UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO MARK I CONTAINMENT LONG-TERM PROGRAM

POOL DYNAMIC LOADS REVIEW

VERMONT YANKEE NUCLEAR POWER CORPORATION

DOCKET NO. 50-271

1.0 INTRODUCTION

In July 1980, the staff issued a report, NUREG-0661, "Safety Evaluation Report, Mark I Containment Long-Term Program," to address the NRC acceptance criteria for the Mark I containment Long-Term Program, which are intended to establish design basis loads that are appropriate for the anticipated life of each Mark I BWR facility, and to restore the originally intended design safety margins for each Mark I containment system.

Since the issuance of NUREG-0661, the Mark I owners submitted additional reports in which they provided additional justification for the adequacy of: (1) the data base for specifying torus wall pressure during condensation oscillations; (2) the consideration given to asymmetric torus loading during condensation oscillations; and (3) the effect of fluid compressibility in the vent system on pool-swell loads. As a result of the staff's and its consultant's (Brookhaven National Laboratory) evaluation of these reports, Supplement 1 to NUREG-0661, dated August 1982, has been issued.

2.0 EVALUATION

Vermont Yankee Nuclear Power Corporation submitted a Plant Unique Analysis Report (PUAR) on the pool dynamic loads for the Vermont Yankee Nuclear Power Station Mark I containment. This report provides a description of the specific application of the generic Mark I pool dynamic loads and methods for Vermont Yankee Nuclear Power Station and the plant unique loads used in assessing the capability of the containment and components to accomodate the pool dynamic loading phenomena. The Brookhaven National Laboratory (BNL) was contracted to review the PUAR for compliance with the staff's acceptance criteria and to evaluate the acceptability of any proposed alternative load specification.

A summary of the BNL review and status for each of the pool dynamic loads is presented in the attached report titled "Technical Evaluation of the Vermont Yankee Nuclear Power Station Plant Unique Analysis Report." As indicated in the report, Vermont Yankee Nuclear Power Corporation has adopted all but a few of the generic criteria. For those few exceptions alternative criteria were proposed. The BNL evaluation of these criteria is included in the attached report. Based on its review, the staff endorses the BNL evaluation and conclusion.

3.0 CONCLUSIONS

The staff has completed an assessment of Vermont Yankee Nuclear Power Station against generic acceptance criteria contained in NUREG-0661 and its supplement, and has also reviewed those few areas where alternative criteria have been proposed. In addition, the staff has completed its review of those areas where additional information was relegated to the plant unique review. In each of these areas the staff has concluded that the pool dynamic loads utilized by Vermont Yankee Nuclear Power Corporation are conservative and, therefore, acceptable.

Principal Contributor: F. Eltawila

Attached: Technical Evaluation,
dated March 1984, prepared
by Brookhaven National Laboratory

Dated: July 2, 1984

Technical Evaluation of the Vermont Yankee Plant Unique Analysis Report

John R. Lehner

George Bienkowski

Constantino Economos

Reactor Safety Licensing Assistance Division
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, New York 11973

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ABSTRACT

This Technical Evaluation Report (TER) presents the results of the post-implementation audit of the Plant Unique Analysis Report (PUAR) for the Vermont Yankee Nuclear Power Station. The contents of the PUAR were compared against the hydrodynamic load Acceptance Criteria (AC) contained in NUREG-0661. The TER contains a summary of the audit findings, as well as a more detailed discussion of special issues or exceptions to the AC identified during the audit. Two tables are provided. The first is a checklist of PUAR loads versus AC specifications. The second highlights each special issue or AC exception along with an indication of the type and status of each issue.

ACKNOWLEDGEMENTS

The cognizant NRC Technical Monitor for this program was Dr. Farouk Eltawila of the Containment Systems Branch (DSI) and the NRC Project Manager was Ms. Beverly Barnhart of the Technical Assistance Program Management Group of the Division of Licensing. Mr. Byron Siegel of the Operating Reactors Branch Number 2 (DL) acted as Head Project Manager.

