NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

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May 20, 1985

Docket No. 50-423
B11541

Director of Nuclear Reactor Regulation
Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Reference: B. J. Youngblood letter to W. G. Counsil, Safety Evaluation Report for Millstone Nuclear Power Station, Unit No. 3 (NUREG-1031), dated August 2, 1984.

Dear Mr. Youngblood:

Millstone Nuclear Power Station, Unit No. 3
Response to SER Confirmatory Item No. 10
(Structural and Geotechnical Engineering Branch)

Attached is Northeast Nuclear Energy Company's (NNECO) response to your Mr. Nilesh Chokshi's request for additional information concerning the design basis of the Millstone Unit No. 3 spent fuel racks (SER Confirmatory Item No. 10). We expect the attached response will resolve the Staff's concerns regarding this item.

If there are any questions regarding this information, please contact our licensing representative directly.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY, et. al.

BY NORTHEAST NUCLEAR ENERGY COMPANY
Their Agent

J. F. Opeka
J. F. Opeka
Senior Vice President

B001
'1,

cc: Ms. E. L. Doolittle
NRC Project Manager

Mr. Nilesh Chokshi
Structural and Geotechnical Engineering Branch

STATE OF CONNECTICUT)
) ss. Berlin
COUNTY OF HARTFORD)

Then personally appeared before me J. F. Opeka, who being duly sworn, did state that he is Senior Vice President of Northeast Nuclear Energy Company, an Applicant herein, that he is authorized to execute and file the foregoing information in the name and on behalf of the Applicants herein and that the statements contained in said information are true and correct to the best of his knowledge and belief.

Lorraine J. D'Amico
Notary Public

My Commission Expires March 31, 1988

NORTHEAST UTILITIES - MILLSTONE UNIT-3

SPENT FUEL STORAGE RACKS

Design Description

The PWR racks are designed for storage of Westinghouse 17x17 Std. fuel. The fuel cell material is 16 gauge (.062 inch thick) type 304 stainless steel. The nominal inside dimension of the cell is 8.750 inches square and the length from the top of the fuel seating surface to the top of the cell funnel is approximately 168.38 inches. Fuel cells are supported by two grid assemblies which are located at the top and at the bottom elevations of the racks. In addition, shear panels encapsulate each rack module to provide the required shear restraint. The center-to-center spacing between cells is 10.35 inches. Poison neutron absorbing material is attached to the walls of the cells within the active fuel length to achieve subcriticality. The racks are also provided with a .50 inch leveling capability to allow them to be leveled in the field to duplicate the verticality condition to which they were initially setup prior to shipment.

Structural and Seismic Evaluation

The purpose of the structural analysis is to analyze the critical components/load paths under various loading conditions. The structural analysis also determines the margin of safety against overturning due to loads from an SSE. The racks rest freely on the pool floor and are evaluated to ensure that under various loading conditions they do not impact each other, nor do they impact the pool walls.

Component Description

The complete fuel rack assembly is divided into three major sections for stress analysis purposes:

1. Rack Support Assembly

2. Lower and Upper Grids and Shear Panels Assembly

3. Cell Assembly

The following paragraphs describe each assembly.

Rack Support Assembly

The rack support assembly consists of the Support Block and Leveling Pad Assembly. The top of the support block is welded to the base plate. The leveling pad assemblies transmit the loads to the pool floor and provide a sliding contact. There are four leveling pad assemblies for each rack assembly. The leveling pad screw permits the leveling adjustment of the rack. The major components of the leveling pad assembly are the leveling pad and the leveling pad screw.

Lower and Upper Grids and Shear Panels Assembly

The lower and upper grids and shear panels assembly provides the framework for the rack. The components of the lower grid are the side plates, box beam members, and the base plate. The upper grid is comprised of the side plates and box beam members. The shear panels are .25" thick plates that connect the lower and upper grids on the outside of the rack.

The lower grid attaches the cell assemblies to the base plate. The cell assemblies are welded to the grids through integral cell wall dimples. The lower and upper grids maintain the precise center to centerline distance between the cells and provide the structural connections between the cells. The shear panels provide structural stiffness to the rack in order to raise the frequency, reduce the loads on the cell assemblies and minimize deflection.

Cell Assembly

The major components of the cell assembly are the fuel assembly cell, the Boraflex (neutron absorbing) material, and the wrapper.

