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SUBJECT:
RESPONSE TO NRC REQUEST OF 07/11/78...FORWARDING ADDL INFO RE SUBJECT FACILITY"S SPENT FUEL POOL MODIFICATION ...W/ATT.

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WISCONSIN PUBLIC SERVICE CORPORATION

Public Service

P.O. Box 1200, Green Bay, Wisconsin 54305

August 18, 1978

Mr. A. Schwencer, Chief
Operating Reactors Branch #1
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Schwencer:

Docket 50-305
Operating License DPR-43
Spent Fuel Pool Modification

Your letter dated July 11, 1978 requested additional information regarding the Kewaunee Spent Fuel Pool Modification.

Please find attached forty (40) copies of the responses to the twelve specific additional information requests.

Very truly yours,

E. W. James
Senior Vice President
Power Supply & Engineering

snf

Attach.

782120336

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REPRO LTR

QUESTION NO. 1

The analytical model used to represent the fuel racks and base frame for the seismic analysis is not acceptable for the following reasons:

(a) Since the rack assemblies are not physically connected to one another at the top they should not be modeled as being so. If adjacent racks can impact when moving toward each other, this should be accounted for in the analyses.

(b) A linear spring attaching one end of the base structure to the wall does not represent conditions that will actually exist. These members act in compression only on both ends of the base structure and any gaps between the restraints and walls should be considered in the analyses.

(c) Base frame leveling legs should be included in the model. Again these structural members would act only in compression. If the analyses indicate that the base frame can lift off the pool floor, then impacting of the legs on the pool floor should be considered in the loading and stress calculations for both legs and pool floor itself, sizing of bearing plates on legs and possible damage to the liner plate.

RESPONSE

(a) The fuel racks are not physically connected to one another at the top. Groups of four racks (arranged in a 2 x 2 array) abut at the top at the locations of bumper screws (four per rack) while each of the four racks is bolted to a common base support frame. In the linear modal response spectrum analysis, the racks must either be connected or separated at the location of the bumper screws. Preliminary analysis showed that the worst case was for the condition of the bumper screws connected.

Although the maximum displacement at the top of the racks was calculated to be approximately 0.2 inches*, the maximum gap which could occur between adjacent racks at the locations of the bumper screws is 0.14 inches. This conservative estimate of the maximum gap is based on the assumption that two full adjacent racks can vibrate out-of-phase without impact. An impact analysis was performed in which these two racks were assumed to impact with the maximum velocity attainable without prior impacting, i.e., the velocity

*Note that the decimal point was misplaced in the value of the maximum displacement given in our response to Question No. 4 in the NRC letter of January 30, 1978.

obtained from the results of the modal response spectrum analysis. The stresses which result from impact are all less than the allowable stresses.

(b) In the finite element model shown on page 5-7 of the licensing submittal (dated November 14, 1977), the horizontal restraints to the wall are modeled as tension/compression members. This was done such that a modal response spectrum analysis could be performed. In effect, it correctly models a pair of compression only type restraints with no gaps present between the restraints and the walls. The effects of gaps are considered in the non-linear fuel-can interaction analysis. The gap between the restraints and the racks are explicitly considered as shown on page 5-10 of the licensing submittal.

(c) The base frame leveling legs were included in the model. Each of the eight legs per rack consists of a $3\frac{1}{2}$ inch diameter 5 inch long screw which rests on a $1\frac{1}{4}$ inch thick bearing plate. The fundamental frequency of vibration of the rack mass supported on these legs is greater than 100 Hz. Hence, the leveling legs were modeled as very stiff beam elements.

In order to assess the potential for significant bending moments to develop in the base frame structure due to horizontal seismic loading, the end rack shown on page 5-8 of the licensing submittal was cantilevered from the base frame which supports the other three racks. This is a very conservative assumption in that the floor of the fuel pit prevents this mode of deformation in the downward direction. In addition, the weight of the fuel and rack acting downward tends to prevent any lifting of the legs. However, the vertical weight was not included in the horizontal seismic analysis. With the above two conservative assumptions (cantilevered rack and no vertical weight), the maximum vertical displacement was calculated to be approximately 1/10 inch. When the effect of the vertical weight is included, lifting of the legs, if any, is minimal. The legs and bearing plates are designed for a compressive load of approximately 160 Kips each. The loading on each leg due to deadweight and vertical acceleration is approximately 20 Kips A margin of 8 therefore exists to account for additional loading which results from the horizontal seismic loading. This is more than adequate to account for any possible lifting and subsequent impacting of the leveling legs.

QUESTION NO. 2

Describe the properties and methods of calculation for the stick models used to represent the three rack assemblies not modeled in detail in Figure 5-1.

RESPONSE

A rack consists of a 9 x 10 array of fuel storage cans. Therefore, each of the three stick models used to represent a rack not modeled in detail has the stiffness properties of 90 cans and the mass of a fully loaded rack. This results in a conservative calculation of the natural frequencies of the rack (See the response to Question No. 11) since the stiffening effect of the can-to-grid-to-can connections is neglected but all the mass is included.

QUESTION NO. 3

If it is assumed in the seismic analyses that all cans in all racks contain fuel assemblies, then provide justification showing this assumption to be conservative relative to other possible combinations of filled, empty, and partially filled racks. Frequencies, mode shapes, deflection magnitudes, base frame response and other pertinent parameters should be addressed.

RESPONSE

It is assumed in the seismic analyses that all cans in all racks contain fuel assemblies. Since the fuel weight represents a significant portion of the total weight used in the seismic analysis (approximately 60%), the assumption of completely full racks results in the calculation of a lower bound on the frequency and an upper bound on the total weight. Since the racks are designed to be relatively stiff, i.e., their fundamental frequency is greater than the frequency at which the peak of the floor response spectrum occurs, the use of the lower bound frequency results in the use of an upper bound on the spectral acceleration. The use of the upper bound for both the weight and the acceleration results in a conservative calculation relative to that which would be performed for partially filled or empty racks.

