TECHNICAL EVALUATION OF THE FERMI 2
PLANT-UNIQUE ANALYSIS REPORT

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Abstract

The objective of this report is to document the post-implementation audit of the FERMI 2 plant-unique analysis against the hydrodynamic load acceptance criteria presented in NUREG-0661. A brief description of the audit procedure as well as a summary of the various phases of the audit are provided. In addition, an overview of the results of the audit which highlights the various issues or exceptions to the acceptance criteria identified during the audit is included, along with an indication of the status of each issue. At the present time, there are still 2 outstanding issues which require supplemental information in order for the items to be resolved.

ACKNOWLEDGEMENTS

The following individuals participated in the post-implementation audit and contributed substantially to this Report:

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List of Acronyms

AC	Acceptance Criteria
BNL	Brookhaven National Laboratory
CO	Condensation Oscillation
DECO	Detroit Edison Company
DLF	Dynamic Load Factor
FSI	Fluid Structure Interaction
FSTF	Full Scale Test Facility
LDR	Load Definition Report
LOCA	Loss-of-Coolant Accident
LTP	Long Term Program
NPS	Nominal Pipe Size
NUTECH	NUTECH Engineering, Inc.
NRC	Nuclear Regulatory Commission
PUA	Plant-Unique Analysis
PUAAG	Plant-Unique Analysis - Applications Guide
PUAR	Plant-Unique Analysis Report
QSTF	Quarter Scale Test Facility
SER	Safety Evaluation Report
SRV	Safety/Relief Valve
STP	Short Term Program

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1. INTRODUCTION

The suppression pool hydrodynamic loads associated with a postulated loss-of-coolant accident (LOCA) were first identified during large-scale testing of an advanced design pressure-suppression containment (Mark III). These additional loads, which had not explicitly been included in the original Mark I contai ment design, result from the dynamic effects of drywell air and steam being rapidly forced into the suppression pool (torus). Because these hydrodynamic loads had not been considered in the original design of the Mark I containment, a detailed reevaluation of the Mark I containment system was required.

A historical development of the bases for the original Mark I design as well as a summary of the two-part overall program (i.e., Short Term and Long Term Programs) used to resolve these issues can be found in Section 1 of Reference 1. Reference 2 describes the staff's evaluation of the Short Term Program (STP) used to verify that licensed Mark I facilities could continue to operate safely while the Long Term Program (LTP) was being conducted.

The objectives of the LTP were to establish design-basis (conservative) loads that are appropriate for the anticipated life of each Mark I BWR facility (40 years), and to restore the originally intended design-safety margins for each Mark I containment system. The principal thrust of the LTP has been the development of generic methods for the definition of suppression pool hydrodynamic loadings and the associated structural assessment techniques for the Mark I configuration. The generic aspects of the Mark I Owners Group LTP were completed with the submittal of the "Mark I Containment Program Load Definition Report" (Ref. 3) and the "Mark I Containment Program Structural Acceptance Guide" (Ref. 4), as well as supporting reports on the LTP experimental and analytical tasks. The Mark I containment LTP Safety Evaluation

Report (NUREG-0661) presented the NRC staff's review of the generic suppression pool hydrodynamic load definition and structural assessment techniques proposed in the reports cited above. It was concluded that the load definition procedures utilized by the Mark I Owners Group, as modified by NRC requirements, provide conservative estimates of these loading conditions and that the structural acceptance criteria are consistent with the requirements of the applicable codes and standards.

The generic analysis techniques are intended to be used to perform a plant-unique analysis (PUA) for each Mark I facility to verify compliance with the acceptance criteria (AC) of Appendix A to NUREG-0661. The objective of this study is to perform a post-implementation audit of the FERMI 2 plant-unique analysis (Reference 5) against the hydrodynamic load criteria in NUREG-0661. A brief description of the audit procedure, as well as a summary of the various phases of the audit, are included in this technical evaluation report. In addition, the checklists utilized in both the cursory and detailed portions of the audit have also been included for completeness. A chronology of events concerning the FERMI 2 audit and a table summary of items identified during the audit as either exceptions to the AC or as areas where additional information was required are provided as part of an overview of the audit.

2. OVERVIEW OF AUDIT PROCEDURE

The procedure described here is used for a post-implementation audit of the Mark I plant-unique analysis against the pool dynamic acceptance criteria presented in NUREG-0661 (Appendix A). The audit is a two-level procedure whereby the acceptability of the methods used by the utility in the PUA will be evaluated. The procedure as shown in Figure 1 consists of both a cursory and detailed review of the pool dynamic methodology and in addition provides for deviations from the acceptance criteria.

The detailed portion of the review concentrates on a set of key loadings and structures in keeping with the premise of performing a moderately detailed

