Enclosure 3

Technical Evaluation of the Hatch (Units 1 & 2) Plant-Unique Analysis Reports

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September 1983

FIN-A-3713

BNL-04243

ABSTRACT

The objective of this report is to document the post-implementation audit which compared the Hatch (Units 1 & 2) plant-unique analysis reports against the hydrodynamic load acceptance criteria presented in NUREG-0661. A summary of the audit findings, as well as an overview of the various issues or exceptions to the acceptance criteria identified during the audit, is included. In addition, a table highlighting each issue is provided, 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 Operating Reactors Branch No. 2 (DL) was Lead Project Manager for the project.

List of Acronyms

ABSS	Absolute Sum
AC	Acceptance Criteria
ADS	Automatic Depressurization System
BNL	Brookhaven National Laboratory
BWR	Boiling Water Reactor
LDR	Load Definition Report
LTP	Long Term Program
MSIV	Main Steam Isolation Valve
NOC	Normal Operating Conditions
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
PUA	Plant-Unique Analysis
PUAAG	Plant-Unique Analysis - Applications Guide
PUAR	Plant-Unique Analysis Report
PULD	Plant-Unique Load Definition Report
QSTF	Quarter Scale Test Facility
RFI	Request For Information
RHR	Residual Heat Removal
SER	Safety Evaluation Report
SRSS	Square Root of the Sum of the Squares
S/RV	Safety/Relief Valve
S/RVDL	Safety/Relief Valve Discharge Line
STP	Short Term Program

Table of Contents

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 is to perform a post-implementation audit of the Hatch (Units 1 & 2) plant-unique analysis (Reference 5) against the hydrodynamic load criteria in NUREG-0661.

2. <u>Summary of Post-Implementation Audit</u>

The purpose of the post-implementation audit is to evaluate the hydrodynamic loading methodologies used for the major modification and torus attached piping portions of the Hatch (Units 1 & 2) plant-unique analysis with regard to the NUREG-0661 acceptance criteria. The audit procedure consists primarily of a moderately detailed review of the plant-unique analysis report to verify both its completeness and its compliance with the AC. To facilitate this task, a checklist (see Table 1) of the various load categories specified in the AC is used. Table 1 also provides an overview of the audit and presents plant-unique information such as any AC approved alternate methods used in the PUAR. The notes in the right-hand margin which accomplish this task are explained at the end of Table 1.

In general, various exceptions to the AC or areas where additional information is required are identified during the audit of a PUAR. Since Table 1 contains all the load categories considered during an audit, along with its current

status, it is not possible to determine from it the specific issues considered and resolved during the audit. Consequently, a complete listing of all items considered is provided in Section 3 of the report, along with a brief description of each exception to the AC found during the audit.

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	✓				
<u>POOL SWELL</u>						
TORUS NET VERTICAL LOADS	2.3				✓	1
TORUS SHELL PRESSURE HISTORIES	2.4				✓	1
VENT SYSTEM IMPACT AND DRAG	2.6				✓	2
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				✓	2

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	✓				
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	✓				
LOADS ON SUBMERGED STRUCTURES	2.14.6	✓				
VENT SYSTEM LOADS	2.12.3	✓				
LATERAL LOADS ON DOWNCOMERS	2.12.2	✓				

TABLE 1. (CONTINUED)

LOADS	NUREG-0661 AC SECTION	CRITERIA MET	CRITERIA NOT MET	NOT APPLICABLE	ALTERNATE APPROACH	NOTES
<u>T-QUENCHER LOADS</u>						3
DISCHARGE LINE CLEARING	2.13.2	✓				
TORUS SHELL PRESSURES	2.13.3				✓	4
JET LOADS ON SUBMERGED STRUCTURES	2.14.3	✓				
AIR BUBBLE DRAG	2.14.4	✓				
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 MET	CRITERIA NOT MET	NOT APPLICABLE	ALTERNATE APPROACH	NOTES
1	SUPRESSION POOL TEMPERATURE LIMIT	2.13.8				✓	5
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			✓		
4	SRV LOAD ASSESSMENT BY IN-PLANT TEST	2.13.9			✓		

TABLE 1. (CONTINUED)

Notes to Table 1

NUMBER

1 The AC requires the torus net vertical loads and the torus shell pressure histories to be based on the mean of four QSTF tests. Since the decision was made to operate Hatch 1 at a zero drywell-to-wetwell pressure differential, the Hatch 1 vertical loads were based on only a single QSTF test (i.e. Test 5). Consequently, additional margin was added to the Hatch 1 loads to account for the larger statistical variance associated with the smaller number of tests. The amount of increase was found acceptable. No margins were required for Hatch 2 since its QSTF data base was obtained at its normal operating condition as specified in the AC. See Section 3.1 for additional details concerning this subject.