QUESTION NO. 4

It is stated in response to Question No. 2 that 89% of the total weight in the X_1 direction is accounted for in the total modal effective weight from the first three modes and, therefore, only the first three modes need be considered. However, the staff does not consider this to be sufficient. Provide further justification or consider the following in order to qualify the racks seismically:

(a) In accordance with Regulatory Guide 1.92, the three orthogonal spatial components of the earthquake shall be considered simultaneously. The responses to earthquakes applied in all three directions, X_1, X_2, and X_3, should be combined by the SRSS method. Additionally, the requirements concerning combining responses of closely spaced modes should be considered.

(b) All modes with frequencies up to 33 Hz in each of the three directions should be included in the analyses.

(c) Discuss the boundary conditions assumed in the model when the X_2 and X_3 earthquakes are imposed on the racks and base.

Following modification of the model, as discussed in Comment No. 1, and considering the above comments, resubmit the results of the seismic analyses.

RESPONSE

(a) In the seismic analysis of the fuel racks, the total response due to seismic loading is determined by adding the response obtained from the modal response spectrum analysis to the response obtained from the impact analysis in an SRSS manner. In the modal response spectrum analysis, it was conservatively assumed that the entire mass of fuel, as well as the effective weight of water, was uniformly distributed over the height of the fuel storage can. The velocity of the rack obtained from this analysis is then used in the impact analysis. This method of determining the total response is very conservative in that the total mass of the fuel is included in both analyses. A more reasonable method would be to neglect the mass of the fuel in the modal response spectrum analysis. This, however, would be nonconservative since there is a hydrodynamic mass effect associated with the fuel. Consequently, if the hydrodynamic effect is included in the analysis, a consistent pair of analyses will exist.

QUESTION NO. 4 (Continued)

The conservatism inherent in the Kewaunee analysis will now be determined and will be based only on the load response of removing the fuel mass in the linear modal response analysis. The conservative frequency response and consequently g loads, including this fuel mass, as well as the conservative rack cantilever boundary conditions will remain as presented in the subject design analysis. In addition, the velocity used in the impact analysis will conservatively use the results of the modal response analysis including the fuel mass.

Since the response due to the horizontal motion is approximately proportional to the mass included in the linear analysis, the linear load response can be reduced in proportion to the appropriate masses. Considering the weight of the can, W_c, the weight of water, W_w, the weight of the fuel, W_f, and the weight of the base and grids, W_b and W_g, we have the following:

$$W_c = 352 \text{ lbs.}$$

$$W_w = W_w \text{ (inside)} + W_w \text{ (outside)}$$

$$= 280 + 231$$

$$= 511 \text{ lbs.}$$

$$W_f = 1404 \text{ lbs.}$$

$$W_b = 19 \text{ lbs.}$$

$$W_g = 64 \text{ lbs.}$$

The above weights are taken from the subject design analysis where the effective water weight was calculated using the fluid dynamic relations of Fritz*. A copy of these fluid dynamic calculations is attached in which the water inside the can and surrounding the fuel, as well as the water surrounding the can itself, are taken into account. As seen from the above weights, the fuel mass accounts for 60% of the total mass. However, considering the effective mass, including the water weight as presented in the attached calculations, the total effective mass excluding the fuel is 1300 lbs. Therefore, the weight ratio, W_r, by which the horizontal load response determined from the modal analysis should be reduced is:

$$W_r = \frac{1300}{2350} \doteq 0.55$$

* Fritz, R. J. "The Effect of Liquids on the Dynamic Motions of Immersed Solids", Journal of Engineering for Industry, February, 1972.

QUESTION NO. 4 (Continued)

In an attempt to determine the extent of conservatism in the Kewaunee analysis, the method of earthquake directional combination will be included. In the Kewaunee analysis, the absolute sum of the maximum horizontal response was combined with the vertical response. That is:

$$R_{abs} = |H_1| + |V|$$

where the maximum horizontal response was determined in the most flexible north/south direction (long direction) which accounted for four (4) racks in a row verse two (2) in the east/west direction. The responses when combined in accordance with Regulatory Guide 1.92 would result in a total response, R_{srss}, of

$$R_{srss} = \sqrt{H_1^2 + H_2^2 + V^2}$$

Taking the maximum horizontal response determined in the Kewaunee analysis, H_1, and conservatively setting it equal in both horizontal directions, $H_1 = H_2$, the above R_{srss} response can be rederived. Conservatively ignoring the vertical component in both the R_{abs} and R_{srss} response, the maximum difference between R_{abs} and R_{srss} is:

$$\frac{R_{srss}}{R_{abs}} = \frac{\sqrt{H_1^2 + H_2^2}}{|H_1|} = \sqrt{2}$$

Combining the linear and nonlinear responses in a SRSS manner, as completed in the Kewaunee analysis, the horizontal response is determined from

$$H = \sqrt{H_{mrs}^2 + H_{impact}^2}$$

where H_{mrs} is the response obtained from the modal response spectrum analysis and H_{impact} is the response obtained from the impact analysis. Utilizing the conservative, yet more realistic total weight in the modal response analysis, the linear plus nonlinear combination would be:

$$\overline{H} = \sqrt{W_r^2 H_{mrs}{}^2 + H_{impact}{}^2}$$

Substituting the above realistic horizontal response into the equation for the R_{srss} response, we have

$$R_{srss} = \sqrt{2}\ \overline{H}$$

Equating this response to that obtained from the Kewaunee analysis, it is the intent to show that:

QUESTION NO. 4 (Continued)

$$\frac{R_{abs}}{R_{srss}} = \frac{H}{\sqrt{2}\,\overline{H}} \geq 1$$

$$\frac{H}{\sqrt{2}\,\overline{H}} = \frac{\sqrt{H^2_{mrs} + H^2_{impact}}}{\sqrt{2(W^2_r H^2_{mrs} + H^2_{impact})}}$$

therefore

$$\frac{R_{abs}}{R_{srss}} = \sqrt{\frac{1 + H^2_r}{2(1 + W^2_r H^2_r)}}$$

where

$$H_r = \frac{H_{mrs}}{H_{impact}}$$

From the response to NRC first round Question No. 7:

Force	H_{impact}	H_{mrs}	H_r	R_{abs}/R_{srss}
M_{top} (in#)	23159	38092	1.64	1.01
V_{top} (#)	671	509	0.76	0.82
M_{bot} (in#)	33443	62335	1.86	1.04
V_{bot} (#)	714	766	1.07	0.89

Of prime concern in the rack analysis are the moments M_{top} and M_{bot}. The effect of V_{top} and V_{bot} is negligible.

