TECHNICAL EVALUATION REPORT

AUDIT FOR MARK I CONTAINMENT

LONG-TERM PROGRAM - STRUCTURAL ANALYSIS

ENRICO FERMI ATOMIC POWER PLANT, UNIT 2

FRC PROJECT C5506

FRC ASSIGNMENT 9

NRC CONTRACT NO. NRC-03-81-130

FRC TASK 309

Prepared by

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Author: N. Subramonian
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FRC Group Leader: N. Subramonian

Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: H. Shaw

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

Contributors to the technical preparation of this report were Dr. Vu Con, Dr. B. Dhillon, T. Stilwell, and M. Darwish of the Franklin Research Center.

1. INTRODUCTION

The capability of the boiling water reactor (BWR) Mark I containment suppression chamber to withstand hydrodynamic loads was not considered in the original design of the structures. The resolution of this issue was divided into a short-term program and a long-term program.

Based on the results of the short-term program, which verified that each Mark I containment would maintain its integrity and functional capability when subjected to the loads induced by a design-basis loss-of-coolant accident (LOCA), the NRC staff granted an exemption relating to the structural factor of safety requirements of 10CFR50, 55(a).

The objective of the long-term program was to restore the margins of safety in the Mark I containment structures to the originally intended margins. The results of the long-term program are contained in NUREG-0661 [1], which describes the generic hydrodynamic load definition and structural acceptance criteria consistent with the requirements of the applicable codes and standards.

The objective of this report is to present the results of an audit of the Fermi Unit 2 plant-unique analysis (PUA) report with regard to structural analysis. The audit was performed using a moderately detailed audit procedure developed earlier [2] and attached to this report as Appendix A. This report does not include results of the audit related to torus attached piping, which will be provided in a supplementary report. The key items of the audit procedure are obtained from "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide" [3], which meets the criteria of Reference 1.

2. AUDIT FINDINGS

A detailed presentation of the audit for Fermi Unit 2 is provided in Appendix A, which contains information with regard to several key items outlined in the audit procedure [2]. Based on this detailed audit, it was concluded earlier that certain items in the Fermi Unit 2 PUA report [4] indicated noncompliance with the requirements of the criteria [3] and several aspects of the analysis required further information. Based on this conclusion, the Licensee was requested to provide additional information on these aspects in order to indicate compliance with the criteria. The items contained in the request for additional information are attached to this report as Appendix B.

The Licensee has responded [5] to all the items contained in the request for additional information (Appendix B) as discussed in the following subsections.

Question 2.1.1

(NRC Question 10.1)

In response to this question, the Licensee has shown that the method of analysis used in Reference 4 gives a more conservative estimate of the lateral load compared to the result of an analysis based on a 180° beam model. Also, the magnitude of the stresses that would be indicated in the region surrounding the support columns using a 180° beam model is estimated to be negligible due to the fact that the overturning moments are small. The Licensee has provided adequate justification for not considering an analysis using a 180° beam model.

Question 2.1.2

(NRC Question 10.2)

In response to this question, the Licensee has provided justification for assuming that only 20% of the total mass of water in the suppression chamber acts as a rigidly attached mass, based on experimental evidence [6] which is shown to be applicable to Fermi Unit 2 analysis. The Licensee's response is considered to be technically adequate.

Question 2.1.3

(NRC Question 10.3)

In response to this question, the Licensee has indicated the basis for obtaining the modal correction factors used in Reference 4 and has shown that the results are applicable to multidegree-of-freedom systems if the modal superposition method is employed. The Licensee's derivations and assumptions are technically adequate since their conservatism is demonstrated using Monticello tests.

Question 2.1.4

(NRC Question 10.4)

In response to this question, the Licensee has shown that the bending moments in the suport columns are small since the columns are permitted to slide horizontally at their base; further, the effects of buckling are negligible since the columns are heavily braced. The Licensee's response is considered to be technically adequate.

Question 2.1.5

(NRC Question 10.5)

In response to this question, the Licensee has provided justification for not performing a nonlinear time history analysis based on the fact that the Fermi Unit 2 suppression chamber is fully anchored to the basemat and that the tensile forces are less than the allowable anchorage capacity. The Licensee's justification is satisfactory.

Question 2.1.6

(NRC Question 10.6)

In response to this question, the Licensee has indicated that two different tempertures, 173°F for the suppression chamber and 100°F for the base plate of the support system, were used in the analysis since these were the maximum values expected in the specified regions. The Licensee's explanation is satisfactory.

Question 2.2.1

(NRC Question 11.1)

In response to this question, the Licensee has provided justification for using the square root of the sum of the squares (SRSS) method for combining the responses in the SRV piping based on Reference 7, which indicates that the probability of exceeding the loads is 16% or less when the SRSS method is used. The Licensee's justification is satisfactory.

Question 2.2.2

(NRC Question 11.2)

In response to this question, the Licenseee has justified the use of Markl's equation for SRV piping fatigue analysis since the SRV piping is a Class 2 system and Markl's equations are applicable for this class. The Licensee has further indicated that the fatigue analysis for SRV piping presented in Reference 4 incorporates the recommendations of the generic approach developed by the Mark I Owners Group, which is subject to NRC approval.

Question 2.2.3

(NRC Question 11.3)

In response to this question, the Licensee has provided the reasons for not using the fatigue equation for Class 1 piping and indicates conformity to the recommendations of the Mark I Owners Group. The Licensee's approach is satisfactory subject to NRC approval of the recommendations of the Mark I Owners Group.

