50-259

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 21, 1996

MEMORANDUM TO: Frederick J. Hebdon, Director
Project Directorate II-3
Division of Reactor Projects I\II

FROM: Joseph F. Williams, Project Manager
Project Directorate II-3
Division of Reactor Projects I\II

SUBJECT: SPENT FUEL COOLING AND CORE OFFLOAD PRACTICE LICENSING AND DESIGN BASIS REVIEW FOR THE BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3 (TAC M94480)

This memorandum documents my review of the current licensing and design basis for spent fuel cooling and refueling practices at the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 operated by the Tennessee Valley Authority (TVA). The review was conducted as directed by memoranda from John Stolz dated February 8, March 1, and March 8, 1996. Much of the requested information was gathered during a site visit from February 13 - 16.

BFN Unit 2 is scheduled to begin a refueling outage on March 22, 1996, with a planned partial-core offload. My review concludes that the current licensing and design basis should be satisfied for this activity. Some minor discrepancies were identified, but are not safety-significant.

Two other refueling outages conducted since BFN Unit 2 restart in 1991 included full-core offloads. The FSAR and other licensing basis information clearly state such an offload is acceptable.

Details of the review are discussed below. A summary table of spent fuel cooling design and operating practice information as requested by the Stolz memo of February 8 is included in the attachment.

SYSTEM DESCRIPTION

Each BFN reactor has its own spent fuel pool. There is a transfer canal between the Unit 1 and 2 pools; the Unit 3 pool is stand-alone. Each of the three pools is cooled by a fuel pool cooling (FPC) system, consisting of two pumps which take suction from two fuel pool skimmer surge tanks, two heat exchangers, a filter-demineralizer system, and associated piping and instrumentation. Decay heat is removed by the reactor building closed cooling water (RBCCW) system, which in turn is cooled by the raw cooling water system. The system is designed to be single-failure tolerant, and meets seismic Class I standards.

FPC pump power is divisionalized; each pump is powered from a different 480V shutdown board, which can be powered by a diesel generator. However, FPC is not an essential load, and so requires operator action to provide power to the pumps if offsite power is lost.

Technical Specifications limit pool temperature to 150°F, and pool level to no less than 8½ feet above the fuel in the storage racks. Normal water level is about 22 feet above the bail at the top of a fuel assembly.

The system can be cross-connected with the residual heat removal (RHR) system for additional heat removal capability. This alignment is referred to as the RHR-assist mode. The FSAR states this alignment can be implemented if pool temperature is expected to exceed 125°F for the benefit of personnel working in the area. Decay heat is removed from the RHR system via the RHR service water system. Equipment required to perform this function is designated safety-related, and is designed to meet seismic Class I standards. However, the RHR-assist function itself is not considered to be a safety-related function, since it is not required to shut down and maintain the reactor in a safe condition.

The combination of the FPC and RHR systems is analyzed to be capable of removing the decay heat from a full-core offload and a filled fuel pool. This combined heat load was evaluated as part of the submittal and amendment to install high density fuel storage racks in the late 1970's. The pools are able to store up to 3471 fuel assemblies. Presently, the pools are approximately half-full.

Normal water makeup is via the condensate storage system. The RHR cross-connect can also provide makeup water. In addition the emergency equipment cooling water (EECW) system can be used for this purpose via permanently-installed hoses from the two EECW headers. Finally, the RHR service water system can provide raw cooling water makeup via its connection with the RHR system.

LICENSING BASIS REQUIREMENTS AND COMPLIANCE REVIEW

As requested by the Stolz memo of March 1, FSAR, Technical Specification, and rerack amendment information was provided to the Lead Project Manager on March 5. Licensing basis requirements developed from these documents were provided to me by Joe Shea via electronic mail on March 8. The requirements are given below, with a discussion of the compliance review performed in bold text.

