SAFETY EVALUATION OF THE FERMI 2 PLANT-UNIQUE ANALYSIS REPORT

Introduction

The purpose of the Mark 1 Containment Long Term Program (LTP) is to establish final design loads and load combinations and to verify that the existing or modified containment and related structures are capable of withstanding these loads with acceptable structural design margins. The staff has reviewed and evaluated the results of the LTP and issued a generic SER, NUREG-0661 (1), delineating the staff's acceptance criteria for the Mark 1 containment evaluation of the effects of the LOCA and SRV hydrodynamic pool loads. A supplement to NUREG-0661 (2) resolves the open issues identified in NUREG-0661.

Detroit Edison, as stated in the staff's SER for FERMI 2, committed to submit a Plant Unique Analysis Report (PUAR) prior to May 1982 for post-implementation audit review by the staff. The submittal, which is dated April 1982 (3) addresses all major and minor containment modifications as previously committed to by the applicant. The torus attached piping analysis will be submitted by the applicant in March 1983 and reviewed by the staff and its contractors prior to the Fermi 2 scheduled fuel load date in June 1983. The results of the torus attached piping evaluation will be addressed in a future SSER.

The staff has utilized two contractors to review the FERMI 2 PUAR. Brookhaven National Laboratory (BNL) performed the load audit review and Franklin Research Center (FRC) performed the structural audit review.

Load Audit Review Procedure

The post-implementation load audit review procedure developed by BNL was derived from a study of the three plant-unique analyses (3, 4 & 5) submitted prior to the start of this review. The procedure described herein compares the acceptability of the method used by the applicant in the PUAR to the pool dynamic acceptance criteria contained in Appendix A of NUREG-0661, and in the supplement to NUREG-0661.

The first phase of the audit entailed the reading of the pertinent sections or volumes of the PUAR to identify the following: 1) aspects of the methodology requiring clarifications; 2) plant-unique exceptions to the acceptance criteria; 3) the effect of plant modifications on the acceptance criteria load specifications; and 4) the availability of the required reference documentation.

In the next phase of the audit procedure a cursory overall review of the wetwell structures to ascertain that they were analyzed for all applicable LOCA and Safety/Relief Valve loads was performed. This was accomplished by using the checklist to verify the completeness of the loads considered in the PUAR. If any loads were found to have been omitted it was considered as a plant-unique exception to the acceptance criteria.

In the final phase of the audit procedure, a detailed load review, which was divided into five categories (pool swell, impact, submerged structure, condensation oscillation and chugging, and a random plant-unique load), was performed. Each of the loads in these categories was carefully evaluated to verify compliance with the acceptance criteria. If sufficient detail is not provided in the PUAR for any given load, a load of a similar type was substituted in its place to determine if the acceptance criteria methodology has been adequately implemented. If it was not possible to substitute a load, or one of the loads did not conform to the acceptance criteria, the load was considered as an exception to the criteria and was considered during the review of the exceptions to the acceptance criteria.

The audit procedure had the capability of identifying deviations from the acceptance criteria during each of the three different phases of the audit, namely, from the reading of the PUAR, from the cursory checklist or from the detailed load review. Where deviations were identified additional documentation and communication with the utility was required.

At the conclusion of the audit review, BNL prepared and submitted to the staff a Technical Evaluation Report (TER) which summarized the results of their evaluation (6).

Structural Analysis Review Procedure

The key items for the post-implementation structural audit review procedure developed by FRC were obtained from the Mark 1 containment program Plant Unique Analysis Application Guide (7) which was found acceptable in NUREG-0661. The procedure used compares the acceptability of the method used by the applicant in the PUAR to the requirements contained in Reference 7. When a requirement was not met but an alternative approach was used, the alternative approach was reviewed and compared with the audit requirement. If an alternative approach was not identified or insufficient information was provided to complete the evaluation or the approach was found to be non-conservative additional information was requested from the applicant. Provisions to explain the acceptability or non-acceptability of deviations from the acceptance criteria were included in the audit procedure.

At the completion of the audit review, FRC prepared and submitted a TER which summarized the results of their evaluation (8).

Evaluation of Load Audit Review

A copy of the BNL-TER (6) is contained in Appendix *. Figure 2 of the TER contains a checklist which identifies the structures that have been analyzed for the loading conditions specified in NUREG-0661. Figure 3 of the TER identifies the set of key loadings for which a detailed audit review was performed. During the various phases of the audit review procedure twelve items were identified as either exceptions to the acceptance criteria contained in NUREG-0661 or as areas where additional information was required to continue with the review. These issues are listed in Table 1 of the TER along with an indication of the type and status of each item.

