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Vogtle Project

August 12, 1988

U. S. Nuclear Regulatory Commission
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Log: GN-1479

PLANT VOGTLE - UNIT 2
NRC DOCKET NUMBER 50-425
CONSTRUCTION PERMIT NUMBER CPPR-109
SPENT FUEL RACKS

Gentlemen:

Our letters GN-1475 and GN-1477 provided responses to the questions contained in your letters of June 15 and June 24, 1988 except for question IV and additional information for the response to question 470 #7 concerning the analysis of dropped fuel assemblies. The evaluation of a dropped fuel assembly is included as Attachment 1 of this letter. We have noted that page III.1-3 of our letter GN-1475 inadvertently omitted part of the equation for the frequency of rack vibration. A corrected page III.1-3 is also included in Attachment 2.

Our letter GN-1422, of December 23, 1987 included summary reports on rack design and layout, seismic analysis and criticality analysis as Attachment B. Attachment 3 of this letter contains a revised criticality analysis report and revised pages for the report on rack design and layout and the report on seismic analysis. Additional revisions are provided to incorporate two changes that occurred during the rack manufacturing process as discussed below.

The first change involves the boraflex coverplate. Initially the boraflex poison was held in place by a flat coverplate attached to the sides of tubes with a series of spot welds. As a result of a slightly undersized coverplate and stresses during fabrication and testing, a few of the spot welds detached. Auxiliary retainers are now installed between the interior cells which hold the coverplates in place along their entire length. The exterior cells have been fully inspected.

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The second change involves the spacing between the cells. Fabrication activities were underway on the first five racks when it was determined that the spacing between cells (watergap) was not consistent with the dimensions used in the criticality analysis attached to our December 23, 1987 letter. The spacing between cells was measured on the first five racks and it has been determined that the revised criticality analysis based on as-built dimensions of rack A-5, using Westinghouse standard 17 x 17 fuel, bounds all existing and future racks. Increased attention has been given to the precise placement of cells during the manufacturing process beginning with the sixth rack (B-2). This was confirmed by a criticality analysis based on the as-built dimension of the sixth rack (B-2) which was manufactured with the improved process. The results of the analysis of rack B-2 is also being incorporated into the criticality report. The revised criticality analyses demonstrate that K_{eff} values for all racks remain less than 0.95 when using standard Westinghouse 17x17 fuel, which is the current fuel design for Vogtle Electric Generating Plant Units 1 and 2.

Attachment 2 contains the revised criticality report and changed pages for the Design and Layout report and Seismic report. These changes have no effect on the results of thermal hydraulic analysis. Actual changes are identified by change bars in the margins of the pages.

Should your staff require additional information concerning these changes, feel free to contact me. If necessary we will be pleased to organize a meeting with the NRC to respond to your questions concerning these changes.

Sincerely,

J. A. Bailey

J. A. Bailey
Project Licensing Manager

JAB/HWM/lg
Enclosure

xc: NRC Regional Administrator
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Attachment 1 to Letter GN-1479

Response to Question IV of NRC letter dated June 15, 1988 and additional information related to the response to question 470 #7 of NRC letter of June 24, 1988

IV. Dropped Fuel Assembly Impact

1. Provide calculations demonstrating the assertion in the submittal that the high shear stresses due to the postulated impact load will be above the active fuel region.

2. Provide calculations showing the effects of the postulated impact load on the rack base plate will not damage the pool liner.

Response

Three scenarios of fuel assembly drop (the term fuel assembly herein implies the assembly along with the control rod assembly and the handling tool, plus additional margin) are considered:

(i) The fuel assembly falls from 36" above the rack in a vertical orientation, and drops through a storage cell all the way down to the base. The storage cell is located above a support foot.

(ii) The drop scenario is identical to (i) above, except that the storage cell is located away from a support location.

(iii) The fuel assembly drops from a 36" height, and hits the top of two walls comprising a flux trap region.