The ID of the cell is 8.750 with a 0.062 inch wall. The upper end of the cell has a funnel shape flare for easy insertion of the fuel assembly. The wrapper is attached to the outside of the cell through spot welding along the length of the wrapper. Thus, the wrapper surrounds the Boraflex material, and also provides for venting to the pool environment. Dimples are formed in the upper and lower cell walls to position the cell within grid assembly openings and to provide for a structural weld connection between the cell and the grid assembly.

Depending upon the criticality requirements, some cells have a Boraflex wrapper on all four sides, some on three sides and some on two sides.

Seismic Analysis Models

The dynamic response of the fuel rack assembly during a seismic event is the condition which produces the governing loads and stresses on the structure. The dynamic response and internal stresses and loads are obtained from a seismic analysis which is performed in two phases. The first phase is a time history analysis on a single cell nonlinear finite element model shown in Figure 2-4(a). The second phase is a response spectrum analysis of a detail rack assembly linear finite element model shown in Figure 2-4(b). The damping values used in the seismic analysis are two percent damping for OBE and four percent damping for SSE as specified in NRC Regulatory Guide 1.61.

The single cell nonlinear finite element model is used to determine the fuel rack response for full, partially filled, and empty rack module loading conditions. This nonlinear model has the structural

characteristics of an average cell within a submerged rack assembly. The nonlinearities of the fuel rack assembly which are accounted for in the model are due to changes in the gap between the fuel cell and the fuel assembly, the boundary conditions of the fuel rack support locations and energy losses at the support locations.

The fuel assembly to cell impact loads, support pad lift off, rack sliding, and overall rack response are obtained from the nonlinear time history model. In determining the maximum fuel rack response, the response value for each item of interest is searched for maximum values.

The detail linear model is a three-dimensional finite element representative of a rack assembly consisting of discrete three-dimensional beam and plate elements interconnected at a finite number of nodal points. Figure 2-4(b) shows the cell and grid beam elements in one view and the shear panel plate elements in the other view. The plate elements and top and bottom grid elements are connected at the perimeter nodes of the grids.

The results of the single cell nonlinear time history model are incorporated in the detail model. Since the detail model does not account for the nonlinear effect of a fuel assembly impacting the cell and the support pad movements, the internal loads and stresses for the rack assembly obtained from this model are corrected by load correction factors. The load correction factors are derived from the single cell nonlinear model results and are applied to the components in the structural analysis. The responses of the model from accelerations in three directions are combined by the SRSS method in the structural analysis. The loads in five major components (rack support assembly, bottom grid, top grid, shear panel, and fuel cell) are examined, and the maximum loaded section of each of these components was found. These maximum loads are used in the structural analysis to obtain the stresses within the rack assembly.

Loads and Load Combinations for Structural Analysis

The loads and load combinations to be considered are those given in the "NRC Position For Review and Acceptance of Spent Fuel Storage and Handling Applications". The major seismic loads are produced by the operational basis earthquake (OBE) and safe shutdown earthquake (SSE) events.

It is noted from the seismic analysis that the magnitude of stresses varies considerably from one geometrical location to the other in the model. Consequently, the maximum loaded cell assembly, grid assembly, shear panel and rack support assembly are analyzed. Such an analysis envelops the other areas of the rack assembly.

The margins of safety for the multi-direction seismic event are produced by combining x-direction, y-direction, and z-direction loads by the SRSS method.

The loads used in the seismic analysis are corrected by load correction factors obtained from the nonlinear analysis.

Fuel Handling Crane Uplift Analysis

The objective of this analysis is to ensure that the rack can withstand the maximum uplift load of 6,000 pounds of the fuel handling crane without violating the criticality acceptance criteria.

The accident loading condition assumes that the uplift load is applied to a fuel cell. Calculations show that the resulting stresses are within acceptable stress limits. There is no change in rack geometry and the criticality acceptance criteria are not violated.

Fuel Assembly Drop Accident Analysis

The objectives of this analysis are to ensure that, in the unlikely event of dropping a fuel assembly, accidental deformation to the rack will not cause the criticality acceptance criteria to be violated, and the spent fuel pool liner will not be perforated.