List of Acronyms

AC	Acceptance Criteria
ADS	Automatic Depressurization System
BNL	Brookhaven National Laboratory
BWR	Boiling Water Reactor
CO	Condensation Oscillation
DBA	Design Basis Accident
DL	Division of Licensing
DSI	Division of System Implementation
FSI	Fluid Structure Interaction
FSTF	Full Scale Test Facility
GE	General Electric Company
IBA	Intermediate Break Accident
LDR	Load Definition Report
LOCA	Loss-of-Coolant Accident
LTP	Long Term Program
NRC	Nuclear Regulatory Commission
PUAR	Plant-Unique Analysis Report
RFI	Request for Information
RHR	Residual Heat Removal
SBA	Small Break Accident
SMA	Structural Mechanics Associates
SRSS	Square Root Sum of the Squares
SRV	Safety Relief Valve
SRVDL	Safety Relief Valve Discharge Line
STP	Short Term Program
TER	Technical Evaluation Report
T/Q	T-Quencher
VY	Vermont Yankee

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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 containment 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 was to perform a post-implementation audit of the Vermont Yankee plant-unique analysis (Reference 5) against the hydrodynamic load criteria in NUREG-0661.

2. POST-IMPLEMENTATION AUDIT SUMMARY

The purpose of this post-implementation audit is to evaluate the hydrodynamic loading methodologies used to modify the suppression chamber, vent system and internal structures of the Vermont Yankee Nuclear Power Station. The methodologies of the Vermont Yankee PUAR (Reference 5) are compared to those presented in the LDR (Reference 3) which were approved in the AC of NUREG-0661 (Reference 1). The audit procedure consists of a moderately detailed review of the plant unique analysis report to verify both its completeness and its compliance with the acceptance criteria. A checklist of the various load categories specified in the AC, as shown in Table 1, is used to facilitate this task. Besides providing an overview of the audit, Table 1 supplies plant unique information through the notes in the right hand margin which are explained at the end of the table.

The next section of this TER, Section 3, identifies the exceptions to the AC, as well as those special areas detected during the Vermont Yankee PUAR audit, where additional information was needed.

LOADS	NUREG-0661 AC SECTION	CRITERIA		NOT APPLICABLE	ALTERNATE APPROACH	NOTES
		MET	NOT MET			
CONTAINMENT PRESSURE & TEMPERATURE	2.1	✓				
VENT SYSTEM THRUST LOADS	2.2	✓				
POOL SWELL						
TORUS NET VERTICAL LOADS	2.3	✓				
TORUS SHELL PRESSURE HISTORIES	2.4	✓				
VENT SYSTEM IMPACT AND DRAG	2.6	✓				
IMPACT AND DRAG ON OTHER STRUCTURES	2.7	✓				
FROTH IMPINGEMENT	2.8	✓				
POOL FALLBACK	2.9	✓				
LOCA JET	2.14.1	✓				
LOCA BUBBLE DRAG	2.14.2	✓				
VENT HEADER DEFLECTOR LOADS	2.10	✓				

TABLE 1. LOAD CHECKLIST FOR POST-IMPLEMENTATION AUDIT

LOADS	NUREG-0661 AC SECTION	CRITERIA		NOT APPLICABLE	ALTERNATE APPROACH	NOTES
		MET	NOT MET			
<u>CONDENSATION OSCILLATION</u>						
TORUS SHELL LOADS	2.11.1				✓	1
LOADS ON SUBMERGED STRUCTURES	2.14.5				✓	2
VENT, SYSTEM LOADS	2.11.3	✓				3
DOWNCOMER DYNAMIC LOADS	2.11.2	✓				4
<u>CHUGGING</u>						
TORUS SHELL LOADS	2.12.1				✓	5
LOADS ON SUBMERGED STRUCTURES	2.14.6				✓	6
VENT SYSTEM LOADS	2.12.3	✓				7
LATERAL LOADS ON DOWNCOMERS	2.12.2	✓				

TABLE 1. (CONTINUED)