By virtue of the fact that the dropped assembly hits the top of a support foot in condition (i), we expect the foot to liner interface load to be the maximum in this condition, even though the relatively constricted flow passage through the baseplate/support has the effect of reducing the impact velocity.

Condition (ii), on the other hand, maximizes the velocity with which the fuel assembly impacts the rack base plate. The integrity of the rack welds in the baseplate region is an item of concern in this case with the main concern being to demonstrate that integrity of the liner is maintained.

Condition (iii) is studied to determine the extent of permanent deformation of the lead-in region of the rack module.

The weight of the impacting assembly is assumed to be 2300 lb. and the pool is assumed to be flooded.

The analysis is performed in two steps. In the first step, the velocity of the fuel assembly during its fall is evaluated using classical principles of continuity of mass and momenta. The fluid resistance is included when the fuel assembly is within the rack structure.

Having determined the impact velocities for each scenario, the next step of the analysis for the three drop cases treats the non-linear impact problem using appropriate spring-mass-damper models and studying the response subsequent to impact, due to the specified initial velocity.

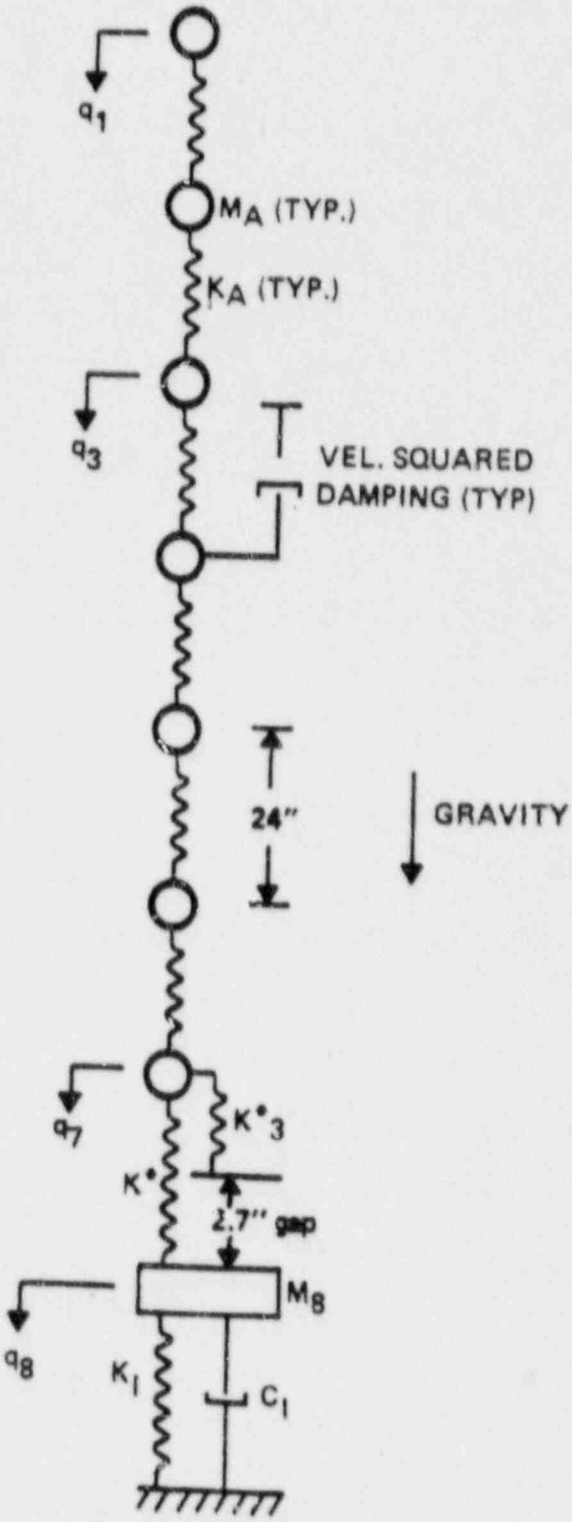
Figure 1 shows the dynamic model of the fuel assembly. Seven masses are used for the fuel assembly. The elasticity of the fuel rods is modelled by non-linear spring elements. The spring element non-linearity consists of a limiting load supporting capability; the limit load is taken as the failure load, under direct compression, of the rod bundle. A non-linear spring and stop element, in parallel, model the supports at the base of the fuel assembly. The stop element acts only if the supports completely crush under impact. Velocity square damping elements are associated with the moving masses.

