SEISMIC EVALUATION OF NON-SEISMIC CATEGORY I PIPING IN SEISMIC CATEGORY I BUILDINGS

PREPARED FOR

MILLSTONE NUCLEAR POWER STATION - UNIT NO. 3
NORTHEAST UTILITIES SERVICES COMPANY

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1.0 PURPOSE

This report summarizes the evaluation of Non-Seismic Category I piping and its supports in Seismic Category I buildings in Millstone Nuclear Power Station Unit 3. The evaluation critera, a summary of the analysis performed, the results of the evaluation, and the generic recommendations are presented in this report.

The seismic adequacy of Non-Seismic Category I piping, its standard piping support components and auxilliary steel for piping support are addressed in this report. The qualification of piping support concrete embedments, the baseplate for the embedments and the transfer of loadings to the main structure are performed by others, and therefore, are not covered by this report.

2.0 INTRODUCTION

It is required by NRC regulation that plants evaluate the interaction of non-safety and safety-related systems during normal operation, transients, and design basis accidents to assure that any interaction between such systems will not result in exceeding the acceptance criteria for any design basis event.

The Millstone Unit 3 Seismic Interaction Program was designed to address the above concern. The Seismic Interaction Program consists of three distinct subprograms.

i) Perform walkdowns to identify swing/sway interaction between Non-Seismic Category I piping and equipment and Seismic Category I piping and equipment. This program is based on maximum swing/sway of 6 inches and no structural failure (falling or turning over) of Non-Seismic Category I piping and equipment in Seismic Category I buildings.

ii) Demonstrate the adequacy of equipment anchorage of Non-Seismic Category I equipment in Seismic Category I Buildings.

iii) Demonstrate the structural integrity of Non-Seismic Category I piping in Seismic Category I structures.

The evaluation documented in this report was performed to satisfy the requirements of the last subprogram. The seismic structural integrity of non-seismic piping is demonstrated by evaluating a bounding sample of the above piping for seismic and other applicable loads.

The evaluation criteria (Reference 1) developed for the evaluation has been accepted by the NRC. The evaluation criteria is summarized in Section 3.0. Using the above criteria typical piping subsystems were selected. A field walkdown was performed to verify pipe routing and support details. The selected piping subsystems and their supports were evaluated in detail to demonstrate structural integrity. The analysis performed and the results are summarized in Section 6.0. Generic recommendations resulting from the evaluation and the conclusions are given in Sections 7.0 and 8.0, respectively.

3.0 EVALUATION CRITERIA

The structural adequacy of non-seismic Category I piping and its associated supports installed in Category I buildings were reviewed to assure that they will not fail and impair the capability of any safety related system to perform its intended functions during and after the design basis seismic event (SSE).

This was accomplished by the detailed evaluation of several typical piping subsystems which are bounding in terms of size, configuration, and the potential for seismic interactions, to demonstrate sufficient margin against collapse of piping and support structure.

The review included piping, piping component supports, and auxiliary steel for piping supports. Main steel and structural members, equipment foundations, concrete embedment and embedment baseplates are evaluated by others and are not addressed in this report.

3.1 SELECTION OF TYPICAL PIPING SUBSYSTEM

A sufficient number of subsystems were selected to be a bounding sample of the Class 4 non-seismic piping in the Millstone Unit 2 plant. The following were considered in the selection of typical subsystem:

a. Size of pipe
b. Type of support used (Rod hanger, Pipe Rack, etc.)

c. Analysis method or design guidelines used

d. Pipe temperature

e. Location in the plant

f. Pipe Material

g. Type of pipe connection (Welded, Threaded, etc.)

The sample was weighted towards larger pipe size, higher seismic load areas and areas with more potential interactions with seismic plant components.

3.2 ANALYSIS METHOD

3.2.1 PIPING ANALYSIS

Each of the selected piping subsystems were evaluated for weight, thermal, and seismic loads as applicable. All piping analyses were performed using the PIPSYS (Reference 2) and/or the ANSYS (Reference 3) computer programs.

a. Weight Loads

The piping was evaluated for dead weight load due to piping, insulation, contents and concentrated masses, such as valves, traps and strainers.

b. Thermal Loads

The piping was analyzed for thermal expansion due to the maximum operating temperature of the line as specified in the System Design. Thermal movement of equipment nozzle was considered in the analysis. Cold piping with maximum operating temperature less than 150^{o}F and nozzle movements less than 1/8 inch were not analyzed for thermal loads.

c. <u>Safe Shutdown Earthquake</u>

(i) <u>Inertia Load</u>

The piping was evaluated for seismic inertia loads using response spectra methods. The damping values were based on ASME Code Case N-411. Spectra amplification due to equipment or slab flexibility was also addressed in the response spectrum analysis.

(ii) <u>Displacement Loads</u>

The piping was also evaluated for loads due to building relative displacement. If the absolute values of the building displacement at all support locations due to any given seismic excitation is less than a sixteenth of an inch, then the displacement effects due to that excitation were not considered.

(iii) <u>Piping Uplift</u>

One way vertical restraints were reviewed for upward load. All subsystems with potential for piping uplift were reviewed to select three bounding subsystems. Time history analysis was performed and the supports were evaluated for uplift.

