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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October 12, 1984

Docket No. 50-423
F0443A

Dr. Thomas E. Murley
Regional Administrator
Region I
U. S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, PA 19406

References: (1) W. G. Counsil to T. E. Murley, B10964, dated December 1, 1983.

(2) W. G. Counsil to T. E. Murley, B10815, dated June 17, 1983.

(3) Stone & Webster Engineering Corporation, NERM-59, Millstone Nuclear Power Station, Unit No. 3, "Evaluation of Anchor Stud Spacing Containtment Structure Steel Liner," dated May 23, 1984.

Dear Dr. Murley:

Millstone Nuclear Power Station, Unit No. 3
Reporting of Potential Significant Deficiencies
in Design and Construction: Containment
Liner Stud Spacing (SD-38)

In a May 19, 1983, telephone conversation between your Mr. T. Elsasser and our Mr. R. R. Viviano, Northeast Nuclear Energy Company (NNECO) reported a potential significant deficiency in the construction of Millstone Unit No. 3 as required by Title 10 Code of Federal Regulations Part 50, Paragraph 55(e). The potential significant deficiency involves containment liner stud (anchor) spacing in excess of specification requirements. (See References 1 and 2).

We have completed our evaluation of the stud spacing in the Millstone Unit No. 3 containment liner to determine its potential impact on containment liner integrity. The results of this evaluation are documented in a report by our architect-engineer (Reference 3) and a copy of this was given to your Mr. K. A. Manoly during his site visit on August 14, 1984.

We have concluded that the present containment liner stud spacing for Millstone Unit No. 3 is adequate and that it would have had no adverse effect on safety had the condition gone undetected. Hence, this is not a significant deficiency for Millstone Unit No. 3.

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Changes to the Millstone Unit No. 3 FSAR, Section 3.8 (Design of Category I Structures) have been initiated to make the FSAR consistent with our findings and are attached for your information.

This constitutes our final report closing out SD-38. We trust that the above information satisfactorily responds to your concerns.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

W. G. Counsil

W. G. Counsil
Senior Vice President

W. F. Fee

By: W. F. Fee
Executive Vice President

cc: Mr. R. C. Young, Director
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Phillips Building
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Mr. K. A. Manoly
Office of the Executive Director for Operations
Region I
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631 Park Avenue
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The liner plate is a continuously welded steel membrane supported by and anchored to the inside of the containment at sufficiently close intervals with anchor studs and deformed bars in diamond pattern so that the overall deformation of the liner under the parameters derived from the design basis accident (DBA) and normal operation will be essentially the same as that of the concrete containment structure.

The function of the liner is to act as a gas-tight membrane under conditions that can be encountered throughout the operating life of the plant. The liner is designed to resist all direct loads and accommodate deformation of the concrete containment structure without jeopardizing leak-tight integrity, since stress levels will be kept within allowable stress levels specified in ASME III Division 1 Class MC. Under DBA conditions, the liner is under a state of biaxial compressive strain due to thermal effects and during the test condition, the liner plate is under a state of biaxial tensile strain. The anchor studs prevent buckling of the liner and act as nodal points. Tests conducted at Northeastern University, Boston, Massachusetts, using 5/8-inch diameter studs and 3/8-inch thick plate, show that shear failure occurs in the stud adjacent to the weld connecting the stud to the plate; in no instance was the plate damaged. Tests conducted for the stud manufacturer under the direction of Dr. I.M. Viest (TRW, Inc. 1975) indicate that, with the manufacturer's recommended depth of embedment of the stud in concrete, the ultimate strength of the stud material can be developed in direct tension. The reinforcement ring and liner adjacent to the hatches are anchored to the concrete containment with a denser stud pattern.

The liner pressure boundary includes embedments, insert plates, and penetrations. Liner dimensions are given in Sections 3.8.1.1.1 to .3 and shown in Figure 3.8-14. Leak chase channels are installed over penetration to liner seams and over knuckle plate to liner seams.

B. Embedments

Three types of embedments are used to maintain the leaktightness of the steel membrane while transferring loads across the mat liner plate to the concrete mat. One is a 3 x 6 rectangular forged bar also called a bridging bar, another is a 1 1/4-inch thick plate, and the other is a 5-inch thick forged plate to which the neutron shield tank is mounted. Leak test channels are welded all around the embedments to ensure the leaktightness of the steel membrane. Vertical reinforcing steel is Cadwelded to the top and bottom of the embedments providing reinforcing bar continuity without creating multiple penetrations.

