hoisting or lowering is prevented until specific corrective action is taken.

End-of-travel limit switches are provided for the trolley. These switches are set to trip just before the trolley comes into contact with the bumper, thus providing confidence that the kinetic energy of the trolley is within the energy-absorbing capacity of the bumpers.

9.1.5.3 Safety Evaluation

The design and arrangement of heavy load handling systems promotes the safe handling of heavy loads by one of the following means:

- A single-failure-proof system is provided so that a load drop is unlikely.

- The arrangement of the system in relationship to safety-related plant components is such that the consequences of a load drop are acceptable per NUREG 0612. Postulated load drops are evaluated in the heavy loads analysis.

The polar crane and the equipment hatch hoist systems are single failure proof. These systems stop and hold a critical load following the credible failure of a single component. Redundancy is provided for load bearing components such as the hoisting ropes, sheaves, equalizer assembly, hooks, and holding brakes. These systems are designed to support a critical load during and after a safe shutdown earthquake. The seismic Category I equipment and maintenance hatch hoist

systems are designed to remain operational following a safe shutdown earthquake. The polar crane is designed to withstand rapid pressurization of the containment during a design basis loss of coolant accident or main steam line break, without collapsing.

The spent fuel shipping cask storage pit is separated from the spent fuel pool. The spent fuel shipping cask crane cannot move over the spent fuel pool because the crane rails do not extend over the pool. Mechanical stops prevent the spent fuel shipping cask crane from going beyond the ends of the rails.

A heavy loads analysis is performed to evaluate postulated load drops from heavy load handling systems located in safety-related areas of the plant, specifically the nuclear island. No evaluations are required for critical loads handled by the containment polar crane or the equipment hatch hoists, since a load drop is unlikely.

The heavy loads analysis is to confirm that a postulated load drop does not cause unacceptable damage to reactor fuel elements, or loss of safe shutdown or decay heat removal capability.

9.1.5.4 Inservice Inspection/Inservice Testing

Preoperational inspection and testing of overhead cranes is governed by ASME NOG-1. Tests include operational testing with 100 percent load to demonstrate function and speed controls for bridge, trolley, and hoist drives and proper functioning of limit switches, locking, and safety devices. A rated load test is performed with a 125 percent load.

Following plant startup, inservice inspection of overhead cranes is governed by site-specific procedures in accordance with ANSI B30.2. Testing of crane modifications is governed by ASME NOG-1. Inservice inspection and testing of other cranes and hoists is in accordance with manufacturer's recommendations and applicable industry standards.

In-service inspection and testing of special lifting devices and slings used in safety-related areas of the plant are in accordance with ANSI N14.6 and ANSI B30.9.

9.1.6 Combined License Information for Fuel Storage and Handling

The Combined License applicant is responsible for a confirmatory structural dynamic and stress analysis for the new fuel rack, as described in subsection 9.1.1.2.1.

The Combined License applicant is responsible for a confirmatory criticality analysis for the new fuel rack, as described in subsection 9.1.1.3. This analysis should address the degradation of integral neutron absorbing material in the new fuel pool storage racks as identified in GL-96-04, and assess the integral neutron absorbing material capability to maintain a 5-percent subcriticality margin.

The Combined License applicant is responsible for a confirmatory structural dynamic and stress analysis for the spent fuel racks, as described in subsection 9.1.2.2.1. This includes reconciliation of loads imposed by the spent fuel racks on the spent fuel pool structure described in subsection 3.8.4.

The Combined License applicant is responsible for a confirmatory criticality analysis for the spent fuel racks, as described in subsection 9.1.2.3. This analysis should address the degradation of integral neutron absorbing material in the spent fuel pool storage racks as identified in GL-96-04, and assess the integral neutron absorbing material capability to maintain a 5-percent subcriticality margin.

The Combined License applicant is responsible for a program for inservice inspection of the light load handling system as specified in subsection 9.1.4.4 and the overhead heavy load handling system in accordance with ANSI B30.2, ANSI B30.9, ANSI N14.6, and ASME NOG-1 as specified in subsection 9.1.5.4.

The Combined License applicant/holder is responsible to ensure an operating radiation monitor is mounted on any crane or fuel handling machine when it is handling fuel.

9.1.7 References

1. ANSI N16.1-75, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.
2. ANSI N16.9-75, Validation of Calculational Methods for Nuclear Criticality Safety.
3. ANSI N210-76, Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations.
4. ANS 57.2-1983, Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants.
5. Nuclear Regulatory Commission letter to All Power Reactor Licensees, from B. K. Grimes, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," April 14, 1978.
6. ANS 57.1-1992, Design Requirements for Light Water Reactor Fuel Handling Systems.
7. Specifications for Electric Overhead Travelling Cranes CMAA, Specification 70 - 1999.
8. USNRC, "Control of Heavy Loads at Nuclear Power Plants," NUREG-0612, July 1980.
9. "Overhead and Gantry Cranes," ANSI/ASME B30.2-1990.
10. Deleted.
11. USNRC, "Single-Failure-Proof Cranes for Nuclear Power Plants," NUREG-0554, May 1979.
12. "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)," ASME NOG-1-1998.
13. Deleted.

14. "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More," ANSI N14.6-1993.

15. "Slings," ASME/ANSI B30.9-1996.

Table 9.1-1

LOADS AND LOAD COMBINATIONS FOR FUEL RACKS

Load Combination
D + L
$D + L + T_o$
$D + L + T_o + P_f$
$D + L + T_a + E'$

Notes:

1. The abbreviations in the table above are those used in NUREG-0800, Section 3.8.4 of the Standard Review Plan (SRP) where each term is defined except for T_a and P_f.