This can be shown by reviewing the critical locations of the rack assembly. As an example, the results shown below indicate that the shear stress components are a very small portion of the total stress as compared to the tensile stress and can be neglected:

Inner to outer can weld	Can to grid weld
τ_b = 11595 psi	τ_b = 11541 psi
τ_{x_2} = 185 psi	τ_{x_2} = 247 psi
τ_{x_3} = 226 psi	τ_{x_3} = 248 psi

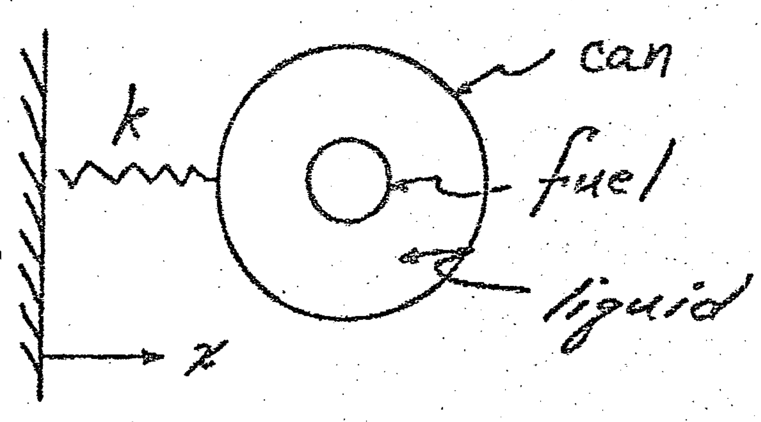
Hence, the above table shows that the response used in the Kewaunee analysis is greater than the response that would have been obtained if the SRSS approach to the combination of spatial components had been used with a more realistic estimate of the fuel mass. Therefore, the analysis completed is in accordance with and exceeds the requirements of Regulatory Guide 1.92.

(b) It is our experience that a sufficient number of modes is included in the analysis if the sum of the modal effective weight of the modes included is greater than 80% of the total weight of the structure. Since, in general, the response of the structure in the first few modes dominates, the contribution of higher modes is insignificant when the modal responses are summed in an SRSS manner. In this particular case, use of only the first three modes results in the calculation of a response equal to approximately 99% of the response which would have been obtained if all modes were used in the calculation.

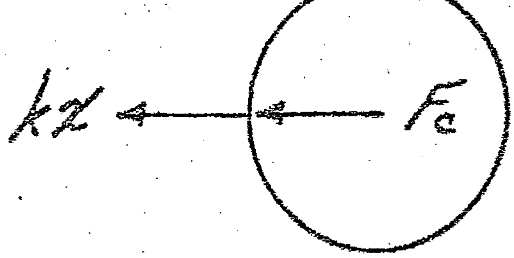
(c) See the response to Question No. 1.

EFFECTIVE MASS OF A FUEL ASSEMBLY CONTAINED WITHIN A STORAGE CAN

The effective mass of a system consisting of can containing water plus fuel as shown in the sketch below will be calculated. The approach taken follows the paper by Fritz (see Ref. 1) in which the fluid is taken to be frictionless and incompressible. Based upon potential theory fluid forces are developed for two-body motions with fluid coupling.



For the can:



where from Ref. (1),

$$F_c = (M_1 + M_H)\ddot{x}_f - (M_1 + M_2 + M_H)\ddot{x}_c$$

and

M_1 = mass of fluid displaced by the fuel

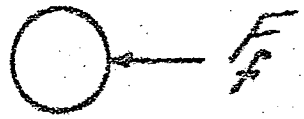
M_2 = mass of fluid that could fill the can in the absence of the fuel

M_H = hydrodynamic mass of the fuel

Dynamic equilibrium requires that

$$M_c\ddot{x}_c - (M_1 + M_H)\ddot{x}_f + (M_1 + M_2 + M_H)\ddot{x}_c + kx_c = 0$$

For the fuel:



where from Ref. (1),

$$F_f = -M_H \ddot{x}_f + (M_1 + M_H)\ddot{x}_c$$

Dynamic equilibrium requires that

$$M_f \ddot{x}_f + M_H \ddot{x}_f - (M_1 + M_H)\ddot{x}_c = 0$$

therefore,

$$\ddot{x}_f = \frac{M_1 + M_H}{M_f + M_H}\ddot{x}_c$$

the equation of motion of the can therefore reduces to

$$\left[M_c - \frac{(M_1 + M_H)^2}{M_f + M_H} + M_1 + M_2 + M_H\right]\ddot{x}_c + k x_c = 0$$

or

$$\bar{M}_c \ddot{x}_c + k x_c = 0$$

where

$$\overline{M}_c = M_c - \frac{(M_1 + M_H)^2}{M_f + M_H} + M_1 + M_2 + M_H$$

$\overline{M}_c$ can also be put in the form of

$$\overline{M}_c = M_c + M_2 + \left(\frac{1+\beta}{\gamma+\beta}\right)(\gamma - 1) M_1$$

where

$$\beta \equiv \frac{M_H}{M_1}$$

$$\gamma \equiv \frac{M_f}{M_1}$$

The effective mass of the can reduces to the sum of the mass of the can, the mass of the water within the can in the absence of the fuel, and a factor times the mass of water displaced by the fuel.