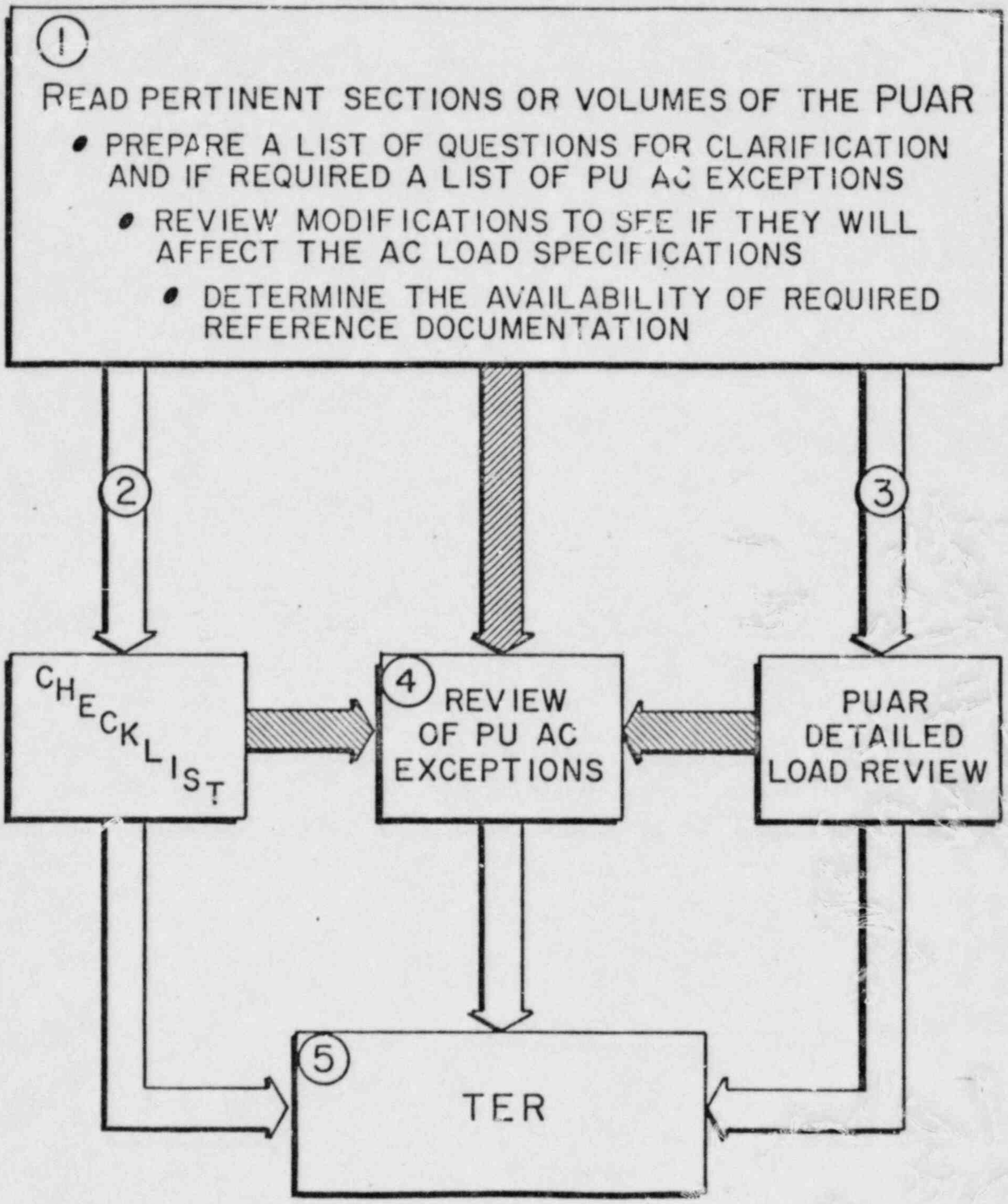

FIGURE 1. SCHEMATIC OVERVIEW OF TWO LEVEL AUDIT PROCEDURE

audit. Each load reviewed during this phase of the audit will be carefully scrutinized to verify compliance with the acceptance criteria. The loads selected correspond to the primary loading categories associated with a postulated LOCA or SRV actuation as identified during the Mark I long term program, namely, pool swell vertical loads, condensation oscillation and chugging loads, vent system impact and submerged structure loads. In addition, a load is selected on a plant unique basis to enable the audit to be fitted to the plant under consideration. As a consequence, dead weight loads, seismic loads and pressure and temperature loads which were previously considered in the original containment design and documented in the plant's FSAR have not been included in this portion of the audit. In the same vein, the internal structures such as the catwalk, monorail, etc. which are not required for the safe operation of the containment during accident conditions are not considered in detail. However, t[illegible]ructures are checked during the cursory review phase of the procedure to ensure that they were analyzed for the appropriate loading conditions as specified in NUREG-0661. The cursory overall review of the wetwell structures to ascertain that they have been analyzed for all applicable LOCA and SRV loads is accomplished by means of a checklist to verify the completeness of the PUA. The checklist used in the FERMI 2 cursory review is included in the following section of the report where the summary of the post-implementation audit is presented.

As shown in Figure 1, the audit procedure also possesses the capability of dealing with deviations from the acceptance criteria. The cross-hatched arrows indicate that exceptions to the criteria may arise at three different times during the audit, namely, from the reading of the PUAR, from the cursory checklist or from the detailed load review. It is anticipated, however, that the majority of the exceptions will be found during the reading of the PUAR.

The AC exceptions or deviations in the plant-unique analysis are carefully reviewed to determine the acceptability of the method used by the utility to predict the hydrodynamic loads on the wetwell structures.

3. SUMMARY OF CURSORY AND DETAILED REVIEWS

The purpose of the cursory review portion of the post-implementation audit is to provide a quick evaluation of the overall completeness of the PUAR under consideration with regard to the NUREG-0661 acceptance criteria. The checklist utilized in the cursory review of the FERMI 2 plant-unique analysis is presented in Figure 2. Check marks are used to indicate that the structures have been analyzed for the loading conditions as specified in NUREG-0661. On the other hand, if compliance with the acceptance criteria is not indicated by the review, a cross is inserted in the appropriate box. This figure is also used to present any plant-unique information useful for an overview of the audit and methods used to satisfy the AC such as any AC approved alternate methods used in the PUAR. The notes in the right-hand margin which accomplish this task are explained after the checklist in table fashion.

The detailed load review portion of the post-implementation audit concentrated on the set of key loadings listed in Figure 3. These loads have been carefully scrutinized and where possible duplicated to verify compliance with the AC. The method used to summarize the results of the detailed portion of the audit is similar to that used for the cursory review with notes being used to provide any additional information required.

In general, various exceptions to the AC or areas where additional information is required will be identified during both the cursory and detailed reviews. Since these items are not shown in the above figures, if they have been resolved, a complete listing is provided in the following section of the report.

