GPU Nuclear

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October 29, 1982

Mr. Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Crutchfield:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
Systematic Evaluation Program (SEP)
Topic III-6, Seismic Design Consideration

Attached are the results of our evaluation of the structural adequacy of the Oyster Creek CRD hydraulic control unit racks for the seismic loads resulting from the site specific spectra.

The NRC evaluation conducted previously indicated that the structural integrity of the CRD hydraulic control units is still an open issue due to lack of design information. By letter dated November 24, 1981, GPU transmitted to the NRC our analysis entitled "Evaluation of CRD Hydraulic Control Units" which shows that the units are structurally adequate for SSE loads. Subsequently, in April 1982, the NRC requested additional information regarding effects of axial-bending stress interaction and whether the resulting stresses meet ASME Code, Service Level D allowables.

The attached analysis dated May 7, 1982, responds to the NRC questions and demonstrates that axial-bending stress interaction effects are negligible and that Service Level D limits are met. Accordingly, all outstanding questions on the CRD hydraulic control units are considered resolved.

Very truly yours,

Peter B. Fiedler
Vice President and Director
Oyster Creek

A035

PBF:lse

Attachments

cc: Mr. Ronald C. Haynes, Administrator
Region I
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, PA 19406

NRC Resident Inspector
Oyster Creek Nuclear Generating Station
Forked River, NJ 08731

May 7, 1982

EVALUATION OF CRD HYDRAULIC CONTROL UNITS
OYSTER CREEK NUCLEAR GENERATING STATION

Purpose:

To re-evaluate the structural adequacy of the Oyster Creek CRD hydraulic control unit racks for the seismic loads resulting from the site specific spectra (SSS).

Background:

The seismic adequacy of the CRD control unit racks was previously evaluated in MPR analysis "Evaluation of CRD Hydraulic Control Units" dated September 15, 1981, Reference 1. This analysis was provided to NRC representatives (Mr. T. Cheng and Dr. J. Stevenson) on October 19, 1981. The results of this analysis indicated that for floor response spectra developed by MPR for the Oyster Creek SSS, the maximum seismic loads result in a bending stress in the tubular support frame of 30,120 psi. This stress is less than the effective elastic stress of 34,250 psi at the pipe limit moment and was therefore considered to be acceptable.

In subsequent communications received from the NRC (Messrs. Cheng and Stevenson) on April 1 and 19, 1982, the NRC requested that the previous analyses be re-evaluated to determine if the "stress in limiting support elements are within ASME Service Condition D stress limits for supports when considering deadweight, axial-bending interaction effects and the effects of element curvature". The analyses which follow respond to this request.

Evaluation:

1. Seismic Stresses and Moments

The evaluation of the Oyster Creek CRD control unit support racks is based on a generic finite element analysis performed by General Electric (GE) in Reference 2. The racks analyzed in Reference 2 have been confirmed by inspection to be identical to those installed at Oyster Creek (see Reference 3).

The significant results of the GE analyses are presented below for the limiting support element - the 1-1/2" Schedule 40 curved pipe elements at the base of the support racks.

Earthquake Direction	Nat'l Freq. (HZ)	Peak Accel. (gs)	Bending Stress (psi)	Axial Stress (psi)
Worst Horizontal	2.27	11.5	335,300	3,755
Vertical	23.8	5.3	13,745	660

The above elastic stresses calculated separately for horizontal and vertical earthquake components are ratio'd to the peak acceleration valves expected for the Oyster Creek SSE and combined by the square root of the sum of the squares (SRSS) of the vertical and two horizontal components. The expected peak accelerations for the CRD control units are obtained from the amplified floor response spectra curves presented in Reference 4 for the 0.165g SSS, 23' elevation and 7% damping - the same inputs used in the previous analyses of Reference 1. The peak accelerations and the resulting bending and axial stresses are given below.

Earthquake Direction	Nat'l Freq. (HZ)	Peak Accel. (gs)	Bending Stress (psi)	Axial Stress (psi)	Total (psi)
Worst Horizontal	2.27	0.72	20,993	235	21,228
Vertical	23.8	0.16	2,531	122	2,653

Total SRSS Bending and Axial Stress = 30,140 psi.

This value is within 1% of the maximum bending stress reported in Reference 1 and confirms that deadweight and axial stress effects are negligible. The net moment corresponding to the above stress is 30,140 psi x the section modulus for 1-1/2 Schedule 40 pipe, or 9,826 in-lbs.

The fact that the structural element in question is a curved beam can be accounted for by the application of a stress intensification factor applicable to the maximum stress on the concave side of the elbow. This factor is given in Reference 5, Table VII, as

$$\text{S.I. Factor} = 1 + 1.05 \cdot \frac{I}{dc^2}\left[\frac{1}{R-C} + \frac{1}{R}\right]$$

where

d = pipe diameter = 1.900"

c = pipe radius = 0.950

R = elbow radius = 4.5"

I = moment of inertia = 0.31 in^4

For these values,

S.I. Factor = 1.096

This indicates that the curvature effects are about 10% at the worst location on the pipe element. The maximum peak stress is therefore:

Maximum combined peak stress = 1.096 x 30,140 psi, or 33,033 psi. As indicated above, this stress is essentially all due to bending.