   The term T_a is defined here as the thermal loads due to highest temperature associated with the postulated abnormal design conditions. The term P_f is the uplift force on the rack caused by a postulated stuck fuel assembly accident condition.

2. For the faulted load combination, thermal loads will be neglected when they are secondary and self limiting in nature and the material is ductile.

Table 9.1-2

SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM DESIGN PARAMETERS

Spent fuel pool storage capacity	10 yrs spent fuel plus one core
Spent fuel pool water volume (including racks without fuel at water level of 2 foot 6 inch below the operating deck) (gallons)	181,000
Fuel transfer canal, including gate, water volume (gallons)	64,100
Minimum combined volume of spent fuel pool and fuel transfer canal above fuel to elevation 6 feet below the operating deck) (gallons)	46,700
Minimum volume of the cask washdown pit (gallons)	30,900
Nominal boron concentration of water (ppm)	2500
Maximum normal refueling case (full core offload) Water temperature with one spent fuel cooling system cooling train and one normal residual heat removal system cooling train in operation (°F)	<140
Maximum emergency core unload case Water temperature with both spent fuel cooling system cooling trains and one normal residual heat removal system cooling train in operation (°F)	<140

Table 9.1-3 (Sheet 1 of 2)

**COMPONENT DATA –
SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM**

Spent Fuel Pool Pump		
Number		2
Design pressure (psig)		150
Design temperature (°F)		250
Nominal flow (gallons/minute)		1200
Minimum flow to support normal cooling (gpm)		900
Material		Stainless Steel
Spent Fuel Pool Heat Exchangers		
Number		2
Type		Plate
Design heat transfer (Btu/hour)		14.75×10^6
Design capacity (Btu/hour-°F)		24.0×10^5
Minimum capacity to support normal cooling (Btu/hour-°F)		22.0×10^5
	Side 1	**Side 2**
Design pressure (psig)	150	150
Design temperature (°F)	250	250
Nominal flow (pounds/hour)	6.23×10^5	5.94×10^5
Inlet temperature (°F), typ.	89.5	120
Outlet temperature (°F), typ.	113.3	95.1
Fluid circulated	Component cooling water	Spent fuel pool water
Material	Stainless steel	Stainless steel
Spent Fuel Pool Demineralizers		
Number		2
Design pressure (psig)		150
Design temperature (°F)		200
Nominal flow (gallons/minute)		250
Nominal resin volume (cubic feet)		75
Material		Stainless steel

Table 9.1-3 (Sheet 2 of 2)

COMPONENT DATA – SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM

Spent Fuel Pool Filter	
Number	2
Design pressure (psig)	150
Design temperature (°F)	250
Nominal flow (gallons/minute)	250
Filtration requirement	98% retention of particles above 5 μm
Material, vessel	Stainless steel

Table 9.1-4

STATION BLACKOUT/SEISMIC EVENT TIMES(1)

Event	Time to Saturation(1) (hours)	Height of Water Above Fuel at 72 Hours(4) (feet)	Height of Water Above Fuel at 7 Days(4) (feet)
Seismic Event(2) – Power Operation Immediately Following a 44% Core (68 Fuel Assemblies) Refueling	8.8	4.6	4.6(6)
Seismic Event(8) – Refueling, Immediately Following a 44% Core (68 Fuel Assemblies) Offload(3)	6.4	8.3(5)	8.3(5)
Seismic Event(7) – Refueling, Full Core Off-Load(3) Immediately Following a 44% Core (68 Fuel Assemblies) Refueling	2.5	8.3(5)	8.3(6)

Notes:
1. Times calculated neglect heat losses to the passive heat sinks in the fuel area of the auxiliary building.
2. Seismic event assumes water in the pool is initially drained to the level of the spent fuel pool cooling system connection simultaneous with a station blackout. Fuel cooling water sources are spent fuel pool, fuel transfer canal (including gate), and cask washdown pit for 72 hours. Between 72 hours and 7 days fuel cooling water provided from passive containment cooling system ancillary water storage tank.
3. Fuel movement complete, 150 hours after shutdown.
4. See subsection 9.1.3.5 for minimum water level.
5. Alignment of PCS water storage for supply of makeup water permits maintaining pool level at this elevation. Decay heat in reactor vessel is less that 9 MW, thus no PCS water is required for containment cooling.
6. Alignment of the PCS ancillary water storage tank and initiation of PCS recirculation pumps provide a makeup water supply to maintain this pool level or higher above the top of the fuel.
7. Seismic event assumes water in the pool is initially drained to the level of the spent fuel pool cooling system connection simultaneous with a station blackout. Fuel cooling water sources are spent fuel pool, fuel transfer canal (including gate), cask washdown pit, and passive containment cooling system water storage tank for 72 hours. Between 72 hours and 7 days fuel cooling water provided from passive containment cooling system water storage tank and passive containment cooling system ancillary water storage tank.
8. Seismic event assumes water in the pool is initially drained to the level of the spent fuel pool cooling system connection simultaneous with a station blackout. Fuel cooling water sources are spent fuel pool, fuel transfer canal (including gate), cask washdown pit, and passive containment cooling system water storage tank for 7 days.