Question 2.2.4

(NRC Question 11.4)

In response to this question, the Licensee has provided the basis for developing maximum-stress cycle factors and indicated that these are derived from Class 2 piping thermal fatigue techniques which are defined in Section

NC-3611.1(e)(3) of Reference 8. The Licensee's approach is satisfactory subject to NRC approval of the recommendations of the Mark I Owners Group.

Question 2.2.5

(NRC Question 11.5)

In response to this question, the Licensee has provided information on the dynamic load factors used in Reference 4 with justification for the values assumed. The Licensee's response is satisfactory.

Question 2.2.6

(NRC Question 11.6)

In response to this question, the Licensee has indicated that the SRV support connection stresses are within the allowable limits. The Licensee's response to this question is satisfactory.

Question 2.3.1

(NRC Question 12.1)

In response to this question, the Licensee has provided the basis for calculating the hydrodynamic masses used in Reference 4 for evaluating submerged structures as the relationship contained in Table 4.3-4.1 of Reference 9. The Licensee's approach is technically adequate.

Question 2.3.2

(NRC Question 12.2)

In response to this question, the Licensee has indicated that all the applicable loads included in Table 1 of Appendix B have been considered in the analysis. The Licensee has provided justification for not considering a few of these loads in the analysis based on the fact that these are of negligible magnitude. The Licensee's response is satisfactory.

Question 2.3.3

(NRC Question 12.3)

In response to this question, the Licensee has indicated that the attachment welds to the torus shell connecting the internal structures have been evaluated as Class MC components and are within allowable limits. The Licensee's response is satisfactory.

3. CONCLUSIONS

From the audit of the Fermi Unit 2 plant unique analysis report, it was concluded earlier that certain aspects required additional information. The Licensee's response [5] to the request for additional information indicates that the Licensee's structural analysis with regard to major modification is in general conformance to the criteria requirements [3]. The Licensee's approach to fatigue analysis of SRV piping as clarified in response to questions 11.2 to 11.4 of Appendix B indicates conformity with the approach recommended by the Mark I Owners Group, which is subject to NRC approval.

The Licensee's analysis of torus attached piping will be audited at a later date and the findings will be included in a supplementary technical evaluation report.

4. REFERENCES

1. NUREG-0661
   "Safety Evaluation Report, Mark I Containment Long-Term Program
   Resolution of Generic Technical Activity A-7"
   Office of Nuclear Reactor Regulation
   USNRC
   July 1980

2. Technical Evaluation Report
   Audit Procedure for Mark I Containment Long-Term Program - Structural
   Analysis
   Franklin Research Center, Philadelphia, PA
   June 1982, TER-C5506-308

3. NEDO-24583-1
   "Mark I Containment Program Structural Acceptance Criteria Plant Unique
   Analysis Application Guide"
   General Electric Co., San Jose, CA
   October 1979

4. Enrico Fermi Atomic Power Plant, Unit 2
   Plant Unique Analysis Report, Volumes 1-5
   Prepared by NUTECH Engineers, Inc.
   April 1982

5. H. Tauber (Detroit Edison)
   Draft copy of letter to B. J. Youngblood (Division of Licensing, USNRC)
   Letter identification EF2-59, 222, and attachments

6. NEDC-23702-P
   "Mark I Containment Program Seismic Slosh Evaluation"
   March 1978

7. NUREG-0484, Revision 1
   "Methodology for Combining Dynamic Responses"
   USNRC
   May 1980

8. American Society of Mechanical Engineers
   Boiler and Pressure Vessel Code, Section III, Division 1
   "Nuclear Power Plant Components"
   New York: 1977 Edition and Addenda up to Summer 1977

9. NEDO-21888 Revision 2
   "Mark I Containment Program Load Definition Report"
   General Electric Co., San Jose, CA
   November 1981

APPENDIX A

AUDIT DETAILS

1. INTRODUCTION

The key items used to evaluate the Licensee's general compliance with the requirements of NUREG-0661 [1] and specific compliance with the requirements of "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide" [2] are contained in Table 2-1. This audit procedure is applicable to all Mark I containments, except the Brunswick containments, which have a concrete torus.

For each requirement listed in Table 2-1, several options are possible. Ideally, the requirement is met by the Licensee, but if the requirement is not met, an alternative approach could have been used. This alternative approach will be reviewed and compared with the audit requirement. An explanation of why the approach was found conservative or unconservative will be provided. A column indicating "Additional Information Required" will be used when the information provided by the Licensee is inadequate to make an assessment.

A few remarks concerning Tables 2-1 and 2-2 will facilitate their future use:

- o A summary of the audit as detailed in Table 2-1 is provided in Table 2-2, highlighting major concerns. When deviations are identified, reference to appropriate notes are listed in Table 2-1.
- o Notes will be used extensively in both tables under the various columns when the actual audits are conducted, to provide a reference that explains the reasons behind the decision. Where the criterion is satisfied, a check mark will be used to indicate compliance.
- o When a particular requirement is not met, the specific reasons for noncompliance will be given.
- o Where the Licensee's response to the request for additional information provided satisfactory evidence for compliance with the criteria, an appropriate remark is made and the original audit finding is provided only for the sake of completeness.