Additional information was requested for items 6, 9, 10 and 11 of Table 1 and the response provided by the applicant (9, 10, 11) was sufficient for BNL to determine that these issues are resolved. The staff has been following the resolution of these items and has reviewed the BNL evaluation of these items contained in Appendix *. Based on our review we agree with BNL on the acceptability of the applicants responses.

The items in Table 1 that were identified as exceptions to NUREG-0661 are discussed below:

Item 1. The applicant used "published" acceleration drag volumes to determine the drag loads on sharp cornered submerged structure, instead of the equivalent cylinder procedure specified in NUREG-0661. On the basis of comparisons consistent with the acceptance criteria to the methodology in the PUAR BNL concluded that while the direct use of "published" acceleration volumes for sharp edged 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. The staff agrees with the BNL evaluation.

Item 2. The DBA condensation oscillation and post-chug load definitions on the torus shell and on submerged structures, accepted in NUREG-0661 were based on data from tests in the full scale test facility (12) and confirmed by additional tests reported in Reference 13.

In the PUAR a "phasing factor" of 0.65 is used to multiply the condensation oscillation and post-chug loads computed by the applicant. The justification is based on comparisons of measured and predicted stresses in the full scale test facility using different phasing models (14). BNL has determined, based on additional information provided by the licensee

* To be filled in by LPM

(9), that the "phasing factor" of 0.65 coupled with the inclusion of an additional conservatism related to the condensation oscillation loading used by the applicant provides a sufficiently conservative representation of the condensation oscillation and post-chug loads. The staff concurs with the BNL evaluation that this deviation is acceptable.

Item 3. The downcomer dynamic load methodology, which was accepted in the supplement to NUREG-0661, was derived for tied downcomers from the supplemental Full Scale Test Facility (FSTF) test (13). The Fermi 2 downcomer pairs are stiffened at each intersection by a crotch plate and by outer stiffener plates. Is response to the BNL request for additional information (9). The applicant 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, BNL determined the use of the downcomer dynamic load methodology is acceptable for the Fermi 2 plant-unique analysis. The staff agrees with the BNL evaluation.

Item 4. The acceptance criteria in NUREG-0661 specifies that for multiple downcomer chugging the force per downcomer shall be based on an exceedence probability of 10-4 per LOCA. However, the applicant used its own correlation between load magnitude and probability level derived from a statistical analysis of full scale test facility data. In the additional information provided (11), the applicant concluded that the probability of the force per downcomer in a pool chug being exceeded once per LOCA for Fermi 2 is 5.5 X10-3. This was based on a conservative estimate of the Fermi 2 citing duration of 900 seconds during which 182 synchronized pool chugs could be expected to occur (1/182 or 5.5 x 10-3 probability). While the exceedence probability of 5.5 X 10-3 is still higher than 10-4 and in BNL's opinion not correctly obtained, BNL determined that the lateral loads in the PUAR can be justified by other full scale test facility results. FSTF data showed that a time "window" of at least 78 milliseconds exists during a pool chug between the first and last vent chug. Also only 90% of all vents participated in the typical pool chug. Therefore, when phasing between vents during a pool chug is

taken into account the probability that a group of two vents will exceed the PUAR specified loads once per LOCA will be comparable to the NUREG-0661 value of 10-4. For large groups of vents the probability will be even smaller. The staff concurs with the BNL evaluation that this deviation is acceptable.

Item 5. The applicant has used a T-Quencher configuration which differs in several ways from the General Electric design approved for the Mark I long term programs. These differences could result in the Load Definition Report specification (15) for the SRV loads at the torus shell and submerged structures, as amended by the staffs acceptance criteria, not being applicable for Fermi 2.

The applicant has submitted an in-plant SRV test plan (16) to eliminate this uncertainty with regard to SRV loads on the torus shell. BNL and the staff have reviewed this test plan and determined that it is in compliance with the NRC guidelines for in-plant tests contained in NUREG-0661 (1) and NUREG-0763 (17) and is therefore acceptable.