The impacted structure (support foot, baseplate, or top of rack) is modelled by a mass, spring, and damper. The stiffness, etc., of this element reflects the local characteristics of the particular location being impacted under the given scenario. A time history analysis is undertaken, based on a given initial velocity of the assembly masses, to determine the maximum force in the spring damper element representing the impact body. The initial velocities at time zero are determined using classical momentum equations including the effect of fluid resistances to the drop. For drops to the baseplate or support foot, the drop is assumed to start when the assembly enters the top of the rack with an initial speed $(2gh)^{1/2}$ where h = 36".

Table 1
Summary of Results

Condition	Impact Velocity (ft/sec)	Maximum Impact Load (lb)	Comments
(i)	4.225	137,100 (on support foot)	Max. support foot load is less than the SSE limiting value.
(ii)	20.45	180,000# (on baseplate)	Welds will fail locally but surrounding welds will support the assembly; no liner impact will occur.
(iii)	13.9	50,840# (assuming 2 cells are impacted)	Max. depth of indentation is less than 2.75 inches.

The above analyses demonstrate the ruggedness of the Vogtle Unit 2 racks to withstand the postulated impact phenomena without violating any of its functional requirements.



INITIAL CONDITIONS
AT TIME $t = 0$

$q_i(0) = 0$

$\dot{q}_i(0) = V_o$

OBJECT:
DETERMINE MAX. FORCE

$F = K_I q_8 + C_I \dot{q}_8$

FIGURE 1 - DYNARACK MODEL

Attachment 2 to Letter GN-1479

Revised page III.1-3 to Georgia Power letter GN-1475 dated July 25, 1988.

For Young's Modulus, we use E so that the frequency is

$$\text{freq} = \left[\frac{1.875^2}{2\pi}\right]\left[\frac{E\ I}{m\ L^4}\right]^{1/2}$$

For the 10x12 rack,

$a = 105$ in., $b = 124$ in., $A = 362$ in.^{2},
$L = 169$ in.

A conservative estimate of the weakest metal moment of inertia is

$I = 202{,}757$ in.^{4}

For $E = 27.9 \times 10^6$ psi

$$m_1 = 0.293 \times 362/386.4 = 0.2744 \ \frac{\#\ \sec^2}{in^2};\ m_2 = 1.213\ \frac{\#\ \sec^2}{in^2}$$

$$\frac{E\ I}{m\ L^4} = \frac{27.9 \times 10^6 \times 0.202757 \times 10^6}{1.4874 \times 8.157 \times 10^8}$$

$$= 0.4662 \times 10^6$$

Therefore, using the previous frequency formula

freq = 38.2 Hz

This value is greater than 33 Hz; therefore, the assumption of a rigid rack is justified.