Two accident conditions are postulated. The first accident condition assumes that the weight of a fuel assembly (1,616 pounds) impacts the top end fitting of a stored fuel assembly from a drop height of 2.5 feet. Calculations show that the impact energy is absorbed by the dropped assembly, the stored fuel assembly, the cell funnels and the section of cell above the upper grid. If in the unlikely event that two adjacent cells are crushed together for their full length, criticality calculations show that $K_{eff} < 0.95$. Under these faulted conditions, credit is taken for dissolved boron in the water, and the criticality acceptance criteria are not violated.

The second accident condition assumes that the dropped assembly (1,616 lbs.) falls straight through an empty cell, and impacts the rack base plate from a drop height of 203 inches. The results of this analysis show that the impact energy is absorbed by the fuel assembly and the rack base plate. The spent fuel pool liner is not perforated. Criticality calculations show that $K_{eff} < 0.95$ and the criticality acceptance criteria are not violated.

In both these accident conditions, the criticality acceptance criteria are not violated and the spent fuel pool liner is not perforated.

Fuel Rack Sliding and Overturning Analysis

Consistent with the criteria of "NRC Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," the racks are evaluated for overturning and sliding displacement due to earthquake conditions.

The nonlinear model previously described is used in this evaluation to account for fuel to rack impact loading, hydrodynamic forces, and the nonlinearity of sliding friction interfaces.

The horizontal resistive force at the interface between the rack module and pool floor is produced by friction. A low coefficient of friction ($\mu = 0.2$) produces maximum rack horizontal displacement or sliding while a high value ($\mu = 0.8$) produces maximum rack horizontal overturning force.

The fuel rack nonlinear time history analysis shows that the fuel rack slides a minimal distance (< .100 inches). This distance is less than the rack-to-rack, or rack-to-wall clearances; thus, impact between adjacent rack modules, and rack module and pool wall is prevented. Also, the factor of safety against overturn is > 100 which is well within the values permitted by Section 3.8.5.II.5 of the Standard Review Plan.

Structural Acceptance Criteria

The fuel racks are analyzed for normal and faulted load combinations in accordance with the "NRC Position for Review and Acceptance of Spent Fuel Storage and Handling Applications." It is noted that these load combinations and acceptance limits meet the requirements of the Standard Review Plan Section 3.8.4 Appendix D using the 1980 Edition W82 Addenda of Subsection NF of the ASME Code. See Attachment 1.

The major normal and upset condition loads are produced by the operational basis earthquakes (OBE).

The faulted condition loads are produced by the safe shutdown earthquakes (SSE) and a postulated fuel assembly drop accident.

The computed stresses are below the allowable stresses as required by the ASME B&PV Code, Section III, Subsection NF.

In summary, the results of the seismic and structural analysis show that the spent fuel storage racks meet all the structural acceptance criteria.

Attachment 1

Millstone 3 Load Combinations and Allowables

The Millstone 3 fuel storage racks were designed to the 1977 Edition Winter 79 Addenda of the ASME Code using the load combinations and limits from the OT Position paper, as outlined in the table below.

Table 1

Combination	Limit
1) D + L	Normal Limits of NF-3231.1a
2) D + L + E	Normal Limits of NF-3231.1a
3) D + L + To	Lesser of 2 Sy or Su - Stress Range
4) D + L + To + E	Lesser of 2 Sy or Su - Stress Range
5) D + L + Ta + E	Lesser of 2 Sy or Su - Stress Range
6) D + L + Ta + E'	Faulted Limits of NF-3231.1c

The load combinations and acceptance limits from the SRP Section 3.8.4 Appendix D are shown below.

Table 2

Load Combination	Acceptance Limit
a) D + L	Level A Service Limits
b) D + L + To	Level A Service Limits
c) D + L + To + E	Level B Service Limits
d) D + L + Ta + E	Level B Service Limits
e) D + L + To + Pf	Level B Service Limits
f) D + L + Ta + E'	Level D Service Limits
g) D + L + Fd	The functional capability of the fuel racks should be demonstrated