Table 9.1-5

NUCLEAR ISLAND HEAVY LOAD HANDLING SYSTEMS[1]

Name	Crane/Hoist Type	Location (Building)	Maximum Load Rating (tons)
Containment Polar Crane	Overhead bridge	Containment	275[2]
Equipment Hatch Hoist	Fixed hoist	Containment	10
Maintenance Hatch Hoist	Fixed hoist	Containment	10
Spent Fuel Shipping Cask Crane	Overhead bridge	Auxiliary	150
MSIV Monorails Hoist A	Monorail hoists	Auxiliary	2
MSIV Monorails Hoist B	Monorail hoists	Auxiliary	2

Notes:
1. Nuclear island elevators are discussed in the heavy loads analysis.
2. Trolley maximum load rating for a critical load.

Table 9.1.5-1 (Sheet 1 of 2)

SPENT FUEL SHIPPING CASK CRANE COMPLIANCE WITH ANSI/ANS-57.1 AND ANSI/ANS-57.2

The design of the spent fuel shipping cask crane meets the applicable provisions of ANSI/ANS-57.1-1992, R1998 and ANSI/ANS-57.2-1983, except as described below.

ANSI/ANS-57.1		Exceptions and Clarifications
6.3.1.1	Interlock Protection	Interlocks are provided in accordance with the applicable provisions of ASME NOG-1 for a Type III crane.
6.3.1.6	Emergency shutdown capability	A motor power circuit disconnect device is provided.
6.3.3.1	Parts retainers	Retaining devices are generally not provided because the crane cannot travel over the spent fuel pool.
6.3.3.2	Fastener locking devices	Fastener locking devices are provided in accordance with the applicable provisions of ASME NOG-1.
6.3.3.10	Lubricant Collection	Methods for lubricant collection are provided in accordance with the applicable provisions of ASME NOG-1.
6.3.3.22	Materials and design stresses	Material selection and allowable design stresses are in accordance with the applicable provisions of ASME NOG-1.
6.3.3.23	Joint and weld details	Joint and weld details are in accordance with the applicable provisions of ASME NOG-1.
6.3.4.1.9	Overload switch reset	Overload switch function not provided.
6.4.2.1.9	Wiring connections	Electrical wiring connections are provided in accordance with the applicable provisions of ASME NOG-1.

Table 9.1.5-1 (Sheet 2 of 2)

SPENT FUEL SHIPPING CASK CRANE
COMPLIANCE WITH ANSI/ANS-57.1 AND ANSI/ANS-57.2

ANSI/ANS-57.2		Exceptions and Clarifications
6.2.1	Codes and standards	The cask crane is designed in accordance with later industry standards as described in subsection 9.1.5.1.2.
6.2.2.8	Height limits	The height of a postulated cask drop is limited by the crane configuration. A hoist high limit switch is also provided.
6.2.4.1	Testing, maintenance & inspection	Applicable codes for inspection and testing are described in subsection 9.1.5.4.
6.2.5	Design documentation	Documentation maintenance and verification are in accordance with the applicable provisions of ASME NOG-1.
6.5.2.9	Spent fuel pool interlocks	The spent fuel shipping cask crane cannot move over the spent fuel pool because the crane rails do not extend over the pool. Mechanical stops prevent the spent fuel shipping cask crane from going beyond the ends of the rails.

Table 9.1.5-2

SPECIAL LIFTING DEVICES USED FOR THE HANDLING OF CRITICAL LOADS

Polar Crane Special Lifting Devices	Description
Integrated head package (IHP)	The IHP combines several separate components into an integral unit. It incorporates the lifting device that provides the interface between the polar crane and the reactor vessel head.
Reactor internals lifting rig	The reactor internals lifting rig is a three-legged carbon steel and stainless steel structure that is attached to the main hook for handling of the upper and lower reactor internals packages.
Reactor coolant pump (RCP)	The RCP handling machine is used for removal of the RCP motor and hydraulic elements from the pump casing. The pump/motor shell includes lifting lugs which are attached to a lifting device to allow the RCP motor and hydraulic elements to be handled by the polar crane auxiliary hook.

Table 9.1.5-3

POLAR CRANE COMPONENT DATA

Bridge	
Bridge span	See Figure 1.2-12
Travel speed	See Note 1
Braking systems (type)	Service, parking and emergency
Trolley	
Travel speed	See Note 1
Braking systems (type)	Service, parking and emergency
Main Hoist	
Approximate capacity	See Table 9.1-5
Hook speed	See Note 1
Approximate hook travel (elevation)	To reactor vessel internals
Load brakes (type and number)	Electric (one)
Holding brakes (type and number)	Friction (two)
Auxiliary Hoist	
Approximate capacity	75 tons
Hook speed	See Note 1
Approximate hook travel (elevation)	To reactor coolant pump
Load brakes (type and number)	Electric (one)
Holding brakes (type and number)	Friction (two)

<u>Note:</u>
1. Bridge, trolley and hoist speeds are within the recommended ranges of ASME NOG-1.