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
1.2	All structural elements of the vent system and suppression chamber must be considered in the review.							
	The following pressure retaining elements (and their supports) must be considered in the review:							
	o Torus shell with associated penetrations, reinforcing rings, and support attachments	✓						
	o Torus shell supports to the containment structure	✓						
	o Vents between the drywell and the vent ring header (including penetrations therein)	✓						
	o Region of drywell local to vent penetrations	✓						
	o Bellows between vents and torus shell (internal or external to torus)	✓						
	o Vent ring header and the downcomers attached to it	✓						
	o Vent ring header supports to the torus	✓						
	o Vacuum breaker valves attached to vent penetrations within the torus (where applicable)			*				* TO BE AUDITED LATER
	o Vacuum breaker piping systems, including vacuum breaker valves attached to torus shell penetra-			*				

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria: Met	Criteria: Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
1.2	(Cont.)							
	tions and to vent penetrations external to the torus (where applicable)							
	o Piping systems, including pumps and valves internal to the torus, attached to the torus shell and/or vent penetrations			*				* TO BE AUDITED LATER
	o All main steam system safety relief valve (SRV) piping †	✓						† INCLUDES SUPPORTS
	o Applicable portions of the following piping systems:			*				
	- Active containment system piping systems (e.g., emergency core cooling system (ECCS) and other piping required to maintain core cooling after loss-of-coolant accident (LOCA))							
	- Piping systems which provide a drywell-to-wetwell pressure differential (to alleviate pool swell effects)							
	- Other piping systems, including vent drains							
	o Supports of piping systems mentioned in previous item			*				
	o Vent header deflectors including associated hardware	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
1.2	(Cont.)							
	o Internal structural elements (e.g., monorails, catwalks, their supports) whose failure might impair the containment function	✓						
1.3	a. The structural acceptance criteria for existing Mark I containment systems are contained in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section III, Division 1 (1977 Edition), with addenda through the Summer 1977 Addenda [3] to be referred herein as the Code. The alternatives to this criteria provided in Reference 2 are also acceptable.	✓						
	b. When complete application of the criteria (item 1.3a) results in hardships or unusual difficulties without a compensating increase in level of quality and safety, other structural acceptance criteria may be used after approval by the Nuclear Regulatory Commission.						✓	

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
2.1	a. Identify the code or other classification of the structural element	✓		SEE SECT. 2.3.3 OF				Licensee's response is satisfactory
	b. Prepare specific dimensional boundary definition for the specific Mark I containment systems (Note: Welds connecting piping to a nozzle are piping welds, not Class MC welds)	✓		AP-PENDIX A				
2.2	Guidelines for classification of structural elements and boundary definition are as follows: (Refer to Table 2-3 and Table 2-4 for non-piping and piping structural elements, respectively, and to item 5 in this table for row designations used for defining limits of boundaries)							
	a. Torus shell (Row 1) - The torus membrane in combination with reinforcing rings, penetration elements within the NE-3334 [3] limit of reinforcement normal to the torus shell, and attachment welds to the inner or outer surface of the above members but not to nozzles, is a Class MC [3] vessel.	✓		SEE SECT. 2.3.3 OF AP-PENDIX A				Licensee's response is satisfactory

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
2.2	(Cont.)							
	b. Torus shell supports (Row 1) - Subsection NF [3] support structures between the torus shell and the building structure, exclusive of the attachment welds to the torus shell; welded or mechanical attachments to the building structures (excluding embedments); and seismic constraints between the torus shell and the building structure are Class MC [3] supports.	✓						
	c. External vents and vent-to-torus bellows (Row 1) - The external vents (between the attachment weld to the drywell and the attachment weld to the bellows) including: vent penetrations within the NE-3334 [3] limit of reinforcement normal to the vent, internal or external attachment welds to the external vent but not to nozzles, and the vent-to-torus bellcws (including attachment welds to the torus shell and to the external vents) are Class MC [3] vessels.	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach Conservative	Licensee Uses Alternate Approach Unconservative	NA	Remarks
2.2	(Cont.)							
	d. Drywell-vent connection region (Row 1) -- Vent welded connections to the drywell (the drywell and the drywell region of interest for this program is up to the NE-3334 [3] limit of reinforcement on the drywell shell) are Class MC [3] vessels.	✓						
	e. Internal vents (Rows 2 and 3) - Are the continuation of the vents internal to the torus shell from the vent-bellows welds and include: the cylindrical shell, the closure head, penetrations in the cylindrical shell or closure head within the NE-3334 [3] limit of reinforcement normal to the vent, and attachment welds to inner or outer surface of the vent but not to nozzles.	✓						
	f. Vent ring header (Rows 4 and 5) and downcomers (Row 6) - Vent ring header including the downcomers and internal or external attachment welds to the ring header and the attachment welds to the downcomers are Class MC [3] vessels.	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
2.2	(Cont.)							
	- The portion of the downcomer within the NE-3334 [3] limit of reinforcement normal to the vent ring header and portion of the vent ring header within NE-3334 limit of reinforcement arc considered under Row 5.	✓						
	g. Vent ring header supports (Row 7) - Subsection NF [3] supports, exclusive of the attachment welds to the vent ring header and to the torus shell, are Class MC [3] supports.	✓						
	h. Essential (Rows 10 and 11) and non-essential (Rows 12 and 13) piping systems - A piping system or a portion of it is essential if the system is necessary to assure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a shutdown condition, or the capability to prevent or mitigate the consequences of	†		*				* TORUS ATTACHED PIPING TO BE AUDITED LATER. † SRV PIPING SYSTEM HAS BEEN TREATED AS ESSENTIAL

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
2.2	(Cont.)							
	accidents which could result in potential off site exposures comparable to the guideline exposure of 10CFR100 [4]. Piping should be considered essential if it performs a safety-related role at a later time during the event combination being considered or during any subsequent event combination.							* TORUS ATTACHED PIPING TO BE AUDITED LATER
	i. Active and inactive component (Rows 10-13) - Active component is a pump or valve in an essential piping system which is required to perform a mechanical motion during the course of accomplishing a system safety function.			*				
	j. Containment vacuum breakers (Row 2) - Vacuum breakers valves mounted on the vent internal to the torus or on piping associated with the torus are Class 2 [3] components.			*				