3.2.2 <u>PIPING SUPPORT EVALUATION</u>

All piping support hardware adequacy was demonstrated by detailed analysis.

a. <u>Standard Component Supports and Auxiliary Steel</u>

Standard component supports and auxiliary steel, except U-Bolts and U-Straps used to attach piping to supports, were evaluated in accordance with the requirements of the ASME Code, Section III, Subsection NF.

b. <u>U-Bolts and U-Straps Used to Attach Piping to Supports</u>

The ultimate strength of U-Bolts and U-Straps was estimated using plastic analysis in accordance with the requirements of the ASME Code Section III, Appendix F. The detailed methodology is documented in Reference 9. The conclusion in Reference 9 compare favorably with Grinnell test results.

3.3 LOAD COMBINATION

The following load combinations were used to combine the applicable loads:

3.3.1 PIPING STRESS

ASME Code Equation 9D = Pressure + Weight + Safe Shutdown Earthquake

Seismic inertia loads and seismic displacement loads are combined using the square root of the sum of squares (SRSS) method.

3.3.2 PIPING SUPPORT LOAD

Service Level D = Thermal Load + Weight Load + Safe Shutdown Earthquake Load

Seismic inertia loads and seismic displacement loads are combined using the square root of the sum of squares (SRSS) method.

3.4 ACCEPTANCE CRITERIA

3.4.1 PIPING ACCEPTANCE CRITERIA

The pipe stresses were compared against ASME Code, Section III, 1983 Edition Summer 1985 Addenda Service Level D allowables to demonstrate that collapse will not occur. All points in piping exceeding Service Level D allowables were accepted by detailed evaluation showing sufficient margin against collapse of the piping subsystem.

3.4.2 PIPING SUPPORTS ACCEPTANCE CRITERIA

The seismic adequacy of all supports including standard components were demonstrated by one of the following:

a. The load on the support or support component is below the Service Level D load capability values provided by the vendor.

b. Support or support component meets the requirements of ASME 1983 Code, Section III, Appendix F Summer 85 Addenda allowable values.

All supports are adequate for the normal operating condition (Service Level A) loads specified in the piping support drawing. The Service Level D, ASME Code Section NF, allowables are generally two times the Service Level A (Design) allowables with the following exceptions:

(i) Shear stress is limited to .42 Su.

(ii) Compressive stress is limited to half the buckling stress.

Most of the support members were either rod hangers or auxiliary steel members with short slenderness ratio. Further, shear stresses were relatively small when compared to bending and membrane stresses. Also, the Service Level A load shown on the support drawing was generally much less than the Service Level A capability of the support.

Based on the above, the Service Level D support capability was conservatively assumed to be at least twice the Service Level A (Design) load given in the hanger drawing. Therefore, detailed support qualification calculations were not required for supports whose combined support load is less than twice the Service Level A support load shown on the support drawing.

3.4.3 EQUIPMENT NOZZLE ACCEPTANCE CRITERIA

Piping loads at equipment nozzles were reviewed for structural integrity of the nozzle. Equipment anchorage is evaluated by others and is therefore not covered by this report.

4.0 SELECTION OF TYPICAL SUBSYSTEMS

A set of 27 piping subsystems (24 piping models) were selected by Northeast Utilities using the selection critera given in Section 3.1. Sargent & Lundy has reviewed the selected sample and found them to be bounding of Class D piping in the Millstone Unit 3.

The characteristics of the selected piping subsystem are given in Table 1. (Subsystems AX-107X, AX-107X-1, AX-107X-2 and AX-107X-3 are referred to as AX-107X in Tables 1 and 2). Table 2 shows the Large Bore piping support distribution as a function of pipe size and support type for both the sample and the entire plant. The above table shows that the selected sample contain a bounding sample of various support types and pipe sizes, and is weighted towards the larger pipe size.

The severity of earthquake response in various buildings in Millstone Unit 3 as a function of elevation is illustrated in Figure 1. Table 3 shows the distribution of pipe supports as a function of pipe size and building. A detailed review of Figure 1, Table 1, and Table 3 show that the sample is weighted towards areas with higher seismic spectra loads.

Based on the above, it is concluded that the selected sample satisfies the selection criteria established in Section 3.1. It bounds the piping in Millstone Unit 3 and the sample systems are located in areas with bounding seismic load.

5.0 WALKDOWN FOR FIELD VERIFICATION

A field walkdown was performed to verify the pipe routing and support details. Whenever piping support drawings were not available, field sketches containing design information were prepared. All field obtained information were gathered into packages by subsystem. The subsystem number and the corresponding package document number are given in Table 4. Additional information, where needed, was obtained and was documented per Project Instruction PI-ME-11 (Reference 4).

6.0 ANALYSIS

Each of the selected 27 piping subsystems (24 piping models) and their supports were analyzed in detail. All relevant calculations are documented in the corresponding subsystem evaluation report. Table 4 lists the subsystem number and the corresponding evaluation report document number. Subsystems AX-107X-1, AX-107X-2, and AX-107X-3 were branch piping from subsystem AX-107X. The above three subsystems were included in the AX-107X piping subsystem model. Wherever AX-107X is referenced in the discussion, it refers to subsystems AX-107X, AX-107X-1, AX-107X-2 and AX-107X-3.