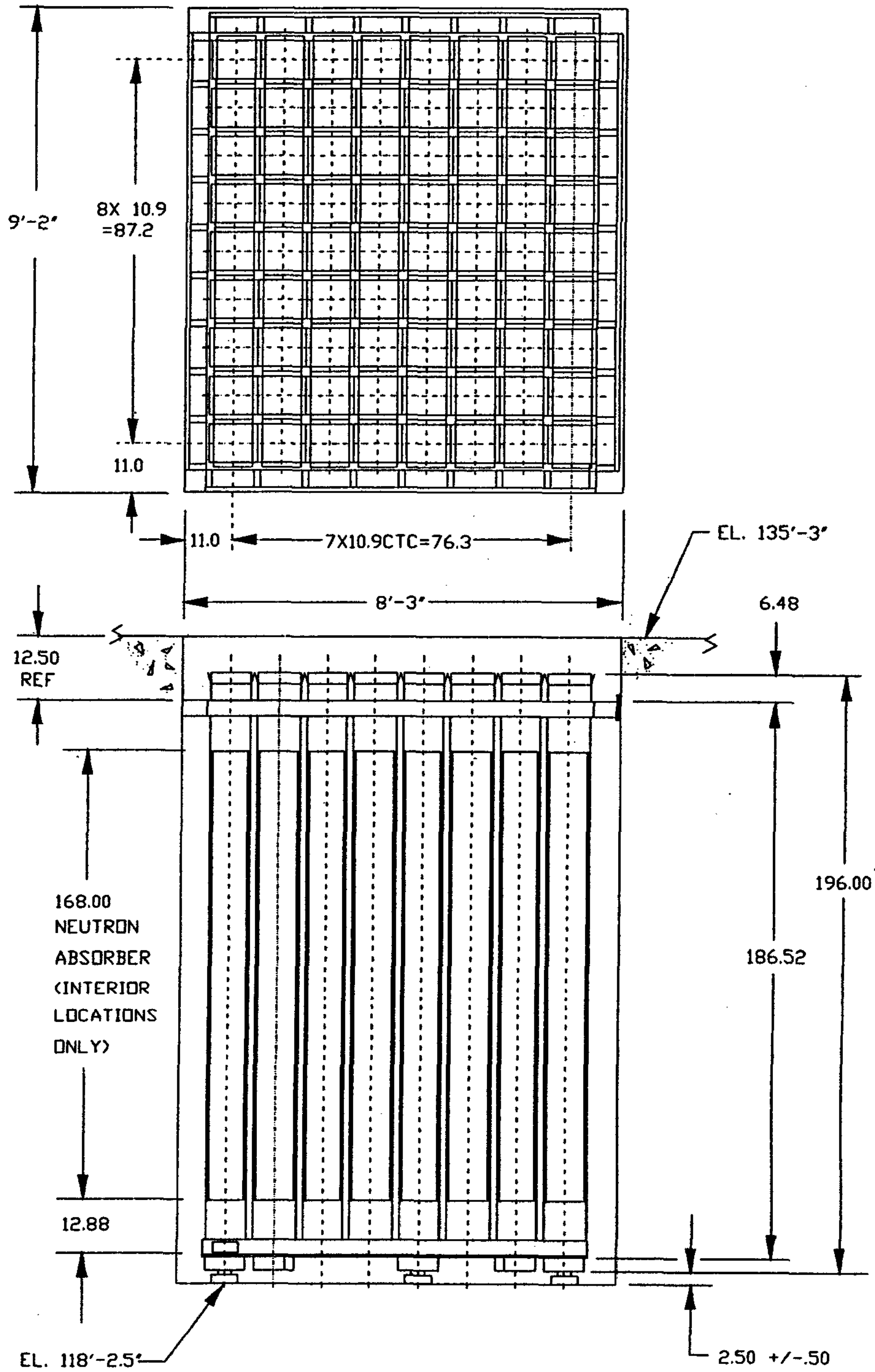

Figure 9.1-1

New Fuel Storage Rack Layout

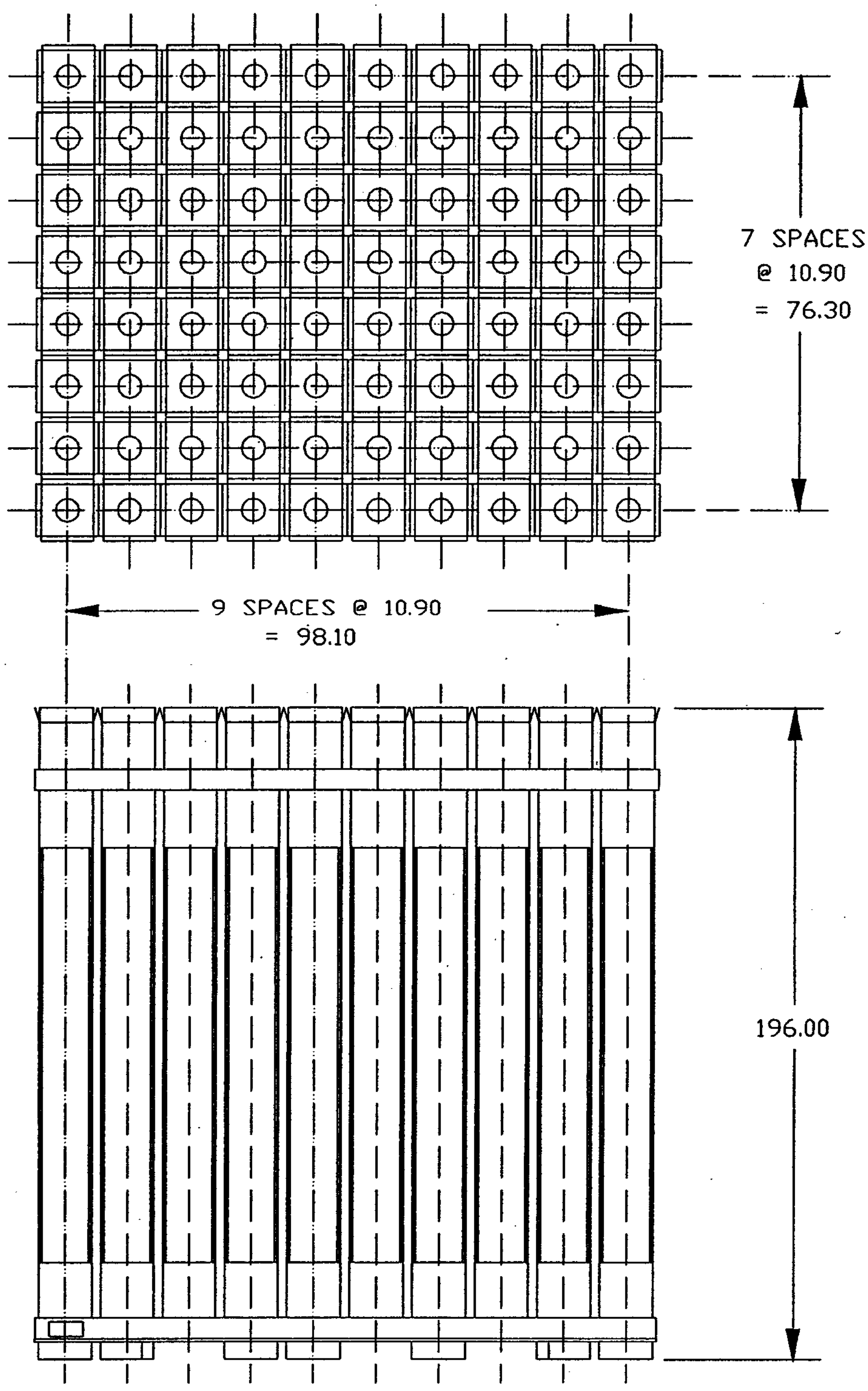

