The Light company
Houston Lighting & Power

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August 19, 1938
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10CFR50

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project Electric Generating Station
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
Response to NRC Questions Regarding the
Use of High Density Spent Fuel Racks

Reference (1): HL&P Letter to USNRC, G.E. Vaughn to Document Control Desk, ST-HL-AE-2417 dated March 8, 1988.

(2): HL&P Letter to USNRC, ST-HL-AE-2738; Summary of Meeting on July 11 & 12 to discuss High Density Spent Fuel Racks.

On July 11 & 12, 1988, personnel from Houston Lighting & Power Company (HL&P), Bechtel Energy Corporation (BEC) and U.S. Tool & Die, Inc. (UST&D) met with members of the NRC Staff to discuss the proposed license amendment regarding expansion of the spent fuel pool storage capacity using high density spent fuel racks that was submitted to the NRC via letter dated March 8, 1988 (reference 1). Minutes of the meeting are documented in reference 2.

As a result of the meeting, HL&P committed to provide additional information for some of the questions discussed during the meeting. Attached are revised responses to questions 2, 6, 7, 8, 9, 15, 16, 17 and 18. This information should close these items.

Proprietary Drawings To: Reg Files
B021 1/1

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If you should have any questions regarding this matter, please contact Mr. A. W. Harrison at (512) 972-7298.

M A McBurnett
M. A. McBurnett
Manager,
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MEP/hg

Attachment: (1) Revised Responses to Questions 2,6,7,8,9,15,16,17 & 18.
(2) UST&D Drawing 8709-59 (Rev. 0)
UST&D Drawing 8709-60 (Rev. 0)
UST&D Drawing 8709-01 (Rev. 1)
(3) Spent Fuel Rack Handling and Installation Instructions
(4) Annotated revisions to the High Density Spent Fuel Rack Safety Analysis Report and the STP FSAR.

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cc:

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(*) Attachments 1-4. All others with attachment 1 only.

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QUESTION #2:

Provide legible drawings of rack structural details showing clearances between modules, pool walls, piping interferences, etc.

RESPONSE #2:

Attachment 2 contains the 3 drawings representing the 3 phases of installation for the spent fuel racks. The 3 phases of installation are defined below:

- Phase I (Unit 2 only) - Region 1 dry new fuel storage (Reference UST&D drawing 8709-59, Rev. 0)
- Phase II (Unit 1 & 2) - Region 1 and 2 wet spent fuel storage and consolidated fuel storage without a three rack row at the south end of the spent fuel pool (Reference UST&D drawing 8709-60, Rev. 0)
- Phase III (Unit 1 & 2) - Region 1 and 2 wet spent fuel and consolidated fuel storage, full pool (Reference UST&D drawing 8709-1, Rev. 1).

Each phase of installation considers the interaction between individual rack modules as well as between the modules and pool walls during a seismic event (i.e., OBE or SSE). Sufficient clearances are provided between modules (Phase I) and between modules and pool walls (Phase I, II, & III) for maximum rack sliding. Due to hydrodynamic coupling of the racks in the wet storage condition, in Phases II & III the racks are installed rack-to-rack (i.e., no gap). Attachment # 3 contains the spent fuel rack installation instructions.

As a result of final dimensional reconciliation of the fuel racks in the spent fuel pool, the dimensions between the outer racks and the pool walls were revised to meet the minimum distance required between a rack and any interferences (e.g., pipe support, hanging tools). As a part of the response to this question, Attachment # 4 contains the necessary changes to Attachments # 3 and 4 of reference 1 of this transmittal letter. These revised dimensions provide sufficient clearance for maximum rack movement due to the seismic events (i.e., 1 SSE plus 5 OBEs). These suggested changes were discussed with the NRC Staff during the July 21, 1988 technical audit at the UST&D facilities.

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QUESTION #6:

Provide calculations supporting the assumption that the racks are rigid.

RESPONSE #6:

During a meeting with the NRC Staff on July 11 & 12, 1988, UST&D provided a copy of the following calculations regarding the seismic and stress analysis for the racks for NRC review.

Calculation No.	Title
14926-4480/8480-00049	Seismic Analysis Report - Spent Fuel Storage Racks.
14926-4480/8480-00064	Mechanical Report - Spent Fuel Storage Racks.

These calculations were provided as Attachments 3 and 4 to the meeting summary as documented in reference 2 of this transmittal letter.