6.1 PIPING STRESS ANALYSIS

All piping subsystems were modeled following Sargent & Lundy standard practice as defined in References 2, 5, and 6, and were analyzed using the Sargent & Lundy PIPSYS piping analysis computer program. Piping was analyzed for weight and thermal loads using the static analysis option.

Piping subsystems were analyzed for seismic inertia loads using the Response Spectrum Analysis option of PIPSYS. PVRC recommended damping values (ASME Code Case N-411) were used in the analysis. Evaluation for seismic building displacement was performed using the static displacement option of the PIPSYS program (Reference 2).

Piping stress due to various applicable loadings were combined together and compared against allowables specified in the evaluation critera in Section 3.0. If piping stresses exceeded allowables, the piping was reevaluated for inertia loads using the building acceleration time history provided by Northeast Utilities (Reference 7). The piping stresses were combined and rechecked against allowables. All subsystems except two met Service Level D allowable values at all locations. The two subsystems exceeding allowables, AX-107X and SL-7A are discussed in detail below. The peak stress in each subsystem, the allowable stress and the subsystem characteristics are summarized in Table 5.

6.1.1 Subsystem AX-107X

The piping model of this subsystem also includes branch piping subsystem AX-107X-1, AX-107X-2 and

AX-107X-3. Main subsystem AX-107X is a 10 inch pipe routed circumferentially around the containment. The three branch piping subsystems are 3 and 4 inch branches coming from the header. The stress calculated using elastic analysis method at the following two locations in the branch subsystem AX-107X-3 exceed allowables.

Node	Description	B_1	B_2	Combined Stress (psi)	Allowable (psi)
835	Welding Tee	.5	6.15	61700	45000
840A& 840B	Elbow	.5	3.17	75000	45000

Node 835 is the tee connection to the by-pass line in AX-107X-3 and Node 840 is the first elbow close to the anchor at the end of AX-107X-3. The branch subsystem is not flexible in some directions and therefore it was suspected that the higher stress at the two locations are due to deflections imposed by the 10 inch header on the branch line. It was also observed that the stress level at the elbow was large enough to cause a plastic hinge at the elbow (Node 840A and 840B). The nominal stress at the tee is below yield.

Based on the above, it was concluded that a plastic hinge would form at elbow node 840 and relieve the stress problem. In order to verify the above, an additional seismic analysis was performed with a hinge at node 840. The analysis showed that the stress problem at node 835 was resolved by the plastic deformation at the elbow and all locations met allowables. The angular rotation at the hinge was 2.2 degrees. The limited angulation of 2.2° demonstrates that the hinge at the elbow will not lead to elbow collapse. The angulation of 2.2 degrees is small when compared to angulation without failure observed in Reference 8.

Also this shows that the highest stresses are caused by the imposed header displacement and not due to branch pipe inertia. If the displacement component of the stress is removed from the calculated stresses the stresses would meet code allowables.

6.1.2 Subsystem SL-7A

This subsystem mainly consists of one inch and two inch pipe. Pipe stresses at all locations are within allowables except at two socket welded tees. The stresses at the above location exceed allowables by less than 20%. The stresses were recalculated using the actual size of the fillet weld at the socket and found to be within allowables.

6.2 PIPING DEFLECTION EVALUATION

Dynamic deflection of piping in all subsystems were reviewed to judge the adequacy of six inch deflection envelope used in the swag/swing interaction walkdown. The maximum deflection was generally small and is within the six inch deflection envelope, except for the subsystems AX-110V, SL-2A, SL-3A and SL-5A. The above subsystems have localized regions exceeding the six inch envelope due to unique routing configurations.

Generally the deflections were within six inches and therefore it is judged that the use of the deflection envelope of six inches is adequate for the interaction walkdown.

6.3 PIPING UPLIFT EVALUATION AT SLIDING SUPPORTS AND ROD HANGERS

Review of the Millstone Unit 3 spectra indicate that the vertical acceleration in the low frequency range (less than 3H_z) is generally small and is always less than the acceleration due to gravity. Therefore, it is impossible to have overall uplift of the subsystem. However, it is possible to have localized uplifting of pipe due to unique routing configuration and support locations. A generic study was performed to determine the significance of potential uplifting of piping at rod hanger and sliding support locations.

The response spectrum analysis of all 27 subsystems were reviewed and the dynamic upward load was compared against the vertical downward static load to identify subsystems with potential piping uplift. Based on the above review, subsystems AX-110V, AX-110Y-1 and SL-1A were selected to be bounding of the subsystems with negative loads.

The above three subsystems were reevaluated for seismic load using Seismic Acceleration Time History Analysis option of PIPSYS. The revised seismic upward vertical load was compared against the downward static load at sliding support and rod hanger location. Most of the supports no longer had any negative loads. However, some support locations showed net negative loads. The negative loads were generally small when compared to the combined total load on the support. Therefore the piping is not expected to uplift significantly at the support locations. The effect of this small uplift would be to increase the downward load slightly due to bouncing of the pipe at the support. Therefore, the affected supports were reevaluated to a load thirty percent above the original values and found to be adequate.