1. Technical Specification limits are provided for:

   a. Spent fuel pool (SFP) level (> 8.5 ft over top of spent fuel) (TS 3.10.C.1)

   b. Spent Fuel Pool Temperature: < 150°F (TS 3.10.C.2)

Control room logs were reviewed on February 15, 1996 to confirm level and temperature surveillances were performed daily, as required by the Technical Specifications.

   c. Crane travel over SFP: loads over racks are limited (TS 5.5.C)

TVA conformance to heavy load requirements was verified as part of the BFN Unit 3 restart. See Inspection Report 95-38.

e. spent fuel pool criticality (TS 5.5.B)

TVA provided information verifying that the k_∞ for new fuel is less than that assumed in the analysis of the high density fuel storage racks.

f. spent fuel pool chemistry (TS 3.10.C.3)

No review of pool chemistry requirements was conducted. These requirements were not considered germane to cooling or reactivity requirements. Soluble poisons are not used for reactivity control.

2. Maximum pool temperature during all plant operating conditions is 150°F per TS 3.10.C.

Licensee compliance was verified by review of surveillances implementing Technical Specification requirements. In addition, plant procedures provide for alignment of additional cooling capability if pool temperature is expected to exceed 125°F.

3. If RHR SFP assist is not available, SFP heat load should be limited to values such that two trains of SFP cooling can maintain less that 125°F.

   If licensee plans to place heat load larger than capacity of SFP cooling system at 125°F (as would be expected for full core offload), RHR shall be operated to maintain SFP temperature less than 125°F.

   PM should look for licensee controls and procedures which manage SFP cooling and RHR SFP assist operation to meet these commitments. PM should note the discrepancy between the 150° TS limit and the licensee commitments to conduct operation such that pool temperature is maintained less than 125°. PM should look for licensee controls to meet these commitments.

Procedures (for example 2-AOI-78-1 and 2-OI-74) require use of the RHR-assist mode if fuel pool temperature increases above 125°F. However, it should be noted that 125°F is not the licensing basis for the fuel pool cooling function. There is a minor inconsistency between the FSAR, which indicates the RHR-assist mode "can" be used for additional cooling, vs. the Technical Specification Bases, which state this mode "will" be used to maintain pool temperature below 125°F. Revision of the FSAR and/or Bases would resolve this inconsistency.

4. Maximum heat load in SFP is limited to FSAR value of 27.6 MBTU/hr. This appears to be combined capacity of SFP cooling system and RHR SFP assist at 125°F.

The license amendment for installation of the high density storage racks gives a maximum heat load of about 29 MBTU/hr for a full-core offload that fills the

pool. The FSAR heat load is based on the original pool design, and should be clarified.

PM should review controls on SFP heat load. Any licensee plans to place higher heat load in pool should have appropriate safety evaluations.

For refueling outages since BFN Unit 2 restart in 1991, TVA has performed analyses of the expected fuel pool heat load over the course of refueling outages. This heat load is compared against the expected capability of heat removal systems for bounding water temperature conditions (which may be less limiting than design conditions due to seasonal conditions at the time of the outage). This analysis is included in the outage risk management evaluation. This evaluation is performed in accordance with Site Standard Practice 7.2, "Outage Management." Fuel pool cooling is designated as a key safety function by this procedure. This evaluation appears to adequately consider SFP heat load, and provide appropriate controls to preserve fuel cooling.

5. CLB includes assumed values of delay time (prior to transfer of fuel to the SFP) in generating SFP heat loads. Licensee should ensure that refueling outage schedule is consistent with these assumption or that any accelerated outage schedules are appropriately evaluated. (Rerack application dated December 2, 1977)

   Assumed values: 8 days for completion of partial core offload
   16 days for completion of full core offload.

As noted above, TVA analyzes fuel pool heat load over the course of an outage as part of the outage risk management evaluation.

6. FSAR Section 13.9 contains detailed discussion of various refueling outage controls and procedures. PM should review licensee programs to meet these commitments.

FSAR section 13.9 discusses the following procedural controls:

shutdown margin checks

detailed channeling and fuel handling techniques,

steps to assure compliance with the license and technical specifications

licensed operators in the control room and on the refueling floor for fuel and control rod movement

proper fuel location and orientation

control rod location recording by serial number

fuel assemblies identified by serial number

special nuclear material record-keeping

detailed procedures for fuel handling

independent check of fuel assembly loading

None of these items explicitly affects the capability to remove the spent fuel decay heat load. Therefore, no verification of these items was performed as part of this effort.

7. No other implicit or explicit prohibitions exist within the CLB against performing a full-core offload for any given refueling outage.

No action required.