C. Insert Plates

Loads from supports for piping such as the spray headers and other miscellaneous equipment are transferred to the containment concrete wall through insert plates and their anchors. Each

28. ASTM C 260-69 Air-entraining Admixtures for Concrete

29. ASTM C 289-71 Test for Potential Reactivity of Aggregates (Chemical Method)

30. ASTM C 295-1965 (1973) Recommended Practice for Petrographic Examination of Aggregates for Concrete

31. ASTM C 586-69 Test for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates

32. AWS D1.1-72 Rev.1-73 Structural Welding Code

33. AWS D12.1-61 Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction

34. NRC Regulatory Guides as qualified in Section 1.8 on the following topics:

a.	Cadweld Splices	1.8.1.10
b.	Reinforcing Bar Testing	1.8.1.15
c.	Structural Acceptance Testing	1.8.1.18
d.	Placement of Concrete	1.8.1.55
e.	Design Response Spectra	1.8.1.60
f.	Seismic Damping Values	1.8.1.61

35. BOCA Basic Building Code of the Building Officials and Code Administrators International, Inc., 1970

36. State of Connecticut Basic Building Code, 1971

3.8.1.2.3 Steel Liner and Penetrations

There was no applicable code for the design of concrete containment structure liners at the beginning of the construction of the Millstone liner. However, ASME Sections III and VIII, 1971 edition were used as a guide.

SECTION III DIVISIONS 1 AND 2, AND SECTION VIII

Design, materials, fabrication, testing, and inspection, where applicable, conform to the following codes, standards, and specifications:

a. ASME Boiler and Pressure Vessel Code Sections II, III and V, 1971 issue including addenda up to and including the 1973 Summer addenda. AND SECTION III DIVISION 2 SUBSECTION CC 1980 ISSUE INCLUDING ADDENDA UP TO AND INCLUDING SUMMER 1982.

b. ASME Boiler and Pressure Vessel Welding Qualifications, Section IX, issue in effect at the time of qualification.

is added to areas of marked deviation from the normal pattern.

3.8.1.4.2 Steel Liner and Penetrations

Stresses due to strain compatability of the liner with the reinforced concrete shell were due to various combination of pressure, thermal, self-weight and seismic load were determined using Stone & Webster's "KALNINS" program. This is a direct integration program for static analysis of multilayered thin shells of revolution. The stress analysis of a shell subjected to mechanical and thermal surface loads and edge loads, is reduced to a boundary value problem governed by a system of nonhomogeneous, linear, partial differential equations. The equations are separable with respect to the meridional and circumferential coordinates of the shell. The solution for each separable component of the loads is obtained by solving a typical two point boundary value problem governed by eight first order linear ordinary differential equations using direct integration. Analytical evaluation of the penetration discontinuities were modeled on the ASAAS program (Asymmetric Stress Analysis of Axisymmetric Solids). The method of analysis employed is based on a finite element idealization of an axisymmetric solid. Each element is an axisymmetric ring of a constant cross section. Since such a solid may be loaded and may deform in nonaxisymmetric modes and since the properties of the material may vary in all directions (e.g., due to temperature variations), all the dependent variables including the material properties are expressed as truncated Fourier series with the circumferential coordinate being the independent variable.

LOCAL STRESSES DUE TO IRREGULAR SPACING OF LINER HEADED ANCHOR STUDS WERE DETERMINED USING THE "ANSYS" FINITE-ELEMENT PROGRAM AND BY MANUAL CALCULATIONS

Influence coefficients of penetrations due to applied temperature, pressure, movement, axial, shear and torsional loads were determined using TAC-2D analysis. TAC-2D is a computer program for calculating steady-state and transient temperatures in two dimensional problems by the finite difference method. The configuration of the body to be analyzed is described in the rectangular, cylindrical, or circular (polar) coordinate system by orthogonal lines of constant coordinate called grid lines. The grid lines specify an array of nodal elements. Nodal points are defined as lying midway between the bounding grid lines of these elements. A finite difference equation is formulated for each nodal point in terms of its capacitance, heat generation and heat flow paths to neighboring nodal points.

3.8.1.5 Structural Acceptance Criteria

3.8.1.5.1 Containment Structure

The containment structure is designed for the loads and load combinations presented in Section 3.8.1.3.1. Allowable stresses, unless otherwise defined, are in accordance with ACI 318-71. For the factored load combinations, design of the containment structure meets the broad intent of Article CC-3400 of ASME III Division 2. Details of the design conform to ACI 318-71 and the additional requirements discussed in Section 3.8.1.4, rather than the parallel requirements

ultrasonically tested prior to installation for the purpose of detecting possible laminations.

Toughness tests (Charpy V-notch) were performed on all materials which form part of the containment structure boundary. Nil-ductility Transition Temperature Tests were also performed on all ferritic steel that formed part of the pressure boundary but were not required of backing plates, test channels, hatch bolts, and hatch nuts.