The results of the evaluation show that the concerns related to piping uplift are not significant. The minor uplift observed in the subsystems does not increase the pipe stress in any significant manner.

6.4 EVALUATION OF PIPING WITH VICTAULIC COUPLING

One of the subsystems (SL-5A) in the sample contained Victaulic couplings. A review of the design of this coupling show that the coupling is flexible and that the rubber or elastomer used as a seal will provide significant damping under dynamic loading.

The coupling allows small movement in the axial direction of pipe prior to lock up. It can transmit lateral (shear) force in piping. It takes a finite value of moment (depending on the coupling size and construction) to cause angulation at the coupling. But once the angulation starts, it can allow a few degrees of rotation before the coupling binds.

Based on the above, it was concluded that the Victaulic couplings will cause the bending stresses in the piping to be lower than that of a welded pipe. The increased damping would tend to reduce support loads and piping deflection. However, it is difficult to accurately model the dynamic behavior of the coupling during earthquake using either the response spectrum or the time history analysis method.

The piping subsystem SL-5A was evaluated using a bounding analysis approach. First the piping subsystem was analyzed with all Victaulic Couplings modeled as rigid. The analysis showed low stress levels and the support loads were acceptable. The analysis results were reviewed to identify the location with the highest nominal bending stress (moment) due to earthquake. The coupling location closest to the node with the highest nominal bending stress was assumed to be a hinge and the analysis repeated. The point with the highest nominal stress was identified and the procedure repeated.

When the first few couplings were modeled as hinges the support loads and piping stresses increased. However, as more couplings were released the pipe stresses and support loads stablized. Pipe stresses and support loads from all the above analyzes were found to be within allowables.

6.5 SUPPORT EVALUATION

The combined faulted condition support loads were compared against the Service Level A loads on the hanger drawing and it was found that the load ratio was small with most being less than 2.0. Based on the evaluation criteria given in Section 3.4.2, all supports with a ratio less than 2.0 were accepted as being adequate for the design basis seismic loads. Supports with ratios greater than 2.0 were evaluated individually and found to be adequate. The relevant calculations are included in the applicable stress reports (See Table 4).

6.6 SUPPORT FUNCTIONABILITY REVIEW

All supports were reviewed for its ability to restrain the pipe in the designed direction during a design basis earthquake. All supports except some of the sliding supports were found to be functionally adequate.

Some of the sliding supports were not wide enough to support the pipe during dynamic movement. The piping had the potential to fall off the above type of support during design basis earthquake. It is recommended that the above type of support be reviewed and modified as required to exclude the possibility of piping falling on Category I Components.

7.0 GENERIC RECOMMENDATIONS

Some piping subsystems had sliding supports. The sliding supports restrain the pipe in the downward vertical direction. The piping is not fastened to the support by means of clamp, strap or U-bolt. Therefore, the pipe is free to move in the lateral horizontal direction. Some of the supporting members of the sliding support were not large enough to support the pipe during dynamic deflection.

It is recommended that all sliding supports of the above type be reviewed for its ability to accommodate the seismic movement of pipes at the support location. If no dynamic movement is available, a deflection envelope of six inches could be used for the review.

It is judged that the above review would show that the majority of supports are adequate with a few requiring hardware changes.

8 CONCLUSIONS

Twenty seven piping subsystems that bound Class D piping design, and are located in areas with bounding seismic loads were selected and evaluated. The evaluation demonstrated sufficient margin against collapse due to seismic loads.

Pipe stresses were within ASME Code, Section III, Subsection ND, Summer 1985, allowables at all locations except those discussed in detail in Section 6.0. The forces and moments at locations exceeding code stress allowables were also found to be acceptable.

All supports show sufficient margin to accommodate the load due to the design basis earthquake. All supports were reviewed for functionability. All except some of the sliding supports were found to be functionally adequate (See Section 7.0 for Generic Recommendations).

Based on the above, it is concluded that the Class D piping and its supports have sufficient margin in their design to accommodate increased loads, str sses and displacements due to a design basis earthquake.

9.0 REFERENCES

1. Sargent & Lundy Design Criteria DC-ME-01-NE Rev. 01 Dated 11-12-85 "Design Criteria for Evaluation of Seismic Category II Piping in Category I Buildings" Millstone Nuclear Power Station Unit 3

2. Integrated Piping Analysis System (PIPSYS) Sargent and Lundy Program No. 09506561

3. ANSYS Engineering Analysis System, Swanson Analysis System Inc. Sargent and Lundy Program No. 09518541

4. Sargent & Lundy Project Instruction PI-NE-03. "Project Instruction for Documentation of Field and Verbal Input" Northeast Utilities, Millstone Unit 3

5. Sargent and Lundy Engineering Mechanics Division, "Lesson Plan for Training Personal in Piping Analysis", EMD-TP-1, Rev. 5

6. Sargent and Lundy Engineering Mechanics Division "Lesson Plan for Training Personnel in Coding Piping Systems", EMD-TP-3, Rev. 3

7. Letter from Salvatore Orefice of Northeast Utilities to R. H. Pollock dated November 14, 1985 NEC-11187 "Analysis of Non-Seismic Piping Millstone Nuclear Power Station, Unit No. 3"