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
2.2	(Cont.)							
	k. External piping and supports (Rows 10-13): - No Class 1 piping	✓		*				* TORUS ATTACHED PIPING TO BE AUDITED LATER
	- Piping external to and penetrating the torus or the external vents, including the attachment weld to the torus or vent nozzle is Class 2 [3] piping. The other terminal end of such external piping should be determined based on its function and isolation capability.			*				
	- Subsection NF [3] support for such external piping including welded or mechanical attachment to structure; excluding any attachment welds to the piping or other pressure retaining component are Class 2 [3] supports.			*				
	l. Internal piping and supports (Rows 10-13) - Are Class 2 or Class 3 piping and Class 2 or Class 3 component supports.	✓						
	m. Internal structures (Row 8) - Non-safety-related elements which are not pressure retaining, exclusive of attachment welds to any pressure retaining	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
2.2	(Cont.) member (e.g., monorails. ladders, catwalks, and their supports).							
	n. Vent deflectors (Row 9) - Vent header flow deflectors and associated hardware (not including attachment welds to Class MC vessels) are internal structures.	✓						
3.2	Load terminology used should be based on Final Safety Analysis Report (FSAR) for the unit or the Load Definition Report (LDR) [5]. In case of conflict, the LDR loads shall be used.	✓						
3.3	Consideration of all load combinations defined in Section 3 of the LDR [5] shall be provided.	✓		SEE SECT. 2.3.2 OF APPENDIX A				Licensee's response is satisfactory
4.3	a. No reevaluation for limits set for design pressure and design temperature values is needed for present structural elements.						✓	
	b. Design limit requirements used for initial construction following normal practice with respect to load definition and allowable stress shall be used for systems or	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
4.3	(Cont.) portions of systems that are replaced and for new systems.							
4.4	Service Limits and Design Procedures shall be based on the B&PV Code, Section III, Division 1 including addenda up to Summer 1977 Addenda [3], specifically:							See definition for Service Limits in Section 4 of Reference 2.
	a. Class MC containment vessels: Article NE-3000 [3]	✓						
	b. Linear-type component (Class 2 and 3) support - with three modifications to the Code:							
	- For bolted connections, the requirements of Service Limits A and B shall be applied to Service Limits C and D without increase in the allowables above those applicable to Service Levels A and B;			⊛				⊛ THERE IS NO INDICATION OF ANY BOLTED CONNECTION
	- NF-3231.1 (a) [3] is for primary plus secondary stress range;			⊛				

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
	- All increases in allowable stress permitted by Subsection NF [3] are limited by Appendix XVII-2110(b) [3] when buckling is a consideration.			⊛				⊛ THERE IS NO INDICATION OF ANY BOLTED CONNECTION
	c. Class 2 and 3 piping, pumps, valves, and internal structures (also Class MC)			*				* TORUS ATTACHED PIPING TO BE AUDITED LATER
5.3	The components, component loadings, and service level assignments for Class MC [3] components and internal structures shall be as defined in Table 5-1 of Reference 2.	†						† AIR LOADING ON THE TORUS IS NEGLECTED SINCE SRV AND POOL SWELL EVENTS ARE ASSUMED TO COINCIDE
5.4	The components, component loadings, and service level assignments for Class 2 and Class 3 piping systems shall be defined in Table 5-2 of Reference 2.	†						
5.5	The definition of operability is the ability to perform required mechanical motion and functionality is the ability to pass rated flow.							
	a. Active components shall be proven operable. Active components shall be considered operable if Service Limits A or B or more conservative limits (if the original design criteria required it) are met.			*				

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
5.5	(Cont.)							
	b. Piping components shall be proven functional in a manner consistent with the original design criteria.			*				* TORUS ATTACHED PIPING TO BE AUDITED LATER
6.1	Analysis guidelines provided herein shall apply to all structural elements identified in item 1.2 of this table.							
	a. All loadings defined in subsection 3.2 of Reference 2 shall be considered.	✓		SEE SECT. 2.3.2 OF APPENDIX A				Licensee's response is satisfactory See Section 3.3 of this table.
	b. A summary technical report on the analysis shall be submitted to the NRC.			*				
6.2	The following general guidelines shall be applied to all structural elements analyzed:							
	a. Perform analysis according to guideline defined herein for all loads defined in LDR [5]. (For loads considered in original design, but not redefined by LDR, previous analyses or new analyses may be used.)	✓		SEE SECT. 2.3.2 OF APPENDIX A				Licensee's response is satisfactory
	b. Only limiting load combination events need be considered.	✓		SEE SECT. 2.3.2 OF APPENDIX A				Licensee's response is satisfactory

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
6.2	(Cont.)							
	c. Fatigue effects of all operational cycles shall be considered.			SEE SECT. 2.2.2 To 2.2.4 OF APPENDIX A			✓	Licensee's responses are satisfactory subject to NRC approval of the Generic Approach
	d. No further evaluation of structural elements for which combined effect of loads defined in LDR [5] produces stresses less than 10% of allowable is required. Calculations demonstrating conformance with the 10% rule shall be provided.							
	e. Damping values used in dynamic analyses shall be in accordance with NRC Regulatory Guide 1.61 [6].	✓						
6.3	Structural responses for loads resulting from the combination of two dynamic phenomena shall be obtained in the following manner:							
	a. Absolute sum of stress components, or			SEE APPENDIX A SECT. 2.2.1			✓	Licensee's response is satisfactory
	b. Cumulative distribution function method if absolute sum of stress components does not satisfy the acceptance criteria.	✓			✓			
6.4	Torus analysis shall consist of:							