Figure 9.1-2 (Sheet 1 of 2)

Spent Fuel Storage Rack Array

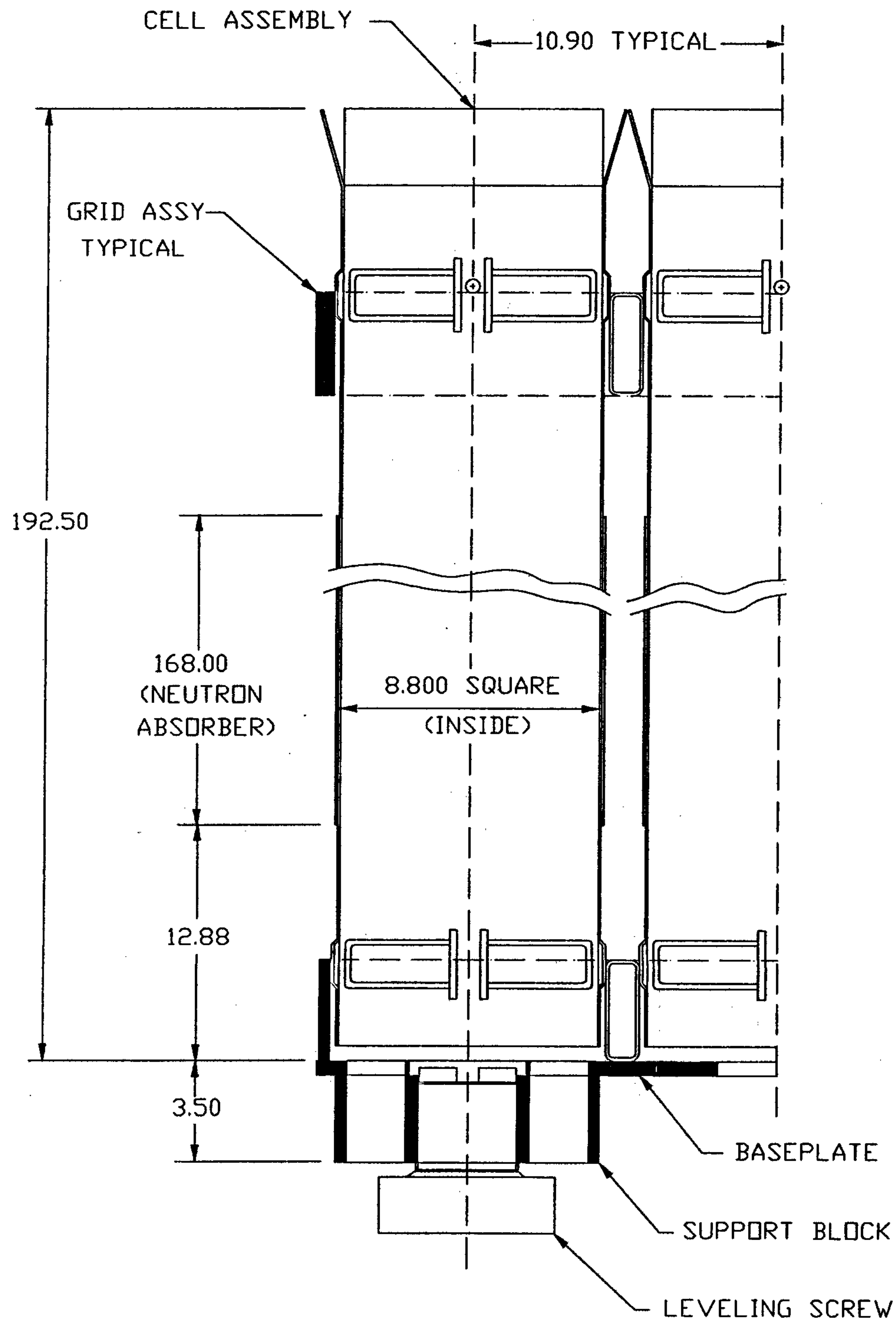

Figure 9.1-2 (Sheet 2 of 2)