8. Experimental Study of Plastic Responses at Pipe Elbows. W. L. Greenstreet. Prepared for U.S. Nuclear Regulatory Commission Under Interagency Agreement ERDA 40-551-75 and 40-552-75

9. EMD-050690 Analytical Estimate of U-Bolt Failure Loads. Sargent and Lundy Engineering Mechanics Division

TABLE I

PIPING SUBSYSTEM INFORMATION

Subsystem	Building	Elevation Maximum/Minimum	System	Temp.*	Material	Pipe Size Maximum/Minimum	Anchor**	Rigid Support	[illegible] Hanger	Sliding Support	Spring Hanger
Ax-BBA	Auxiliary	24' to 7'	Boron Recovery	Hot	SS	12	2	1	0	0	2
Ax-BBA-1	Auxiliary	21' to 13'	Boron Recovery	Hot	SS	12	2	1	0	0	2
Ax-BBA-2	Auxiliary	33'	Boron Recovery	Hot	SS	12	2	[illegible]	0	0	1
Ax-110-A	Auxiliary	17' to 5'	Auxiliary Condensate	Cold	CS	4, 3	3	0	5	0	0
Ax-110-B	Auxiliary	20' to 5'	Auxiliary Condensate	Cold	CS	3	[illegible]	1	4	[illegible]	0
Ax-110Z	Auxiliary	17' to 8'	Auxiliary Condensate	Cold	CS	4, 2	4	6	3	2	0
Ax-110D	Auxiliary	28' to 20'	Auxiliary Steam	Hot	CS	8, 4	3	2	9	1	2
Ax-110[illegible]	Auxiliary	13'	Auxiliary Steam	Hot	CS	8, 6	3	0	2	[illegible]	0
Ax-110[illegible]	Auxiliary	102' to 13'	Auxiliary Steam	Hot	CS	6, 4	2	2	1	3	2
Ax-110[illegible]-1	Auxiliary	15.2' to 7.8'	Auxiliary Steam	Hot	CS	6	[illegible]	[illegible]	3	13	0
[illegible]-1A	Containment	66' to (-)19'	Chilled Water	Cold	CS	4, 2	[illegible]	0	3	3	0
[illegible]-110[illegible]	Auxiliary	99' to 37'	Containment Vacuum	Hot	SS	4	8	1	3	0	4
Ax-110[illegible]-1	Auxiliary	78' to 59.5'	Gaseous Vents	Hot	SS/ CS	6, 3	4	0	4	3	0
Ax-110[illegible]	Auxiliary	94' to 12'	Auxiliary Steam Containment Vacuum	Cold	SS/ CS	8, 4	3	0	0	1	3
Ax-91C	Auxiliary	102' to 34'	Gaseous Waste, Boron Recovery	Hot	CS/ SS	8, 1-1/2	5	10	14	[illegible]	6

*Hot is defined as greater than 150°F

**Intermediate anchors separating subsystem in this table are counted under both subsystems

TABLE 1 (Cont'd)

PIPING SUBSYSTEM INFORMATION

Subsystem	Building	Elevation Maximum/Minimum	System	Temp.*	Material	Pipe Size Maximum/Minimum	Anchor**	Rigid Support	Rod Hanger	Sliding Support	Spring Hanger
[illegible] 28	Containment	31' to 3'	Chilled Water	Cold	CS	4, 2-1/2	3	0	1	5	0
[illegible] 110B-1	Auxiliary	102' to 10'	Auxiliary Steam	Hot	CS	6	1	2	0	7	7
[illegible] 93A	[illegible]	32' to 16'	Auxiliary Steam	Hot	CS	4, 3	[illegible]	6	5	6	0
[illegible] 103B	Containment	5' to (-11)'	Chilled Water	Cold	CS	10, 3	5	0	4	15	0
[illegible] 3A	Containment	40' to 24'	Fire Protection Sprinkler Piping	Cold	CS	4, 1	1	2	23	0	0
[illegible] 4A	Auxiliary	66.5' to 43.5'	Fire Protection	Cold	CS	4, 1-1/2	1	7	19	1	0
[illegible] 5A	Auxiliary	66.5' to 24.5'	Fire Protection	Cold	CS	5, 1	0	10	16	0	0
[illegible] 6A	Containment	41.6' to 25.5'	Reactor Aerated Drains	Cold	CS	1, 3/4	[illegible]	13	2	1	0
[illegible] 7A	Auxiliary	66.5' to 24.5'	Boron Recovery	Hot	SS	2, 1	[illegible]	3	6	2	1
[illegible] 1011	Auxiliary Containment	65' to -6'	Boron Recovery	Hot	SS	4", 2"	6	4	5	7	0