2 The AC approved methodology for treating the pool swell impact loads on vent headers or vent header deflectors consists of using QSTF data or a combination of an analytical method in conjunction with QSTF data. Neither Hatch unit has sufficient QSTF data to enable a direct application of the AC approved LDR procedures since both units utilize vent header deflectors in non-vent bays and no deflectors in the vent bays. This is due to the fact that Hatch 1 was tested with a vent header deflector, whereas Hatch 2 was not. A procedure was used in the PUAR whereby the results from the Hatch 2 tests (no deflector) were adjusted to be representative of Hatch 1 "bare vent" impact data and similarly, the Hatch 1 tests with deflector were adjusted to determine the impact

which would occur in the Hatch 2 non-vent bays where deflectors have been installed. The procedure which was approved is described in more detail in Section 3.2.

3 S/RV low-low setpoint relief logic and level 1 MSIV trip setpoint were used to mitigate subsequent actuation induced loads.

4 For multiple valve actuation events, the AC requires absolute summation (ABSS) of the bubble pressure spatial distributions due to single valve actuations. However, an SRSS method was used to combine peak pressure loads in the Hatch (Units 1 & 2) PUAR for multiple valve actuations. The use of the alternate approach was justified by the inherent conservatism in the load definition and by the structural modelling techniques utilized in the analysis. The approach was found acceptable in this present application. A more detailed description of the method is provided in Section 3.3.

5 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. Conformance with the above criteria was indicated in the PUAR. However, the applicant utilized a local pool temperature model that was only recently presented to the staff. It has been concluded that the overall methodology provides a conservative way of computing pool temperature transients for purposes of demonstrating compliance with the provisions of NUREG-0783. Additional information can be found in Section 3.4.

3. Synopsis of the Hatch Request For Information

During the post-implementation audit of the Hatch (Units 1 & 2) plant-unique analysis reports, various issues were identified as either exceptions to the acceptance criteria or as areas where additional informa .un was required. In order to resolve these issues, a request for information was sent to the licensee to obtain supplemental information to the PUAR. An overview of the Hatch (Units 1 & 2) request for information (Reference 6) is presented in Table 2, along with an indication of the type and status of each item. As can be seen from this table, four exceptions to the AC were identified in the Hatch (Units 1 & 2) plant-unique analyses.

A meeting was held on August 31, 1983 in Gaithersburg, Md. for the purpose of resolving the various issues contained in the RFI. The meeting was attended by Georgia Power Company, Southern Company Services, Bechtel Power Corporation, as well as NRC and its consultants. The formal documentation of the material presented at the meeting in response to the RFI is contained in Reference 7. As a result of our review of the Hatch responses, all issues have been resolved. For completeness, a brief description of each exception to the AC and its justification is provided in the following sections. The numbering system of the various items discussed is consistent with the table.

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	Comparison of Hatch T-Quencher with Monticello T-Quencher.		X	X	
2	Provide Justification for Factors Used to Account for Non-uniform Downcomer Flow.		X	X	
3	Drag Coefficient Used for Impact on Internal Cylindrical Structures.		X	X	
4	Description of S/RV Asymmetric Discharge Load Case.		X	X	
5	Clarify Method Used for Maximum S/RVDL and Discharge Device Wall Temperature.		X	X	

TABLE 2 (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	DESCRIBE CONSERVATISM ASSOCIATED WITH USING AN UNDISTURBED POOL ASSUMPTION.		X	X	
7	INCLUSION OF ALL LDR AND AC LOADS IN PUAR.		X	X	
8	TORUS NET VERTICAL LOADS BASED ON SINGLE QSTF TEST.	X		X	
9	DESCRIBE METHOD USED TO DEFINE VENT HEADER AND VENT HEADER DEFLECTED IMPACT LOADS.	X		X	
10	JUSTIFY THE USE OF SRSS FOR MULTIPLE S/RV ACTUATIONS.	X		X	