The seismic rack stick model is detailed in the "RACKOE & NORMOD INSTRUCTION MANUAL" (NORMOD is not used for STP), F16.1.0. This proprietary manual was provided to the NRC during the July 11 & 12, 1988 meeting.

The RACKOE code provides the seismic induced dynamic pedestal loads, rack vertical and horizontal displacement, as well as the vertical, horizontal and angular accelerations.

The resulting RACKOE code output is used to produce loads imposed on a free body representation of a single interface between two rows of cells in the E-W or N-S direction. The loads include the pedestal loads (vertical & horizontal), center-of-gravity vertical, and rotational inertial loads. Subsequent analysis of these loads in both the E-W and N-S planes through the racks results in combined stresses (square root of the sum of the squares (SRSS)). The maximum combined loads for a given interface provide the maximum stresses for the fusion welds.

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QUESTION #7:

Indicate how the vertical mass of the fuel assemblies are accounted for in the model.

RESPONSE #7:

UST&D presented a comparative study to the Staff on July 21, 1988 during the NRC technical audit of the UST&D facilities of both the single lumped rotational inertia located at the base of the rack and the multiple mass distribution over the vertical height of the rack. The multiple mass rotational inertia was distributed over six levels of the rack stick model. The individual mass of the fuel cell and the fuel assembly was combined as a single mass at each level. The analysis was performed using unconsolidated spent fuel. The results of the study indicated an eight (8) percent increase in loads for the multiple mass distribution method.

After the July 21, 1988 NRC technical audit, UST&D performed a subsequent multiple mass distribution model separating the mass of the fuel cell and the fuel at each level of the rack stick model. This model contains 12 mass points, 2 at each level. This analysis was performed using consolidated spent fuel. UST&D believes that this method of modelling the mass distribution is more representative of the actual mass distribution. This analysis resulted in a small decrease in the loads on the rack and a small increase in the factor of safety. For example, the rack pedestal bottom plate factor of safety was calculated as 1.07 using this multiple mass distribution model. Previously, using the single lumped rotational inertia located at the base of the rack, this factor of safety was calculated as 1.06.

During the July 21, 1988 NRC technical audit, it was our understanding that the staff found the results of the multiple mass distribution model acceptable. UST&D believes that the subsequent analysis, which more explicitly defines the mass distribution, provides even a higher level of confidence in the original UST&D analysis using the single lumped rotational inertia located at the base of the rack.

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QUESTION #8:

Discuss impact analysis and indicate whether the analysis considers impact between individual modules as well as impact between modules and pool walls.

RESPONSE #8:

In a meeting with the NRC Staff on July 11 & 12, 1988, HL&P provided the following two (2) papers on hydrodynamic coupling which forms the basis for the methodology used in the analyses performed by UST&D.

(1) Appendix C of the Seismic Analysis Report on the fluid structure coupling of rectangular modules.

(2) Scavuzzo, R. J., Stokey, W. F., Radke, E. F., "Dynamic Fluid Structure Coupling of Rectangular Modules in Rectangular Pools", reprinted from "Dynamics of Fluid-Structure Systems in the Energy Industry", ASME PVP-39, pp. 77-86.

These were provided as Appendix C to Attachment #3 and Attachment #5 respectively to the meeting summary as documented in reference 2 of this transmittal letter.

During the July 21, 1988 meeting with the Staff, UST&D presented a detailed discussion of the hydrodynamic mass matrix model. The hydrodynamic mass matrix model for STP is based on a 1-inch rack-to-rack gap. The base model is a 3-rack model (132-cell racks) with the first rack filled with spent fuel, the second rack half filled with spent fuel, and the third rack empty. Using a 0.2 coefficient of friction (i.e., sliding occurs), the maximum relative motion between racks is 0.128 inches. Using a 0.8 coefficient of friction (i.e., no sliding occurs), the maximum relative motion between racks is 0.29 inches.

Since the hydrodynamic mass matrix model is based on a 1-inch rack-to-rack gap, there is no physical interaction of the racks. As the racks are moved closer together, the hydrodynamic coupling forces increase resulting in smaller relative motion between racks. UST&D has performed a similar analysis for another rack order (132-cell rack) using a 0.25 inch gap. The relative motion between the racks was 0.03 inches. As in

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QUESTION # 8 (RESPONSE CONT'D):

the STP rack analysis, there was no physical interactions between the racks. The relative motion between racks as discussed above for a 1-inch gap and a 0.25-inch gap demonstrates the increasing strength of the hydrodynamic coupling as the rack-to-rack gap is decreased, preventing physical interaction of the racks.