LOADS	NUREG-0661 AC SECTION	CRITERIA		NOT APPLICABLE	ALTERNATE APPROACH	NOTES
		MET	NOT MET			
T-QUENCHER LOADS						
DISCHARGE LINE CLEARING	2.13.2	✓				
TORUS SHELL PRESSURES	2.13.3	✓				8
JET LOADS ON SUBMERGED STRUCTURES	2.14.3				✓	9
AIR BUBBLE DRAG	2.14.4				✓	9
THRUST LOADS ON T/Q ARMS	2.13.5	✓				
S/RVDL ENVIRONMENTAL TEMPERATURES	2.13.6	✓				

TABLE 1. (CONTINUED)

	DESCRIPTION	NUREG-0661 AC SECTION	CRITERIA		NOT APPLICABLE	ALTERNATE APPROACH	NOTES
			MET	NOT MET			
1	SUPRESSION POOL TEMPERATURE LIMIT	2.13.8				✓	10
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	✓				11
4	SRV LOAD ASSESSMENT BY IN-PLANT TEST	2.13.9	✓				12

TABLE 1. (CONTINUED)

Table 1 Notes

1. The AC requires absolute summation of the CO load harmonics (from 1 to 50 Hz) for the analysis of structures affected by CO loads. Vermont Yankee used a random phasing methodology instead, whereby the absolute sum of the four highest component responses is added algebraically to the SRSS of the remaining component responses to get a total shell response. Loads on support and anchor systems were determined by adding the absolute value of the three highest harmonic contributors to the SRSS of the others. Combination of individual harmonic stresses into total element stress was done by considering frequency contributions at 31 Hz and below. This methodology was found acceptable. See Section 3.1 for additional details.
2. For condensation oscillation loads on submerged structures, the AC requires that loads be computed on the basis of both the average of all sources and maximum nearest source as derived from FSTF data. FSI effects must be included. For Vermont Yankee phased CO sources were used for CO and CO-FSI drag. Final loads were determined by adding the four maximum frequency contributors to the SRSS sum of the others. See Section 3.1 for additional details.
3. Instead of using a sinusoidal load superimposed on a static load for a CO vent system load, both loads were applied in a static manner to calculate pressures for Vermont Yankee. The low frequency of the applied pressure was cited as justification. This analysis was found acceptable.
4. The licensee states that an evaluation was performed which showed that the combined effects (i.e. horizontal and vertical components) of the CO downcomer load is bounded by chugging lateral loads. Therefore the licensee used chugging lateral load results for all load cases in place of CO downcomer loads. This analysis was found acceptable.

5. The AC requires that total response to post-chug loads is obtained by summing steady state response from each frequency from 1 to 50 Hz. For Vermont Yankee post chug, response was obtained by combining the 4 maximum harmonic responses with the SRSS of the others for frequencies below 31 Hz. This methodology was found acceptable. See Section 3.2 for further discussion.
6. For chugging loads on submerged structures, the approach used for Vermont Yankee differs from that approved in the AC. As for CO, source strength for post chug loads is based on a phasing methodology. However, for post chug loads five maximum frequency contributors are added to the SRSS sum of the others. This method was found acceptable. See Section 3.2 for further discussion.
7. For internal vent system loads due to chugging, the licensee states that an evaluation was performed which showed that internal vent system pressures were substantially less than internal vent pressures resulting from pool swell. The licensee used the pool swell pressure values in all combined load cases involving chugging pressures. This analysis was found acceptable.
8. Torus shell pressures due to T-quencher loads were based on data collected from in-plant SRV tests for Vermont Yankee. These tests followed in general the guidelines given in the AC for deriving loads from in-plant test data. After several discussions with the licensee, the Staff's concerns regarding pressure measurements and design load extrapolations were resolved. See Section 3.3 for details of this issue and its resolution.
9. Drag loads on submerged structures in Vermont Yankee were not computed according to AC approved methods. Instead, drag loads were based on data collected during in-plant SRV tests. Test data was scaled to correct for

appropriate SRV conditions and then applied to the structural model to determine stress. This methodology represents an exception to the AC and was discussed extensively with the licensee. See Section 3.4 for additional information regarding this issue.