DISCREPANCIES AND OBSERVATIONS

FSAR Discrepancy

An FSAR discrepancy was identified in section 13.9, where there was a statement that refueling is conducted on an approximate annual basis. In fact, refueling takes place about every 18 months. FSAR section 3.7.5.1 correctly refers to an 18-month cycle. TVA initiated a Problem Evaluation Report for this issue, and is taking steps to correct the error. This issue is not safety-significant, since the heat load used in the rerack analysis assumed 18-month fuel cycles. A discussion of this issue was provided to the resident inspectors for inclusion in an upcoming inspection report.

Submersible Pump Safety Assessment

During recent refueling outages, TVA has used a submersible pump to mix the water in the Unit 1 and 2 fuel pools. This mixing was desired to stabilize level control in the two sets of skimmer surge tanks, and to provide additional heat removal by the Unit 1 FPC system. The safety assessment of the associated procedure change was reviewed, and questions have been raised about its thoroughness. For example, the assessment relies heavily on a "yes/no" checklist which does not provide for a descriptive argument on why the selected item is appropriate. The assessment also references affected FSAR sections, but does not provide an evaluation of the effect of submersible pump installation on those sections. This issue has been referred to the resident inspectors for followup and resolution.

FSAR Clarifications

My review of the FSAR and other licensing and design information indicates clarification of some items would be useful. However, the items discussed below are not considered to be discrepancies where an inaccurate FSAR statement is at odds with actual design or operating practice.

1. The FSAR describes EECW as an "additional qualified source" of makeup water to the SFP. It is unclear what is meant by "qualified" in this context. TVA states that this statement means that the EECW system is capable of providing adequate makeup to the SFP. I believe there could be some confusion as to the scope of qualification included in the FSAR

statement. For example, the bulk of the EECW system is safety-related and qualified to seismic Class I. However, the fuel pool makeup function is not safety-related, and dedicated hoses used for the SFP makeup do not meet seismic design requirements. Therefore, clarification would be helpful to describe actual equipment capability and qualification.

2. The maximum SFP heat load specified in the FSAR is based on decay heat from a full core offload plus the heat from fuel discharged from the two previous batches. This heat load is given as 27.6 MBTU/hr, and is derived from the original design specifications developed by General Electric in the late 1960s and early 1970s. Therefore, it is an accurate description of the design parameters of the system.

   The high density rack analysis performed in the late 1970s is provides a heat load of about 29 MBTU/hr (there are two slightly different numbers given: one by TVA, and an independent NRC calculation). This heat load is based upon a full-core offload which completely fills the SFP, and is based on 18-month fuel cycles. This heat load is well within the capability of the FPC and RHR systems to maintain SFP temperature less than 150°F.

   While the current FSAR provides an accurate description of the original design parameters of the fuel pool cooling system, it does not describe the current licensing basis for the facility. Therefore, the FSAR should be revised to provide the appropriate description.

3. As discussed above, the FSAR and Technical Specifications Bases should be clarified for consistency in discussion of circumstances for use of the RHR-assist mode of fuel pool cooling.

Site Engineering Assessment

The Site Engineering organization performed an assessment of the acceptability of a full-core offload as part of TVA's review of Information Notice 95-54. The assessment reviewed FSAR and design specification information, correctly concluding a full-core offload is acceptable. However, this assessment did not include the high density storage rack submittal and amendment safety evaluation. Therefore, this review was not comprehensive.

SUMMARY

The Browns Ferry plant is designed to accomodate a full-core offload from each of the three reactors on the site. TVA evaluates outage decay heat loads and equipment availability on a cycle-specific basis in an effort to ensure adequate fuel cooling. The licensee's activities appear to conform to design and licensing requirements. No safety-significant discrepancies were identified in this review.

I can be reached at 415-1470 if there are any questions or comments on this review.

