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BWR PROJECTS DEPARTMENT

AUG 3 1976

July 30, 1976

Letter No. 183-205-76

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AUG 03 1976
U.S. NUCLEAR REGULATORY COMMISSION
Mail Section

Director of Nuclear Reactor Regulation
ATTN: Mr. D.B. Vassallo, Chief
Light Water Reactors Branch No. 4
Division of Project Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: MARK III SUPPRESSION POOL DYNAMIC LOADING, 238 NI GESSAR, DOCKET NO. STN-50-447

Dear Mr. Vassallo:

Your July 16, 1976 letter to I.F. Stuart states that the GE statistical approach and methodology are acceptable for establishing safety relief valve (SRV) air clearing loads where a quencher discharge device is installed in the Mark III containment. It is also stated that the design loads for the six cases of SRV operation determined by these methods and presented in Amendment 43 are acceptable for the GESSAR 238 Nuclear Island (NI) application. GE is grateful for the formal acknowledgement from the NRC that there is an acceptable quencher design together with the methodology for establishing design loads for the Mark III containment. You added, however, that even though the NRC staff agrees that the methodology has properly treated all available test data and has been conducted in a conservative manner, the supporting test data could not be applied directly for the Mark III without some extrapolation and therefore verification by in-plant Mark III containment tests will be required. It was indicated that the GESSAR NI application must be amended to reflect a commitment to perform tests of this type before the portion of the Preliminary Design Approval (PDA) condition relating to SRV loads will be removed.

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In the attached "Position on Safety Relief Valve Loads", it is stated that a prototype plant should be selected for each type of containment to be tested. This is interpreted to mean that every Mark III plant with quencher devices will not be required to perform in-plant SRV tests to measure air clearing loads. Since GESSAR only represents the design which can be used by a utility for a construction permit application, GE cannot make this commitment in GESSAR. To make such a commitment places GE in the position of having to commit major portions of a customer's facility to be available for the test. Since this test utilizes equipment and structures outside the control of the General Electric Company, the customer should be involved to a large degree in making the commitment. In this respect, such a commitment would then be properly considered as part of the reference application instead of the standard application.

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It is our understanding that the lead plants with Mark III containments have already made formal commitments to perform in-plant SRV tests to measure air clearing loads. Therefore, as you desire, prototype plants are going to be tested. I am sure that GE will be requested to assist in the planning and performance of the testing already committed. GE will provide the support requested by applicants who have made this SRV test commitment as well as any who do so in the future. For the above reasons, we believe that the PDA condition involving SRV loads should be considered resolved.

The attached position also states that the spacial variation of the quencher loads should be calculated by methods shown in Section 2.4 of Topical Report NEDE-21078. GE feels that it would be more appropriate to refer to the methods presented in Section A.5 and A.10 of GESSAR Appendix 3B. Both documents utilize the same basic formula for determining the pressure distribution along the suppression pool boundary. That is:

$$P(r) = P_B \quad \text{where } r \leq 2r_o$$

$$P(r) = P_B \frac{2r_o}{r} \quad \text{where } r > 2r_o$$

This can be shown by referring to the example calculations in Section 2.6 of NEDE-21078 and in Section A10.3 of GESSAR Appendix 3B. The pressure calculated at the center of S, and at point 10 on the containment wall is 9.76 psid (r_n = 13.5 ft) for the single valve case using the two examples. The information in the GESSAR Appendix 3B is complete in that it identifies how vertical attenuation is treated where NEDE-21078 does not. Also, there are inconsistencies in the examples in NEDE-21078 which, in our opinion, will create unnecessary confusion for the user if applied as a design tool. All other references in the Regulatory Position (Section IV) are to GESSAR Appendix 3B, and therefore, it is recommended that the spacial variation in quencher loads be calculated by the methods in Section A5 and A10 of that document.