Spent Fuel Storage Rack Array, Cross Section

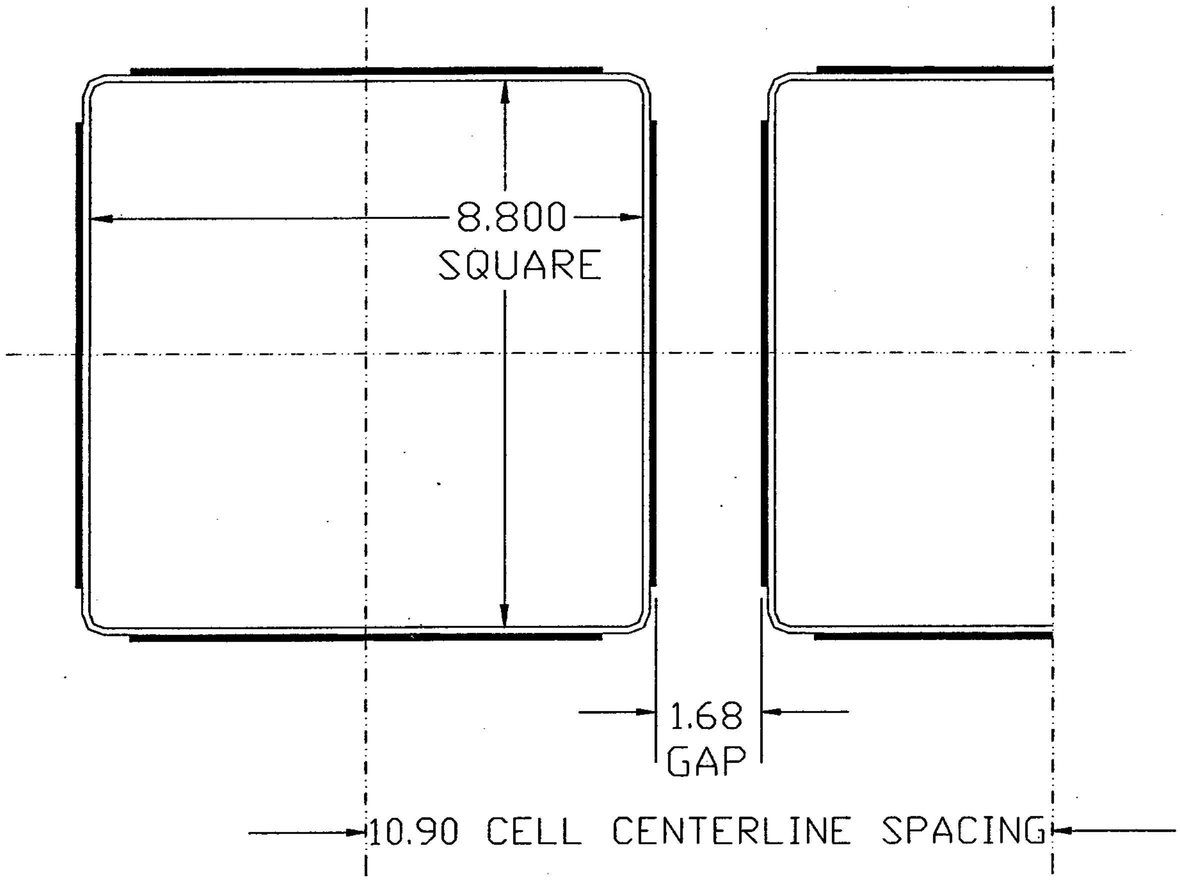

Figure 9.1-3

Spent Fuel Storage Rack Nominal Dimensions

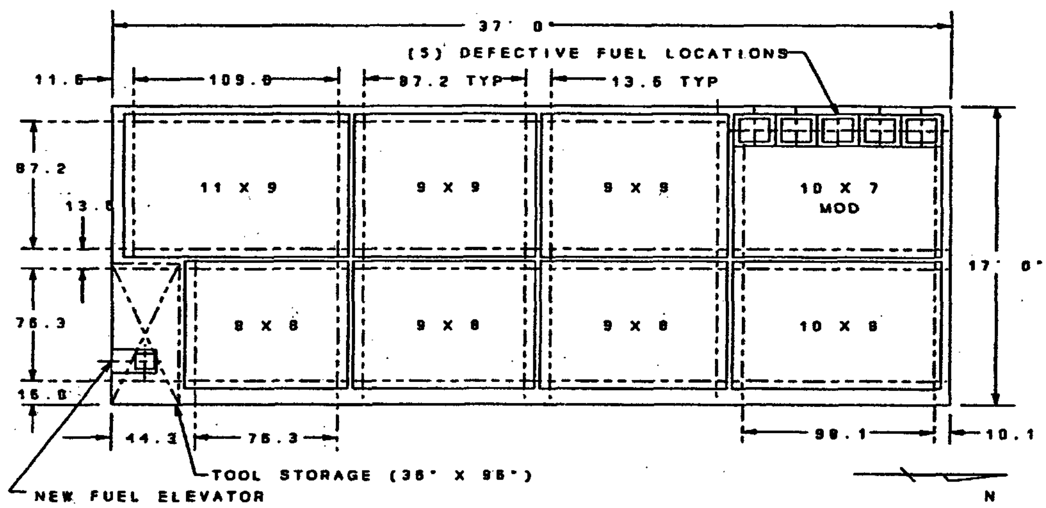

