September 21, 1982

Docket No. 50-213
LS05-82-09-068

Mr. W. G. Counsil, Vice President
Nuclear Engineering and Operations
Connecticut Yankee Atomic Power Company
Post Office Box 270
Hartford, Connecticut 06101

Dear Mr. Counsil:

SUBJECT: SEP TOPIC III-6, SEISMIC DESIGN CONSIDERATIONS, STAFF GUIDELINES FOR SEISMIC EVALUATION CRITERIA FOR THE SEP GROUP II PLANTS - REVISION 1

On June 26, 1982, we forwarded criteria acceptable to the staff for your seismic analysis of systems and components entitled, "Reevaluation Guideline Seismic Criteria for SEP Group II Plants (Excluding Structures)." Based upon discussions of this criteria with the licensees for Haddam Neck, Yankee and San Onofre 1, and further review of the criteria by the staff and its consultants, we have determined that some aspects of these guidelines require clarification and that a revision is warranted. The revision 1) clarifies the intent of certain load combinations; 2) provides criteria for both Class 1 and Class 2 supports and mechanical equipment; 3) references the ASME Code for scope and evaluation criteria for pump and valve structural integrity and 4) limits active component deformation evaluations for valve operators, pump internals and similar mechanical components (e.g., CRDs) to items contained in safe shutdown systems. Other methods or approaches to seismic reanalysis of systems and components may be acceptable, however, they will require specific justification and will be reviewed on a case-by-case basis.

SEO4
DSU WSE(02)

Sincerely,

ADD:
S. BROWN

Dennis M. Crutchfield, Chief
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Enclosure: Reevaluation Guideline for SEP Group II Plants (Excluding Structures) (REVISION)

cc w/enclosure:
See next page

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REEVALUATION GUIDELINE

SEISMIC CRITERIA

FOR

SEP GROUP II PLANTS

(EXCLUDING STRUCTURES)

INTRODUCTION

In support of NRC's Systematic Evaluation Program (SEP) for Group II Plants, the following Reevaluation Criteria have been established. These criteria include recommended load combinations with allowable stresses and/or loads for piping systems, component supports, concrete attachments, and equipment. These criteria are based on linear elastic analyses having been performed. The acceptance criteria are generally based on the ASME Code. For situations not covered by these criteria, (i.e. items constructed of cast iron) compatible criteria shall be developed by the licensee and will be reviewed on a case-by-case basis. The licensee is requested to justify major deviations in criteria which appear less conservative than those specified herein. 1

DEFINITIONS

Code = ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Plant Components," 1980 Edition, Winter 1980 Addenda.

σ_m = General membrane stress. This stress is equal to the average stress across the solid section under consideration, excludes discontinuities and concentrations, and is produced only by mechanical loads.

σ_b = Bending stress. This stress is equal to the linear varying portion of the stress across the solid section under consideration, excludes discontinuities and concentrations, and is produced only by mechanical loads. 1

P_D = Design or maximum operating pressure loads and design mechanical loads.

SSE = Inertial loads due to Safe Shutdown Earthquake (SSE) and design mechanical loads where applicable.

T = Loads due to thermal expansion of attached pipe (constraint of free end displacement).

W = Loads due to weight effects.

AM = Loads due to SSE anchor movement effects.

S_{bk} = Critical buckling stress.

S_m = Allowable stress intensity at temperature listed in ASME Code.

S_y = Yield strength at temperature listed in ASME Code.

S_u = Ultimate tensile strength at temperature listed in ASME Code.

σ_ℓ = Local membrane stress. This stress is the same as σ_m except that it includes the effect of discontinuities. 1

S = ASME Code Class 2 allowable stress value. The allowable stress shall correspond to the metal temperature at the section under consideration.

P_m = General Primary Membrane Stress Intensity. This stress intensity is derived from the average value across the thickness of a section of the general primary stresses produced by design internal pressure and other specified Design Mechanical Loads, but excluding all secondary and peak stresses. Averaging is to be applied to the stress components prior to determination of the stress intensity values. 1

P_L = Local Membrane Stress Intensity. This stress intensity is the same as P_m except that it includes the effects of discontinuities.