Attached to this letter is a marked up version of the attachment to your letter which offers several editorial corrections that we would suggest to improve the document quality and clarify the Staff position. These might also be considered in any future documentation of the Staff position on quencher application.

If you have any questions concerning the information presented, please contact me, J.F. Quirk (extension 2606), or L.J. Sobon (extension 3495).

Very truly yours,

W.H. D'Ardenne for

W.D. Gilbert, Manager
Safety and Standards

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Attachment

ACCEPTANCE CRITERIA FOR QUENCHER LOADS FOR THE MARK III CONTAINMENT

JUL 1 2 1976

I. INTRODUCTION

On September 2, 1975, the General Electric Company submitted topical reports NEDO-11314-08 (nonproprietary) and NEDE-11314-08 (proprietary) entitled, "Information Report Mark III Containment Dynamic Loading Conditions," docketed as Appendix 3-B to the Amendment No. 37 for GESSAR, Docket No. STN-50-447. As part of this report, a device called a "quencher" would be used at the discharge end of safety/relief valve (SRV) lines inside the suppression pool. Tests were performed in a foreign country to obtain quencher load data that were used to establish the Mark III data base. A statistical technique using the test data to predict quencher loads for Mark III containment was also presented. GE had submitted another topical report NEDE-21073 entitled, "Test Results Employed by GE for BWR Containment and Vertical Vent Loads," to substantiate their method to extrapolate the loads obtained from the tests to the Mark III design.

We reviewed the above topical reports and had identified several areas of concern. Meetings with GE were held to discuss these concerns. As a result, GE presented a modified method during the April 2, 1976, meeting held in Bethesda, Maryland. Subsequent to the meeting, this modified method and proposed load criteria were reported in Amendment No. 43, which was received on June 22, 1976. Our evaluation, therefore, is based on the modified method and the load criteria calculated by this method.

II. SUMMARY OF THE METHOD OF QUENCHER LOAD PREDICTION

The statistical method proposed by GE to arrive at design quencher loads for the Mark III containment consists of a series of steps. Initially, a multiple linear regression analysis for the first actuation event is performed with a data base taken from three tests series: mini-scale (9 points), small scale (70 points) and large scale (37 points).

Non-linearities are introduced where necessary by using quadratic variables and formed straight line segments. The regression coefficients are estimated from the appropriate data set. The resulting equation contains a constant term plus corrective terms that take into account the influence of all key parameters.

In the second step, the subsequent actuation effect is determined by postulating a direct proportionality between the observed maximum subsequent actuation pressure and the predicted first actuation pressure. The proportionality constant is found by considering the large-scale data.

In the third step, the total variance of the predicted future SRV subsequent actuation is found by noting that the total variance is the sum of three terms: (1) a term due to the uncertainty in the first actuation prediction which is calculated from standard (normal variate) formulas, (2) a term due to the uncertainty in the proportionality factor as was calculated in the second step above, and (3) a term due to the variance of the residual maximum subsequent pressure. It is now assumed that this variance is proportional to the square of predicted maximum subsequent actuation pressure. The proportionality constant is found from the large scale subsequent actuation data (10 values).

In the fourth step, design values for Mark III are determined from the estimated (i.e., predicted) values of maximum subsequent actuation pressure and its standard deviation by employing standard tables of so-called "tolerance factors." These tables are entered with three quantities: (1) n, the number of sample data points from which the estimate of the mean and standard deviations are obtained. GE has set n = 10, based on 10 maximum subsequent actuation points used in the third step, (2) the probability value, and (3) the confidence level. The design value is then simply the predicted value plus the tolerance factor times the estimated standard deviation.

The approach as outlined above is used to calculate the positive pressures for a single SRV considering multiple actuations which represents the most severe SRV operation condition. For the single actuation case, the calculational procedures are similar with the method mentioned above with the following exceptions:

1. The calculation which involves subsequent actuations is eliminated; and,
2. Thirty-seven data points were selected for establishing the tolerance factor since these data points in the large-scale tests relate to single value actuation.