Figure 9.1-4

Spent Fuel Storage Pool Layout

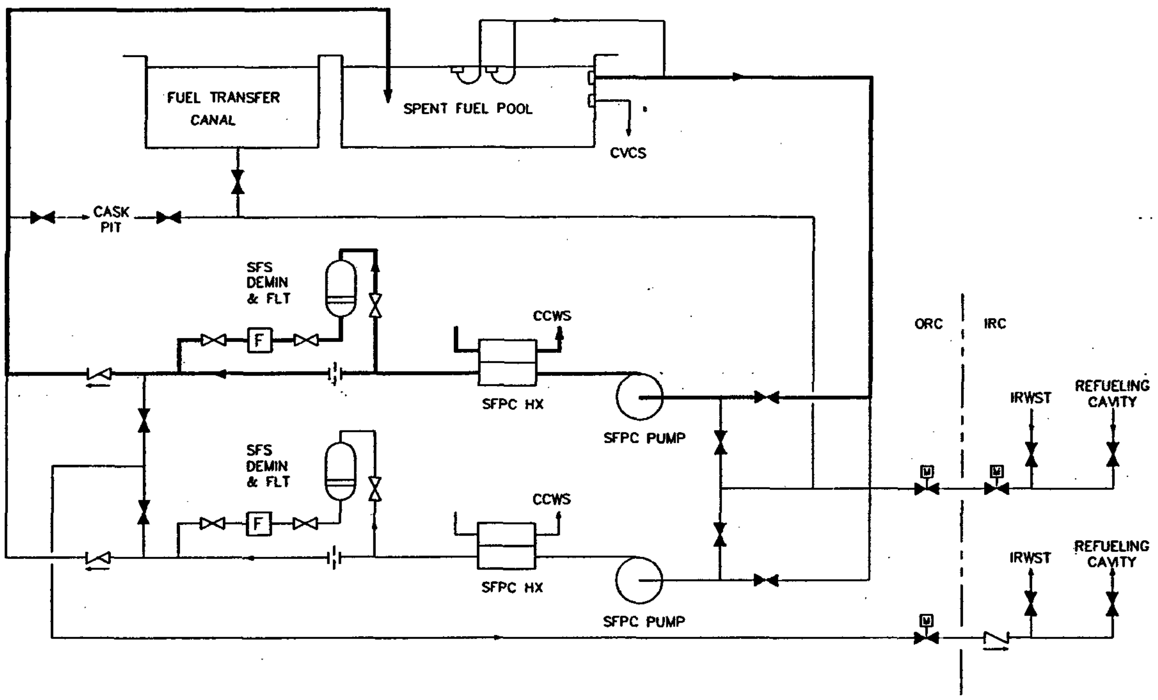

Figure 9.1-5

Spent Fuel Pool Cooling System (Normal Operation)