This paragraph presents a case by case comparison of the load combinations used for Millstone (OT Position Paper and 1977 Edition W79 Addenda) and the load combinations of the SRP 3.8.4 Appendix D and ASME Code 1980 Edition W82 Addenda (see Tables 1 and 2). Load combinations 1) and a) are the same. Load combinations 3) and b) are the same. Load combination c) must be split into primary and secondary stress. For primary plus secondary stress load combinations c) and 4) are the same. For primary stress load combinations c) and 2) are the same except for the 1.33 increase allowed by W82. (Millstone 3 is designed to the 77-W79 Code and does not use this increase.) Load combinations 5) and 3) are the same. Load combinations 6) and f) are the same. While load combinations e) and g) are not explicitly shown for the Millstone 3 load combinations the crane uplift accident (Pf) was analyzed using the normal limits, and the fuel drop accident (Fd) was analyzed to insure the racks maintain their functional capability. It is noted that the allowable design limits utilized are less than or equal to the corresponding acceptance service limits from SRP Section 3.8.4, Appendix D.

Thus, the Millstone 3 racks which were analyzed to the requirements of the OT position paper using the 1977 Edition Winter 79 Addenda of the ASME Code meet the requirements of the SRP Section 3.8.4 Appendix D using the 1980 Edition Winter 82 Addenda of the ASME Code.