10. In discussions the staff has had with Vermont Yankee, the licensee has stated that the maximum bulk pool temperature will not exceed 175°F during any of the NRC required transient analyses. The temperature remains below this level because VY has committed itself to remain in the suppression pool cooling mode for the entire length of each transient (i.e., not to switch over to a reactor shutdown cooling mode requiring removal of the RHR from suppression pool cooling.) Based on data supplied by the applicant to characterize the VY RHR performance (Reference 14), we estimate that such operation will maintain a local-to-bulk pool temperature difference of 20°F. This implies that pool local temperature will stay below the limits imposed by the NRC staff (Reference 6).
11. As a means to reduce shell pressures related to DBA pool swell, a minimum positive pressure difference of 1.7 psi is maintained between the Vermont Yankee drywell including the vent system and the torus air space. A nitrogen inerting system is used to pressurize the drywell to 1.7 psi while the torus remains at ambient pressure. While the PUAR states that other methods are also available to maintain this Δp, the plant is required to come to shutdown according to technical specifications if the main Δp system fails.
12. A series of four in-plant SRV tests, each with one cold line actuation followed by one hot line, were conducted at Vermont Yankee in 1981. Results from these tests have been used for formulating various SRV loads on the containment. See Section 3.3 and 3.4 for additional discussion of the VY in-plant SRV tests and the design load extrapolated from them.

3. SUMMARY OF THE NRC REQUEST FOR INFORMATION REGARDING THE VERMONT YANKEE PUAR.

During the post-implementation audit of the Vermont Yankee PUAR, various issues were identified as either exceptions to the AC or as areas where additional information was required. To resolve these issues, a request for information (RFI) (Reference 7) was sent to the licensee to obtain further details which would supplement the information contained in the PUAR. Most of the requested details were presented by the licensee at a meeting in Framingham, MA on July 26, 1983. This meeting was attended by Yankee Atomic Electric Company and Teledyne Engineering Services, as well as NRC and its consultants. Additional information on a few items was furnished by the licensee at a later date: A memorandum (Reference 13) was sent to NRC from VY on September 7, 1983 and telephone conferences were held on the 26th and 27th of September 1983. As a result of a final meeting between Yankee Atomic, Teledyne and NRC held on February 16, 1984 in Waltham, MA, all remaining open items regarding the Vermont Yankee PUAR review were closed.

An overview of the RFI sent to Vermont Yankee is presented in Table 2 along with an indication of the type and status of each item. As the table shows, four exceptions to the AC have been identified in the Vermont Yankee PUAR. As stated above, all have been satisfactorily resolved. For completeness, following Table 2 a brief description of any exceptions to the AC and their justification as presented by the licensee, along with the staff's evaluation, is provided. While the Vermont Yankee SRV shell loads were not considered an exception to the AC, a brief discussion of the staff's concerns and their resolution is also provided in Section 3.3. It should be noted regarding Item 23 of Table 2 that review of the Torus Attached Piping Analysis for Vermont Yankee was not performed by BNL.

TABLE 2. 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	Clarification of Pool Temperature Monitoring System.		X	X	
2	Torus Pressure Load Distribution During Pool Swell.		X	X	
3	Application of Pre-Chug and IBA/CO Load Analysis.		X	X	
4	SRV Load Computer Modeling.		X	X	
5	Instrumentation Used During In-Plant SRV Tests.		X	X	
6	Calibration Factors Relating In-Plant SRV Test Results to Load Case Calculations.		X	X	

TABLE 2 (Continued)

		TYPE OF ISSUE		STATUS OF ISSUE	
ITEM	DESCRIPTION	EXCEPTION TO NUREG-0661 AC	REQUESTS FOR ADDITIONAL INFORMATION	RESOLVED	OPEN
7	Vent Header Deflector Load Application.		X	X	
8	Details of Single Vent Lateral Chugging Loads.		X	X	
9	Multiple Downcomer Lateral Chugging Loads.		X	X	
10	Calculation of Pool Swell Impact Loads on Downcomers.		X	X	
11	LOCA Bubble Drag Loads.		X	X	
12	Similarity of Vermont Yankee Ring Girder with Computer Model Used for Calculation.		X	X	
13	Ring Girder Drag Loads.	X		X	
14	Method Used to Include FSI Effects on Submerged Structures.		X	X	