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
6.4	(Cont.)							
	a. Finite element analysis for hydrodynamic loads (time history analysis) and normal and other loads (static analysis) making up the load combinations shall be performed for the most highly loaded segment of the torus, including the shell, ring, girders, and support.	✓		SEE SECT. 2.1.2 AND 2.1.6 OF APPENDIX-A				
	b. Evaluation of overall effects of seismic and other nonsymmetric loads shall be provided using beam models (of at least 180° of the torus including columns and seismic restraints) by use of either dynamic load factors or time history analysis.		SEE SECT 2.1.1 OF APPENDIX A	SEE SECT. 2.1.3 AND 2.1.4 OF APPENDIX A	✓			Licensee's response is satisfactory
	c. Provide a non-linear time history analysis, using a spring mass model of torus and support if net tensile forces are produced in columns due to upward phase of loading.			SEE SECT. 2.1.5 OF APPENDIX A.			✓	Licensee's response is satisfactory
	d. Bijlaard formulas shall be used in analyzing each torus nozzle for effect of reactions produced by attached piping. If Bijlaard formulas are not			*				* TORUS ATTACHED PIPING TO BE AUDITED LATER

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach Conservative	Licensee Uses Alternate Approach Unconservative	NA	Remarks
6.4	(Cont.) applicable for any nozzle, finite element analysis shall be performed.							
6.5	In analysis of the vent system (including vent penetration in drywell, vent pipes, ring header, downcomers and their intersections, vent column supports, vent-torus bellows, vacuum breaker penetration, and the vent deflectors), the following guidelines shall be followed:							
	a. Finite element model shall represent the most highly loaded portion of ring header shell in the "non-vent" bay with the downcomers attached.	✓						
	b. Finite element analysis shall be performed to evaluate local effects in the ring header shell and downcomer intersections. Use time history analysis for pool swell transient and equivalent static analysis for downcomer lateral loads.	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
6.5	(Cont.)							
	c. Evaluation of overall effects of seismic and other nonsymmetrical loads shall be provided using beam models (of at least 180° of the vent system including vent pipes, ring header and column supports) by the use of either dynamic load factors or time history analysis.	✓						
	d. Use beam models in analysis of vent deflectors.						✓	VENT DEFLECTOR IS INCLUDED IN THE OVERALL MODEL
	e. Consider appropriate superposition of reactions from the vent deflectors and ring headers in evaluating the vent support columns for pool swell.						✓	
6.6	a. Analysis of torus internals shall include the catwalks with supports, monorails, and miscellaneous internal piping.	✓						
	b. It shall be based on hand calculations or simple beam models and dynamic load factors and equivalent static analysis.	✓						

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
6.6	(Cont.)							
	c. It shall consider Service Level D or E when specified by the structural acceptance criteria using a simplified nonlinear analysis technique (e.g., Bigg's Method).			(*)				(*) Method of Analysis not indicated. However, this information is not considered to be important
6.7	Analysis of the torus attached piping shall be performed as follows:							
	a. Designate in the summary technical report submitted all piping systems as essential or non-essential for each load combination.			*				* TORUS ATTACHED PIPING TO BE AUDITED LATER
	b. Analytical model shall represent piping and supports from torus to first rigid anchor (or where effect of torus motion is insignificant).			*				
	c. Use response spectrum or time history analysis for dynamic effect of torus motion at the attachment point, except for piping systems less than 6" in diameter, for which equivalent static analysis (using appropriate amplification factor) may be performed.			*				

Table 2-1. Audit Procedure for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Section No. [2]	Key Items Considered in the Audit	Criteria Met	Criteria Not Met	Addtl. Info. Reqd.	Licensee Uses Alternate Approach: Conservative	Licensee Uses Alternate Approach: Unconservative	NA	Remarks
6.7	(Cont.)							
	d. Effect of anchor displacement due to torus motion may be neglected from Equation 9 of NC or ND-3652.2 [3] if considered in Equations 10 and 11 of NC or ND-3652.3 [3].			*				* TORUS ATTACHED PIPING TO BE AUDITED LATER
6.8	Safety relief valve discharge piping shall be analyzed as follows:							
	a. Analyze each discharge line.	✓		SEE SECT. 2.2.1 TO 2.2.6 AND 2.3.1 OF APPENDIX A.				Licensee has provided adequate justifications for comments in sections 2.2.1, 2.2.5, 2.2.6 and 2.3.1. Licensees approach to fatigue analysis of SRV piping is satisfactory subject to NRC approval of the Generic Approach
	b. Model shall represent piping and supports, from nozzle at main steam line to discharge in suppression pool, and include discharge device and its supports.	✓						
	c. For discharge thrust loads, use time history analysis.	✓						
	d. Use spectrum analysis or dynamic load factors for other dynamic loads.	✓						