*Hot is defined as greater than 150°F

**Intermediate anchors separating subsystems in this table are counted in both subsystems

TABLE 2
NON-SEISMIC CATEGORY I
LARGE BORE PIPING SUPPORTS
IN SAFETY-RELATED AREAS BY HANGER TYPE

Pipe Size/Hanger Type	Anchor		Spring Hanger		Rigid Restraint		Rod Hanger		Sliding Support		Snubber		TOTALS		Percentage	
	S*	P**	S	P	S	P	S	P	S	P	S	P	S	P	S	P
2 1/2"	7	6	0	7	6	131	10	93	1	37	0	1	19	220	5.8	11.6
3"	14	43	1	8	19	112	25	151	16	202	0	0	75	571	26.8	28.1
4"	20	57	9	24	16	196	26	190	19	234	0	9	90	710	32.1	[illegible]
6"	10	11	4	11	3	42	14	45	18	55	0	0	49	167	17.5	8.7
8"	7	5	5	5	2	30	3	6	5	8	0		22	54	7.9	2.9
10"	2	6	0	3	0	9	0	50	9	66	0	0	11	134	3.9	6.1
12"	6	3	5	8	3	3	0	7	0	2	0	0	14	[illegible]	5.0	1.2
TOTALS	61	151	24	61	49	523	78	522	68	607	0	10	280	[illegible]		
PERCENTAGE	21.8	7.1	8.6	3.3	17.5	28.2	27.9	28.7	24.3	32.7	0	.54				

*Based on the selected sample of bounding subsystems.
Intermediate anchors are counted twice.
**Plant total population based on Northeast Utilities NRC Submittal dated October 31, 1985.

TABLE 5

NON-SEISMIC CATEGORY I PIPING SUPPORTS
IN SAFETY RELATED AREAS

[illegible] Sys/ Bldg	Auxiliary Building		Control Building		Containment Structure		Intake Structure		Diesel Generator Enclosure		Emergency Safety Features Building		Fuel Building		Hydrogen Recombiner Building		Main Steam Valve Building		Total		Percentage	
	S*	P**	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P
[illegible]	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	[illegible]	.04
[illegible]	1	115	0	0	0	88	0	0	0	21	0	9	0	0	0	0	0	75	1	302	.28	6.1
[illegible]	11	471	0	49	0	211	0	17	0	2	0	28	0	133	0	41	0	70	11	1022	3.1	20.5
[illegible]	36	360	0	70	15	153	0	9	0	12	0	164	0	97	0	43	0	15	51	923	14.2	18.5
[illegible]	2	79	0	32	3	23	0	3	0	0	0	5	0	107	0	0	0	1	5	244	1.4	4.9
[illegible]	1	273	0	16	5	164	0	6	0	0	0	87	0	76	0	2	0	13	6	637	1.7	12.8
[illegible]	14	203	0	15	5	14	0	0	0	7	0	0	0	31	0	0	0	0	19	270	5.3	5.4
[illegible]	50	245	0	0	12	132	0	25	0	5	1	6	0	71	0	0	0	37	72	521	20.1	10.5
[illegible]	61	353	0	0	17	154	0	16	0	6	17	26	0	101	0	[illegible]	0	46	78	710	22.5	14.2
[illegible]	49	107	0	0	0	21	0	0	0	0	0	7	0	25	0	0	0	2	49	162	13.6	3.3
[illegible]	22	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	54	6.1	1.1
[illegible]	0	57	0	0	11	46	0	0	0	0	0	11	0	0	0	0	0	0	11	114	3.1	2.3
[illegible]	14	16	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	14	23	3.9	.46
Total	273	2337	0	183	68	1002	0	76	0	32	18	362	0	647	0	86	0	252	359	[illegible]		
Percentage	76.	46.9	0	3.7	18.9	20.1	0	1.5	0	.64	5.	7.3	0	13.0	0	1.7	0	5.2				

*[illegible] on the selected sample of bounding subsystems.
**[illegible] total population. Based on Northeast Utilities NRC submittal dated October 31, 1985.

TABLE 4

SUBSYSTEM EVALUATION SUMMARY

Subsystem	Accession No. of Walkdown Package	Accession No. of Stress Report
AX-110X-1	EMD-054751	EMD-055017
AX-88A	EMD-054753	EMD-055016
AX-110Q	EMD-054752	EMD-055095
AX-110G	EMD-054755	EMD-055022
AX-110Y-1	EMD-054756	EMD-055160
AX-110S-A	EMD-054757	EMD-055093
AX-88A-1	EMD-054759	EMD-055020
AX-88A-2	EMD-054760	EMD-055021
AX-110V	EMD-054754	EMD-055023
AX-110L	EMD-054758	EMD-055018
AX-107X-2	EMD-054764	EMD-055223
AX-107X-3	EMD-054765	EMD-055223
AX-110S-B	EMD-054761	EMD-055162
AX-107X	EMD-054762	EMD-055223
AX-107X-1	EMD-054763	EMD-055223
AX-110N	EMD-054768	EMD-055166
AX-110R	EMD-054769	EMD-055309
AX-94A	EMD-054766	EMD-055233
EL-1A	EMD-054772	EMD-055167
EL-2A	EMD-054767	EMD-055234
EL-3A	EMD-054773	EMD-055371
AX-91G	EMD-054774	EMD-055222
AX-110R-1	EMD-054770	EMD-055247
EL-6A	EMD-055051	EMD-055296
EL-7A	EMD-055052	EMD-055376
EL-4A	EMD-054778	EMD-055367
EL-5A	EMD-055053	EMD-055105