For the Kewaunee fuel and rack design:

$M_f = 1404$ #/g (Ref. 2, p. 4-44)

$M_c = 352$ #/g (Ref. 2, p. 4-44)

$M_1 = \rho V_{fuel}$

$= (0.0361)(3644)/g$ (Ref. 2, p. 4-44)

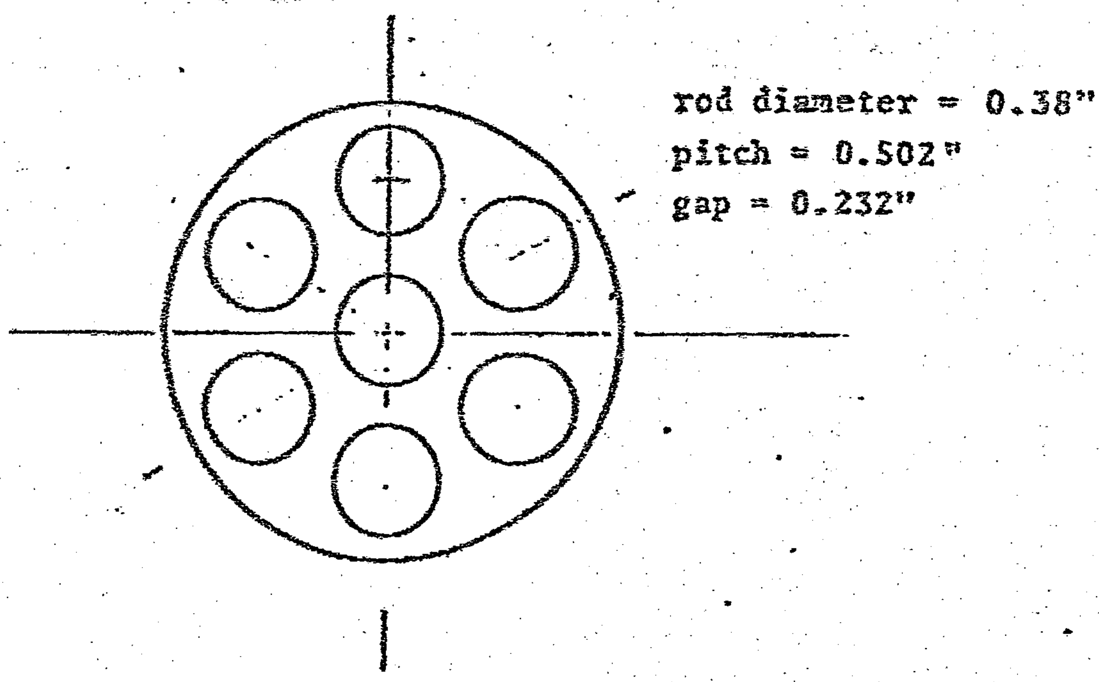
$= 132$ #/g

$M_2 = \rho V_{can}$

$= (0.0361)(11400)/g$ (Ref. 2, p. 4-45)

$= 412$ #/g

For a cylinder immersed in an infinite fluid, $M_H = M_1$ i.e., $\beta = 1$. For an array of cylinders contained within a cylinder, i.e., a fuel assembly within a fuel storage can, $\beta > 1$. For arrays of circular cylinders, a computer program, AMASS (Ref. 3) is available to calculate β. The model shown on the next page was used to calculate β for a typical geometry. Due to computer limitations, the fuel was modeled as an array of seven rods surrounded by a circular cylinder. Fuel rod diameter and pitch and fuel assembly to can gap were maintained. A value of 1.9 was calculated for β. Use $\beta = 2$ as a typical value. Then $M_H = 2 M_1$.



AMASS Fuel/Can Model

Hence,

$$\gamma = \frac{1404}{132} = 10.6$$

$$\left(\frac{1+\beta}{\gamma+\beta}\right)(\gamma-1) = \left(\frac{1+2}{10.6+2}\right)(10.6-1) = 2.29$$

The effective mass of the can, $\overline{m}_c$, is therefore

$$\overline{m}_c = \left[352 + 412 + (2.29)(132)\right]/g$$

$$= 1066 \ \#/g$$

Additional hydrodynamic mass to be added to $\overline{M}_c$ is the mass of water surrounding the can = 231 #/g.

Total effective mass to be considered in the linear analysis = 1066+231 = 1297 #/g

NUS CORPORATION

BY HKE DATE 8/1/78
CHKD. AWD DATE
JOB NO. 5122.FA

REFERENCES

(1) Fritz, R.J., "The Effect of Liquids on the Dynamic Motions of Immersed Solids," Journal of Engineering for Industry, February 1972.

(2) NUS Technical Report No. NUS-1931, Part E, December 9, 1977.

(3) Chung, H. and S.S. Chen, "Vibration of a Group of Circular Cylinders in a Confined Fluid," ANL-CT-76-25, February, 1976.

QUESTION NO. 5

A qualitative treatment of the effects of a dropped fuel assembly is not acceptable. Quantitative analyses should be made considering the three cases outlined in question number 9. The case of a straight drop through a can should be examined at a can directly over, or as close as possible, one of the leveling legs on the base frame, and at a can location in a more flexible area of the rack assembly. Provide the gross stresses calculated, discuss the local deformations that would occur and the ductility ratios assumed, and verify that the gross stresses will be less than 1.5S.