Table 2-2. Audit Summary for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Structural Element	General Requirements			Analysis Requirements					Remarks
	Code Classification	Loads	Service Limits	Method of Analysis	All Limiting Loads Considered	Fatigue Effects	Method of Combining Response	Results	
a. Torus shell with associated penetrations, reinforcing rings, and support attachments	✓	✓	✓	✓	✓	✓	✓	1	1-(Actual Stress / Allowable) >0.98 for load combinations IBA III and IBA IV defined in Table 2-2.2-12 [7]
b. Torus shell supports to the building structure	✓	✓	✓	✓	✓	✓	✓		
c. Vents between the drywell and the vent ring header (including penetrations therein)	✓	✓	✓	✓	✓	✓	✓	2	2-(Actual stress / Allowable) >0.9 for load combination DBA II defined in Table 2-2.2-12 [7]
d. Region of drywell local to vent penetrations	✓	✓	✓	✓	✓	✓	✓		
e. Bellows between vents and torus shell (internal or external to torus)	✓	✓	✓	✓	✓	✓	✓		
f. Vent ring header and the downcomers attached to it	✓	✓	✓	✓	✓	✓	✓	3	3-(Actual stress / Allowable) >0.9 for DBA II and SBA II defined in Table 2-2.2-12 [7]
g. Vent ring header supports to the torus shell	✓	✓	✓	✓	✓	✓	✓		
h. Vacuum breaker valves attached to vent penetrations within the torus (where applicable)	*	*	*	*	*	*	*	*	
i. Vacuum breaker piping systems, including vacuum breaker valves attached to torus shell pen[...]ations and to vent penet[...]ons external to the [...] (where applicab[...]	*	*	*	*	*	*	*	*	* TORUS ATTACHED PIPING TO BE AUDITED LATER
j. Piping syst[...]ding pumps and [...]rnal to the tor[...] to the torus sh[...]vent penetrations	*	*	*	*	*	*	*	*	

Table 2-2. Audit Summary for Structural Acceptance Criteria of Mark I Containment Long-Term Program

Structural Element	General Requirements			Analysis Requirements					Remarks
	Code Classification	Loads	Service Limits	Method of Analysis	All Limiting Loads Considered	Fatigue Effects	Method of Combining Response	Results	
k. All main steam system safety relief valve (SRV) piping	✓	✓	✓	✓	✓	(*)	✓		(*) conforms to a Generic Approach to be approved by the NRC.
l. Applicable portions of the following piping systems:									
(1) Active containment system piping systems (e.g., emergency core cooling system (ECCS) suction piping and other piping required to maintain core cooling after loss-of-coolant accident (LOCA))	*	*	*	*	*	*	*	*	
(2) Piping systems which provide a drywell-to-wetwell pressure differential (to alleviate pool swell effects)	*	*	*	*	*	*	*	*	
(3) Other piping systems, including vent drains	*	*	*	*	*	*	*	*	
m. Supports of piping systems mentioned in previous item	*	*	*	*	*	*	*	*	
n. Vent header deflectors including associated hardware	✓	✓	✓	✓	✓	✓	✓	✓	
o. Internal structural elements (e.g., monorails, catwalks, their supports) whose failure might impair the containment function	✓	✓	✓	✓	✓	✓	✓	4	4 · (Actual stress / Allowable) > .9 for catwalk vertical hanger for DBA 25 defined in Table 4-2.2-2 of [7].

Table 2-3. Non-Piping Structural Elements

STRUCTURAL ELEMENT	ROW
External Class MC	
Torus, Bellows, External Vent Pipe, Drywell (at Vent), Attachment Welds, Torus Supports, Seismic Restraints	1
Internals Vent Pipe	
General and Attachment Welds	2
At Penetration (e.g., Header)	3
Vent Ring Header	
General and Attachment Welds	4
At Penetrations (e.g., Downcomers)	5
Downcomers	
General and Attachment Welds	6
Internals Supports	7
Internals Structures	
General	8
Vent Deflector	9

Table 2-4. Piping Structural Elements

STRUCTURAL ELEMENT	ROW
Essential Piping Systems	
With IBA/DBA	10
With SBA	11
Nonessential Piping Systems	
With IBA/DBA	12
With SBA	13

2. AUDIT FINDINGS

A detailed presentation of the audit for Fermi Unit 2 and a summary are provided, respectively, in Tables 2-1 and 2-2, which contain information with regard to several key items outlined in the audit procedure [8]. The following sections indicate the areas that required justification for noncompliance with the criteria and/or additional information necessary to indicate if the criteria are met. The Licensee was required to provide information required in the questions for each of the items. Based on the Licensee's responses, it is concluded that the Licensee's analysis conforms to the requirements of the criteria with regard to the key items audited except for fatigue analysis of SRV piping where the generic approach used by the Licensee is satisfactory subject to the NRC approval.

2.1 SUPPRESSION CHAMBER

2.1.1 The PUA report [7] does not indicate compliance with the criteria requirement that a beam model representing at least 180° of the torus, columns, and seismic restraints should be analyzed to consider the effect of seismic and other lateral loads. (The Licensee's response has resolved this concern.)

2.1.2 Proper justification is not provided to indicate the applicability of test results based on which only 20% of the total mass of water is assumed to contribute to lateral seismic loads in the suppression chamber. (The Licensee's response has resolved this concern.)

2.1.3 Proper justification is not provided for the modal correction factors given in Sections 1-4.2.3 and 2-2.4.1 of the PUA report [7] which are used to convert forced vibration response to free vibration response. (The Licensee's response has resolved this concern.)

2.1.4 In the analysis for the suppression chamber support columns, the effect of bending moments has not been included, and there is no indication of any interaction formula used. (The Licensee's response has resolved this concern.)

2.1.5 Although net tensile forces are indicated in the columns (Table 2-2.5-2 of Reference 7), there is no indication that the Licensee performed a nonlinear time history analysis as required by the criteria. (The Licensee's response has resolved this concern.)

2.1.6 The PUA report [7] indicates on page 2-2-94 that the allowable stresses in the suppression chamber components and the vertical support system are based on a 173°F temperature as compared to 100°F temperature for the vertical support system baseplate. (The Licensee's response has resolved this concern.)