TABLE 2 (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
11	DESCRIBE THE METHOD USED TO CALCULATE THE LOCAL-TO-BULK TEMPERATURE DIFFERENCE FOR THE VARIOUS S/RV LOAD TRANSIENTS CONSIDERED.	X		X	

3.1 Discussion of Item 8

The acceptance criteria specifies that a minimum of four QSTF tests are to be used as a data base for defining net torus vertical loads at the plant unique normal operating condition (NOC). In addition, margins were imposed upon the mean from these tests to account for the statistical variance of the measurements and to provide for possible three-dimensional effects. The four NOC Hatch 1 QSTF tests were performed with a drywell-to-wetwell pressure differential (Δp) of 1.5 psid, whereas the PUAR states that Hatch Unit 1 will operate with a zero drywell-to-wetwell pressure differential. As a consequence, the only available Hatch 1 QSTF test available to define the net torus vertical loads corresponds to Test 5 which was originally only intended to be used in a structural analysis to demonstrate the capability of the containment assuming loss of Δp control.

The approach used by Hatch 1 to account for the increased uncertainty in the torus loads due to having only one test instead of four in the data base consisted of increasing the margins for both the net vertical upload and download by a factor of two. This factor is based on the fact that the standard deviation is inversely proportional to the square root of the sample number and going from a four test basis to a one test basis decreases the sample size by a factor of four. Therefore, the standard deviation was increased by a factor of two. No margins were required for Hatch 2 since its QSTF data base was obtained at its normal operating condition as specified in the AC.

BNL and its consultants, including those involved in approving the original uncertainty margins for four QSTF tests, reviewed the licensee's arguments and found them acceptable. The conclusion was that the amount of margin increase in both up and down load accounted for the reduced data base in a conservative manner.

3.2 Discussion of Item 9

The AC approved methodology for defining the pool swell impact loads on vent headers or vent header deflectors consists of using QSTF data or a combination of an analytical method in conjunction with QSTF data. The configurations tested in QSTF had a vent header deflector in the Hatch 1 tests and no vent header deflector in the Hatch 2 tests. As a consequence, neither Hatch unit has sufficient QSTF data to enable a direct application of the AC approved LDR procedures since both units utilize vent header deflectors in non-vent bays and no deflectors in the vent bays.

The procedure used in the plant-unique analysis made use of the generic sensitivity tests of Reference (8) which showed that the measured pressures on the vent header vary as the square of the pool impact velocity and that the impact duration is inversely proportional to the impact velocity. Therefore, scaling of the results from one plant to another is accomplished by determining the ratio of the pool impact velocity between the two plants. The required velocity ratios were derived from the generic sensitivity tests (Reference 8) and, in addition, the results were also verified by detailed calculations. Using these velocity ratios, the results from the Hatch 2 tests (no deflector) were adjusted to be representative of Hatch 1 "bare vent" impact data and similarly, the Hatch 1 tests with deflector were adjusted to determine the impact which would occur in the Hatch 2 non-vent bays where deflectors have been installed.

The above alternate approach is considered acceptable since it appears to be a reasonable method for scaling the QSTF results for the Hatch plants and should provide for a conservative pool swell impact load definition for the vent header and vent header deflectors.

3.3 Discussion of Item 10

Section 2.13.3.3 of the Acceptance Criteria specifies that the multiple S/RV actuation loads, at a given location on the torus shell, should be determined by the absolute sum of the peak pressure loads predicted to occur at that location due to each individual S/RV actuation. In addition, if the combined peak torus shell pressure exceeds 1.65 times the local predicted peak bubble pressure due to a single valve actuation, the resultant torus shell peak pressure shall be taken to be the lower value. However, the Hatch plant-unique analyses utilized an alternate procedure whereby the single valve actuation loads were combined by SRSS combination instead of the ABSS method specified in the AC.