Docket Nos. 50-259, 260, 296

cc: J. Shea
C. Poslusny
M. Lesser
L. Wert

DISTRIBUTION
Docket File
BFN Rdg.
S. Varga
J. Zwolinski
PUBLIC

DOCUMENT NAME: G:\BFN\BFN-SFP.MEM

To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

OFFICE	PDII-3/LA C	PDII-4/PM C	PDII-4/D E	
NAME	BClayton	JWilliams	FHebdon	
DATE	03/21/96	03/21/96	03/21/96	

OFFICIAL RECORD COPY

250166

DF01

Attachment

Browns Ferry Nuclear Plant

Spent Fuel Storage Data Table

Facility	Brown Ferry Nuclear Plant Units 1, 2, and 3	
SFP Contact	Steve Kane, Regulatory Licensing Manager	(205)729-7854
SFP TS	Thermal power: License 2.C(1) Unit 3	3293 Mwt
	SFP Level: TS 3/4.10.C.1	8.5 feet above active fuel
	SFP Temperature: TS 3/4.10.C.2	≤150°F
	Time before fuel movement: none	
	SFP Inventory: none	
	SFP cooling availability: none	
	SFP boron concentration: NA	
	Fuel storage zones: NA	
SFP structures	The Browns Ferry spent fuel pools are located in the Reactor Building. The upper levels of the pools are in a common area on the 664 ft. elevation at the top of the Reactor Building.	Seismic Class I (system design criteria)
	SFP Volume 51340 ft^3 FSAR Table 10.5-1	SFP temp for stuctural analysis 150°F
Leakage collection	liner type: stainless steel FSAR pg. 10.3-5	Leakage monitoring: liner leakage checked weekly for Units 2 and 3, monthly for Unit 1.

drainage prevention	There are no drain lines in the SFP itself; the pump discharge lines are protected by anti-siphon vent valves, and the suction lines are from the skimmer surge tanks. The SFP liner leakage drains are not capable of draining the SFP. Numerous lines are available in the Reactor Well, Transfer Canal, Dryer/Separator Storage Pool, and Gate Slot for both drainage and leakage monitoring. These lines are not capable of draining the SFP unless the refueling gates are removed. The level loss from the SFP is limited to 640'4" with the gates removed due to the physical elevation of the transfer slots (with the exception of the 3" Fuel Pool Gate Slot Drain about 8 inches below the top of active fuel (Elev. 638'8.5")). All above drain paths with the capability to drain the SFP with the gates removed are Seismic Class I to the first normally closed isolation valve.	gate elevation relative to fuel Bottom of transfer canal: 640' 4" Top of fuel assembly bail: 640' 11" Top of active fuel: 639'4"
Siphon prevention	Lowest elevation of connected piping relative to fuel see response immediately above	anti-siphon devices: check valve with siphon-breaking vent; limits siphoning to no more than 6 inches below normal water level
make-up capability	Qualified source: RHR (FSAR 10.5)	Function: non-safety-related components: Seismic Class I Safety-related
	Normal: Condensate (FSAR 10.5)	Seismic Class II non-safety-related

	Other: EECW - "additional qualified source" (flow path via hoses not seismically designed or safety-related) (FSAR 10.5) RHRSW - provides raw water via RHR (FSAR 10.5)	Function: non-safety-related System: Seismic Class I Safety-related (does not include hoses) Function: non-safety-related Components: Seismic Class I Safety-related
reactivity	k_{eff}: < 0.95 (TS 5.5.B) enrichment: no limit specified in TS; high density rack analysis specifies k_∞ < 1.35	soluble boron: none
reactivity control	solid neutron poisons: Boral	fuel storage zones: no differentiation for differentiate enrichment or burnup (rerack analysis and amendment)
Shared/split SFPs?	Three pools. Units 1 and 2 can be connected. Unit 3 is stand-alone.	Unit 1 and 2 pools can be cross-connected, so Unit 2 fuel can be places in the Unit 1 pool. Unit 1 is in long-term shutdown, with no date established for restart. The Unit 3 pool is stand-alone.
SFP Design inventory	Normal: 3471 fuel assemblies maximum (FSAR 10.3) Current: (February 1996) Unit 1: 1864 Unit 2: 1700 Unit 3: 1036	Emergency/abnormal: not defined. Normal capacity includes full-core offload.
SFP Design heat load	"Maximum normal heat load" = 8.8E6 BTU/hr (one train fuel pool cooling)	"Maximum possible heat load" = 27.6E6 BTU/hr