For negative pressure calculation, a correlation of peak positive and negative pressures is developed. The correlation is based on the principle of conservation of energy and verified by the small-scale and large-scale test results.

Based on the method outlined above, GE has calculated the SRV quencher loads for the Mark III and established the load criteria for six cases of SRV operation. The calculated load criteria based on 95-95% confidence level are given on Table 1 which is attached.

III. EVALUATION SUMMARY

As a result of our review, we have concluded that the statistical method proposed by GE and the ~~load criteria~~ calculated maximum bubble pressures shown on Table 1 are acceptable. This conclusion is based on the following:

1. The method has properly treated all available test data and is based essentially on the large-scale data with correction terms that take into account the influence of non-large-scale variables. Since the large-scale tests were performed in an actual reactor

with a suppression containment conceptually similar with GE containment, extrapolation from the large-scale by statistical technique, therefore, is appropriate and acceptable.

2. The method has been conducted in a conservative manner. The primary conservatisms are:

   a. The calculation is based on the most severe parameters. For example, the maximum air volume initially stored in the line, the maximum initial pool temperature and the highest primary system pressure were selected to establish quencher load criteria.

   b. For the cases of multiple valve actuation, the load criteria are based on the assumption that the maximum pressures resulting from each valve in a pressure setpoint group will occur simultaneously. We believe that the assumption is conservative since different lengths of line and SRV pressure set points will result in the occurrence of maximum pressures at different times and consequently lower loads.

3. The ~~proposed~~ acceptable load criteria~~, which~~ are provided ~~on the attached Table 1, are acceptable.~~ in Section IV. The criteria were established by using 95-95% confidence limit. Our consultant, the Brookhaven National Laboratory, has performed an analysis for the effect of confidence limit. The result of this analysis indicates that for 95-95% confidence limit, approximately 1% of the number of RSV actuations may result in containment loads above the design value. We believe that

this low probability is acceptable considering the conservatism of the method of prediction, i.e., the actual loads should not exceed the design value.

4. With regard to the subsequent actuation, the load criteria are based upon a single SRV actuation. G.E. has established this basis by regrouping the SRV's in each group of pressure set points. As indicated in Amendment 43, there are three groups of pressure set points for the 19 SRV's for the 238-732 standard plant, namely, one SRV at a pressure set point of 1103 psig, 9 SRV's at 1113 psig, and the remaining 9 SRV's at 1123 psig. Only one SRV is now set at the lowest pressure set point. Based on this pressure set point arrangement for the 19 SRV's, GE has analyzed the most severe primary pressure transient, i.e., a turbine trip without bypass. Results of the analysis shows that initiation of reactor isolation will activate all or a portion of the 19 SRV's which will release the stored energy in the primary system. Following the initial blowdown, the energy generated in the primary system consists primarily of decay heat which will cause the lowest set SRV to reopen and reclose (subsequent actuation). The time duration between subsequent actuation was calculated to be a minimum of 62 seconds and increasing with each actuation. The time duration of each blowdown decreases from 51 seconds for the initial blowdown and decreases to 3 seconds at the end of the period of subsequent actuations which is 30 minutes after initiation of

reactor isolation.

The staff finds the result of the GE analysis reasonable. Therefore, the assumption of only the lowest set SRV operating in subsequent actuation is justified and acceptable.

The acceptance of the quencher load criteria is based on the test data available to us. We realize, however, that the tests lack exact dynamic or geometric similarity with the quencher system for the Mark III containment. The test results, therefore, could not be applied directly. Though the quencher loads for the Mark III appear conservative in comparison with the test data, some degree of uncertainty is acknowledged. The uncertainty is primarily due to a substantial degree of scatter of all test data. We therefore will require in-plant testing.