TABLE 2 (Continued)

		TYPE OF ISSUE		STATUS OF ISSUE	
ITEM	DESCRIPTION	EXCEPTION TO NUREG-0661 AC	REQUESTS FOR ADDITIONAL INFORMATION	RESOLVED	OPEN
15	Loads on Catwalk Grating		X	X	
16	Calculation of Local-to-Bulk Pool Temperature Differences.		X	X	
17	Specification of Procedures by Which Operator Will Identify SBA and Insure Manual Operation of ADS.		X	X	
18	Details of Pool Swell Load Calculations for Vent System.		X	X	
19	Submerged Structure Drag Loads Calculated From SRV Test Data.	X		X	
20	Water Jet and Bubble Drag Loads on T-Quencher, Supports and SRVDL.		X	X	

TABLE 2 (Continued)

		TYPE OF ISSUE		STATUS OF ISSUE	
ITEM	DESCRIPTION	EXCEPTION TO NUREG-0661 AC	REQUESTS FOR ADDITIONAL INFORMATION	RESOLVED	OPEN
21	Random Phasing of Load Harmonics to Analyze Structures Affected by CO Loads.	X		X	
22	Chugging Load Application.	X		X	
23	Torus Attached Piping Analysis.		X	X	

3.1 Harmonic Phasing for CO Response. (Item 21 of Table 2).

The CO torus shell load is an oscillating load caused by periodic pressure oscillations superimposed upon the prevailing local static pressure. The LDR defines the load in terms of a rigid wall pressure amplitude versus frequency spectra from 0 to 50 Hz which is to be used in conjunction with a flexible wall coupled fluid structure model. In addition, three alternate sets of spectral amplitudes are provided in the range from 4 to 16 Hz and the alternate which maximized the response is to be used. The resulting responses from applying the amplitude at each frequency given in the total spectra to be analyzed are to be summed. The above procedure was found acceptable in the AC because the high degree of conservatism associated with the direct summation of the Fourier components of the spectrum was more than sufficient to compensate for any uncertainties associated with the FSTF data from which the load specification was developed. Direct application of the above methodology to the Vermont Yankee torus proved to be too conservative and so an alternate approach based on a study performed in Reference 8 was used. The alternate approach obtains the total response for CO by taking the absolute sum of the four highest harmonic component responses and adding algebraically the SRSS of the remaining component responses for shell stresses. Loads on the support and anchor systems are determined by adding the three highest harmonics to the SRSS of the others. For CO drag loads on submerged structures the four maximum harmonic contributors added to the SRSS sum of the others are used for source strength. In all these cases only harmonics of 31 Hz or below are considered, while the AC requires harmonics to 50 Hz.

The Vermont Yankee procedure is one of several variations for implementing phasing in the CO load definition discussed in Reference 8 and subsequent SMA Reports (References 9, 10) which accounts for data obtained after Reference 8 was published. Reference 11 reviews the various design rules and their justification as given in References 8, 9 and 10 and discuses why they are acceptable alternatives to the LDR procedure. The method used for Vermont Yankee shell stresses and torus loads was one which was found to be marginally acceptable in Reference 11 provided stresses are not within a few percent of allowables. Since critical stresses in the Vermont Yankee shell and its support system are well below allowables (see pp. 38-43 of the PUAR) for controlling load combinations which include CO, the alternate approach for obtaining shell and support system CO response has been found acceptable. Using phased CO sources for submerged structure drag loads has been found acceptable since one can expect the CO pressure signals to be considerably more desynchronized for this loading phenomena than for the shell pressure loads.

3.2 Harmonic Phasing for Post-Chug Response. (Item 22 of Table 2).

Post-chugging is defined as a spectral load across a wide band of frequencies, similar to CO, but lower in amplitude. The AC requires that total response to post-chug loads is obtained by summing steady state response from each frequency from 1 to 50 Hz. For Vermont Yankee the response of the torus shell and associated support system was obtained by combining the 4 maximum harmonic responses with the SRSS of the others for frequencies below 31 Hz. The licensee states in the PUAR that post-chug stresses were small and loads due to post-chug were always bounded by pre-chug values. Therefore, the licensee used pre-chug stress values for all analysis involving post-chugging. The PUAR further states that these pre-chug stresses may be increased by 53% and still meet allowables. Based on these statements by the licensee and the fact that chugging is generally acknowledged to be an asynchronous load, the use of pre-chug stresses for all load combinations involving post-chugging to evaluate shell and support system stresses has been found acceptable.