P_b = Primary Bending Stress Intensity. This stress intensity is derived from the linear varying portion of stresses across the solid section under consideration produced design pressure and other specified design mechanical loads. Secondary and peak stresses are not included. 1

SPECIAL LIMITATIONS

1. Critical buckling loads (stresses) must be determined taking into account combined loading (i.e., axial, bending, and shear), initial imperfections, residual stresses, inelastic deformation, and boundary conditions. Both gross and local buckling must be evaluated. Critical buckling loads (stresses) shall be determined using accepted methods such as those contained in NASA Plates and Shells Manual or ASME Code Case N-284. 1

2. Where stresses exceed material yield strength, it shall be demonstrated that brittle failures and detrimental cyclic effects are precluded, and that dynamic analysis assumptions are not nonconservatively affected. Where significant cyclic effects are identified, it shall be demonstrated that the structure or component is capable of withstanding ten full peak deformation cycles.

3. Where results of analysis indicate that the allowable stresses of the original construction code are exceeded in any of the load combinations specified herein, it shall be demonstrated that the in-situ item was designed and fabricated using rules compatible with those required for the appropriate ASME Code Class (Subsection NX2000,

4000, 5000, and 6000). In cases where compatibility with the appropriate ASME Code Subsections was not substantially achieved, appropriate reductions in these limits shall be established, justified, and applied.

ACCEPTANCE CRITERIA FOR PIPING

Using Code[a] Class 2 analytical procedures [Equation (9), NC-3653.1], the following stresses are not to be exceeded for the specified piping: 1

Class 1: $P_m + P_b = |W + P_D| + |SSE| \leq 1.8\ S$

Class 2: $P_m + P_b = |W + P_D| + |SSE| \leq 2.4\ S$ 1

The effects of thermal expansion must meet the requirements of Equation (10) or (11) of NC-3653, including moment effects of anchor displacements due to the SSE if anchored displacement effects are omitted from Equation (9) of NC-3653. Class 1 analytical procedures (NB-3600) can also be utilized if appropriate allowable stresses specified in NB-3650 are used. 1

Branch lines shall be analyzed including the inertial and displacement input due to the response of the piping to which it is attached at the attachment point.

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a. The references to ASME Code equation and paragraph numbers on this page correspond to the 1980 edition of the code, 1981 winter addenda. This was done in order to avoid confusion introduced by the initial 1980 edition of the code which renumbered the equations differently from past and present editions of the code. Equation numbers presented on this page reflect common nomenclature utilized in the nuclear industry. 1

ACCEPTANCE CRITERIA FOR CLASS 1 COMPONENT SUPPORTS

Imposed Load Combinations	Acceptance Criteria[a]	
	Linear	Plate and Shell[b]
The higher of:		
$\lvert W + P_D \rvert$ or $\lvert W + P_D + T \rvert$	Code Subsection NF Design, Level A, and Level B Limits	$P_m \leq 1.0\ S_m$ $P_\ell + P_b \leq 1.5\ S_m$
The higher of:	- - - - - - - - - -	
$\lvert W + P_D \rvert + \lvert SSE \rvert + \lvert AM \rvert$ or $\lvert W + P_D + T \rvert + \lvert SSE \rvert + \lvert AM \rvert$	Code Subsection NF Level D Limits	$P_m \leq 1.5\ Sm$ or $1.2\ Sy$[c] not to exceed $0.7\ Su$ $P_\ell + P_b \leq 2.25\ Sm$ or $1.85\ Sy$[c] not to exceed $1.05\ Su$

In addition to the above criteria, the allowable buckling stress shall be limited to 2/3 S_{bk}, where S_{bk} is determined in accordance with Special Limitation 1.

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a. These load combinations shall be used in lieu of those specified in ASME Code Subsection NF. In addition, for brittle types of material not specified in the Code, appropriate stress intensification factors for notches and stress discontinuities shall be applied in the analysis.

b. The 1.5 Sm value from NB 3221 on which these are based (Code Appendix F 1323.1) shall be limited by Code Section NB 3221.3.

c. Use larger of.