In addition, UST&D performed the hydrodynamic mass matrix model with a 1-inch rack-to-rack gap for a 3-rack model using two (2) 132-cell racks (one filled with spent fuel and the second half filled with spent fuel) and a 110-cell rack that was empty using a 0.2 coefficient of friction. The maximum relative motion between racks was 0.11 inches. As concluded above, there was no physical interaction of the racks.

Finally, UST&D performed the hydrodynamic mass matrix model with a one (1) inch rack-to-rack gap for a 3-rack model using the 110-cell racks. The first rack was filled with consolidated spent fuel, the second rack was half filled with consolidated spent fuel, and the third rack was empty. Using a 0.2 coefficient of friction (i.e., sliding occurs), the maximum relative motion between racks is 0.61 inches. Using a 0.8 coefficient of friction (i.e, no sliding occurs), the maximum relative motion between racks is 0.34 inches. This demonstrates that the lighter racks will also not have any physical interaction during a seismic event.

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Question #9:

Discuss vibration between fuel assemblies and rack storage walls due to hydrodynamic loads.

RESPONSE #9:

During a meeting with the NRC Staff on July 11 & 12, 1988, UST&D explained that a hydrodynamic mass matrix is included in the math model, modelling the fluid-structure interaction between the fuel and rack based on methods presented in References 3, 4 & 5 of the Seismic Analysis Report (Attachment #3 to reference 2) and in Page 6-10 and Figure 6-12 of the license amendment (reference 1).

During the July 21, 1988 NRC technical audit of the UST&D facilities, UST&D presented their methodology and justification for their treatment of the rack honeycomb structure with beam theory analysis to obtain the highest cell loading and stresses. In the seismic analysis, UST&D assumed that the motion of the fuel assemblies in the individual fuel storage cells are in the same mode and move in phase. This assumption provides the highest fusion weld loading as discussed below.

(1) The in-phase motion would produce the largest horizontal loads and shear stresses since the mass of all the fuel assemblies in any given rack would be exerting their force (mass) in the same direction at the same time.

(2) Out-of-phase motion would result in smaller loads or cancellation of localized loads. Also, since the fuel assemblies have less stiffness than the fuel storage cell wall, localized horizontal impact with the wall is distributed over the cell vertical surface.

(3) Within a rack geometry, similarity of the cell design does not support different mode shapes from cell to cell. With the same energy input to a given rack, all fuel assemblies will be subject to the same forcing functions.

Also refer to the responses to Question # 7 and # 17. It is our understanding that the NRC Staff found this macro-analysis method acceptable for determining the fuel storage cell wall strength and the fusion weld loading during the July 21, 1988 technical audit.

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QUESTION #15:

How is Section 3.8 of the FSAR affected by this amendment? Why aren't there any references to Appendix D of 3.8.4 of SRP in the FSAR?

RESPONSE #15:

In the response to NRC Question 220.32N, HL&P committed to design the high density spent fuel racks in accordance with appendix D to SRP 3.8.4. This was provided to the NRC previously as part of FSAR amendment 32. Since the commitment was made as part of the question response (which is contained in a separate volume that is already part of the FSAR), HL&P elected not to revise FSAR Section 3.8.4. In addition, the proposed license amendment identifies the same commitment. The information required by Appendix D of SRP 3.8.4 is contained both in the FSAR and in the license amendment.

HL&P has reviewed the NRC criteria contained in both the "OT Position for Review and Acceptance to Spent Fuel Storage and Handling Applications" and Appendix D to SRP 3.8.4. A summary of our review is tabulated below. In cases where one document contained more stringent or additional requirements, the more conservative document was met.

The NRC "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications" (hereafter OT Position Paper) includes criteria for all aspects concerning the modification of spent fuel storage. Appendix D to SRP 3.8.4 includes criteria associated with only the mechanical, material, and structural considerations. The first part of the review involved only the OT Position Paper.