LOADS	NUREG-0661 AC SECTION	STRUCTURES: TORUS SHELL	STRUCTURES: TORUS SUPPORT SYSTEM	STRUCTURES: MAIN VENTS	STRUCTURES: VENT HEADER	STRUCTURES: DOWNCOMERS (DC)	STRUCTURES: VENT HEADER DEFLECTOR	STRUCTURES: S/RV DISCHARGE LINES	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: ABOVE NORMAL WATER LEVEL	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: BELOW NORM. WTR. & ABOVE DC EXIT	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: BELOW DOWNCOMER EXIT	NOTES
CONTAINMENT PRESSURE & TEMPERATURE	2.1	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	
VENT SYSTEM THRUST LOADS	2.2			☑	☑	☑						
POOL SWELL												
TORUS NET VERTICAL LOADS	2.3	☑	☑									1
TORUS SHELL PRESSURE HISTORIES	2.4	☑	☑									1
VENT SYSTEM IMPACT AND DRAG	2.6			☑	☑	☑	☑					1
IMPACT AND DRAG ON OTHER STRUCTURES	2.7							☑	☑			1
FROTH IMPINGEMENT	2.8	☑	☑	☑				☑	☑			2
POOL FALLBACK	2.9							☑	☑	☑		
LOCA JET	2.14.1							☑			☑	
LOCA BUBBLE DRAG	2.14.2							☑		☑	☑	

Figure 2. Checklist for Cursory Overall Review

LOADS	NUREG-0661 AC SECTION	STRUCTURES: TORUS SHELL	STRUCTURES: TORUS SUPPORT SYSTEM	STRUCTURES: MAIN VENTS	STRUCTURES: VENT HEADER	STRUCTURES: DOWNCOMERS (DC)	STRUCTURES: VENT HEADER DEFLECTOR	STRUCTURES: S/RV DISCHARGE L.NES	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: ABOVE NORMAL WATER LEVEL	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: BELOW NORM. WTR. & ABOVE DC EXIT	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: BELOW DOWNCOMER EXIT	NOTES
<u>CONDENSATION OSCILLATION</u>												
TORUS SHELL LOADS	2.11.1	☑	☑									1
LOADS ON SUBMERGED STRUCTURES	2.14.5							☑		☑	☑	
VENT SYSTEM LOADS	2.11.3			☑	☑	☑						
DOWNCOMER DYNAMIC LOADS	2.11.2				☑	☑						
<u>CHUGGING</u>												
TORUS SHELL LOADS	2.12.1	☑	☑									1
LOADS ON SUBMERGED STRUCTURES	2.14.6							☑		☑	☑	3
VENT SYSTEM LOADS	2.12.3			☑	☑	☑						
LATERAL LOADS ON DOWNCOMERS	2.12.2				☒	☒						4

FIGURE 2 (CONTINUED)

LOADS	NUREG-0661 AC SECTION	STRUCTURES: TORUS SHELL	TORUS SUPPORT SYSTEM	MAIN VENTS	VENT HEADER	DOWNCOMERS (DC)	VENT HEADER DEFLECTOR	S/RV DISCHARGE LINES	OTHER WETWELL INTERIOR STRUCTURES AND PIPES: ABOVE NORMAL WATER LEVEL	BELOW NORM. WTR. & ABOVE DC EXIT	BELOW DOWNCOMER EXIT	NOTES
<u>T-QUENCHER LOADS</u>												5
DISCHARGE LINE CLEARING	2.13.2							☑				
TORUS SHELL PRESSURES	2.13.3	☑	☑									6
JET LOADS ON SUBMERGED STRUCTURES	2.14.3					☑		☑		☑	☑	
AIR BUBBLE DRAG	2.14.4					☑		☑		☑	☑	6
THRUST LOADS ON T/Q ARMS	2.13.5							☑				
S/RVDL ENVIRONMENTAL TEMPERATURES	2.13.6							☑				

FIGURE 2 (CONTINUED)

CONFORMANCE WITH THE ACCEPTANCE CRITERIA IS ALSO REQUIRED OF THE FOLLOWING:

	DESCRIPTION	NUREG-0661 AC SECTION	CRITERIA: MET	CRITERIA: NOT MET	NOT APPLICABLE	NOTES
1	SUPRESSION POOL TEMPERATURE LIMIT	2.13.8		✓		7
2	SUPRESSION POOL TEMPERATURE MONITORING SYSTEM	2.13.9	✓			
3	DIFFERENTIAL PRESSURE CONTROL SYSTEM FOR THOSE PLANTS USING A DRYWELL-TO-WETWELL PRESSURE DIFFERENCE AS A POOL SWELL MITIGATOR	2.16			✓	8
4	SRV LOAD ASSESSMENT BY IN-PLANT TEST	2.13.9	✓			9

FIGURE 2 (CONTINUED)

NOTES TO FIGURE 2

NUMBER	EXPLANATION OF NOTE
1	These loads were examined in depth as part of the detailed review portion of the post-implementation audit procedure.
2	For some structures, the standard procedures described in NUREG-0661 result in unrealistically conservative loads. In these situations, the alternate procedure described in Section 2.8 of Appendix A to NUREG-0661 is used. This procedure enables the Region I froth loads to be based on the high-speed QSTF movies.
3	The post-chug submerged structure load on the ring beam was considered as part of the detailed review portion of the post-implementation audit procedure.
4	A concern has arisen as to a possible non-conservatism in the single downcomer lateral load specifiction (see Item 12 in Section 4). Pending the receipt of a response from the applicant on this issue, this item will be considered an open issue.
5	The T-Quencher loads, in general, were considered as the load to be selected on a plant-unique basis for the detailed review portion of the audit. The SRV loads were chosen because of the plant-unique aspects of the FERMI plant T-quencher as compared with the Mark I T-quencher described in the LDR.

6 A series of in-plant SRV tests will be performed to confirm that the computed loadings and predicted structural responses for SRV discharges are conservative.