ACCEPTANCE CRITERIA FOR CLASS 2 COMPONENT SUPPORTS

Imposed Load Combinations	Acceptance Criteria[a]	
	Linear	Plate and Shell
The higher of:		
$\lvert W + P_D \rvert$	Code Subsection NF Design, Level A, and Level B Limits	$\sigma_\ell \leq 1.0\ S$
or		
$\lvert W + P_D + T \rvert$		$\sigma_\ell + \sigma_b \leq 1.5\ S$
The higher of:	- - - - - - - - - -	
$\lvert W + P_D \rvert + \lvert SSE \rvert + \lvert AM \rvert$	Code Subsection NF Level D Limits	$\sigma_\ell \leq 1.5\ S$ or $0.4\ S_u$ (b)
or		
$\lvert W + P_D + T \rvert + \lvert SSE \rvert + \lvert AM \rvert$		$\sigma_\ell + \sigma_b \leq 2.25\ S$ or $0.6\ S_u$ (b)

In addition to the above criteria, the allowable buckling stress shall be limited to 2/3 S_{bk}, where S_{bk} is determined in accordance with Special Limitation 1. 1

a. These load combinations shall be used in lieu of those specified in ASME Code Subsection NF. In addition, for brittle types of material not specified in the Code, appropriate stress intensification factors for notches and stress discontinuities shall be applied in the analysis.

b. Use lesser of.

ACCEPTANCE CRITERIA FOR CONCRETE ATTACHMENTS

I. Concrete Expansion Anchor Bolts[a]

Load Combinations: Same as for component supports.

Acceptance Criteria:[b]

Wedge type: 1/4 ultimate as specified by manufacturer.

Shell type: 1/5 ultimate as specified by manufacturer.

II Grouted Bolts: Replace[a],[b],[c]

III. Concrete Embedded Anchors[a]

Load Combinations: Same as for component supports.

Acceptance Criteria[b]: 0.7 S_u

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a. Base plate flexibility effects must be considered.

b. Both pullout and shear loads must be considered in combined loading situations.

c. Unless stresses in the bolts and structure to which they are attached are shown to be sufficiently low to preclude concrete/grout/steel interface bond failures. Load combinations are the same as those for component supports.

ACCEPTANCE CRITERIA FOR CLASS 1 MECHANICAL EQUIPMENT

Component	Loading Combination[b]	Criteria[d] [g]
Pressure vessels and heat-exchangers	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$P_m \leq 2.4\ S_m$ or $0.7\ S_u$ [e] $(P_m$ or $P_\ell) + P_b \leq 3.6\ S_m$ or $1.05\ S_u$ [e]
Active pumps and other mechanical components[a],[c],[d]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$P_m \leq 1.2\ S_m$ or S_y [f] $(P_m$ or $P_\ell) + P_b \leq 1.8\ S_m$ or $1.5\ S_y$ [f]
Inactive pumps and other mechanical components[c]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$P_m \leq 2.4\ S_m$ or $0.7\ S_u$ [e] $(P_m$ or $P_\ell) + P_b \leq 3.6\ S_m$ or $1.05\ S_u$ [e]
Active valves[a],[c],[d]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$P_m \leq 1.2\ S_m$ or S_y [f] $(P_m$ or $P_\ell) + P_b \leq 1.8\ S_m$ or $1.5\ S_y$ [f]
Inactive valves[c]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$P_m \leq 2.4\ S_m$ or $0.7\ S_u$ [e] $(P_m$ or $P_\ell) + P_b \leq 3.6\ S_m$ or $1.05\ S_u$ [e]
Bolt stress shall be limited to:		Tension = Sy or $0.7\ S_u$ [e] Shear = 0.6 Sy or $0.42\ S_u$ [e]

1

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a. Active pumps, valves, and other mechanical components (e.g., CRDs) are defined as those that must perform a mechanical motion to accomplish a system safety function.