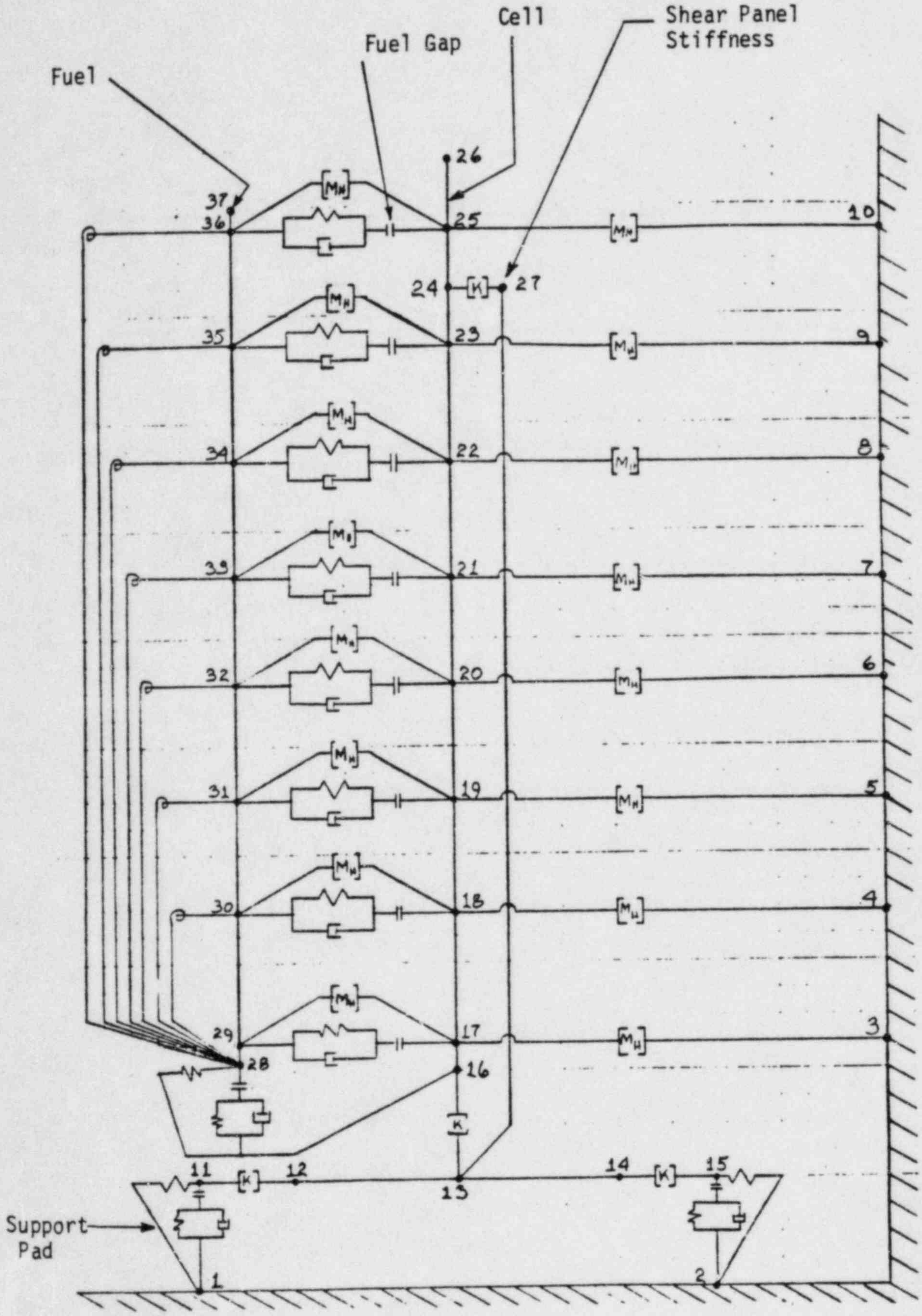
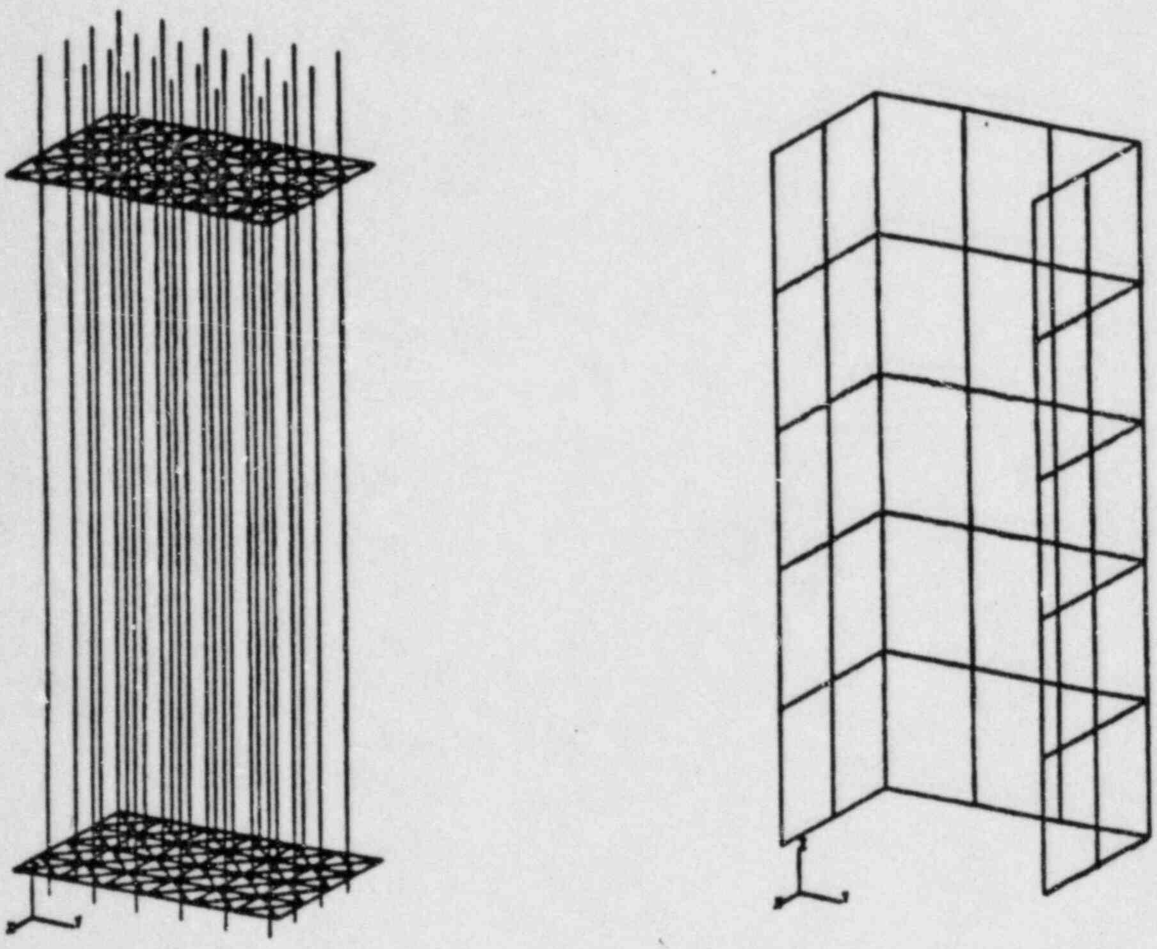


Figure 2-4 (a) Nonlinear Seismic Model



(Cells and Grids) (Shear Panels)

Figure 2-4(b) Linear Seismic Model