RESPONSE

For a straight drop on top of a rack, the kinetic energy to be dissipated by deformation of the rack and fuel assembly is 30530 in#. If the fuel assembly should strike only one side of the lead-in guide on a can, the guide will deform such that the fuel either continues falling down the can or rotates until it impacts the top of the rack in a horizontal position. Based upon the results of impact testing (see "Plastic Impact Testing of Shipping Cask Fin Specimens", by F. C. Davis and H. Pik, Nuclear Engineering and Design 24, 1973pages 322-331), the dropping fuel assembly will collapse the side of the lead-in guide. If it should strike two sides of the lead-in guides, the guides will be compressed approximately one inch. If the fuel then rotates and strikes the rack in a horizontal position, the kinetic energy of 137380 in# will be absorbed by a sufficient number of lead-in guides such that the damage to the rack is minimal. In all cases, gross weld stresses in the vicinity of the impact are well below 1.5S. Gross buckling loads are well below critical buckling loads.

For the case of a fuel assembly dropped such that it falls directly down a can, a kinetic energy of approximately 240,000 in# is developed at the time the lower end fitting of the fuel assembly strikes the fuel support bars near the base of the can. Assuming (conservatively) that the fuel assembly is a rigid body, the force of the impact is sufficient to shear off these two support bars. If the fuel is dropped in a relatively flexible location, i.e., near the center of a rack, gross stresses in the lower grid structure are on the order of 15000 psi. If the fuel is dropped in a relatively stiff location, i.e., near the location of a leveling leg, most of the force will be transmitted directly to the leveling leg. A conservative calculation shows that the stress in the leveling leg is well below yield.

QUESTION NO. 6

Verify that the loading combination with a stuck fuel assembly meets a stress allowable of 1.5S.

RESPONSE

For the loading combination with a stuck fuel assembly, i.e., dead loads plus thermal loads plus a stuck fuel assembly, the critical location is at the fuel can to grid welds. At this location the maximum stress was calculated to be 6668 psi. This stress is well below a stress allowable of 1.5S or 14700 psi.

QUESTION NO.7

Indicate whether or not the 17-4 PH stainless steel components will be heat treated to at least 1100°F, each piece hardness tested, and either pickled or grit blasted in order to remove the surface film resulting from the heat treatment.

RESPONSE

The 17-4 PH stainless steel components will be heat treated to at least 1100°F. After heat treatment, the heat tint is specified to be removed by either pickling or grit blasting. Each piece will not be hardness tested but correct heat treatment will be verified by destructive examination of test samples heat treated along with each lot of material.

QUESTION NO. 8

Verify that the permissible stresses for the stainless steel welds are no greater than those specified in Table NF-3292.1-1 of the ASME B&PV Code Section III.

RESPONSE

The structural acceptance criteria adopted for the analysis are those given in Section 3.8.4 of the Standard Review Plan. Hence, permissible stresses are in accordance with Table 1.5.3 of the AISC Specification for the Design, Fabrication & Erection of Structural Steel for Buildings.

QUESTION NO. 9

Indicate whether a fuel assembly is the heaviest object and will develop the highest kinetic energy of all objects that could possibly be dropped into the spent fuel pools. If not, provide an analysis demonstrating that the pool and racks will maintain their structural integrity and meet the required stress allowable for the heaviest object.

RESPONSE

Response to Question No. 9 is as presented in answer to previous Question No. 8 and 19 transmitted by letter dated March 13, 1978.

In addition, Proposed Amendment No. 31 to the Kewaunee Technical Specification states "Heavy loads, greater than the weight of a fuel assembly, will not be transported over or placed in either spent fuel pool when spent fuel is stored in that pool. Placement of additional fuel storage racks is permitted, however, these racks may not traverse directly above spent fuel stored in the pools".

QUESTION NO. 10

Indicate the values of the section strengths, S, for all materials used in the racks and base frame and where they are taken from.

RESPONSE

The section strength, S, is proportional to the yield strength of the material. Yield strengths for the rack and base frame structural materials are tabulated below.

Material	Yield Strength (psi) @150°F	Yield Strength (psi) @220°F	Reference
ASTM A-240 Type 304	27500	24500	1
ASTM A-564 Type 630 (17-4PH H1100)	110600	105400	2
ASTM A-240 Type XM29 (Nitronic 33)	49000	43760	3
ASTM UNSS 210800 (Nitronic 60)	Not used	37900	4

References:

(1) ASME B&PVC, Section III, Div. 1, Subsection NA, Table I-2.2, (W 1976).

(2) ASME B&PVC, Section III, Div. 1, Subsection NA, Table I-2.1, (W 1976).

(3) Product Data S-53a, "Armco Nitronic 33 SS," Armco Steel Corp.

(4) Product Data S-56a, "Armco Nitronic 60 SS," Armco Steel Corp.

QUESTION NO. 11

Indicate whether the impact loading and resultant stresses from the non-linear dynamic analysis of the fuel/can assemblies is added to the other stresses and loads present. Discuss the local effects where the assembly impacts the can and the structural integrity of the fuel assembly itself.

RESPONSE

A response spectrum modal dynamic analysis of the racks was performed in which the racks were assumed to be completely filled with fuel assemblies. The mass of the fuel was distributed uniformly over the height of the fuel storage cans in the model while the fuel stiffness was neglected. Since the rack is designed to be relatively stiff, i.e., the rack fundamental frequency is greater than twice the dominant frequency of motion of the fuel pit, inclusion of all the mass of the fuel and omission of the fuel stiffness results in a low estimate of the fundamental frequency of the rack and, hence, a conservatively high estimate of the spectral accelerations.

The effect of impact between the fuel and the cans was evaluated using a nonlinear dynamic analysis in which it was assumed that all fuel impacts at the same time. Because the parameters which govern nonlinear aspects of the fuel-can interaction (such as initial gaps, straightness, local flexibilities, local seismic induced accelerations, vary throughout the rack assembly, identical behavior of all fuel assemblies is highly improbable.