d. The effect of local floor elasticity on rocking motion (bending of the support) is represented by a rotational spring having spring rate

$$K_R = 2E_c\ I/_B\ (1-\mu^2)$$

Attachment 3 to Letter GN-1479

1. Change pages for "Synopsis of Module Design and Layout"

   page 1
   page 5
   Figure 4
   Figure 5

2. Change pages for "Seismic Analyses for Vogtle Electric Generating Plant Spent fuel Storage Racks"

   page 6
   pages 30 and 30a

3. Revision to "Criticality Safety Analyses for Vogtle Electric Generating Plant Spent Fuel Storage Racks"

Change Pages for the Synopsis
of Module Design and Layout

1.0 GENERAL

The spent fuel storage racks scheduled to be installed in the West pool consist of 20 free standing modules arranged as shown in Figure 1. Table 1 gives the cell count and module I.D. data. The storage cells consist of 8.75 inches nominal prismatic openings formed by seam welding precision formed channels. These cells are interconnected using longitudinal angle connectors to form a honeycomb construction structure. Each fuel storage location incorporates the Boraflex neutron absorbing material (boron carbide powder uniformly dispersed in a polymeric matrix) which is held in place by a stainless steel sheathing which is attached by a series of spot welds. In order to provide an added measure of lateral support to the sheathing, auxiliary retainers are provided in the flux trap space when the integrity of spot welds could not be verified during fabrication. The auxiliary retainer is made from a strip of 20 gauge stainless steel that is 8" wide and 165" long which is folded and inserted between cells in such a way as to retain the sheathing in place. The Boraflex encasement method provides for unconstrained in-plane contraction (or expansion) of the poison material and lends complete lateral support to it to protect it from slumping. The material is not sealed since it is compatible with the pool environment.

The fuel storage cell walls, as well as all other structural components, are fabricated from SA240 Type 304L stainless steel. The only exception is the bottom portion of the support spindle which is made out of precipitation hardened stainless steel (ASME SA564-630). The cell pitch is 10.58 inch in the north-south direction, and 10.40 inch in the east-west direction. Table 2 gives the essentials of rack construction data. These racks are free standing and are not inter-connected to each other or the pool walls. Each rack is equipped with a minimum of four adjustable support feet (Figure 2).

The poison sheet can now be installed in the picture frame space, and covered with .020" thick (nominal) sheathing. The "sheathing" overlaps the picture frame strips at the bottom, side and top. and is spot welded to them. Finally, 1-1/2" diameter flow holes are punched near the bottom on all four sides of this "composite box assembly." The top of the box is equipped with a lead-in as discussed later (Fig. 4). Added lateral support to the sheathing is provided in the form of auxiliary retainers wherever the sheathing to box weld integrity could not be verified during fabrication. Figures 4 and 5 show the auxiliary retainers schematically.

Having fabricated the required number of the composite box assemblies, they are joined together in a fixture in the manner shown in Fig. 5. The pitch between the box centerlines is 10.40" (nominal) in one principal direction and 10.58" (nominal) in the other principal direction. The fabrication procedure in either direction is identical, since the protruding angles from adjacent boxes overlap and are fillet welded to each other.

Figure 5 shows an array of boxes attached to each other. Fig. 5 also illustrates that the joining pattern results in a well designed shear flow path; and essentially makes the box assemblage into a multiflanged beam type of structure.

In the next step of manufacture, the "base plate" is attached to the bottom edge of the boxes. The base plate is a 5/8" thick austenitic stainless steel plate stock which has 6" hole (Ref. Fig. 4) burned out in a pitch identical to the box pitch. The base plate is attached to the cell assemblage by fillet welding the box edge to the plate by reaching in through the bottom hole using a "goose neck" welding head (2 sides only; other 2 sides welded from outside) (Ref. Fig. 4).

In the final step, adjustable leg supports (shown in Fig. 6) are welded to the underside of the base plate. The adjustable legs