SFP Cooling system	Two trains per unit	FPC is designed such that no single failure or malfunction will uncover the stored fuel. (System design criteria)
	One SFP served by two trains. One train required.	Seismic Class I Quality Related (system design criteria and Q-List)
Electrical supply	480V Shutdown boards Normal: offsite power Abnormal: diesel generators FPC is "non-essential" DG load, and will be served as required for abnormal conditions.	Unit 2: load shed on accident signal coincident with availability of diesel generators. Unit 3: load shed on under-voltage. system design criteria 3.6(2)
backup SFP cooling	Residual Heat Removal (RHR) (FSAR 10.5)	Function: non-safety related components: seismic class I safety-related
SFP heat exchanger cooling water	Reactor Building Closed Cooling Water (RBCCW) (FSAR 10.5)	seismic class II non-safety related
secondary cooling water loop (if any)	Residual Heat Removal Service Water (RHRSW) for RHR assist mode cooling (FSAR)	seismic class I safety related
ultimate heat sink	Tennessee River (Wheeler reservoir)	design temperatures 10°F max ΔT, 90°F discharge (environmental limits)
SFP cooling heat exchanger performance	Design heat capacity: 8.8E6 BTU/hr (4.4E6 BTU/hr per train) (FSAR Table 10.5-1)	Type: shell and tube (system design criteria)
	SFP side flow: 600 gpm min, 1200 gpm max (FSAR Table 10.5-1)	Cooling water flow: 750 gpm (heat exchanger specification sheet)

	SFP temp: 125°F (FSAR Table 10.5-1)	Inlet cooling temp: 100°F (System Design Criteria)
	SFP return temp: 110°F (by heat balance)	Outlet cooling temp: 112°F (System Design Criteria)
SFP control room alarms	parameters: FUEL POOL SKIMMER SURGE TANK LEVEL FUEL POOL SYSTEM ABNORMAL RBCCW 2-FCV-70-48 CLOSED Fuel pool temperature indication on RHR TEMPERATURES recorder	Setpoints: High Level: El. 650' 4" Low Level: EL. 643' 5" Low-Low: EL. 642' 0" Pump Discharge Low Pressure Pump A and Pump B less than 100 psig or Gate Seal or Drywell to Reactor Well Seal Leakage greater than 5 gpm or Fuel Pool Low Level EL. 662' 8" or Refueling Bellows High Leakage greater than 5 gpm Load Shed Signal orLow RBCCW Header Pressure less than 55.7 PSI >125°F
location of indications	SFP Level - alarm indication on control room panel 9-4 (2-AOI-78-1)	SFP Temperature- control room chart recorder on panel 9-21 (2-AOI-78-1)
SFP cooling system automatic pump trips	pump trip on low suction pressure (2-AOI-78-1)	Independence

SFP boiling	staff acceptance of non-seismic SFP cooling system based on seismic class I ventilation? The Browns Ferry fuel pool cooling system is seismic Class I. Therefore, the question is moot.	Off-site consequences of boiling evaluated? NA Filtration credit: NA
SFP reactor system separation	The surface of the spent fuel pools is at the highest elevation in the reactor building (664'). The three pools share a common refueling floor at this elevation. Ventilation for this area is provided by the refueling zone ventilation system.	The three units share a common refueling floor. Each unit has its own ventilation system.
heavy load handling	SFP area crane(s) single-failure tolerant per NUREG-0612 and/or NUREG-0554: yes (IR 95-38, SEs 6/6/84, 6/28/85)	no routine transfer of spent fuel to ISFSI or alternate
operating practices	adminstrative limit on SFP temperature - 125°F (2-AOI-78-1)	administrative controls on SFP cooling system redundancy and SFP make-up system redundancy 1. FPC availability 2. RHR availability 3. EECW availability 4. Electrical power Fuel pool cooling is identified as a key function in outage management procedure (SSP-7.2).

	frequency of full-core offloads Due to the extended shutdowns of Units 2 and 3, I do not consider pre-1991 operating history to be relevant. Unit 2 January 1993: full Unit 2 October 1994: full Unit 2 March 1996: partial Unit 3 March 1997: partial (subject to change)	administrative controls on fuel decay time prior to transfer from reactor to SFP TVA calculates decay heat load and expected bounding fuel pool cooling capability for each outage, verifying adequate heat removal capability. Results are included in the outage risk assessment report.