August 31, 1982

Docket No. 50-29
LS05-82 -08-075

Mr. James A. Kay
Senior Engineer - Licensing
Yankee Atomic Electric Company
1671 Worcester Road
Framingham, Massachusetts 01701

Dear Mr. Kay:

SUBJECT: SEP TOPIC III-2, WIND AND TORNADO LOADINGS
YANKEE NUCLEAR POWER STATION

Enclosed is an evaluation of SEP Topic III-2. This evaluation compares your facility as described in the Safety Analysis Report you supplied on March 18, 1982, and other information on Docket No. 50-29 with criteria used by the staff for licensing new facilities.

The evaluation identifies structures and portions of structures which cannot withstand the postulated tornado loads.

This evaluation will be a basic input to the integrated safety assessment of your facility. This topic may be changed in the future if your facility design is changed or if NRC criteria relating to this topic is modified before the integrated assessment is completed.

Sincerely,

Ralph Caruso, Project Manager
Operating Reactors Branch No. 5
Division of Licensing

SEO4
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Enclosure:
As stated

cc w/enclosure:
See next page

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SYSTEMATIC EVALUATION PROGRAM
TOPIC III-2

YANKEE

TOPIC: III-2, WIND AND TORNADO LOADINGS

I. INTRODUCTION

The safety objective of this review is to assure that safety-related structures, systems and components are adequate to resist wind and tornado loadings including tornado pressure drop loading.

II. REVIEW CRITERIA

The review criteria governing this topic is General Design Criteria 2, design bases for protection against natural phenomena.

III. RELATED SAFETY TOPICS AND INTERFACES

1. Tornado missiles are reviewed in SEP Topic III-4.A.

2. Structures which are considered safety-related are given in SEP Topic III-1.

3. Wind and tornado parameters are given in SEP Topic II-2.A.

4. Design codes, criteria and load combinations are reviewed in SEP Topic III-7.B.

IV. REVIEW GUIDELINES

The currently accepted design criteria for wind and tornado loadings is outlined in Standard Review Plan Sections 3.3.1, 3.3.2, 3.8 and Regulatory Guides 1.76 and 1.117. Codes and standards used for the review of structures at the Yankee facility are given in Enclosure 1 to this SER.

Site specific windspeed and tornado parameters were developed in Topic II-2.A and the appropriate values were identified for use as input to the wind and tornado loading analyses. Structures important to safety were reviewed in this topic to determine their ability to withstand these values from Topic II-2.A. Appropriate values for the Yankee site are a 300 mph windspeed (corresponding to 230 psf dynamic pressure) and a 2.25 psi (324 psf) differential pressure. The evaluation and conclusions are based on a Safety Analysis Report supplied by the licensee, information available on Docket No. 50-29, and the information developed by the staff given in Enclosure 1 to this SER. For those structures examined by the staff which cannot withstand the postulated tornado loads, limiting capacities were determined and are given in terms of strength and corresponding windspeed.

V. EVALUATION

Enclosure 1 is a report entitled, "Wind and Tornado Loadings" presenting our contractor's findings concerning the Yankee facility. The report identifies limiting structural elements and their associated windspeed. The intent is to verify the SAR submitted by the licensee. No analyses were performed for safety-related systems and components. Systems and components important to safety not housed within safety-related structures should be addressed by the licensee.

Original Design and SAR Conclusions

According to the Safety Analysis Report and other information supplied by the licensee, structures at the site were designed for straight wind pressures given below. The straight wind pressures represent the velocity pressure adjusted by a shape factor for the structure. The American Standard Building Code A58.1-1955 was used.

Height (ft)	Pressure (psf)
Less than 30	20
30-49	25
50-99	30
100-499	40

A summary of the conclusions reached in the licensee's SAR is given below.

Structure	Capacity (mph)
Steel Vapor Container	
Structural	252
Skin	> 252
Turbine Building	
Structural	158
Skin	64
Roof	161
Primary Auxiliary Building	
Structural	192
Skin	40
Roof	165
Diesel Generator Building	
Roof	190
Skin	46