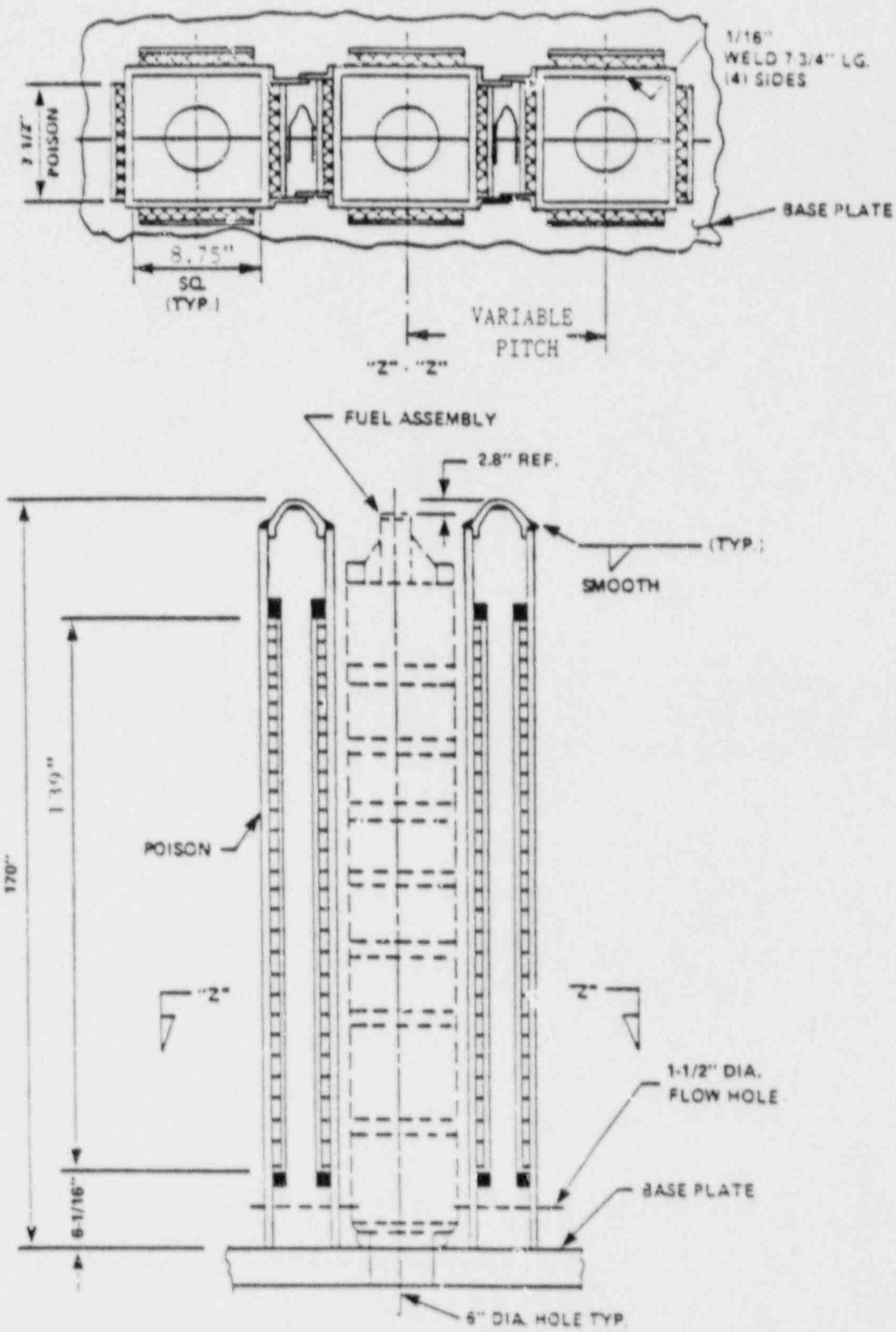


FIGURE 4 - TYPICAL CELL ELEVATION

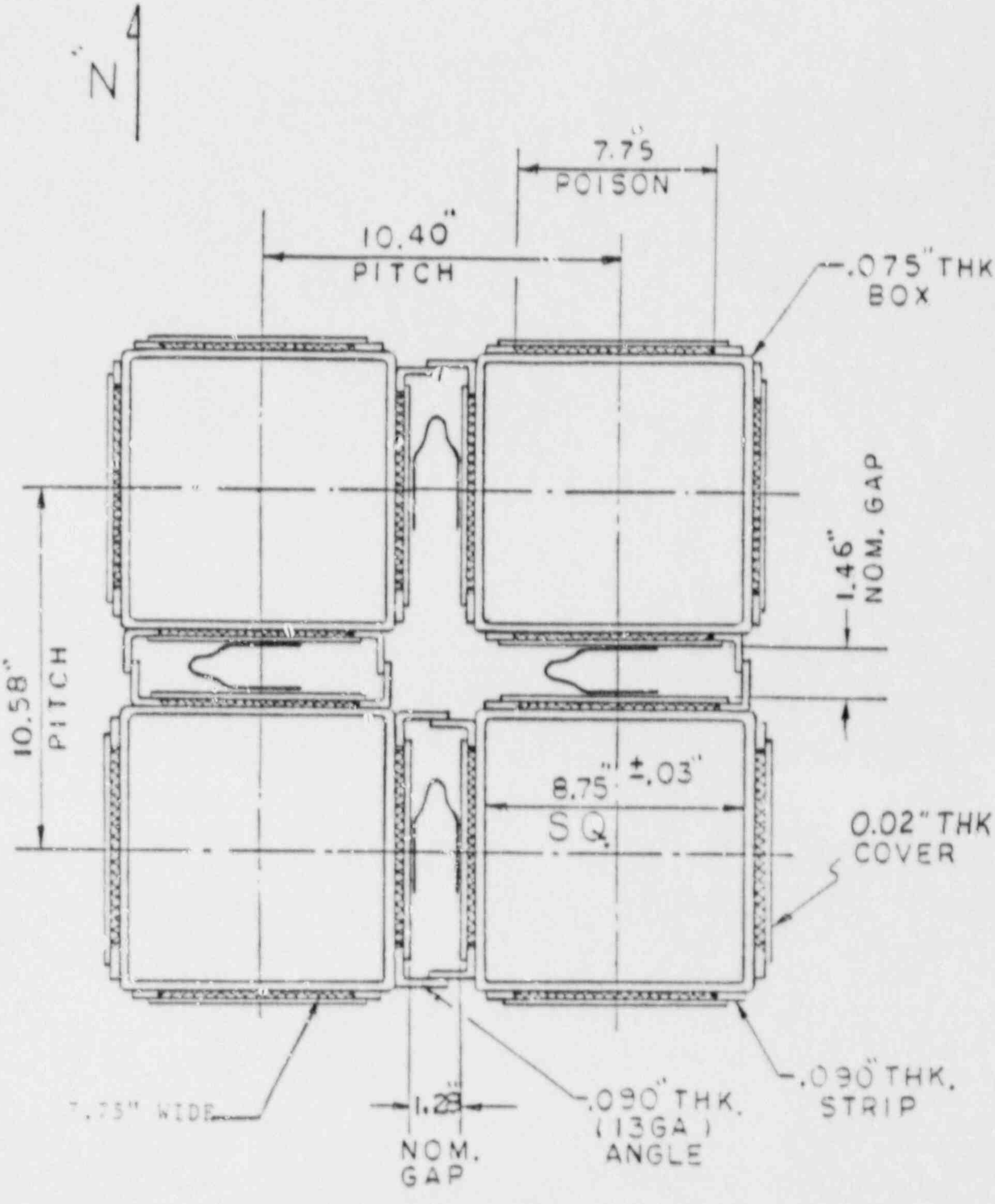


FIGURE 5 - UNIT 2 SPENT FUEL RACK STORAGE CELL GEOMETRY, TOP VIEW

Charge Pages for
Seismic Analysis
for Vogtle Electric Generating Plant
Spent Fuel Storage Racks

j. The effect of sloshing can be shown to be negligible at the bottom of a pool and is hence neglected.