2.2 SAFETY RELIEF VALVE (SRV) PIPING ANALYSIS

2.2.1 Section 5-2.2.3 of the PUA report [7] indicates that the peak responses resulting from safe shutdown earthquake (SSE) and LOCA loads are combined using the square root of a sum of the squares (SRSS) technique, which does not conform to the criteria requirement that the responses should be combined using the absolute sum method or the cumulative distribution function method. (The Licensee's response has resolved this concern.)

2.2.2 The fatigue evaluation given in Section 5-2.4.3 of the PUA report [7] is based on Markl's fatigue equation, which is less conservative than the fatigue curve given in Figure XIV-1221.3(c)-1 of the ASME Boiler and Pressure Vessel (B&PV) Code (Section III, Division I, Appendix XIV [3,) for the range of cycles less than 2×10^4. (This concern is resolved subject to the NRC approval of the generic approach.)

2.2.3 The PUA report [7] indicates (page 5-2.103) that the alternating stress due to dynamic loads is combined with stresses due to dead weight thermal loads and pressure loads using an equation similar to equation 11 of ASME B&PV Code, Section III, Subsection NC [3]. The actual method of combining the stresses is not indicated. (This concern is resolved subject to the NRC approval of the generic approach.)

2.2.4 The PUA report [7] provided the maximum stress cycle factors (R) used for the SRV piping under different loads without explaining how these factors were obtained. (This concern is resolved subject to the NRC approval of the generic approach.)

2.2.5 The PUA report [7] does not provide the values for the dynamic load factors used in calculating the SRV discharge loads shown in Tables 5-3.2-1 to 5-3.2-3. (The Licensee's response has resolved this concern.)

2.2.6 The PUA report [7] does not indicate the results of analysis of bolted or welded connections associated with the SRV piping. (The Licensee's response has resolved this concern.)

2.3 GENERAL

2.3.1 The PUA report [7] indicates that additional fluid masses are lumped along the length of the ring beam and quencher beam (page 2-2.103) and

submerged lengths of the SRV piping, T-quencher, and supports (page 5-3.49) without providing the details of or justification for the method of lumping the mass of fluid. (The Licensee's response has resolved this concern.)

2.3.2 Table 1-4.3-1 of the PUA report [7] indicates that several loads required to be considered by NUREG-0661 [1] are not included in the analysis as shown in Table 1. (The Licensee's response has resolved this concern.)

2.3.3 Section 4-2.5 of the PUA report [7] dealing with internal structures does not present all the information necessary to demonstrate code compliance. In particular, it is not clear that weld stresses at the points of attachment of major components to the torus shell were investigated according to code requirements. (The Licensee's response has resolved this concern.)

2.3.4 Tables 2-2.5-3 and 2-2.5-7 of the PUA report [7] indicate that calculated stresses are very close to the allowables with regard to the torus shell. Similarly, Table 3-2.5-6 of the PUA report indicates that the calculated stresses in the weld are very close to the allowables, and Table 4-2.5-1 indicates that calculated stresses for the catwalk vertical hanger support are very close to the allowables. Although this does not signify any deviation from the criteria [2], this discussion is included as a matter of precaution.

3. REFERENCES

1. NUREG-0661
"Safety Evaluation Report, Mark I Containment Long-Term Program Resolution of Generic Technical Activity A-7"
Office of Nuclear Reactor Regulation
USNRC
July 1980

2. NEDO-24583-1
"Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide"
General Electric Co., San Jose, CA
October 1979

3. American Society of Mechanical Engineers
Boiler and Pressure Vessel Code, Section III, Division 1
"Nuclear Power Plant Components"
New York: 1977 Edition and Addenda up to Summer 1977

4. Title 10 of the Code of Federal Regulations

5. NEDO-21888 Revision 2
"Mark I Containment Program Load Definition Report"
General Electric Co., San Jose, CA
November 1981

6. NRC
"Damping Values for Seismic Design of Nuclear Power Plants"
October 1973
Regulatory Guide 1.61

7. Enrico Fermi Atomic Power Plant, Unit 2
Plant Unique Analysis Report, Volumes 1-5
Prepared by NUTECH Engineers, Inc.
April 1982

8. Technical Evaluation Report
Audit Procedure for Mark I Containment Long-Term Program Structural Analysis
Franklin Research Center, Philadelphia, PA
June 1982, TER-C5506-308

APPENDIX B

ORIGINAL REQUEST FOR INFORMATION

1. ORIGINAL REQUEST FOR INFORMATION

Question 2.1.1 (NRC No. 10.1)	With regard to suppression chamber analysis, provide justification for not analyzing a 180° beam segment including the torus, columns, and seismic restraints as required by the criteria [1, 2] for considering the effect of seismic and other lateral loads. Also, discuss the implications of this approach with regard to stresses in the supression chamber in the region surrounding the support columns.
Question 2.1.2 (NRC No. 10.2)	With regard to the assumption that only 20% of the total mass of water in the suppression chamber contributes to lateral seismic loads, provide justification to indicate the applicability of the tests cited in the PUA report [3] to support this assumption.
Question 2.1.3 (NRC No. 10.3)	a. Provide detailed calculations to indicate how the modal correction factors given in Sections 1-4.2.3 and 2-2.4.1 of the PUA report [3] are obtained. b. Provide justification for the applicability of these factors to 'multidegree-of-freedom' systems since the factors were developed using simple 'one-degree-of-freedom' systems.
Question 2.1.4 (NRC No. 10.4)	Provide justification for not considering the effect of bending moments in column analysis.
Question 2.1.5 (NRC No. 10.5)	With regard to the suppression chamber columns, provide justification and/or additional information to indicate why a nonlinear time history analysis was not performed as required by the criteria when net tensile forces are produced in the columns. Table 2-2.5-2 of Reference 3 indicates that net tensile forces are produced in the columns.
Question 2.1.6 (NRC No. 10.6)	Provide justification for using two different temperatures, 173°F for suppression chamber and vertical support system and 100°F for the base plate of the support system, for calculating the respective allowable stresses.
Question 2.2.1 (NRC No. 11.1)	Provide justification for using SRSS method to combine the SSE and LOCA responses for SRV piping analysis instead of the absolute sum or cumulative distribution function approaches as required by the criteria [1, 2].