Discussion

Current criteria for straight wind loading is given in Standard Review Plan 2.3.1 which references ANSI A58.1, Exposure C. Current criteria requires design for straight wind with a probability of exceedance in one year of 10^{-2} and of 10^{-7} for a tornado. Straight wind loads differ from tornado loads in that straight wind loads are considered in different load combinations, have different load factors in ultimate strength design of concrete and have different acceptance criteria than tornado wind loads. Additionally, straight wind design includes such aspects as gust factors and variation of force with height whereas tornado design does not. Buildings at Yankee were originally designed as stated previously. ANSI A58.1, 1972, specifies a 10^{-2} wind which is approximately 80 mph at an elevation of 30' above grade. Per current criteria, load combinations involving dead, live, wind, pipe reactions, and thermal are allowed a 30% increase in allowable stresses for concrete structures if working stress methods are used and a 50% increase in stress for steel structures if elastic design methods are used. The original design by the licensee utilized working stress design methods for steel and concrete design; therefore, the load factors used in the original design are the same as current criteria. The magnitude of the straight wind loads, excluding localized effects, used in the original design is somewhat less than that required by current criteria (ANSI A58.1, 1972, Exposure C.). Localized loads required by current criteria are, in general, comparable to the wind load considered in the original design for Exposure C. Considering that Exposure C is intended for flat, open country and that Yankee is located in a wooded area, Exposure B is more appropriate for the site. The original design of the plant for wind is conservative when compared to ANSI A58.1, 1972, 80 mph basic windspeed, Exposure B. Further, results of staff calculations indicate that the as-built structures have adequate capacity to resist ANSI A58.1, 1972, 80 mph basic windspeed, Exposure C loads, excluding the skin of the structures (e.g., masonry block walls). It appears that allowable stresses were increased by 1/3 for load combinations involving wind. The 1/3 increase in allowable stress utilized by the licensee for structures does not imply structural failure since increases of 30% and 50% in allowable stress above code allowable are permitted for load combinations involving all operating loads (dead load, live load, wind load, operating pipe reaction loads, and thermal loads). Since it is uncertain whether pipe reaction loads were included in the original design in combination with wind loads, it may be possible to overstress some structural elements if these loads are combined with wind. Allowable bearing stresses were increased by 1/3 for load combinations involving wind. This stress increase is not permitted in all cases by current criteria; rather, the factor of safety with and without the stress increase is examined. The original design at Yankee may be acceptable with the stress increase; however, to state this positively requires the licensee to supply the bearing stress factor of safety used originally.

Although it is possible to overstress some structural members due to the additional loads, it is unlikely to occur for structures that are able to withstand the design tornado loads since these loads are significantly more demanding than the wind load and would, therefore, provide margin to accomodate pipe reaction loads. The licensee has stated that a snow load of 40 psf was used in the original design. This load corresponds to current criteria for a 10^{-2} snow load; however, it is uncertain whether this load was combined with straight wind.

The staff has analyzed the vapor container, primary auxiliary building. diesel generator building, and control room. The results in terms of limiting windspeed at which acceptance criteria for limiting structural elements is exceeded is given below.

Structure	Element[b]	Cause of Failure[c]	Wind Speed (mph)	Corresponding Pressure (psf)
Vapor Container	Supporting Steel Columns	--	--	--
Primary Auxiliary Building	Concrete Block Wall[d]	2	49	13
		3	56	12
		1	77	15
	8W21 Columns	2	162	135
		1	266	168
	16W36 Roof Girders	2	129	86
		1	183	
	12W27 Roof Beams	2	183	171
	10W21 Roof Beams	2	191	186

Structure	Element[b]	Cause of Failure[c]	Wind Speed (mph)	Corresponding Pressure (psf)
Diesel Generator Building	Concrete Block Wall[d]	2	55	16
		3	63	16
		1	87	20
	8W17 Columns	3	80	15
		2	85	37
		1	134	46
	18W50 Roof Girder	2	96	48
		3	133	48
		1	163	68
	10W21 Roof Beam	2	157	127
		1	266	181
	8W17 Roof Beams	2	186	176
		1	313	220
Control Room	Reinforced Concrete Piers	2	120	73
		1	189	92
	Reinforced Concrete Wall Between Elevations 1052 ft and 1066 ft	None	>300	

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a. The ratings of some structural components are not definitive, but are estimates based on approximate modeling.

b. Note that this table does not imply that all inadequate elements have been identified.

c. Key: 1 = tornado dynamic pressure; 2 = differential pressure; 3 = high wind dynamic pressure. Tangential windspeeds are listed for differential pressure failures.

d. The concrete block wall ratings are given for tension stress normal to bed joint in unreinforced block walls.