Since the fuel impact process is somewhat random, it is highly unlikely that all fuel would impact at any particular instant in time and even more unlikely that all the fuel would impact at the time of the maximum response to the seismic acceleration as determined from the response spectrum modal dynamic analysis. The stresses which result from each of the two analyses discussed above were therefore added in an SRSS manner.

The rack is designed such that the fuel assembly upper end fitting will contact the can at the elevation of the upper can spacer grid and thereby distribute the impact load throughout the grid system. This effect is accounted for in the analysis. Local deformation of the can at the locations of impact is elastic. The punching shear stress is estimated to be less than 500 psi while the bending stress is estimated to be less than the yield strength.

Regarding fuel assembly structural integrity, this has been previously analyzed and results presented in the Kewaunee Nuclear Plant Final Safety Analysis Report (Section 14.2.1).

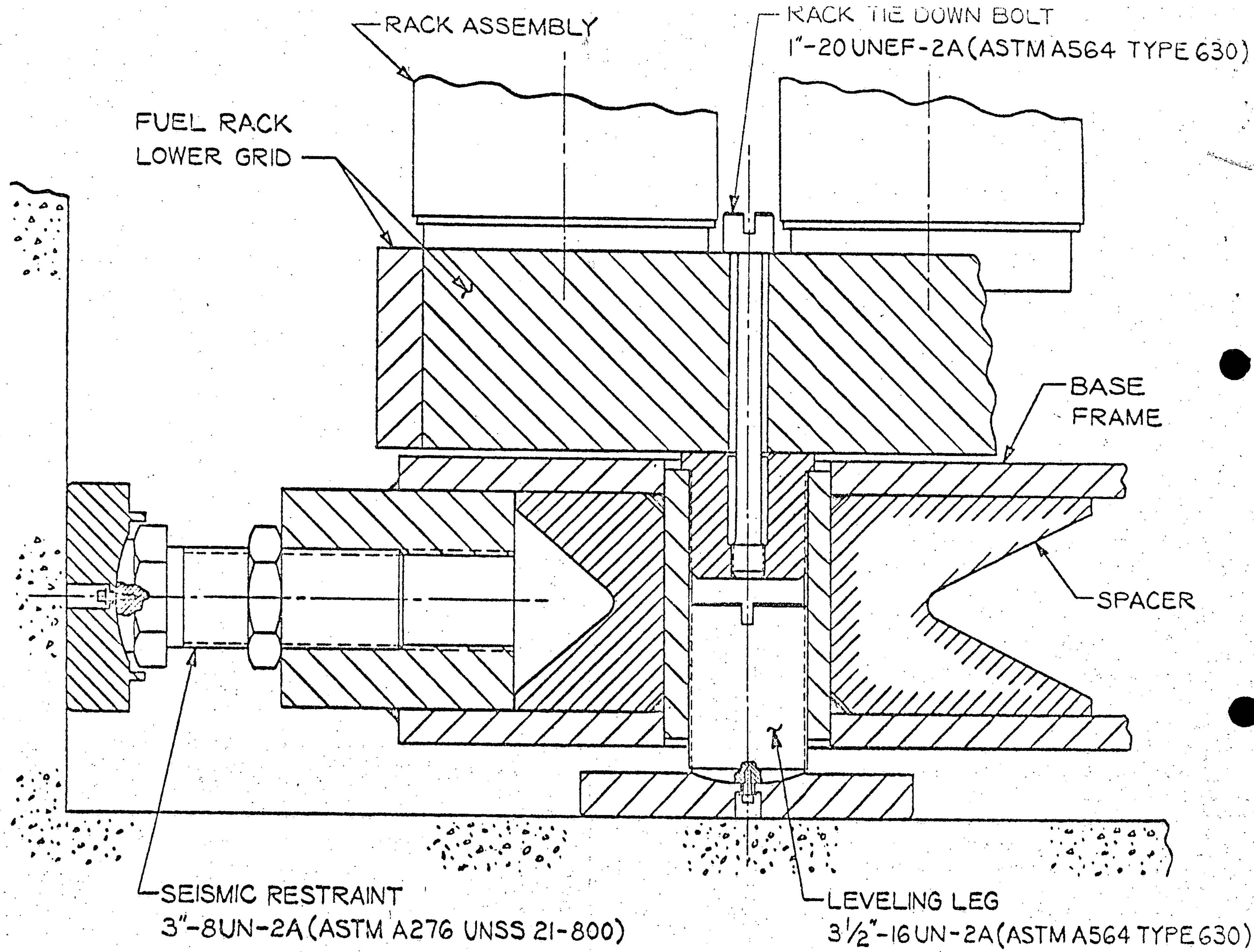
QUESTION NO. 12

Provide details of the interface in the East-West direction between base frames and pool walls. Also, provide details of the interface between the top portions of all rack assemblies. Provide details of the interfaces around the equipment laydown area. Enough details should be provided so that a correlation between the assumed boundary conditions in the seismic analyses and the actual conditions can be made.