IV. REGULATORY POSITION

It is our position that applicants for Mark III containments using the quencher device commit to the criteria specified below:

1. The structures affected by the SRV operation should be designed to withstand the ~~maximum~~ loads determined from the methods shown in Section A5 and A10 of GESSAR Appendix 3B using the maximum pressures specified in Table 1. For the cases of multiple valve actuation, the quencher loads from each line shall be assumed to reach the peak pressure simultaneously and oscillate in phase.

2. The quencher ~~loads as~~ bubble pressure specified in Item 1 above are for a particular quencher configuration shown in ~~the topical reports NEDO-11314-08 and NEDE-11314-08.~~ GESSAR Appendix 3B. Since the quencher loads are sensitive to and dependent upon the parameters of quencher configuration, the following requirements should be met:

   a. the sparger configuration and hole pattern should be identical with that specified in Section A7.2.2.4 ~~of NEDE-11314-08.~~

   b. The value of key parameters should be equal to or less than that specified below:

Total air volume in each SRV line (ft^3)	56.13
Distance from the center of quencher to the pool surface at high water level	13'-11"
Maximum pool temperature during normal plant operation (°F)	100

   c. The value of those key parameters should be equal to or larger than that specified below:

Water surface area per quencher (ft^2)	295
SRV opening time (sec)	0.020

3. The spatial variation of the quencher loads should be calculated by the methods shown in Section ~~2.4 of the topical report NEDE-21078.~~ A5 and A10 of GESSAR Appendix 3B

4. The load profile and associated time histories specified in Figure A5.11 of ~~NEDO-11314-08~~ of GESSAR Appendix 3B should be used with a quencher load frequency of 5 to 11 Hz.

5. For the 40 year plant life, the number of fatigue cycles for the design of the structures affected by the quencher loads should not be less than that specified in Section A9.0 of GESSAR Appendix 3B. ~~NEDO-11314-08~~.

6. In-plant testing of the quencher should be conducted to verify the quencher design loads and oscillatory frequency. The in-plant tests should include the following:

   a. single valve actuation;

   b. consecutive actuation of the same valve; and,

   c. actuation of multiple valves.

   Included should be measurements of pressure load, stress, and strain of affected structures. A prototypical plant should be selected for each type of containment structure. For example, the pressure responses from a concrete containment should not be used for a free-standing steel containment and vice versa. Tests should be conducted as soon as operational conditions allow and should be performed prior to full power operation.

7. Based on the in-plant test results, reanalyses should be performed to ensure the safety margin for the structures, which include the containment wall, basemat, drywell wall, submerged structures inside the suppression pool, quencher supports and components influenced by S/R loads. If the analysis indicates that the safety margin for the structures will be reduced because of the

new loads identified from the test, modification or strengthening of the structures should be made in order to maintain the safety margin for which the structures were originally designed. The applicants for the Mark III containment with quenchers for S/R valves should submit a licensing topical report for approval. This report should present a test program and identify the feasibility of modification or strengthening of the structures.

TABLE 1

QUENCHER BUBBLE PRESSURE MARK III, 238 STANDARD PLANT *

95-95% CONFIDENCE LEVEL

Case Description	Design Value Maximum Pressure (psid) P_B (+)	P_B (-)
1. Single Valve First Actuation, at 100°F Pool Temperature	13.5	-8.1
2. Single Valve Subsequent Actuation, at 120°F Pool Temperature	28.2	-12.0
3. Two Adjacent Valves First Actuation at 100°F Pool Temperature	13.5	-8.1
4. 10 Valves (One Low Set and Nine Next Level Low Set) First Actuation at 100°F Pool Temperature	16.7	-9.3
5. 19 Valves (All Valve Case) First Actuation, at 100°F Pool Temperature	18.6	-9.9
6. 8 ADS Valves First Actuation at 120°F Pool Temperature	17.4	-10.4

* The spacial variation of the loads on the structures affected by the quencher bubble pressure should be determined using the methods presented in Section A.5 and A.10 of GESSAR Appendix 3B.