b. Nozzle loads shall include all piping loads (including seismic and thermal anchor movement effects) transmitted to the component during the SSE.

c. Scope and evaluation of pumps and valves are to be in accordance with NB 3411, NB 3412, and NB 3546 of the Code, including seismic and thermal anchor movement effects.

d. For active mechanical equipment contained in safe shut down systems, it shall be demonstrated that deformation induced by the loading on these pumps, valves and other mechanical components (e.g., CRDs) do not introduce detrimental effects which would preclude function of this equipment following a postulated SSE event. For valve operators integrally attached to valve bodies, binding can be considered precluded if stresses in the valve body and operator housing and supports are shown to be less than yield. In these evaluations, all loads (including seismic and thermal anchor movement effects) shall be included. 1

e. Use lesser of two values.

f. Use greater of two values.

g. The 1.5 Sm value from NB 3221 on which these are based (Code Appendix F 1323.1) shall be limited by Code Section NB 3221.3.

ACCEPTANCE CRITERIA FOR CLASS 2 MECHANICAL EQUIPMENT

Component	Loading Combination[b]	Criteria[d]
Pressure vessels and heat-exchangers	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$\sigma_m \leq 2.0\ S$ $(\sigma_m \text{ or } \sigma_\ell) + \sigma_b \leq 2.4\ S$
Active pumps and other mechanical components[a],[c],[d]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$\sigma_m \leq 1.5\ S$ $(\sigma_m \text{ or } \sigma_\ell) + \sigma_b \leq 1.8\ S$
Inactive pumps and other mechanical components[c]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$\sigma_m \leq 2.0\ S$ $(\sigma_m \text{ or } \sigma_\ell) + \sigma_b \leq 2.4\ S$
Active valves[a],[c],[d]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$\sigma_m \leq 1.5\ S$ $(\sigma_m \text{ or } \sigma_\ell) + \sigma_b \leq 1.8\ S$
Inactive valves[c]	$\|W + P_D\| + \|SSE\| + \|Nozzle\ Loads\|$	$\sigma_m \leq 2.0\ S$ $(\sigma_m \text{ or } \sigma_\ell) + P_b \leq 2.4\ S$
Bolt stresses shall be limited to:		Tension = Sy or $0.7\ S_u$[e] Shear = $0.6\ Sy$ or $0.42\ S_u$[e]

1

a. Active pumps, valves, and other mechanical components (e.g., CRDs) are defined as those that must perform a mechanical motion to accomplish a system safety function.

b. Nozzle loads shall include all piping loads (including seismic and thermal anchor movement effects) transmitted to the component during the SSE.

c. Scope and evaluation of pumps and valves are to be in accordance with NC 3411, NC 3412, and NC 3521 of the Code, including seismic and thermal anchor movement effects.

d. For active mechanical equipment contained in safe shut down systems, it shall be demonstrated that deformation induced by the loading on these pumps, valves and other mechanical components (e.g., CRDs) do not introduce detrimental effects which would preclude function of this equipment following a postulated SSE event. For valve operators integrally attached to valve bodies, binding can be considered precluded if stresses in the valve body and operator housing and supports are shown to be less than yield. In these evaluations, all loads (including seismic and thermal anchor movement effects) shall be included. 1

e. Use lesser of two values.

ACCEPTANCE CRITERIA FOR TANKS

Load Combinations:	$\|W + P_D\| + \|SSE\|$ + $\|$Dynamic Fluid Pressure Loads[a]$\|$
Acceptance Criteria:	Smaller of S_y or 0.7 S_u. In addition, the allowable buckling stress shall be limited to 2/3 S_{bk}, where S_{bk} is determined in accordance with Special Limitation 1.

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a. Dynamic fluid pressure shall be considered in accordance with accepted and appropriate procedures; e.g., USAEC TID-7024. Horizontal and vertical loads shall be determined by appropriately combining the loads due to vertical and horizontal earthquake excitation considering that the loads are due to pressure pulses within the fluid. These loads shall also be applied, in combination with other loads, in tank support evaluations.