2. Allowables

The allowables suggested by the NRC are the Service Level D allowables for component supports given in Subsection NF of the ASME Code, Section III. This subsection provides two alternative acceptance criteria:

a. Elastic Analysis - NF-3231.1 permits application of F-1370 of Appendix F of Section III, which in turn refers to Appendix XV11-2000. Specifically, F-1370 states that for Level D loads the allowables given in XVII-2000 for normal loads may be increased by a factor of

$1.2Sy/_{F_t}$, where

Sy = yield stress = 25000 psi

F_t = tensile allowable = 0.60 Sy,

but not to exceed

$0.7\ Su/_{F_t}$, where

Su = 45000 psi (from Appendix I of Section III for 24000 psi yield strength carbon steel).

The allowable bending stress is then

$\frac{1.2\ Sy}{F_t} \times 0.66\ Sy$, or 1.32 Sy.

For the CRD racks, this allowable is

1.32 (25000) = 33000 psi

This value is greater than the average bending stress of 30,140 psi and only slightly less than the local peak stress of 33,033 psi calculated above for the Oyster Creek racks. Within the normal accuracy for such calculations, the racks are considered to meet this criterion.

b. Inelastic Analysis - A limit analysis in accordance with XVII-4000 is also permitted as an alternative to the elastic analysis. This method requires that the lower bound collapse moment, Mp, be no less tha 1.1 x the applied moment,

where

$Mp = Sy \times Z_x$ and

Z_x = the plastic section modulus.

For 1-1/2 Schedule 40 pipe, the plastic section modulus is

$$Z_x = 1.372 \times \text{Section Modulus}$$
$$= 1.372 \times 0.326 \text{ in}^3$$
$$= 0.447 \text{ in}^3.$$

Then, the lower bound collapse moment is:

$$Mp = 0.447 \times 25000 = 11{,}180 \text{ in-lbs}.$$

This value is greater than 1.1 x the applied moment, which is:

1.1 x 9826 in-lbs, or 10,809 in-lbs.

Thus the alternative, limit analysis criteria for Service Level D loads are met.

c. Buckling

In addition to the above, the Code requires that the critical buckling load for beam sections be at least 1.5 x the applied load. From Reference 5, Table XVI, the critical buckling moment for a thin tube in bending is

$$M_c \geq 0.72 \frac{E}{1-\nu^2} rt^2,$$

where

$E = 28 \times 10^6$ psi

$\nu = 0.3$

r = tube radius - 0.95 inch

t = tube wall thickness = 0.145 inch.

Then,

$Mc \geq 440,000$ in-lbs.

This moment is substantially in excess of 1.5 times the applied moment of 9826 in-lbs. Therefore buckling is not a problem.

Summary of Results

Results of analyses presented herein show that the stresses and moments in the limiting elements of the Oyster Creek CRD control unit support frames essentially meet the Service Level D allowables of the ASME Code for component supports for the 0.165g site specific spectra and the interim floor response spectra given in Reference 4.

In addition, new floor response spectra have recently been generated by URS/Blume and Associates using a conventional time-history analysis method for the 0.165g site spectra. These spectra are presented in Reference 6. These floor response spectra for the 23' elevation of the Oyster Creek reactor building have lower accelerations at the fundamental frequencies of the CRD control unit racks than those calculated in Reference 4 and used in the above analyses. Specifically, the comparable peak horizontal acceleration (at 2.27 Hz) is reduced from 0.72g to 0.58g; the peak vertical acceleration (at 23.8 Hz) is reduced from 0.16g to 0.14g. The net result of these reductions is to reduce the calculated stresses and moments by about 19%. This reduces the highest calculated peak stress in the limiting element to approximately 26,760 psi, which is well within the elastic allowable of 33,000 psi. Similarly, 1.1 x the applied moment is reduced from 10,809 in-lbs to 8755 in-lbs which is well below the lower bound limit moment of 11,180 in-lbs.

Based on the re-analyses presented herein and the additional margin resulting from the use of the latest plant specific floor response spectra, the Oyster Creek CRD hydraulic control units are considered acceptable for the design seismic loads.

References

1. MPR Analysis "Evaluation of CRD Hydraulic Control Units" dated September 15, 1981.

2. General Electric Report 383HA853, "Hydraulic Control Unit, Seismic Analysis of, dated November, 1972.

3. MPR letter to GPUN dated November 30, 1981.

4. MPR-691, "Interim Floor Response Spectra for the Oyster Creek Reactor Building" dated October 15, 1981.

5. Roark, R.J., Formulas for Stress and Strain, McGraw-Hill.

6. URS/J.A. Blume and Associates Report, "Seismic Acceleration Floor Response Spectra for the Reactor Building at Oyster Creek Nuclear Power Plant" dated December 1981.