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FROM: Carolina Power & Light Co.
Raleigh. N.C.
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PLANT NAME: H.B. Robinson # 2

ENCLOSURE

Summary of the Containment Liner Stress Analysis Report.......

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FILE: NG-3514(R) SERIAL: NG-76-443

RECEIVED MAR 29 1976 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Director of Nuclear Reactor Regulation
ATTN: Robert W. Reid, Chief
Branch No. 4
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

50-261

RE: H. B. ROBINSON UNIT NO. 2
DOCKET NO. ~~50-263~~

Dear Sir:

Carolina Power & Light Company has evaluated the bulged containment liner sections and provided information to the Commission by letters dated June 24, 1974, and January 14, 1976, to demonstrate that the bulged sections will perform their containment function under both normal and accident conditions. During telephone discussions with your Messrs. D. N. Bridges and G. Bagchi, they requested additional information concerning the analyses performed by the Company to assure that the bulged areas will provide their containment function during postulated accidents.

An analysis was performed by Ebasco Services, Inc. to determine the response of the bulged liner during normal and accident conditions. The analysis shows that the bulged liner and its anchor studs are effective to meet their functional requirements during loss of coolant accident or normal operating conditions.

Attached is a summary of the analysis performed to demonstrate the integrity of the bulged liner. The documentation provided should be sufficient to assure the Commission that the bulged areas are stable and will maintain containment integrity during normal and accident conditions.

Yours very truly,

E. E. Utley
Vice President
Bulk Power Supply

RLMjr/sh

Attachment

cc: Mr. N. C. Moseley

336 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

3179

Sworn to and subscribed before me this 25th day of March, 1976.

Marilyn V. Pease
Notary Public

My Commission Expires: October 19, 1980

HB ROBINSON UNIT NO. 2
SUMMARY OF THE CONTAINMENT LINER STRESS ANALYSIS REPORT

I. INTRODUCTION

The report summarizes studies made to determine the effects of containment steel liner bulges observed at HB Robinson Steam Electric Plant Unit No. 2. The bulges were observed recently during a plant shutdown for refueling. A full pressure containment integrity test has been performed since bulges were observed and no damage to either the liner or liner anchor studs was found.

II. DESCRIPTION OF LINER ARRANGEMENT

The containment structure at HB Robinson Unit No. 2 utilizes the concept of vertically prestressed reinforced concrete construction. The inner surfaces of the containment are completely lined by steel liner of 3/8" thick except at dome region where a liner thickness of 1/2" is used. The steel liner is designed to serve as a leak proof membrane and is not relied upon for the structural integrity of the containment except for resisting tangential shear force at dome. The liner is anchored to the concrete cylinder wall and dome by means of "KSM" shaped steel studs of 3/8" diameter. The minimum spacing of studs were determined such that buckling of liner plate is avoided. To miminize liner stress below yield stress, sufficient insulation is provided to reduce thermal effect on liner due to LOCA. The liner bulges observed were behind insulation materials and in the region where stud spacing of 16" O_c is used.

III. ANALYTIC APPROACH AND ASSUMPTIONS

A finite element approach was used for the liner and stud stress analysis. The mathematical model used reflects a curved liner plate with the middle portion distorted to simulate an idealized liner bulge. Boundary conditions of this model are assumed fixed at all four edges. Each modal point is assumed to be restrained by shear and tension springs simulating anchor stud. The maximum bulge as measured is approximately 2.5 inches from the true radius of the concrete containment. The complete model has a dimension of approximately 37 ft x 27 ft while the idealized bulged configuration is assumed to be 12 ft x 6 ft. The analysis assumed that two adjacent studs have been broken

III. ANALYTIC APPROACH AND ASSUMPTIONS (Cont'd)

at modal points 262 and 283 in order to assure a conservative result. All other studs are assumed to be fulfilling their intended function. Spring constant of the 3/8" stud is approximated from data in a Nelson Stud Report. All loadings in the model were represented by equivalent thermal load and were analyzed using the STARDYNE Computer Program of the Control Data Corporation.

IV. CONDITION ANALYZED

Analysis was conducted by imposing a 104° F thermal load on the liner plate assuming the concrete to which liner is anchored remain thermally unchanged. This thermal load consists of the net temperature rise above the "as built" temperature due to LOCA, and the equivalent effects of other phenomena such as the vertical prestressing, dead load, shrinkage and creep of concrete. To be more conservative, the LOCA pressure load is completely neglected since it would act favorably to reduce liner and stud stresses.

V. RESULTS AND DISCUSSIONS

In the liner bulged area, maximim tensile and compressive stud load of 6.65^K and 1.94^K are observed at modal points 304 and 219 respectively, both loads are less than the ultimate capacity of studs reported at 8.85^K. Away from the bulged area, maximum compressive stud load of 14.37^K is found at modal point 302. This load, although beyond the ultimate capacity of stud, is of no consequences since the load would eventually be taken by concrete. No tensile load is observed away from the bulged area.

Maximum stud shear force of 1.74^K at modal point 281 is observed. This is less than 2.94^K, the allowable shear load for the 3/8" stud.

Maximum liner compressive stress of 38.45 Ksi is found on plate no. 37. This stress is higher than the yield stress of the liner plate, however, the maximum strain of the liner is only 0.0013 which is only about 40 percent of the strain limit as recommended by the ASME/ACI proposed standard code for concrete reactor vessels and containments.

VI. CONCLUSIONS

Although a maximum liner bulge of 2.5 inches has been measured, a study of contours of solid concrete in the adjacent area of the bulge indicated that

VI. CONCLUSIONS (Cont'd)

the separation between liner and concrete even at the maximum bulge is probably very insignificant. This conclusion is supported by results of the containment full pressure test which reported no damage or permanent set in the liner at the anchor stud hard points. The analysis shows that the effect of liner bulge as observed and measured introduced shear and axial loads to the liner studs which would be free from them if bulge did not exist. Also, when broken studs are postulated, liner stresses and stud loads are significantly increased in and near the area of the assumed broken studs. However, as discussed earlier, neither the stud load nor the liner stress has exceeded the allowable criteria of materials used. It is therefore concluded that under all reasonable assumptions made in this report, the bulged liner and its anchor studs are effective to meet their functional requirements during LOCA or plant normal operating conditions.