7 The local suppression pool temperature limit was defined in NUREG-0661 as 200 °F for the generic Mark I T-quencher as described in Appendix A, Section 2.13.8. Subsequently, NUREG-0783 provided procedures whereby the limit could be increased if certain restrictions could be met. Although conformance with the above criteria was indicated in the PUAR, the applicant utilized an unapproved local pool temperature model. Pending final approval of this model or sufficient other justification for the local to bulk temperature differences used in the PUAR (see item 8 in next section), the suppression pool temperature limit issue will be considered as an open item.

8 The normal operating drywell-to-wetwell pressure differential is zero for the FERMI 2 plant, thus no pool swell load mitigation system is utilized.

9 Requirements and/or guidelines are specified in both NUREG-0661 and NUREG-0763 for in-plant tests of SRV discharges. BNL has reviewed the proposed Fermi SRV in-plant test plan (Reference 6) with regard to the hydrodynamic criteria specified in these reports and find the test plan acceptable.

LOADS	NUREG-0661 AC SECTION	CRITERIA		NOTES
		MET	NOT MET	
1. <u>POOL SWELL</u>				
A. NET TORUS VERTICAL LOADS	2.3	✓		
B. AVERAGE SUBMERGED PRESSURE	2.4	✓		
C. TORUS AIR SPACE PRESSURE	2.4	✓		
D. CIRCUMFERENTIAL AND LONGITUDINAL TORUS SHELL PRESSURES	2.4	✓		
2. <u>IMPACT</u>				
A. VENT HEADER OR VENT HEADER DEFLECTOR	2.6.1	✓		
B. DOWNCOMER	2.6.2	✓		
C. MAIN VENT	2.6.3	✓		
3. <u>SUBMERGED STRUCTURE</u>				
A. RING HEADER OR VENT HEADER SUPPORT COLUMN	2.14	✓		1
4. CC and CHUGGING TABLES OF RIGID WALL TORUS SHELL PRESSURES	2.11.1	✓		
	2.12.1	✓		
5. LOAD SELECTED ON A PLANT-UNIQUE BASIS	2.13		✓	2

FIGURE 3. PUAR DETAILED LOAD REVIEW

NOTES TO FIGURE 3

NUMBER	EXPLANATION OF NOTE
1	The post-chug submerged structure load on the ring beam was considered as part of the detailed review portion of the post-implementation audit procedure.
2	The T-Quencher loads, in general, were considered as the load to be selected on a plant-unique basis for the detailed review portion of the audit. The SRV loads were chosen because of the plant-unique aspects of the Fermi plant T-quencher as compared with the Mark I T-quencher described in the LDR. The detailed review of the SRV loads cannot be completed until the open issue associated with the local-to-bulk temperature differences used in the PUAR is resolved (see item 8 in the following section). Upon resolution of this issue the SRV detailed review will be considered complete.

4. SYNOPSIS OF THE POST-IMPLEMENTATION AUDIT

The post-implementation audit as described in this report was used to evaluate the hydrodynamic loading methodologies used for the major modifications portion of the FERMI 2 plant-unique analysis. During the various phases of the audit, numerous issues were identified as either exceptions to the acceptance criteria or as areas where additional information was required to continue with the review. These issues are listed in Table 1 along with an indication of the type and status of each item. As can be seen from this table, a significant number of exceptions to the AC were found during the audit. In order to resolve these issues, a plant-unique review of additional references and information received from the utility during the audit was performed. A chronology of events concerning the FERMI 2 audit is presented in Table 2.

The outstanding issues as noted in the table still require some supplemental justification in order for the item to be resolved. For completeness, a brief description of each issue identified during the audit is given below. The numbering system is consistent with the table.

Item 1 - The Acceptance Criteria 2.14.2 section 2b in NUREG-0661 states that drag forces on structures with sharp corners (e.g. rectangles and "I" beams) must be computed by considering forces on an equivalent cylinder of diameter $D_{eq} = \sqrt{2}\, L_{max}$, where L_{max} is the maximum transverse dimension. The intent of this criterion is to provide a conservative bound (based on very limited data) that includes non-potential flow effects such as vortex shedding on both the acceleration drag due to hydrodynamic mass and the "standard" drag proportional to velocity squared. Since the dominant loads for the Ring Beam and Quencher Beam (the two non-cylindrical structures) are acceleration loads, the

TABLE 1. ISSUES IDENTIFIED DURING POST-IMPLEMENTATION AUDIT

		TYPE OF ISSUE		STATUS OF ISSUE	
ITEM	DESCRIPTION	EXCEPTION TO NUREG-0661 AC	REQUESTS FOR ADDITIONAL INFORMATION	RESOLVED	OPEN
1	Published Acceleration Drag Volumes Used to Determine Drag on Sharp Cornered Structure.	X		X	
2	Random Phasing of Loading Harmonics for CO and Chugging.	X		X	
3	Downcomer Dynamic Load Methodology for Untied Downcomers.	X		X	
4	Plant Unique Multiple Downcomer Chugging Lateral Load Correlation.	X		X	
5	Water Jet and Air Bubble Drag Load Methodologies For Fermi T-Quencher Design.	X		X	

TABLE 1 (Continued)

ITEM	DESCRIPTION	TYPE OF ISSUE: EXCEPTION TO NUREG-0661 AC	TYPE OF ISSUE: REQUESTS FOR ADDITIONAL INFORMATION	STATUS OF ISSUE: RESOLVED	STATUS OF ISSUE: OPEN
6	Use of Maximum Source Strength for Post-Chug Submerged Structure Loads.		X	X	
7	FSI Methodology Used For CO and Chugging Submerged Structure Loads.	X		X	
8	T-Quencher Local to Bulk Pool Temperature Difference.	X			X
9	Suppression Pool Temperature Monitoring System.		X	X	
10	Torus Shell Pressures Presented in Table 2-2.2-3.		X	X	

TABLE 1 (CONTINUED)

		TYPE OF ISSUE		STATUS OF ISSUE	
ITEM	DESCRIPTION	EXCEPTION TO NUREG-0661 AC	REQUESTS FOR ADDITIONAL INFORMATION	RESOLVED	OPEN
11	Pressure History Presented in Figure 2-2.2-8.		X	X	
12	Single Downcomer Chugging Lateral Load Concern		X		X