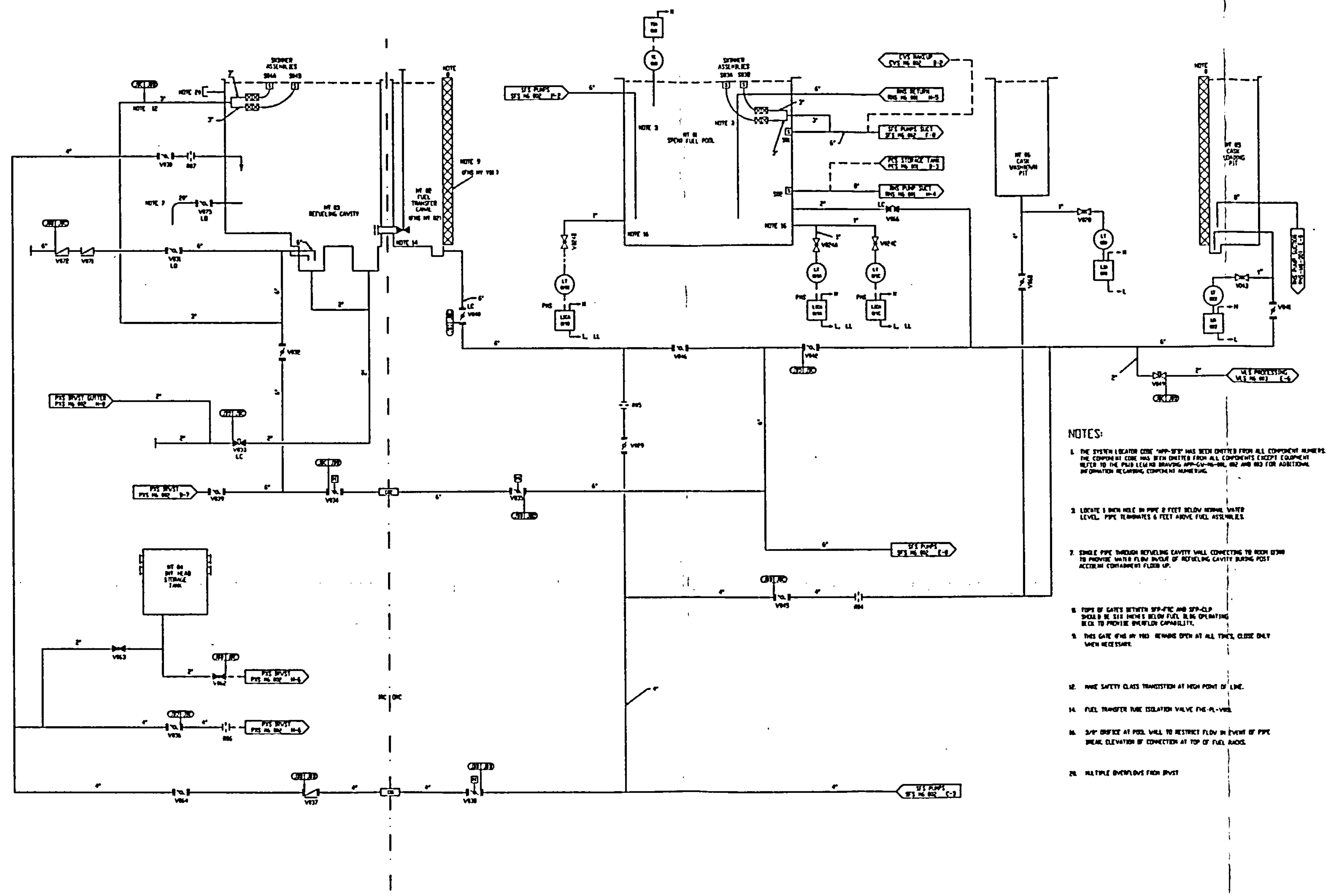

Figure 9.1-6 (Sheet 1 of 2)

Spent Fuel Pool Cooling System Piping and Instrumentation Diagram

(REF) SFS 001

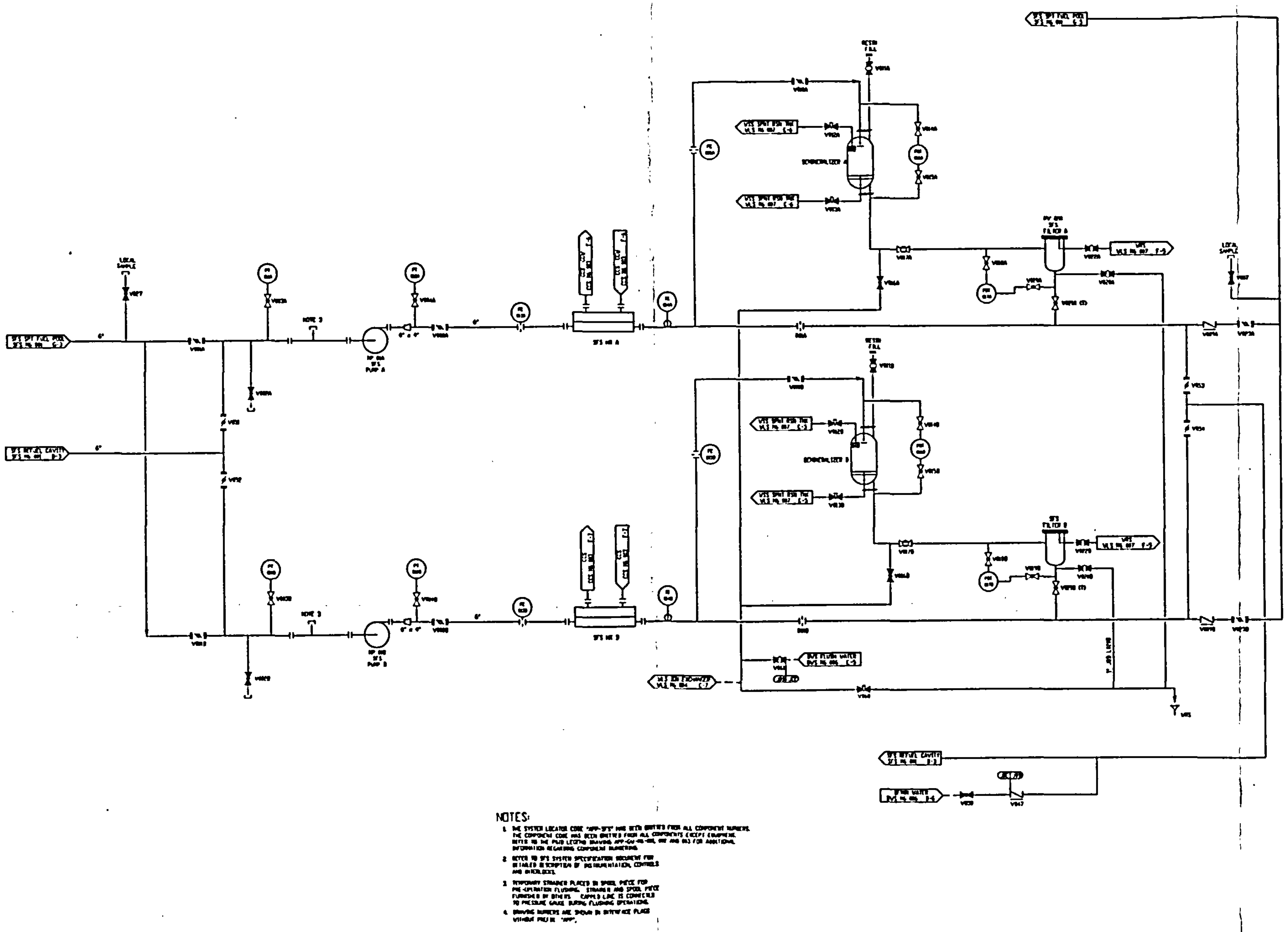

Figure 9.1-6 (Sheet 2 of 2)

**Spent Fuel Pool Cooling System
Piping and Instrumentation Diagram**

(REF) SFS 002

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