The values presented above are given for tornado dynamic pressure (otherwise known as velocity pressure), differential pressure, and high straight wind pressure. The allowable stresses for the tornado loads are according to SRP Section 3.8 which permits stress increases above code allowables for certain types of extreme loadings. The straight wind (non-tornado generated) capacity is also given because it becomes the controlling event for tornado velocities under approximately 120 mph at Yankee.

The straight wind capacity is calculated based on straight wind criteria (e.g., wind velocities vary with height). The capacity given has been normalized to 30 feet above grade since this is the elevation at which basic wind pressures are given for straight winds and because the report performed by McDonald for SEP Topic II-2.A has normalized the straight wind probability curve to this elevation. It should be noted that the straight wind capacities given above have not included the 50% increase in stress allowables for steel since the increase is only permitted for the load combination including pipe reaction loads and thermal loads. If it can be shown that these loads do not significantly add to the loads applied to the wind resisting structure, wind velocities for steel can be increased by approximately 22%.

The results presented by the licensee and those calculated by the staff indicate that the support columns of the vapor container have substantial capacity. The values calculated by the staff show acceptability for the full tornado wind; the licensee indicates that the capacity is less than that required for the design tornado. The licensee has been requested to submit calculations for the sphere so that the difference can be reconciled. The staff is evaluating the capacity of the skin of the vapor container.

The primary auxiliary building cannot withstand the design basis tornado loads according to results obtained by the staff and the licensee. Generally, the capacities of the main structural members presented by the licensee and calculated by the staff agree for externally applied wind dynamic pressure. The licensee did not present capacity values for differential pressure drop. Calculations performed by the staff indicate that differential pressure is controlling and thus, capacities are lower than presented by the licensee. The licensee and the staff conclude that the skin of the PAB does not have capacity to resist the design tornado loads.

Staff calculations indicate insufficient capacity for the masonry block walls; siding calculations were not performed by the staff for Yankee. The licensee has been requested to provide the bases for capacities given so that it can be understood how the siding and roof capacities were obtained for all structures where these values have been provided by the licensee.

Staff calculations indicate that the diesel generator building and portions of the control room have insufficient capacity to resist the design basis tornado loadings.

Capacity of the chimney was not provided by the licensee. Based on original design, it is concluded that the chimney cannot withstand the design tornado loads. The north wall of the control room is constructed of reinforced concrete. This wall will be exposed to the atmosphere upon the expected failure of the siding and roof deck of the turbine building due to differential pressure. The capacity of this wall should be determined by the licensee since it will be exposed to tornado loads.

It should be noted that foundation capacities and soil pressures were not examined by the staff, nor is it clear whether they were considered by the licensee in their SAR. Foundation and soil capacity should be determined by the licensee in order to substantiate that these are not more limiting than values calculated by the staff or presented by the licensee.

Roof decks consisting of built-up roofing as opposed to structural roof slabs made of concrete were not investigated by the staff. It is expected that such roofs will have minimal resistance to differential pressure. Bases for the roof capacities given by the licensee should be provided.

VI. CONCLUSIONS

It is concluded that portions of some structures cannot withstand the postulated design basis tornado loads of 300 mph wind and 2.25 psi pressure drop.

The licensee should: (1) implement modifications for the following structures to meet the design basis tornado loads, (2) demonstrate that the consequences of their failure if subjected to tornado loads are acceptable, or (3) demonstrate adequate resistance for smaller tornado loadings and that the risk associated from larger tornado loadings is acceptable.

1. Turbine Building
2. Diesel Generator Building
3. Primary Auxiliary Building
4. Control Room
5. Siding and Decking
6. Chimney
7. Screenwell House

For safety related components not inside structures the licensee should either demonstrate acceptability for tornado loads or that the consequences of failure if subjected to tornado loads are acceptable.

The licensee should demonstrate that foundation and soil capacities are greater than original design to assure that they are not limiting. Also,

factors of safety used in the original design should be provided in order to determine whether the bearing stress increase for wind design is acceptable.

It should be determined whether operating pipe reaction loads, thermal loads and snow loads were considered with wind in the original design. If these loads were not, the effect of combining them should be addressed.

Where significantly lower capacities were provided by the licensee than those calculated by the staff for tornado dynamic pressure, the licensee's capacity is relied upon. Bases for these capacities should be provided by the licensee so that the discrepancies between the two values can be resolved.

The need to implement modifications or perform additional analysis in order to assure that structures, systems and components can adequately resist wind and tornado loads will be determined during the integrated assessment.