TABLE 2

CHRONOLOGY OF EVENTS CONCERNING THE FERMI 2 AUDIT

1.	March 11, 1982	NRC/DECO/BNL/NUTECH meeting to discuss the FERMI 2 PUAR. An overview of the PUAR contents was presented.
2.	May 3, 1982	FERMI 2 plant unique analysis report received.
3.	June 2, 1982	Letter (Ref. 7) documenting audit procedure sent to NRC. FERMI 2 audit begun.
4.	June 16, 1982	Letter identifying 8 items as exceptions to the AC or as areas where additional information is needed was transmitted to NRC.
5.	June 24, 1982	Conference call between NRC/BNL/DECO/NUTECH to discuss 8 items described in June 16, 1982 letter. Letter (Ref. 8) with revisions made for clarity and with an additional item included was resubmitted to NRC on June 25, 1982.
6.	July 15, 1982	Draft response (Ref. 9) to 9 items described in June 25, 1982 letter received from DECO.
7.	July 22, 1982	Preliminary results of BNL review of DECO responses to 9 items phoned into NRC.
8.	July 28, 1982	Letter (Ref. 10) describing 2 additonal items requiring supplemental information sent to NRC.

TABLE 2 (Continued)

9. August 4, 1982	Conference call between NRC/BNL/DECO/NUTECH to discuss BNL review of the Reference 9 responses by DECO. Items sent on July 28, 1982 as well as possible additional items were also discussed.
10. August 16, 1982	Conference call between NRC/BNL/GE to discuss r. concerns on items 5 and 8 of Reference 8. A meeting to discuss the local pool temperature model was tentatively set for September 9, 1982.
11. August 19, 1982	Attachment to letter (Ref. 6) describing proposed SRV in-plant test plan received from DECO. Draft copy of Fermi technical evaluation report documenting the results of the audit to date was transmitted to NRC.
13. August 23, 1982	Conference call between NRC/BNL/DECO/NUTECH to discuss the multiple downcomer chugging lateral load (item 4) and the submerged structure drag concern (items 1 and 5).
14. August 26, 1982	Draft response (Ref. 11) to 2 items described in July 28, 1982 (Ref. 10) letter received from DECO.

TABLE 2 (Continued)

15.	August 27, 1982	Draft response (Ref. 12) received from DECO providing revised responses to items 1, 4 and 5.
16.	September 9, 1982	NRC/BNL/GE/Mark I Owners Group meeting to discuss the local pool temperature model utilized in the Fermi PUAR.
17.	September 13, 1982	Conference between NRC/BNL/DECO/NUTECH/GE to discuss single downcomer chugging lateral load concern.

issue concerns only the hydrodynamic mass or acceleration volume and not the drag coefficient in the Fermi Unit 2 plant-specific case.

The PUAR states that "published" acceleration drag volumes listed in Table 1-4.1-1 are used for sharp edged structures rather than the equivalent cylinder specified in the acceptance criteria. The detailed response to item 1, in fact, explains that modelling of the actual structures is necessary, and in particular, forces on the web of the ring beam are obtained by modelling the beam by a circumscribed rectangle. In order to evaluate the implications of this modelling, detailed calculations were performed on the ring-beam web forces for the post-chug loading condition.

A direct application of the PUAR methodology but without inclusion of DLF's to account for the structural dynamics leads to a pressure differential on the web of 4.3 psi. A computation of the force using the hydrodynamic mass of the equivalent cylinder of the Acceptance Criteria but the real volume for the "effective" buoyancy force results in a differential pressure of 5.6 psia, a 30% higher load.

The PUAR accounts for the dynamics of the structure, however, by using an equivalent static load and DLF's based on a single degree of freedom model with 2% damping and a natural frequency of 48.5 Hz. This procedure overemphasizes the effect of the 40-50 Hz content of the source term to the extent that this frequency range contributes 87% to the final effective peak pressure differential of 24.1 psi. The direct use of the Figure 2-2.4-3 as an alternative representation of the DLF's of the actual multi-degree of freedom ring-beam system, produces a net equivalent static load of only 14.4 psi for the PUAR acceleration volume and 18.8 psi for the acceleration volume based on the Acceptance Criteria. Since the high-frequency portion of the Post-Chug load

comes largely from the sharp "spikes" within post-chug pressure time histories, there is substantial conservatism in applying those loads in the frequency domain rather than as an initial value problem for each chug. Indeed, the maximum DLF for an initial value problem that one might expect for the "spike" portion of the chug is only about 2, instead of 25 at resonance of a 2% damped single degree of system subject to harmonic loading, or 9 deduced from Figure 2-2.4-3 of the PUAR. A similar comparison for the quencher support beam reveals that substantial conservatism exists in the PUAR methodology for the calculation of equivalent static loads on that submerged structure as well.

On the basis of these comparisons we conclude that while the direct use of "published" acceleration volumes for sharp edge structures may not in general lead to conservative loads, the PUAR methodology for the application of these loads to the relevant structures, has sufficient conservatism to bound any hydrodynamically produced stresses that could arise in these structures.

Item 2 - The DBA condensation oscillation and the post-chug load definitions on the torus shell and on submerged structures, accepted in the NUREG-0661, were based on data from a series of blowdowns in the FSTF facility (NEDE-24539), subject to additional confirmatory tests reported in the General Electric Letter Report M1-LR-81-01 of April 1981.

The condensation oscillation load definition as described in NEDO-21888 is based on taking the absolute sum of 1 Hertz components of a spectrum from 0 to 50 Hz. Three alternative spectra are to be calculated with the one producing maximum response used for load definition. The procedure was found acceptable in the supplement to the SER (NUREG-0661), because the demonstrated high degree of conservatism associated with the direct summation of the Fourier components of the spectrum was sufficient to compensate for any uncertainties

concomitant with the data available. The post-chug load definition is based on bounding FSTF chugging data but otherwise follows similar procedures to those used in the CO load definition.