OT Position Paper Criteria	STP Compliance *
Nuclear & Thermal Hydraulic Considerations	
(1) Neutron multiplication factor assumed conditions	
-Normal Storage	Complies (Section 4.0)
-Postulated Accidents	Complies (Sections 4.0, 5.3, 5.4 & 7.6)

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QUESTION # 15 (RESPONSE CONT'D):

Calculation Methods	Complies (Section 4.0)
Rack Modification	Complies (Section 4.0)
Acceptance Criteria for Criticality	Complies (Section 4.0)
Decay Heat Calculations for the Spent Fuel	Complies (Section 5.0)
Thermal Hydraulic Analyses for Spent Fuel Cooling	Complies (Section 5.0)
Potential Fuel and Rack Handling Accidents	Complies (Sections 4.0, 7.6)
Technical Specifications	Complies (Attachment 2)
(2) Mechanical, Material, & Structural Considerations	
Testing & Inservice Surveillance	Complies (Section 9.0)
Cost/Benefit Assessment	Complies (Section 8.0)
Radiological Evaluation	Complies (Section 7.0)
Accident Evaluation	Complies (Section 7.0)

* Referenced Sections and Attachments are found in reference 1.

The remaining NRC criteria are identified in both the OT Position Paper and in Appendix D to SRP 3.8.4.

Appendix D, SRP 3.8.4 Criteria	OT Position Paper Criteria	STP Compliance*
(1) Description of Spent Fuel Pool & Racks	Same	Complies (Sections 3.0 and 6.0); FSAR Sections 3.8.4, 9.1.4 and FSAR Figures 1.2-39 through 1.2-46
(2) Applicable Codes, Std., and Specifications	See Note 1	Complies (Section 3.0)
(3) Seismic & Impact Loads	Same	Complies (Section 6.0); FSAR Section 3.7

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QUESTION # 15 (RESPONSE CONT'D):

(4)	Loads & Load Combinations	See Note 2	Complies (Section 6.0); NRC Q & R 220.32N
(5)	Design & Analysis Procedures	Same	Complies (Section 6.0); FSAR Section 3.7
(6)	Structural Acceptance Criteria	See Note 1	Complies (Section 6.0)
(7)	Materials, Quality Control, & Special Construction Techniques	See Note 3	Complies (Section 6.0)

Note 1 - The OT Position Paper provides additional discussion regarding selection of AISC specification procedures. STP meets ASME III, Subsection NF.

Note 2 - Appendix D to SRP 3.8.4 contains additional loads and load combinations not included in the OT Position Paper. The loads and load combinations used on STP include all the loads and load combinations from both documents (reference Section 6.4.2 of Attachment #3 to reference 1). The material properties are evaluated at a temperature of 225°F for Service Levels A, B, and C. For the comparison of the load combination D + L + E with service level A limits, the material properties are evaluated at a normal temperature of 120°F.

Note 3 - The OT Position Paper provides additional discussion concerning the qualification of special poison material. STP uses Boraflex as the qualified poison material.

* Referenced Sections are found in Attachment # 3 to reference 1.

As per the Staff's request, STP has reviewed the differences between the OT Position Paper and Appendix D to SRP 3.8.4 and reconfirmed compliance with both of these documents.

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QUESTION #16:

Identify what should be in the Technical Specifications with respect to rack geometry, required gap/clearances between modules and walls, etc.

RESPONSE #16:

The STP Technical Specifications are consistent with the Westinghouse Standard Technical Specifications (STS). As such, the suggested parameters are not provided as part of these Technical Specifications, with regard to fuel storage. Section 5.6 of the STS identifies the appropriate parameters as criticality, pool drainage and capacity. The proposed Technical Specifications that were submitted as part of the Proposed License Amendment (reference 1) are consistent with those previously approved by the NRC. HL&P believes that the suggested parameters do not belong in the Technical Specifications.

During a meeting with the Staff on July 11 & 12, 1988, the Staff stated that since the racks are free standing, they are concerned that after a seismic event, the racks could move (i.e., slide) creating gaps between adjacent racks such that the configuration of the racks would no longer be bounded by the seismic analysis which requires essentially "no rack-to-rack gap." The Staff requested that if the Technical Specifications are not modified, then HL&P must have a requirement in a post-seismic (i.e., OBE or greater) walkdown procedure to verify the proper configuration of the racks in the spent fuel pool.

The applicable plant procedures which govern activities after a seismic event will be revised to include a requirement to perform a walkdown of the spent fuel pool to check the rack configuration. This walkdown will be performed after confirmation of a valid OBE event.

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QUESTION #17:

Identify dimensional tolerances between fuel assembly and storage cell.

RESPONSE #17:

A discussion of the dimensions of the bottom end fitting, storage cell inside dimension (fuel-to-cell) and the clearance (fuel-to-cell) as identified in UST&D Drawing No. 8709-21 was provided to the Staff during the meeting on July 11 & 12, 1988. These clearances are within the range specified by the fuel manufacturer.