Information from the in-plant tests will eliminate any uncertainties relative to bubble induced submerged drag loads, however, not for water jet loads. The applicant has stated that the use of the load definition report (LDR) methodology with appropriate modifications to account for the Fermi 2 design is applicable and provided additional more detailed information to justify that position (11). BNL reviewed the information provided and concluded it represents a correct application of the LDR methodology for defining SRV water jet loads on submerged structures and is therefore, acceptable. The staff agrees with the BNL evaluation.

Item 7. The fluid-structure interaction (FSI) methodology used by the applicant for condensation oscillation and chugging loads on submerged structures differs from the acceptance criteria in NUREG-0661 which states the boundary accelerations should be added directly to the local fluid acceleration to account for FSI effects. The applicant submitted a technical note by Continuum Dynamics Inc. (18) which described the methodology used to determine the acceleration fields across a submerged structure anywhere in the torus resulting from FSI, based on knowing the torus boundary acceleration. BNL has reviewed the method outlined in reference 18 and determined it is reasonable and therefore an acceptable alternative to the acceptance criteria in NUREG-0661. The staff concurs with the BNL evaluation that this is an acceptable alternative approach.

Item 8. The applicant utilized what they characterized as a "Local Pool Temperature Model" to estimate the local pool temperature during SRV transients. BNL in the TER identified this as an exception to the acceptance criteria in NUREG-0661 (Section 2.13.8.2) for which sufficient justification has not been provided. During a September 9, 1982 meeting with General Electric and the Mark I Owners Group the emperical model developed by General Electric to calculate local to bulk pool temperature differences was presented. Since the Monticello test data was used to both determine the constants used in the model and for model verification General Electric was informed by the staff that this approach was not acceptable. General Electric and the Owners Group informed the staff they will reassess their approach and investigate the use an alternate approach.

It is the staff's position that the applicant has two choices with regard to this issue; to commit to accept whatever generic resolution is agreed upon between the staff, General Electric and the Mark I Owners Group or to commit to perform an in-plant test to verify the acceptability of the General Electric model used to determine the Fermi 2 plant specific local to bulk temperature differences reported in the applicants PUAR. If the latter was committed to, this could best be accomplished by including so-called "extended" blowdown in the Fermi 2 in-plant SRV test matrix in accordance with the guidelines in NUREG-0661, Section 2.13.8.2.

Evaluation of Structural Audit Review

The structural audit review of the plant unique analysis for the Fermi 2 Mark I containment was performed by Franklin Research Center. A copy of the FRC-TER is attached in Appendix * of this report. As a result of this audit review, the applicant was requested to submit additional information which was provided in a September 9, 1982 submittal (19). Review of this response indicated that the applicant's structural analyses with regard to major modification is in conformance to the criteria requirement specified in NEDO-24583-1 (7) with the exception of torus attached piping which will be audited at a later date. One deviation from the acceptance criteria has been identified by FRC pertaining to the use of a 180 degree beam model on the seismic and other non-symetrical loads. FRC determined the applicants alternative method provides a more conservative estimate and is therefore acceptable. The staff is in agreement with the FRC evaluation.

FRC has reviewed the fatigue analysis used by the applicant to evaluate the SRV piping systems and found the analysis acceptable provided the NRC approves the generic approach. The staff is in agreement with the FRC evaluation and

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will review the acceptability of the generic approach when it is submitted by General Electric (See Section titled "Evaluation of Additional Issues Applicable to Fermi 2," Issue 4).

Evaluation of Additional Issues Applicable to Fermi 2

In addition to the plant specific deviations to NUREG-0661 identified during the review of the Fermi 2 PUAR there are several additional issues that have been identified associated with the Mark I program that require a combination of generic and plant specific resolutions. These issues which are directly applicable to Fermi 2 are discussed below.

1. Potential Vacuum Breaker Failures From Chugging and Condensation Oscillation Loads

In the latter stages of the generic resolution of the Mark I Containment Long-Term Program suppression pool dynamic load definition, a potential failure mode of the vacuum breakers (connecting the ring header inside the torus to the drywell) in the chugging and condensation oscillation phases of blowdown to the torus during a LOCA was identified. In the "Mark I Containment Program Full-Scale Test Program Final Report" (NEDE-24539-P) it was reported that during the first full-scale test (M1), which had the highest initial vacuum breaker opening pressure, damage to the vacuum breaker pallet hinge and latching magnet occurred. The cyclic impact of the pallet on the valve seat due to chugging in the vent system presented a loading condition which had not been previously included in the vacuum breaker valve design.