TABLE 5

PIPING PEAK STRESS SUMMARY

Subsystem Name	No. of Supports** Restraints	No. of Supports** Anchors	Pipe Size	Stress at Maximum Stress Location* Node No.	Node Type	Intensification Factor B_2	Eq. 90 Stress	Allowable	Available Margin	Maximum Deflection
AX 88A	3	2	12	1050	Elbow	4.65	11500	45200	75%	1
AX 88A 1	3	2	12	15A	Elbow	4.65	8050	37000	78%	1<
AX 88A 2	2	2	12	10A	Elbow	4.65	5100	37000	86%	1<
AX 93C	31	5	8, 6, 4, 3, 1-1/2	7	Unreinforced Tee	11.92	38502	45000	14%	3
AX 94A	12	1	4, 3	45A	Elbow	5.17	23100	45000	49%	2
AX 102***	19	5	10, 4, 3	840B	Elbow	5.17	29432	45000	--	6
				840A	Elbow	5.17	24490	45000	--	
				220	Weldolet	3.47	28322	45000	--	
				835	Welding Tee	6.15	61702	45000	--	
AX 110G	7	3	8, 6	1550	Elbow	2.44	15800	45000	65%	3
AX 110	8	8	4	70	Reducer	1.0	33900	45200	26%	1

TABLE 5 (Cont'd)

PIPING PEAK STRESS SUMMARY

Subsystem Name	No. of Supports: Restraints	No. of Supports: Anchors	Pipe Size	Node No.	Node Type	Stress at Maximum Stress Location*: Intensification** Factor B_2	Eq. 10 Stress	Allowable	Available Margin	Maximum Deflection
AX 1100	4	3	8, 4	10A	Elbow	3.96	23900	47100	49%	4
AX 1100	14	3	8, 6, 4	34C	Branch Connection	4.95	37700	45000	16%	5
AX 1100	5	2	6, 4	460	Unreinforced Tee	7.25	42300	45000	6%	2
AX 1100 1	17	2	6	260A	Elbow	3.68	20900	45000	54%	[illegible]
AX 1105 A	5	3	4, 3	195B	Elbow	1.78	11400	45000	74%	1
AX 1105 B	6	3	3	55A	Elbow	2.57	43900	45000	2%	5
AX 1109	17	4	4, 3, 2	572	Reducer	1.0	32900	45000	27%	9
AX 1104 1	6	1	6	20B	Elbow	3.68	20500	45000	54%	5
AX 1104 1	11	4	3, 4, 6	265	Unreinforced Tee	3.94	36200	45000	19%	4
SI 1A	6	3	3, 2	10A	Elbow	2.80	39600	45000	12%	4
SI 2A	6	3	4, 2-1/2	351	Unreinforced Tee	1.68	41900	45000	7%	6.6
SI 3A	25	1	4, 3, 2-1/2, 2, 1-1/2, 1-1/4, 1	290	Threaded Connection	1.73	30900	45000	31%	2.5

TABLE 5 (Cont'd)