Question 2.2.2 (NRC No. 11.2)	Provide justification for using Markl's equation for fatigue analysis of SRV piping instead of the fatigue curve given in Figure XIV-1221.3(c)-1 of the ASME B&PV Code, Section III, Division 1, Appendix XIV [4].
Question 2.2.3 (NRC No. 11.3)	Provide justification for not using Equation 11 of ASME B&PV Code, Section III, Subsection NB [4] for calculating the fatigue stresses, and explain the method used.
Question 2.2.4 (NRC No. 11.4)	Provide justification and reference for the maximum stress cycle factors given in Table 5-2.4-4 of the PUA report [3].
Question 2.2.5 (NRC No. 11.5)	Provide the magnitudes of the dynamic load factors used in Tables 5-3.2-1 to 5-3.2-3 of the PUA report [3] and the justification.
Question 2.2.6 (NRC No. 11.6)	Provide the results of the analysis of bolted or welded connections associated with the SRV piping.
Question 2.3.1 (NRC No. 12.1)	Provide justification for the method of lumping additional fluid masses along the ringbeam, quencher beam (page 2-2.103 of Reference 3), submerged length of SRV piping, T-quencher, and supports (page 5-3.49 of Reference 3) as indicated in the PUA report.
Question 2.3.2 (NRC No. 12.2)	Provide justification for not considering the loads indicated in Table 1 which are required in the analysis according to NUREG-0661 [5].
Question 2.3.3 (NRC No. 12.3)	Provide information on the analysis of the attachment welds of regions connecting the internal structures to the torus shell, indicating whether the criteria rec irements have been satisfied.

Table 1. Structural Loading (from Reference 6)

Loads	Structures: Torus Shell	Structures: Torus Support System	Structures: Main Vents	Structures: Vent Header	Structures: Downcomers	Structures: SRV Piping	Other Wetwell Interior Structures: Above Norm Water Level	Other Wetwell Interior Structures: Above Bottom of Downcomers and Below Norm Water Level	Other Wetwell Interior Structures: Below Bottom of Downcomers
1. Containment Pressure and Temperature	X	X	X	X	X	X	X	X	X
2. Vent System Thrust Loads			X	X	X				
3. Pool Swell									
3.1 Torus Net Vertical Loads	(X)	(X)							
3.2 Torus Shell Pressure Histories	X	X							
3.3 Vent System Impact and Drag			X	X	X				
3.4 Impact and Drag on Other Structures			X			X	X		
3.5 Froth Impingement	(X)	(X)	X			(X)	X		
3.6 Pool Fallback						X	X	X	
3.7 LOCA Jet						X			X
3.8 LOCA Bubble Drag						X		(X)	X
4. Condensation Oscillation									
4.1 Torus Shell Loads	X	X							
4.2 Load on Submerged Structures						X		X	X
4.3 Lateral Loads on Downcomers				X	X				
4.4 Vent System Loads			X	X					
5. Chugging									
5.1 Torus Shell Loads	X	X							
5.2 Loads on Submerged Structures						X		X	X
5.3 Lateral Loads on Downcomers				X	X				
5.4 Vent System Loads			(X)	(X)					
6. T-Quencher Loads									
6.1 Discharge Line Clearing						X			
6.2 Torus Shell Pressures	X	X							
6.4 Jet Loads on Submerged Structures					X	X		X	X
6.5 Air Bubble Drag					(X)	(X)		(X)	(X)
6.6 Thrust Loads on T-Quencher Arms						(X)			
6.7 S/RVDL Environmental Temperature						(X)			
7. Ramshead Loads									
7.1 Discharge Line Clearing						[X]			
7.2 Torus Shell Pressures	[X]	[X]							
7.4 Jet Loads on Submerged Structures					[X]	[X]		[X]	[X]
7.5 Air Bubble Drag					[X]	[X]		[X]	[X]
7.6 S/RVDL Environmental Temperature						[X]			

X Loads required by NUREG-0661[1] and included in PUA report.
(X) Loads required by NUREG-0661[1] and not included in PUA report.
[X] Not applicable.

2. REFERENCES

1. NEDO-24583-1
"Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide"
General Electric Co., San Jose, CA
October 1979

2. Technical Evaluation Report
Audit Procedure for Mark I Containment Long-Term Program - Structural Analysis,
Franklin Research Center, Philadelphia, PA
June 1982, TER-C5506-308

3. Enrico Fermi Atomic Power Plant, Unit 2
Plant Unique Analysis Report, Volumes 1-5
Prepared by NUTECH Engineers, Inc.
April 1982

4. American Society of Mechanical Engineers
Boiler and Pressure Vessel Code, Section III, Division 1
"Nuclear Power Plant Components"
New York: 1977 Edition and Addenda up to Summer 1977

5. NUREG-0661
"Safety Evaluation Report, Mark I Containment Long-Term Program, Resolution of Generic Technical Activity A-7"
Office of Nuclear Reactor Regulation
USNRC
July 1980

6. NEDO-21888 Revision 2
"Mark I Containment Program Load Definition Report"
General Electric Co., San Jose, CA
November 1981