The Fermi PUAR uses a factor of .65 to multiply the CO and post-chug loads computed on the basis of the absolute sum of the harmonic components. The justification is based on comparisons of measured and predicted stresses in the FSTF facility using different phasing models (NEDE-24840). The factor .65 is chosen to give 84% non-exceedance probability with a confidence level of 90%. The PUAR does use, however, an additional alternate 4 for the CO loading, based on test M12 from the supplementary tests reported in the letter report M1-LR-81-01. The information supplied by Detroit Edison, in response to the request for additional information (Ref. 8) provides additional justification to show that the computed loads (using the .65 factor and alternates 1 through 3) bound the measured stresses at critical points in the FSTF facility by 11 to 69%. The use of alternate 4 on the Fermi plant provides an additional conservatism of 11 to 27%.

We have examined this information and conclude that the use of the "phasing factor" of .65 coupled with the inclusion of alternate 4 for CO loading, provides a sufficiently conservative representation of the CO and post-chug loads to account for possible uncertainties associated with the data base.

Item 3 - The downcomer dynamic load methodology, which was accepted in the supplement to NUREG-0661, was derived for tied downcomers from the supplemental FSTF tests (Reference 13). Since the Fermi 2 downcomer pairs are stiffened at each intersection by a crotch plate and by outer stiffener plates as shown in PUAR Figure 3-2.1-12 and are not tied, additional justification for the use of the methodology was requested (see item 3 of Reference 8). The response to our request for additional information (Reference 9) stated

that a frequency analysis of the Fermi 2 downcomers had shown that the predominant fundamental mode of vibration is the sway mode, i.e., both downcomers in a pair simultaneously deflecting in the same direction. As a result, the Fermi 2 downcomers will respond in a manner similar to downcomers which are tied by lateral bracing as was the case in the FSTF tied downcomer pairs. Based on the additional information provided by the applicant, the use of the downcomer dynamic load methodology is found to be acceptable for the Fermi plant-unique analysis.

Item 4 - The acceptance criteria specified that for multiple downcomer chugging the force per downcomer shall be based on an exceedance probability of 10^{-4} per LOCA. However, a correlation between load magnitude and probability level derived from a statistical analysis of FSTF data was utilized in the FERMI PUA. During the review of the specification given in the Fermi 2 PUAR, it was found that the values for the load per downcomer listed in Table 3-2.2-15 are somewhat less than would be obtained by applying the 10^{-4} probability of exceedance criteria specified in NUREG-0661. The difference between the Fermi PUAR values for load per downcomer, and the NUREG-0661 specification increases as the number of downcomers in a group decreases, i.e., for 80 downcomers in a group, the PUAR values are only 5% less, for 5 downcomers 20%, and the worst difference is 26% for 2 downcomers. Based on the review of the available information, it was concluded that the equation on which the PUAR values for different downcomer groups are based is not correct. Therefore, in order to resolve this issue additional information was requested to justify the currently specified load levels in the PUAR.

In response to these concerns, the applicant delved further into the FSTF chugging data report (NEDE-24539-P) on which the lateral load specifications

for Mark I's are based. As stated in the applicant's written response (Ref. 12), extrapolation of the FSTF data most applicable to Fermi 2 conditions showed that a conservative estimate of the Fermi 2 chug duration is 900 seconds during which 182 synchronized pool chugs can be expected to occur. (FSTF data showed that only about 33% of all chugs are synchronized pool chugs.) The applicant then concludes the probability that the force per downcomer in a pool chug can be exceeded once per LOCA for Fermi 2 is 1/182 or 5.5 x 10^{-3}.

While the probability above is still higher than 10^{-4} and, in our opinion not correctly obtained, we feel that the 182 synchronized chug estimate is correct, and that the lateral loads in Table 3-2.2-15 of the PUAR can be justified based on the FSTF results. Besides showing that only 33% of all chugs are synchronized, FSTF also showed that only 90% of the vents participated, on the average, in a synchronized pool chug and that the time between the first vent and the last vent chugging was never less than 78 milliseconds. Therefore, the term synchronized is a relative one, and assuming all vents in a group to be exactly in phase, when applying the multivent chugging load specification, is a very conservative assumption. Since a triangular pulse of 5 millisecond duration would be a reasonable approximation of the lateral chugging load each downcomer experiences, even a one millisecond shift in chugging times between two downcomers would significantly reduce the peak load obtained from a combination of two loadings.

To obtain a quantitative estimate of the conservatism inherent in assuming all vents in a group chug exactly in phase, one can consider further the case of a group consisting of 2 downcomers. As stated previously, it is for a group of 2 downcomers that the values in the Fermi 2 PUAR are most below the values which would be obtained by following the NUREG-0661 specification for

the 10^{-4} probability level. The load per downcomer when two downcomers are in a group, is given in Table 3-2.2-17 of the Fermi 2 PUAR as 11.16 kips. For FSTF, the corresponding load would be 11.16/4.276 or 2.61 kips. Extrapolating from Figure 3.9-3 of NUREG-0661 one can find that for 2 downcomers this load corresponds to a probability level of exceeding once per LOCA of roughly 1.2×10^{-2}. However, Figure 3.9-3 was obtained using 313 synchronized pool chugs. With a simple mathematical manipulation the probability of exceeding a load per downcomer of 2.61 kips corresponding to 182 synchronized pool chugs can be found to be 7.00×10^{-3} if it is 1.2×10^{-2} for 313 chugs.