At the time this was discovered, the generic phase of the Mark I Containment Long-Term Program was nearing completion. Therefore, rather than further delay the completion of this program it was determined it would be preferable to pursue resolution of this potential failure mode of the vacuum breakers outside the framework of the Mark I Program. The Mark I Owners Group did commit to resolve this issue and two vacuum breakers owners groups were formed, one for those with Atwood Morrill Vacuum breakers that are using MPR as consultants, and one for those with General Precision Equipment (GPE) vacuum breakers that are using NUTECH as consultants.

The generic resolution, under which the methodology to determine the plant specific loads was developed, has been completed and the applicant has re-evaluated the design of the GPE vacuum breakers used in Fermi 2 for the new loading conditions (Reference 20) and has ordered components using higher strength materials to provide the necessary corrective action.

Due to the time frame of the applicant's submittal on the Fermi 2 vacuum breakers and the fact that General Electric and the Mark I Owners Group just discussed the generic resolution of this issue with the staff during a meeting on September 10, 1982 the staff and BNL has not had time to review this issue. During this meeting General Electric agreed to provide the staff the methodology for the generic resolution to this vacuum breaker problem. The staff and its contractors will evaluate both the generic resolution and the applicant's plant spicific submittal prior to the Fermi 2 scheduled fuel load date.

2. Low-Low Setpoint Logic

The applicant is using low-low setpoint logic to prevent a second opening of the SRVs during accidents or transients. Since many of the utilities with Mark I Containments are using low-low setpoint logic it is the staffs intention to obtain a generic resolution of this issue. Low-low setpoint logic was one of the topics for discussion during the September 10, 1982 meeting with General Electric and the Mark I Owners Group.

The use of low-low setpoint logic requires changing some of the safety setpoints which results in an unreviewed safety issue. Therefore, the staff will have to review the effects of these changes on the transients and accidents affected by these setpoint changes and the acceptability of the design changes and modifications in satisfying the NRC acceptance criteria for safety systems. During the September meeting General Electric agreed to provide the staff the results of bounding analyses performed to assess the effects of these setpoint changes on transient and accidents. The applicant has agreed to provide the staff the applicable electrical instrumentation and control system drawings which contain the low-low setpoint logic modifications. The staff expects to complete the review and determine the resolution of this issue for Fermi 2 prior to the scheduled fuel load date.

3. Determination of Local to Bulk Suppression Pool Temperatures

This issue has been addressed under deviations to NUREG-0661, see Section titled "Evaluation of Load Audit Review," Item 8.

4. Cyclic Fatigue Analyses

The Mark I containment owners agreed to perform cyclic fatigue analyses on the SRV discharge and torus attached piping after the NRC expressed concern that stresses derived by high cycled Mark I dynamic mechanical loadings were not explicitly considered in their analysis. The proposed generic approach presented during the September 10, 1982 meeting between the staff, General Electric and the Mark I Owners Group uses equation (11) from the ASME Class 2/3 design rules to combine loadings, and the Markl fatigue curve to determine usage factors for the piping. Loadings considered did not include thermal stress caused by temperature gradients (peak stresses). The analyses showed that the Mark I dynamic mechanical loadings had frequencies between 7,000 to 14,000 cycles. The analyses of 25 torus attached piping systems and 11 SRV discharge piping systems indicated that 92% and 73% of the respective resulted usage factors were below 0.3 and all the resulted usage factors were below 0.5 for the entire plant life.

Using equation (11) from the ASME Class 2 and 3 design rules to combine loadings in the proposed way is acceptable. Since the loading frequencies were between 7,000 to 14,000 cycles the Markl curve would yield almost identical usage factors as the Figure XIV-1221.3(c)-1 of the ASME B&PV Code, Section III, Division 1, Appendix XIV. Since both the SRV discharge piping and the torus attached piping systems were thin wall configurations, thermal stresses caused by temperature gradient across walls will be small and the inclusion of these stresses will not substantially change the resulted usage factors. Therefore, the staff is in general agreement with the generic approach discussed at the September 10, 1982 meeting subject to staff approval of a generic report on this scheduled to be submitted by General Electric by November 30, 1982. The staff plans to complete the review of this report prior to the scheduled fuel load date for Fermi 2.