For submerged structure drag due to post-chug sources a phased methodology, using the five maximum harmonic contributors plus the SRSS sum of the others, has been employed for Vermont Yankee. Since post-chug loads for submerged structure drag loads can be expected to be even more desynchronized than for shell loads and since absolute summing of the five maximum harmonics is a fairly conservative phasing approach, this method has also been found acceptable.

3.3 SRV Torus Shell Loads. (Item 6 of Table 2).

According to the PUAR (Section 3.2.4), these loads derive from data obtained during SRV tests performed in the Vermont Yankee (VY) plant. This approach is in conformity with the AC (Section 2.13.9). However, the description provided by the applicant (Appendix 1 of the PUAR) of the tests and procedures used to develop the design loads was deemed inadequate to insure that the load development was in total compliance with the AC requirements. These requirements include conservative interpretation of the in-plant test data (Section 2.13.9.2.3 of the AC) and extrapolation of the results to design basis conditions using approved methods.

In response to the RFI (Reference 7), the applicant provided additional information at the July 26, 1983 meeting (Reference 12). This included more detail relative to test conditions and the measured torus shell pressures. The latter were surprisingly low (2.5 psi maximum compared to about 7 psi in the Monticello plant and 9 psi in Peach Bottom). Of some concern also was the very low design value of torus shell pressure used by the applicant (5.8 psi).

In a continuing effort to clarify this apparently anomalous behaviour, additional information was supplied by the applicant via Reference 13 and the Telecoms of the 26th and 27th of September 1983. This revealed that the measured pressures were not anomalous but simply reflected the load-mitigating effect of the drywell-to-wetwell pressure differential (Δp) which was in place during the VY in-plant SRV tests. We still felt, however, that the value of the torus shell pressure used for design did not provide sufficient margin to accommodate the many uncertainties exhibited by the SRV load phenomenon discussed in Reference 1.

To resolve this concern, the applicant was asked to supply us with the means for making an independent estimate of the design load. This involves a complete description of the conditions prevailing during the tests, a complete tabulation of the data base, and a precise definition of design basis conditions. Most of this information was supplied at the meeting of February 16, 1984. Also provided was an indication of the margins available between design and allowables. The smallest of these margins (on shell stress) could accommodate a greater than three-fold increase in the design pressure.

From the information made available to us, and using load trends derived from the approved LDR methodology, we estimate that a suitable design value of torus shell pressure is above 8.0 psid but no greater than 9.0 psid. This exceeds the value used by the applicant (5.8 psi) but it is well below the value that can be accommodated by the structure (5.8 x 3 ~ 17) psi). On this basis, we find the proposed design acceptable.

3.4 In-Plant SRV Data for Submerged Structure Drag. (Item 19 of Table 2).

The AC and LDR require T-quencher bubble-induced drag loads on submerged structures to be calculated on the basis of an analytical model whose major assumptions are summarized in Section 5.2.5.1 of the LDR (Ref. 3). For Vermont Yankee a completely different approach was used: During in-plant SRV tests in Vermont Yankee and three other plants strains were measured on two or three submerged structures in each plant. From these data (a total of 10 points) an equivalent static load was computed for each structure. This was done by calculating the static pressure load which would produce the same bending stresses as those measured, when applied uniformly to the structure. From these calculations a curve was developed showing static pressure values versus distance from the quencher. The curve is supposed to represent the equivalent static drag pressures, including quencher jet loads. To account for other SRV load cases besides those tested, the curve is scaled by the ratio of the calculated shell pressures for the various cases to the test case.

The staff had several concerns with this methodology, particularly since it did not account for bubble frequency content or structure response characteristics in a direct manner. After extensive discussions of this issue with the licensee at several meetings and teleconferences, some concerns were resolved but others remained. The staff was not fully convinced that the arguments presented were sufficiently substantiated by the limited data base available.