FSTF data showed a 90% participation of vents in a synchronized pool chug. So if one of the vents in the group of 2 chugs, the probability of the second chugging at all is 0.9. FSTF data further showed a time "window" of at least 78 milliseconds during a pool chug. Assuming the probability distribution of a vent chugging to be uniform throughout this window, the probability of the second vent chugging at exactly the same time (i.e., during the same millisecond interval) is $0.9 \times 1/78 = 1.15 \times 10^{-2}$. This is the probability that the two downcomers chug synchronously - which was assumed as certain to get to the 7.00×10^{-3} probability of exceeding the 2.61 kips once per LOCA. So the combined probability of synchronous chugging of the two vents and exceeding the 2.61 kips per vent once per LOCA is the product of the two probabilities, i.e., $(7.00 \times 10^{-3}) \times (1.15 \times 10^{-2})$ or 8.1×10^{-5} which certainly is comparable to the 10^{-4} level of NUREG-0661.

While the above attempt to quantify the conservatism of the "all vents in phase" assumption is a rough one, it does use a conservative time window and in our opinion adequately justifies retaining the chugging lateral load per downcomer values given in the Fermi 2 PUAR.

Item 5 - The applicant uses a T-quencher configuration which differs in several substantive ways from the Mark I version. Some of the differences include the total hole area (Fermi has 8% less), arm diameter (Fermi uses 20" NPS vs 12" for Mark I), and hole pattern (compare Figure 1-4.2-2 of the PUAR with Figure 1-2 of NEDE-21878-P). These differences could imply that the LDR specification for SRV loads on the torus shell and submerged structures (as amended by the staff's acceptance criteria) may not be applicable for Fermi.

The applicant proposes to perfrom in-plant SRV tests to eliminate this uncertainty in regard to SRV loads on the torus shell. This is consistent with the staff's acceptance criteria (2.13.1 and 2.13.9) and is therefore acceptable. Information obtained from these tests ("bubble pressure" measurements) will also serve to eliminate any uncertainty relative to bubble induced submerged structure drag loads (Section 1-4.2.4b of the PUAR). For the water jet loads, however, such confirmation cannot be obtained from the proposed test program. The applicant takes the position that use of the LDR methodology, with appropriate modifications to account for the Fermi design, is applicable. However, the modifications were not described in the PUAR (Section 1-4.2.4a). In response to our request made during the conference call held on August 23, 1982, the applicant has provided a more detailed description of how these modifications were implemented (Reference 12). We have reviewed this information and conclude that they represent a correct application of the LDR methodology. The procedures proposed by the applicant for defining SRV Water Jet Loads on submerged structures is therefore considered acceptable.

Item 6 - The post-chug submerged structure loads, as specified in the acceptance criteria, are to be computed on the basis of the two nearest downcomers chugging at the maximum source strength with phasing between the downcomers that maximizes the local acceleration. On PUAR page 2-2.39, it is stated

that the loads were developed using the average source strength. In response to our request for additional information (Reference 8) the above PUAR statement was identified as being incorrect since the maximum source strengths were utilized in the Fermi 2 analyses in conformance with the acceptance criteria. Correction of the PUAR page 2-2.39 will be included in the next PUAR revision.

Item 7 - In response to the request for a detailed discussion of the method used to account for FSI effects on condensation oscillation and chugging submerged structure loads, the applicant submitted a technical note by Continuum Dynamics, Inc. entitled "Mark I Methodology for FSI Induced Submerged Structure Fluid Acceleration Drag Loads" (Ref. 14). The methodology described in this note is used to compute acceleration fields across a submerged structure anywhere in the torus resulting from FSI, based on knowing the torus boundary acceleration. The method is presented as an alternative to the NRC Acceptance Criteria suggestion of adding the boundary accelerations directly to the local fluid acceleration to account for FSI effects since the latter is deemed too conservative.

The review of the method outlined in Reference 14 has shown it to be reasonable and acceptable. The equations derived for fluid accelerations and pressure fields are plausible approximations for the conditions prevailing in the suppression pool. Assumed boundary conditions including the driving one at the torus wall are suitable. Overall trends as well as the acceleration fields depicted in the selected results appear reasonable.

The accelerations calculated by the method in Reference 14 are only due to FSI and must be added to any local accelerations due to other causes to obtain complete acceleration fields for computing drag loads.

Item 8 - The applicant proposes to use an analytical model to estimate local pool temperatures during SRV transients. This is not in conformance with the AC as presented in 2.13.8 of NUREG-0661. The intent of this AC was for the applicant to develop a bulk temperature history during these transients using conventional (and staff approved) methods. The local pool temperature would then be derived using an experimentally determined (from in-plant tests) local-to-bulk temperature difference. If this were not so, the entire section 2.13.8.2 would be meaningless.

Notwithstanding the above discussion, we need, nevertheless, to examine the viability of the proposed method to serve as an alternative. The applicant has provided a description of the model in Reference 15 and during the meeting of September 9, 1982. Based on this information, we have come to the following preliminary conclusion.

(a) The "momentum model" component of the analysis will most likely be an acceptable way to estimate bulk pool response to RHR operation.

(b) The "energy model" component of the analysis is not acceptable at this time because insufficient verification of its adequacy has been provided. The applicant's claim that it has been verified because it reproduces the Monticello in-plant test results is specious. When they state (in Reference 9) that "the model is calibrated to the Monticello test results", we take this to mean that the (numerous) empirical constants incorporated by the model were adjusted until the model reproduced what was observed during the Monticello tests. This does not constitute verification.

(c) Verification of the analytical model requires additional in-plant tests. At the September 9th meeting, for example, GE indicated that they were confident that the empirical constants derived from the

Monticello tests would be invariant with quencher submergence, torus radius, etc. They obviously have to say that since they have no information to the contrary. If the model successfully predicts temperature responses in a plant with differences in geometry and RHR characteristics, that would constitute its verification, or, at least, its general applicability.

In summary, we consider this item to be still an open issue. In our judgement, its resolution requires, at minimum, a more creative use of the Monticello data (coupled with the "momentum model") or additional in-plant tests (add extended blowdowns to the Fermi in-plant SRV test matrix). We would feel most comfortable with the latter option but judge that we can make do with the minimum option.