RESPONSE

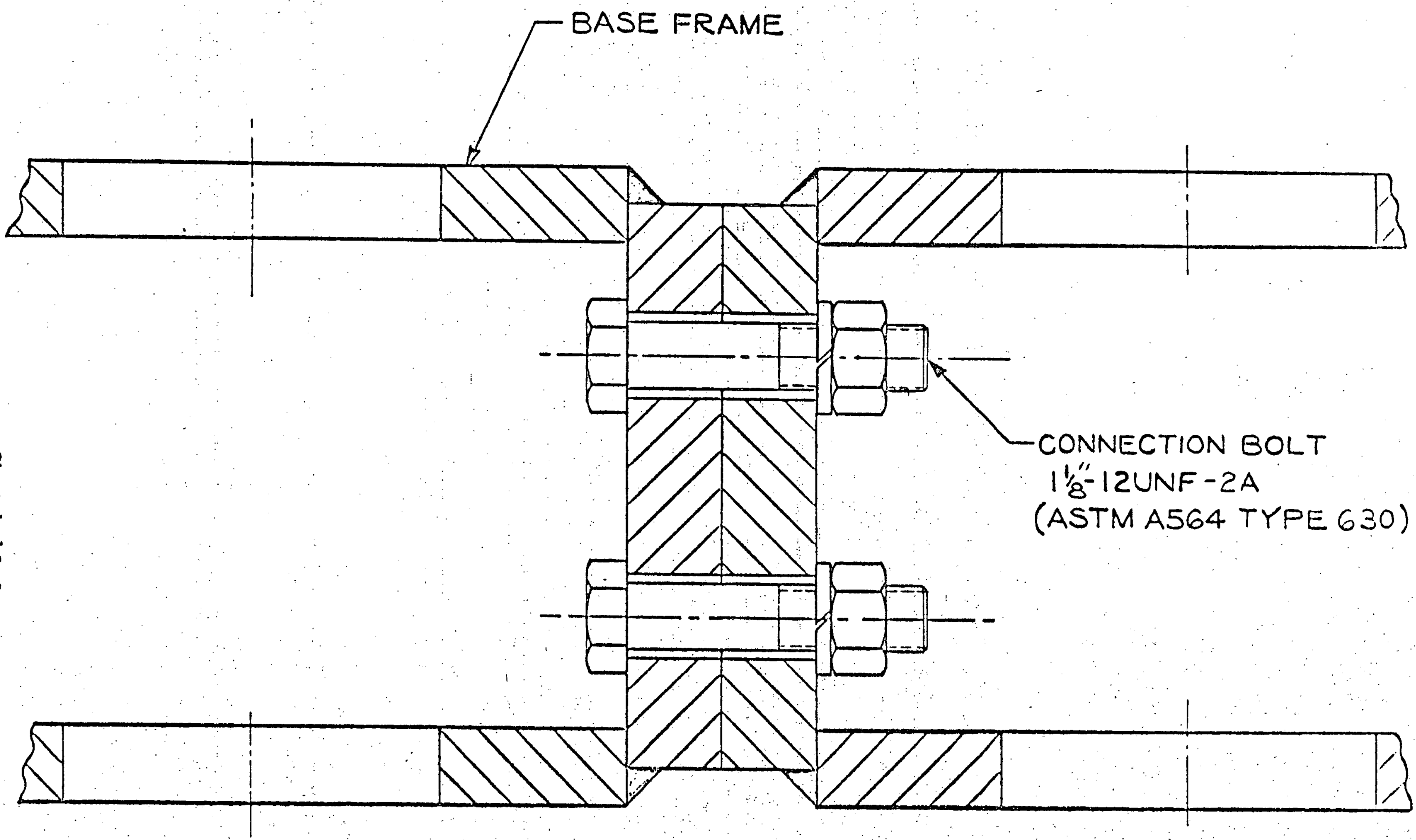
The attached sketches provide the information requested noting that the individual cans are formed into 9 x 10 racks by welding to upper and lower grid structures and the racks are in turn bolted to the base frames which are bolted together to entirely fill the pool and are restrained from moving by "compression only" seismic restraints to the pool walls.