However, the licensee also presented a list of submerged structures in Vermont Yankee, along with a multiplier indicating how much SRV drag loads on the structure could be increased. For all but one structure this multiplier was greater than 5 and for some structures greater than 10, i.e., even if SRV drag loads were 5 times (or in some cases 10 times) greater than the loads calculated by the VY method, allowable stresses would still not be exceeded. The one exception was a downcomer which would reach stress allowables with an 83% load increase. For this structure the licensee presented results calculated by a separate agent for another plant owned by a different utility which used a test calibrated version of the LDR methodology for its SRV drag loads. For a similar downcomer at a similar distance from the quencher, the loads calculated for this plant were the same or less than those obtained by VY, giving the staff confidence that an 83% load margin was quite adequate for the downcomer in VY.

Based on the large margins available for all structures except the downcomer and based on the favorable comparison of loads on a similar downcomer computed with a method acceptable to the staff, the VY submerged structures drag loads are found to be satisfactory by the staff.

3.5 CO/Chugging Ring Girder Drag Loads. (Item 13 of Table 2).

The theoretical hydrodynamic mass coefficient used for the Ring Girder CO and chugging drag analysis of VY is not the limiting one required by the AC, i.e., a circumscribed cylinder of diameter equal to $\sqrt{2}\ L_{max}$ in the maximum transverse dimension. Instead, a circumscribed cylinder of diameter L_{max} is used, justified by the relatively low ratio of fluid motion to structural dimension. The staff finds this calculation acceptable.

Adjustments made to the wall interference factor made in the VY Ring Girder drag calculations are within AC guidelines.

4. CONCLUSIONS

A post-implementation pool dynamic load audit of the Vermont Yankee PUAR was conducted to verify compliance of the plant unique analysis with the acceptance criteria contained in NUREG-0661. As a result of the audit, several items were identified which required additional information for resolution. A request for information was sent to the licensee in May, 1983. At a meeting with the licensee in July, 1983, and through correspondence, as well as telephone conference calls, additional information regarding outstanding items was received. A final meeting in February, 1984 led to the closing of all remaining open items. The review of the VY PUAR Torus Suppression Chamber has been completed with no issues or concerns outstanding.

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) "Plant Unique Analysis Report of the Torus Suppression Chamber for Vermont Yankee Nuclear Power Station", Technical Report TR-5319-1, Teledyne Engineering Services, Revision 1, April 8, 1983.*

(6) "Suppression Pool Temperature Limits for BWR Containments, Generic Technical Activity A-39", NUREG-0783, November 1981.***

(7) Letter from J. R. Lehner, BNL, to F. Eltawila, NRC dated May 16, 1983. Subject: Request For Information Regarding Vermont Yankee PUAR.*

(8) "Mark I Containment Program Evaluation of Harmonic Phasing for Mark I Torus Shell Condensation Oscillation Loads", NEDE-24840, prepared by Structural Mechanics Associates for General Electric Company, October 1980.**

(9) Kennedy, R. P., "Response Factors Appropriate for Use with CO Harmonic Response Combination Design Rules", SMA 12101.04-R002D, prepared by Structural Mechanics Associates for General Electric Company, March 1982.**

(10) Kennedy, R. P., "A Statistical Basis for Load Factors Appropriate for Use with CO Harmonic Response Combination Design Rules", SMA 12101.04-R003D, prepared by Structural Mechanics Associates for General Electric Company, March 1982.**

(11) Bienkowski, G., "Review of the Validity of Random Phasing Rules as Applied to CO Torus Loads", to be published.

(12) "Vermont Yankee Mark I Torus Program, Responses to PUAR Questions", Teledyne Engineering Services, July 26, 1983.

(13) Memorandum from R. E. White to J. B. Sinclair regarding "Mark I Program - Teledyne Response to BNL Questions on PUA", September 7, 1983.

(14) Memo, W. J. Szymczak to A. C. Kadak, File LOCA 83-69, Subject VY Monticello Torus Performance Comparison.