As a result of the July 11 & 12, 1988 meeting, the NRC Staff has requested the following additional information:

- o UST&D to review their analysis to ensure that all possible situations of gap between fuel assembly and rack side have been addressed and that the "worst-case" is considered.
- o What is the mechanism of control of placement of fuel assemblies into the racks and what are the push/pull weight limits for placement of the fuel.

During the July 21, 1988 NRC technical audit of the UST&D facilities, UST&D presented the results of alternate fuel to cell wall initial gap configurations to confirm that a "worst case" had been considered. The three cases are defined below.

Case 1 - Fuel is vertical and located in the middle of the storage cell (assumption used in STP analyses)

Case 2 - Fuel is vertical and located on one side of the storage cell

Case 3 - Fuel is tilted with the top and bottom of the fuel assembly located on opposite walls of the storage cell

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QUESTION # 17 (RESPONSE CONT'D):

The results are summarized below:

	Case 1	Case 2	Case 3
Max vertical force @ pedestal, kips	405.8	413	404
Max horizontal force @ pedestal, kips	173	178	172

It is our understanding that the Staff concurred during the July 21, 1988 technical audit that the differences in results were insignificant and that the assumption used on STP (Case 1) was adequate.

The mechanism of control for placement of fuel assemblies into the racks is via the following plant procedures:

Procedure No.	Title
OPGP03-ZL-0002	New Fuel Receipt, Inspection and Storage
OPOP08-FH-0009	Core Refueling

With regard to push/pull weight limits for placement of the fuel into the racks, the current plant procedures allow a two hundred (200) pound (lb) drag force for placement of the fuel into the racks. If the subject drag force is exceeded, movement is stopped and appropriate action taken to correct the problem.

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QUESTION #18:

What kind of spring element was used in rack model to represent the footings?

RESPONSE #18:

The spring element used to model the rack pedestal is a nonlinear element to account for lift-off conditions and is represented in the math model by a 2 x 2 stiffness matrix. This is identified on page 6-16 of attachment # 3 to the license amendment (reference 1).

Previous UST&D rack design experience has shown that the rack with the greatest mass would transmit the largest loads to the footings (pedestals). In Region 2, the 132-cell rack is the largest and the 110-cell rack is the smallest. UST&D used the 132-cell rack as the design basis for the pedestal loadings on STP.

UST&D performed a comparative study of the seismic loads due to SSE events for the 132-cell rack and the 110-cell rack. The seismic loads generated for the Region 2, 110-cell rack, were determined in the same manner as in the 132-cell rack analysis. The results are summarized below:

Square Root of the Sum of the Squares (SRSS) Load On One Pedestal (Footing)

	110-cell Rack	132-cell Rack
Vertical	430300 lbs.	441129 lbs.
Horizontal	128476 lbs.	141937 lbs.
Vertical Lift-off (E-W direction)	0.1869"	0.1310"

As shown above, the 132-cell rack in Region 2 provides the largest pedestal loadings. These results were presented to the NRC on July 21, 1988 during the NRC technical audit of the UST&D facilities and it is our understanding that the Staff concurs with the use of the 132-cell rack for maximum pedestal loadings.

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QUESTION #18 (RESPONSE CONT'D):

During the July 21, 1988 NRC technical audit of the UST&D facilities, the NRC Staff requested that UST&D analyze the impact of the reduced rack-to-wall distance at the north end of the spent fuel pool (i.e., 4 inches). Using the 132-cell rack, UST&D calculated the additional fluid force on the rack wall due to the north-south SSE seismic event, with no rack sliding. The additional horizontal load on the rack wall is 200,400 lbs.

The maximum rack stress was calculated for the north-south SSE seismic event based on this additional load for Plane C-C (3-cell section). The factor of safety for the design basis Plane C-C analysis was 1.54 (Ref. UST&D Mechanical Report, Page 41 of 69 which was submitted as an attachment to reference 2). The factor of safety for Plane C-C with the additional horizontal load caused by the reduced rack-to-wall distance is 1.46. This reduction in the factor of safety (less than 6 percent) does not impact the integrity of the rack wall. In addition, from an overall rack stress analysis, the most limiting rack wall stresses were experienced for the east-west SSE seismic event with a factor of safety of 1.15 (Ref. UST&D Mechanical Report, Page 41b of 69 which was submitted as an attachment to reference 2).

ATTACHMENT # 3

RACK HANDLING AND INSTALLATION INSTRUCTIONS

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