Sketch 12-1

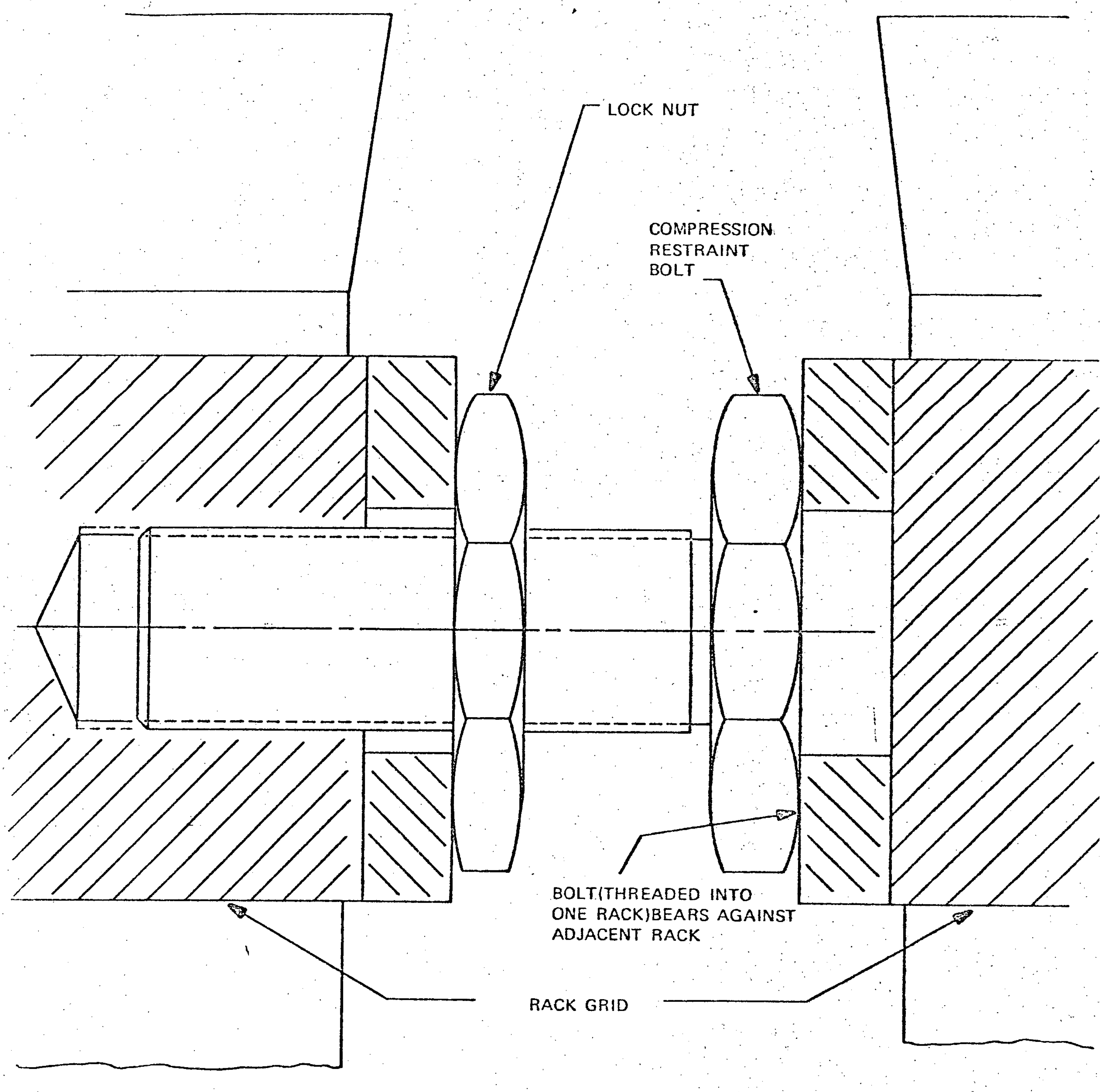


DETAIL OF ① FUEL RACK TO BASE FRAME CONNECTION,
② BASE FRAME LEVELING LEG AND
③ BASE FRAME SEISMIC RESTRAINT

Sketch 12-2

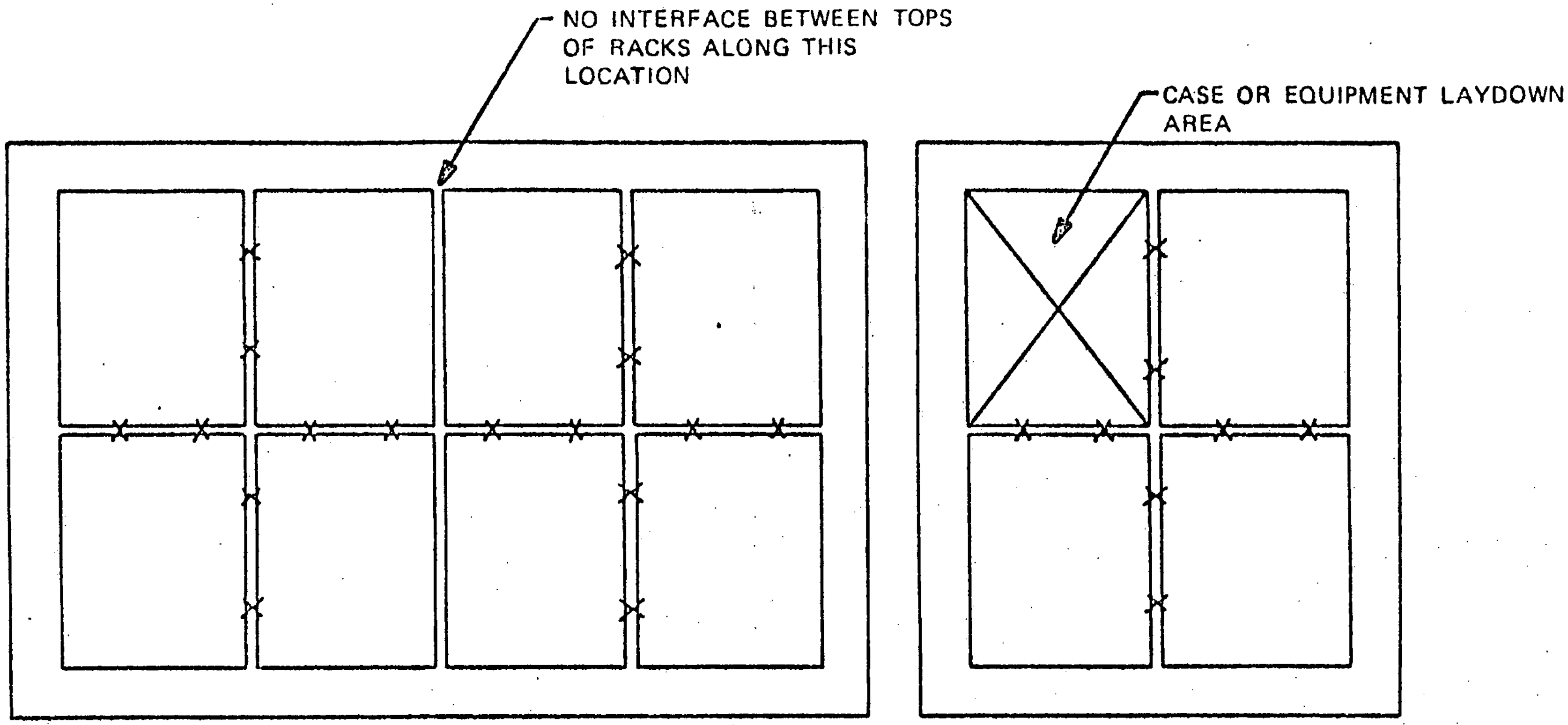


BOLTED CONNECTION BETWEEN BASE FRAMES


LOCK NUT
COMPRESSION RESTRAINT BOLT
BOLT(THREADED INTO ONE RACK)BEARS AGAINST ADJACENT RACK
RACK GRID

SKETCH 12–3

NORTH →



1. INTERFACE BETWEEN BASE FRAMES AND BASE FRAMES & WALLS IN THE EAST/WEST DIRECTION ARE AS SHOWN ON EXISTING SKETCHES 12–1 AND 12–2

2. INTERFACE BETWEEN TOP OF RACKS AT LOCATIONS MARKED "X" ARE AS SHOWN ON ATTACHED SKETCH 12–3

3. INTERFACE BETWEEN RACKS AND FRAME AROUND EQUIPMENT LAYDOWN AREA ARE TYPICAL TO A RACK TO RACK INTERFACE

SKETCH 12–4