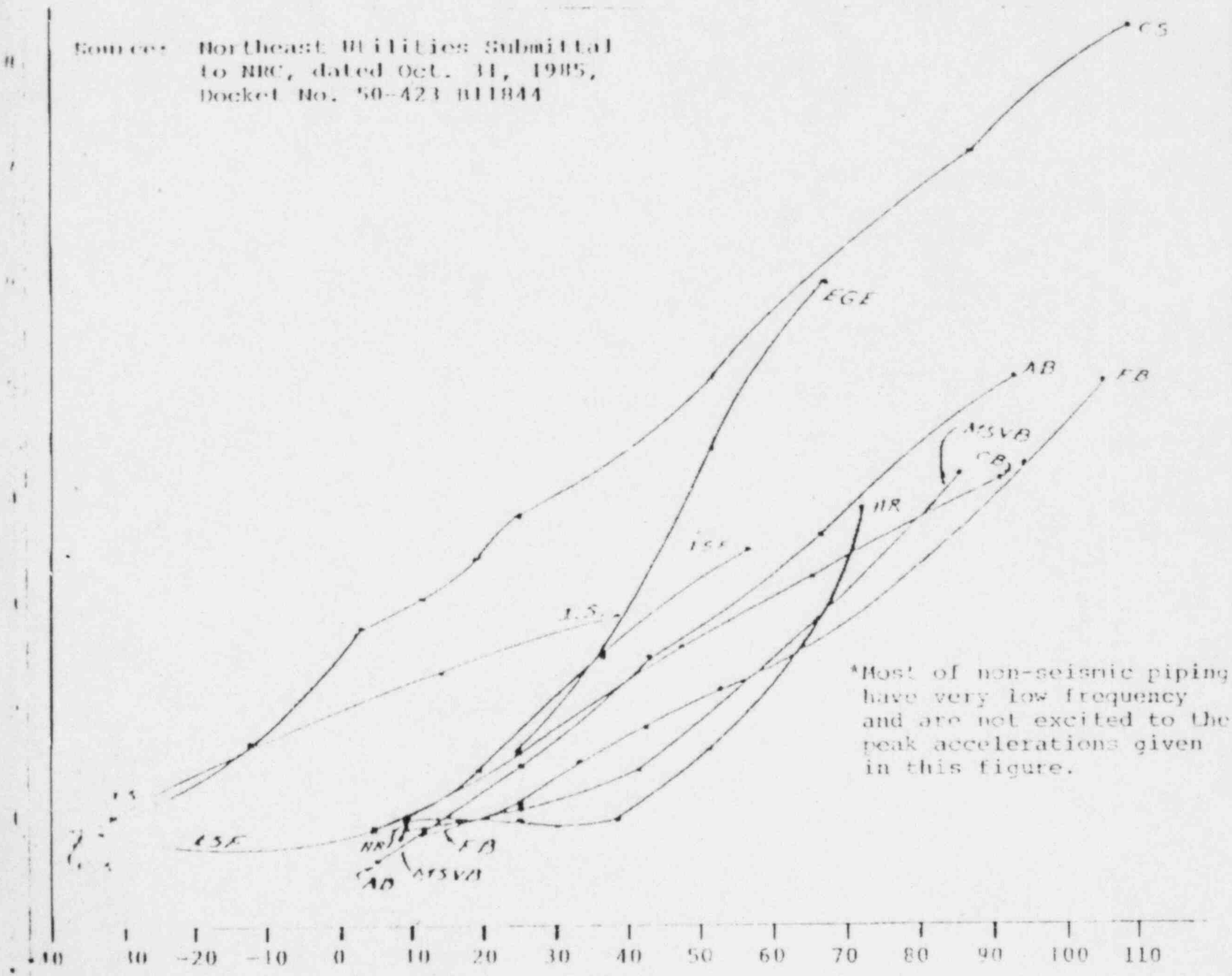
PIPING PEAK STRESS SUMMARY

Subsystem Name	No. of Supports** Restraints	No. of Supports** Anchors	Pipe Size	Stress at Maximum Stress Location* Node No.	Node Type	Intensification Factor B_2	Eq. 9D Stress	Allowable	Available Margin	Maximum Deflection
SI-4A	26	1	4, 2-1/2,	1305	Unreinforced Tee	5.80	38100	45000	15%	6
SI-5A	26	0	3, 1	265	Threaded Connection	1.73	39200	45000	14%	10
SI-6A	13	6	1, 3/4	275	Unreinforced Tee	2.1	36700	45000	18%	5
SI-7A	12	5	2, 1, 3/4, 1/2	340	Socket Weld	1.5	42750	45932	7%	2

*Stress at other locations are generally very small.

**Intermediate anchors separating subsystem in this table are counted under both subsystems.

***The stress at elbow node 840A, 840B and tee node 835 exceed allowables. The above exceedance is due to the displacement imposed by the 10 inch run pipe on the 4 inch branch pipe. The nominal stress (without any B_2 indices) is judged to be acceptable. Further, an additional analysis was performed with a hinge (plastic hinge) at the elbow node 840B and the stresses at all nodes were found to be acceptable. The angulation of the hinge at elbows is 2.2 degrees and it was found to be acceptable.



Seismic Severity Comparison for Seismic Cat[illegible]gory I Buildings

FIGURE 1

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Enclosure 2
Summary of Anchorage Reviews

The anchorage details reviewed in this program consist of three types.

1. Surface Mounted Plates - Plates attached to the structure by Hilti bolts or Richmond inserts.

2. Embedded Plates - Plates installed at the time of concrete placement, which are anchored with Nelson studs.

3. Steel Attachments - Pipe supports which are attached directly to structural steel.

Surface Mounted Plates

All Hilti bolts have a minimum factor of safety of 2 on ultimate. Ultimate capacity is based on minimum values from plant-specific tests. Actual factors of safety are generally much higher than 2. With the exception of 2 plates this program showed a minimum factor of safety of 3 on ultimate for Hilti bolts. Richmond inserts all met the criteria for normal seismic Category I design.

Embedded Plates

All embedded plates with the exception of one, meet the requirements of NETM 41 which establishes the rule for normal seismic Category I design. The one plate which did not meet these requirements was evaluated using the rules of ACI 349-80, which treats SSE as an unfactored load case, and was found to have sufficient capacity. Therefore embedded plates have been shown to be capable of withstanding SSE loads imposed by non-seismically designed piping.

Steel Attachments

All attachments to structural steel have been reviewed considering local stiffening requirements and the ability of the steel to carry the imposed loads. The relative stiffness of piping and support steel was considered in these reviews to account for load redistribution to adjacent supports. All steel attachments were found to be acceptable.

Special Case

Subsystem AX107X was discussed in detail during an audit by the Staff at Sargent & Lundy on January 9, 1986. This subsystem is one of four 10" chilled water lines in containment. Due to the unique routing of these pipes, one bounding problem was selected for analysis (AX107X). Sargent & Lundy calculated very large anchor loads for the subsystem. As part of the seismic interaction walkdown program all of the 10" chilled water lines in containment were extensively modified to prevent interactions. Anchors for this system have been reviewed considering loads estimated from the as modified configuration and found to comply with acceptance criteria.

It is expected that the anchors on AX107X in the unmodified configuration would pass if a detailed non-linear time history analysis were performed. However, since all piping represented by AX107X has been similarly modified this analysis is not warranted.