Item 9 - The description of the Suppression Pool Temperature Monitoring System (SPTMS) that was provided in Section 1-5.2 was judged to be inadequate for the purpose of determining that the SPTMS design was in accordance with the requirements of the AC (Section 2.13.8.3). This was because the location of the temperature sensors in the radial and circumferential directions was not supplied. Only the statement that "... these thermocouples are uniformly distributed throughout the torus" was provided. The applicants response to NRC Question #9 given in Reference 9 supplies this information and permits us to conclude that the Fermi SPTMS is in conformance with the AC.

Items 10 and 11 - The intent of these requests for additional information (Reference 10) was to obtain sufficient detail on the Fermi pool swell load calculations in order that the detailed portion of the post-implementation audit could be accomplished. The information received from the applicant in Reference (11) provided the necessary information to ascertain that the pool swell loads were calculated in conformance with the NUREG-0661 acceptance criteria.

Item 12 - The applicant uses a single vent lateral chugging load for each downcomer based on the highest lateral load observed in the FSTF tests. This basis for load magnitude appears to be non-conservative when the number of lateral loadings recorded in FSTF are compared with the number of individual single downcomer lateral loadings which can be expected during a postulated LOCA in the Fermi Plant. As indicated in Table 6.2.1-1 of NEDE-24539-P (Full-Scale Test Program Final Report), the approximate total number of downcomer chugs for the eight original tests in FSTF was 1460. Since of the eight FSTF downcomers only two, numbers 6 and 8, were instrumented to record lateral loads (NEDE-24537-P), it is reasonable to assume that approximately 1460 x 2/8 = 365 lateral chugging loads were recorded in FSTF during all of the original eight FSTF tests.

The Fermi Plant on the other hand has 80 downcomers. A conservative estimate of the number of pool chugs occurring with 90% of the downcomers participating is 180, resulting in 14,400 downcomer chugs. In addition, many other chugs with only a few downcomers participating can add to this total. While the above may be a conservative estimate, it does not seem unreasonable to expect on the order of 10,000 downcomer chugs (and therefore lateral loads) to occur during a postulated Fermi LOCA. Therefore, the highest load from the 365 observed FSTF events is very unlikely to bound the 10,000 expected Fermi events. On the basis of the above numbers one could expect the maximum FSTF lateral load to be exceeded about 25 to 30 times during a postulated Fermi LOCA.

A response to this concern of the possible non-conservatism in the single downcomer lateral load was requested from the applicant. Pending the receipt of that response and its subsequent review, this item will be considered an open issue.

5. REFERENCES

References cited in this report are available as follows:

Those items marked with one asterisk (*) are available in the NRC Public Document Room for inspection; they may be copied for a fee.

Material marked with two asterisks (**) is not publicly available because it contains proprietary information; however, a nonproprietary version is available in the NRC Public Document Room for inspection and may be copied for a fee.

Those reference items marked with three asterisks (***) are available for purchase from the NRC/GPO Sales Program, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, and/or the National Technical Information Service, Springfield, Virginia 22161.

All other material referenced is in the open literature and is available through public technical libraries.

(1) "Safety Evaluation Report, Mark I Long Term Program, Resolution of Generic Technical Activity A-7", NUREG-0661, July 1980.***

(2) "Mark I Containment Short-Term Program Safety Evaluation Report", NUREG-0408, December 1977.***

(3) General Electric Company, "Mark I Containment Program Load Definition Report", General Electric Topical Report NEDO-21888, Revision 2, November 1981.*

(4) Mark I Owners Group, "Mark I Containment Program Structural Acceptance Criteria Plant-Unique Analysis Applications Guide, Task Number 3.1.3", General Electric Topical Report NEDO-24583, Revision 1, July 1979.*

(5) "Enrico Fermi Atomic Power Plant, Unit 2, Plant Unique Analysis Report", Volumes 1-5, Detroit Edison Company, DET-04-028-1, Revision 0 (prepared by NUTECH Engineers, Inc.), April 1982.*

(6) Attachment to Letter from H. Tauber, V. P., Detroit Edison Company to B. J. Youngblood, Chief, Licensing Branch No. 1, Division of Licensing, NRC, August 18, 1982*

(7) Attachment to Letter from J. D. Ranlet, Brookhaven National Laboratory, to B. Siegel, NRC, Subject: Post-Implementation Pool Dynamic Load Audit Procedure, June 2, 1982.*

(8) Letter from J. D. Ranlet, BNL, to B. Siegel, NRC, Subject: FERMI 2 Plant Unique Analysis Report, Request for Additional Information, July 25, 1982.*

(9) Attachment to letter from H. Tauber, V. P., Detroit Edison Company to B. J. Youngblood, Chief, Licensing Branch No. 1, Division of Licensing, NRC, August 2, 1982 (Letter EF2-58,955).*

REFERENCES (Continued)

(10) Letter from J. D. Ranlet, BNL, to B. Siegel, NRC, Subject: FERMI 2 Plant Unique Analysis Report, Request for Additional Information, July 28, 1982.*

(11) Attachment to Letter from H. Tauber, V. P., Detroit Edison Company to L. L. Kintner, Licensing Branch No. 1, Division of Licensing, NRC (Letter EF2-59,268).*

(12) Attachment to Letter from H. Tauber, V. P., Detroit Edison Company to L. L. Kintner, Licensing Branch No. 1, Division of Licensing, NRC (Letter EF2-59,281).*

(13) Mark I Containment Program Letter Report: Supplemental Full-Scale Condensation Test Results and Load Confirmation, MI-LR-81-01-P, April 1981.**

(14) A. J. Bilanin, "Mark I Methodology for FSI Induced Submerged Structure Fluid Acceleration Drag Loads," Continuum Dynamics Tech Note No. 892-15, June 1982.*

(15) "Analytical Model for T-Quencher Water Jet Loads on Submerged Structures," Task 5.14.2/9.4.1, General Electric Company, NEDE-25090-1-P, Revision 1, May 1981.**