k. The possible incidence if inter-rack impact is simulated by a series of gap elements at the top and bottom of the rack in the two horizontal directions. The most conservative case of adjacent rack movement is assumed; each adjacent rack is assumed to move completely out of phase with the rack being analyzed.

l. The form drag opposing the motion of the fuel assemblies in the storage locations is conservatively neglected in the results reported herein.

m. The form drag opposing the motion of the fuel rack in the water is also conservatively neglected in the results reported herein.

n. The rattling of the fuel assemblies inside the storage locations causes the "gap" between the fuel assemblies and the cell wall to change from a maximum of twice the nominal gap to a theoretical zero gap. Therefore, the fluid coupling coefficients (Refs. 8, 9) utilized are based on the average effective gap during the seismic event. Linear vibration theory is used to simulate the fluid coupling effect.

o. The cross coupling effects due to the movement of fluid from one interstitial (inter-rack) space to the adjacent one is modelled using potential flow and Kelvin's circulation theorem. This formulation has been reviewed and approved by the Nuclear Regulatory Commission, during the post-licensing multi-rack analysis for Diablo Canyon Unit I and II reracking project (Ref. 13).

Figure 7 shows a schematic of the model. Six degrees-of-freedom are used to track the motion of the rack structure. Figures 8 and 9, respectively, show the inter-rack impact springs and fuel assembly/storage cell impact springs at a particular level.

12.0 SUMMARY OF POSTULATED ACCIDENT CASES

1. 5000# Uplift on Corner of Rack

a. The stress at the rack base is less than 160 psi.

b. No yielding will occur in the cell wall at the load point if the load is spread over a distance greater than 2.88". If any local yielding does occur it will be confined to a region well above the top of the active fuel.

2. Dropped Fuel Assembly 2300# Impacting the Rack

Three scenarios of fuel assembly drop (the term fuel assembly herein implies the assembly along with the control rod assembly and the handling tool plus additional margin) are considered:

(i) The fuel assembly falls from 36" above the rack in a vertical orientation, and drops through a storage cell all the way down to the base. The storage cell is located above a support foot.

(ii) The drop scenario is identical to (i) above, except that the storage cell is located away from a support location.

(iii) The fuel assembly drops from a 36" height, and hits the top of two walls comprising a flux trap region.

By virtue of the fact that the dropped assembly hits the top of a support foot in condition (i), we expect the foot to liner interface load to be the maximum in this condition, even though the relatively constricted flow passage through the baseplate/support has the effect of reducing the impact velocity.

Condition (ii), on the other hand, maximizes the velocity with which the fuel assembly impacts the rack base plate. The integrity of the rack welds in the baseplate region is the principal item of concern in this case.

Condition (iii) is studied to determine the extent of permanent deformation of the lead-in region of the rack module.

The weight of the impacting assembly is assumed to be 2300 lb. and the pool is assumed to be flooded.

The analysis is performed in two steps. In the first step, the velocity of the fuel assembly during its fall is evaluated using classical principles of continuity of mass and momenta.

[illegible] determined the velocity of impact the next step of the analysis for the [illegible] cases treats the non-linear impact program using appropriate spring-mass-damper models and studying the response subsequent to impact with a specified initial velocity.

The results show that for condition (i) max. support foot load is less than the SSE limiting value. for Condition (ii) welds will fail locally but surrounding welds will support the assembly; no liner impact will occur, and for Condition (iii) max. depth of indentation is less than 2.75 inches.

13.0 ANALYSIS FOR STORING NEW FUEL IN THE HIGH DENSITY RACKS IN A DRY POOL

Referring to Table 9, the maximum horizontal displacements of the A1 rack is calculated for the bounding conditions of empty, full, checkerboard and half checkerboard. We show that under dry fuel conditions, the rack stress factors do not exceed specified requirements, and that the fuel rack and fuel assemblies maintain integrity during a seismic event. Local bearing stresses on the pool floor are also well within the code allowables. Tables 8, 9, and 10 contain the detailed output data.