Penetration sleeves are made of SA537 Grade B Q&T, SA516 Grade 60 fine grain, normalized and SA333 Grade 6 fine grain normalized, all with a NDTT of -10°F.

Neutron shield tank embedment base and the carbon steel penetration forgings are SA508 Class 1 with a NDTT of +10°F.

Penetration coolers, equipment hatch, personnel airlock, shear lugs, and backing plates are SA516 Grades 60 and 70 fine grain normalized with NDT of -10°F.

Bridging bars are made of SA350 Grade LF1 and SA516 Grade 70 normalized with NDT of 0°F. Sump liners and bellows are made of Type 304 stainless steel SA240. The stainless steel penetration forgings are made of types 304 and 316, SA182.

Quality Control

Quality control procedures are described in the QA plan, Chapter 17.

Special Construction Techniques

Erection of the cylindrical portion of the liner plate followed completion of the concrete mat. The liner plates served as the internal form for the concrete containment during construction. All liner seams are double butt welded, except for the lower 31 feet of the cylindrical shell liner where the mat plates are welded using backing plates. The liner plate is continuously anchored to the concrete shell with steel anchor studs and deformed bars.

The maximum difference in cross-sectional diameters of the liner is in accordance with the rules shown in paragraph NB-4221.1 of Section III, ASME Boiler and Pressure Vessel Code, Nuclear Power Plant Components, 1971 Edition. The maximim misalignment between liner plates is in accordance with paragraph NB-4232 of the ASME Boiler and Pressure Vessel Code, Nuclear Power Plant Components, 1971 Edition. All measurements were taken on parent metal and not at welds. Flat spots or sharp angles were not allowed.

The allowable deviation from true circular form does not affect the elastic stability of the containment liner because of the restraint provided by the anchor studs and deformed bars tying it to the reinforced concrete shell.

TABLE 3.8-1

LOADING CONDITIONS -
LINER PLATE AND ACCESS OPENINGS

Category	Load Conditions	Design Allowables (per ASME III Nomenclature)	
Emergency	$D+P_D+T_D+SSE$	$P_m+P_b+Q<3S_m$	
Test	$D+1.15P$	$P_m<0.9S_y$	
		$P_m+P_b<1.35S_y$	
		+"CAT" curve considerations	
Normal	100 cycles of ΔP 400 cycles of ΔT 100 cycles of 1/2-SSE	NB-3222.4 (d) or (e)	
Severe Operational	$D+P_{min}+T_{min}$ 1/2-SSE	$P_m<S_m$ $P_m+P_b<1.5S_m$	Without temperature
		$P_m+P_b+Q<3S_m$	← INSERT A

ANCHORS

Category	Load Conditions	Design Allowables	
Emergency	$D+P_D+T_D+$ SSE	Max. shear < .425 S_u	
Severe Operational	$D+P_{min}+T_{min}+$ 1/2-SSE	Max. tensile <0.45 S_u	← INSERT B

NOTE:

The normal and test load combinations are producing negligible effects.

Where:

D = Dead load effect of reinforced concrete structure acting on the liner plus dead load of the liner

P_D = Design pressure (pressure resulting from design basis accident and safety margin)

T_D = Load due to thermal expansion, resulting when the liner is exposed to the design temperature

SSE = Stresses in the liner derived from applying the effect of the safe shutdown earthquake

TABLE 3.8-1 (Cont)

ΔP = Differential pressure between operating pressure and atmospheric pressure (100 cycles are assumed on the basis of 2.5 ur refueling cycles per year on a 40 year span)

ΔT = Load due to thermal expansion, resulting when the liner is exposed to the differential temperature between operating and seasonal refueling temperatures (400 cycles are assumed on the basis of 10 such variations per year, on a 40 year span (100 cycles of 1/2-SSE is an assumed number of cycles for this type of earthquake.)

P_{min} = Minimum pressure resulting during operation of the containment

T_{min} = Load due to thermal expansion resulting when the liner is exposed to the minimum pressure

S_y = Yield strength of the material

S_m = The smaller of 1/3-ultimate strength or 2/3-yield strength

S_u = Ultimate strength of the stud material.

δ_a = ALLOWABLE DISPLACEMENT FOR LINER ANCHORS, IN.

δ_u = ULTIMATE DISPLACEMENT CAPACITY FOR LINER ANCHORS, IN.

ϵ_{sc} = ALLOWABLE LINER PLATE COMPRESSIVE STRAIN, IN/IN

INSERT A

EMERGENCY $D + P_{min} + T_D + SSE$ $\epsilon_{sc} = 0.014$

INSERT B

EMERGENCY $D + P_{min} + T_D + SSE$ SHEAR $\delta_a = 0.5\ \delta_u$
TENSION $\delta_a = 0.5\ \delta_u$