5. Single Vent Lateral Chugging Load Magnitude

The applicant uses a single vent lateral chugging load for each downcomer based on the highest lateral load observed in the FSTF tests. BNL has identified that the basis for the load magnitude may be non-conservative when the number of lateral loadings recorded in FSTF are compared with

the number of individual single downcomer vent lateral loading which can be expected during a postulated LOCA in Fermi 2 (see BNL-TER, Item 12 for additional information). The applicant has been requested to respond to this concern. Pending the receipt of that response and its subsequent review, this item will be considered an open issue.

CONCLUSIONS

The staff and its contractors BNL and FRC have reviewed the applicants PUAR and arrived at the following conclusions:

1. The deviations taken from the acceptance criteria in NUREG-0661 pertaining to the load analyses are acceptable subject to the resolution of the emperical model used to determine the local to bulk temperature difference (See Section titled "Evaluation of Load Audit Review," Item 8).

2. The deviation taken from the acceptance criteria in NUREG-0661 which references NEDO-24583-1(7) pertaining to structural analyses is acceptable.

3. Three additional Mark I containment issues have been identified that are applicable to Fermi 2. These are: 1) potential vacuum breaker failures associated with chugging and condensation oscillation loads; 2) low-low setpoint logic; and 3) cyclic fatigue analyses. All these issues require a combination of generic, and plant specific resolutions. The staff review of these issues will be completed prior to the scheduled Fermi 2 fuel load date.

4. A concern related to the possible non-conservatism in the single vent downcomer lateral load magnitude has been identified. Resolution of this issue is pending receipt of the applicant's response and its subsequent review.

1. Mark 1 Containment Long-Term Program, NUREG-0661, July 1980.

2. Mark 1 Containment Long-Term Program, NUREG-0661, Supplement 1, August 1982.

3. Plant Unique Analysis Report for Enrico Fermi, Unit 2, April 1982.

4. Plant Unique Analysis Report for Cooper Nuclear Station, April 1982.

5. Mark 1 Long Term Program Plant Unique Analysis for Peach Bottom Units 2 and 3, April 1982.

6. Brookhaven National Laboratory Fermi 2 Technical Evaluation Report. BNL-04261 August 1982.

7. Mark 1 Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide, General Electric Report NEDO-24583-1, October 1979.

8. Franklin Research Center Technical Evaluation Report, Audit for Mark 1 Containment Long-Term Program - Structural Analysis Enrico Fermi Atomic Power Plant Unit 2, FRC Project C-5506, August 25, 1982.

9. Letter from H. Tauber, Detroit Edison, to B. Youngblood, NRC, Subject: Mark I Containment, Request for Additional Information, EF2 Ltr 58,955 August 2, 1982.

10. Letter From H. Tauber, Detroit Edison, to B. Youngblood, NRC, Subject: Mark I Containment, Request for Additional Information, EF2 Ltr 59,268, September 9, 1982.

11. Letter from H. Tauber, Detroit Edison, to B. Youngblood, NRC, Subject: Mark I Containment, Request for Additional Information, EF2 Ltr 59,281 September 9, 1982.

12. Mark I Containment Program - Full-Scale Test Program, Evaluation of Supplemental Tests, NEDE-24539-P Supplement 1, July 1981.

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

14. Mark I Containment Program Evaluation of Harmonic Phasing for Mark I Torus Shell Condensation Oscillation Loads, NEDE-24840, October 1980.

15. Mark I Containment Program Load Definition Report NEDO-21888, Revision 2, November 1981.

References (Cont'd)

16. Letter from H. Tauber, Detroit Edison, to B. Youngblood NRC, Subject: Submittal of SRV In-Plant Test Plan, EF2 Ltr 59,029, August 18, 1982.

17. Guidelines for Confirmatory In-plant Tests of Safety / Relief Valve Discharges for BWR Plants, NUREG-0763, May 1981.

18. Mark I Methodology for FSI Induced Submerged Structure Fluid Acceleration Drag Loads, A. J. Bilanin, Continuum Dynamics Tech Note No. 82-15, June 1982.

19. Letter from H. Tauber, Detroit Edison, to B. Youngblood, NRC, Subject: Mark I Containment, Request for Additional Information, EF2 Ltr 59,222, September 9, 1982.

20. Letter from H. Tauber, Detroit Edison to R. L. Tedesco, NRC, Subject: Evaluation of Enrico Fermi 2 - Drywell to Wetwell Vacuum Breakers, EF2 letter 59,061, August 18, 1982.