A strict application of the AC implies that the licensee's use of SRSS rather than ABSS for the bounding multiple valve SRV design load case (ADS) introduces a non-conservatism estimated to be about 40%. The staff nonetheless finds this approach acceptable for the following reasons:

1) Use of the QBUBBS computer program introduces a margin of at least 20% in terms of a global (spatially integrated) loading on the torus. This conservatism was recognized during the staff's evaluation of the LDR methodology and is discussed in Section 3.10.2.9 of NUREG-0661. Recognition of this margin is also reflected in acceptance criterion Section 2.13.3.2.

2) The QBUBBS model exhibits a strong conservative trend of pressure loads with increasing suppression pool temperature. This was determined during the staff's earlier evaluation and is discussed qualitatively in Section 3.10.2.3 of NUREG-0661. We have quantified this conservatism and have determined that the use of QBUBBS at a pool temperature of 120°F (the design ADS condition) will introduce an additional conservatism of about 13%.

3) The pressure load used by the licensee for the ADS case corresponds to a "worst case" load in terms of the SRV and discharge line parameters. In particular, for unit 1 the peak pressure associated with the longest discharge line is employed for all seven valves. This introduces a significant conservatism since the LDR methodology exhibits a very strong trend of pressure loads with discharge line length (Section 3.10.2.1 of NUREG-0661). We believe that the use of pressure loads associated with the average discharge line length of the seven ADS valves is justified. The conservatism introduced by use of the worst case load has been estimated to be 14% for Hatch unit 1. For unit 2, the line length used for design (line M) is roughly equal to the average and therefore a corresponding 14% margin cannot be claimed in this case.

In addition to the above, we also believe that the various other components of the governing load combination (see load case 3 of Section 4.3 in NUREG-0661), as well as the structural analysis techniques used for determining the S/RV load, possess additional conservatism, although the amount is not easily quantified. Based on these considerations, the use of the SRSS method in the Hatch (Units 1 & 2) PUA is found accetable for combining the loads due to multiple valve actuations.

3.4 Discussion of Item 11

The licensee has provided the results of certain plant-unique analyses used to obtain pool temperature responses to transients involving safety relief valve actuations as required by the AC. Results from these analyses indicate that the plant would be able to operate within the temperature limits specified in NUREG-0783. The licensee's analyses were developed by using a comprehensive computational methodology developed by the General Electric Company. A key element of

this overall methodology is a computer code known as TPOOL which computes local pool temperatures as a function of NSSS, SRV and RHR performance. A description of TPOOL and the procedures used in its development and qualification have only recently been presented to the staff in a series of meetings, the last of which was on August 25, 1983. Based on the information presented at these meetings, the staff and its consultants have concluded that the total methodology which includes TPOOL, provides a conservative way of computing pool temperature transients for purposes of demonstrating compliance with the provisions of NUREG-0783. The staff will issue a report describing TPOOL and the bases for finding the total computational procedure acceptable for use in performing analyses of pool temperature transients involving operation of the S/RV in the second quarter of 1984. Based on our evaluation of the licensee's analyses, we conclude that the assumptions used are reasonably conservative and in agreement with the staff's recommendations set forth in NUREG-0783 and, therefore, are acceptable.

4. Conclusions

The purpose of the post-implementation pool dynamic load audit of the Hatch (Units 1 & 2) plant-unique analysis reports was to verify compliance with the acceptance criteria of NUREG-0661. As a result of the audit, several aspects of the Hatch (Units 1 & 2) plant-unique analysis required additional information. The licensee's response (Reference 7) to the request for information indicates that the pool dynamic load methodologies utilized in the PUAR are in general conformance with the acceptance criteria requirements.

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) "E. I. Hatch Nuclear Plant Units 1 & 2", Georgia Power Company and Southern Company Services, Inc., Revision 0 (prepared by Bechtel Power Corporation), February 1983.*

(6) Attachment to Letter from J. D. Ranlet, BNL, to F. Eltawila, NRC, Subject: Hatch (Units 1 & 2) Request For Information, July 25, 1983.*

(7) Attachment to Letter from J. T. Beckham, Jr., Georgia Power Company, to J. F. Stolz, NRC, Subject: Response to NRC Request For Information, September 16, 1983 (Letter NED-83-478).*

(8) General Electric Company, "Mark I Containment Program Quarter-Scale Pressure Suppression Pool Swell Test Program: LDR Load Tests - Generic Sensitivity, Task Number 5.5.3, Series 1, "General Electric Proprietary Report NEDE-23545-P, December 1978.**