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

November 4, 1982

TO BWR APPLICANTS WITH MARK II OR III CONTAINMENT (EXCEPT WPPSSII)

SUBJECT: SAFETY/RELIEF VALVE QUENCHER LOADS:
EVALUATION FOR BWR
MARK II AND III CONTAINMENTS
(Generic Letter No. 82-24)

Enclosed is a copy of NUREG-0802, "Safety/Relief Valve Quencher Loads: Evaluation for BWR Mark II and III Containments." NUREG-0802 is being issued to provide acceptance criteria for hydrodynamic loads on piping, equipment, and containment structures resulting from SRV actuation. The NRC staff finds that use of these acceptance criteria satisfy the requirements of General Design Criteria 16 and 29 in Appendix A to 10 CFR Part 50. NUREG-0802, however, is not a subsititute for the regulations, and compliance with the NUREG is not a requirement. An approach or method different from the acceptance criteria contained herein will be accepted if the substitute approach or method provides a basis for determining that the regulations have been met.

The NRC had issued SRV load acceptance criteria for both Mark II (NUREG-0487, Supplement No. 1, September 1980) and Mark III (SER for GESSAR, July 1976). However, the staff, the Mark II Owners Group and GE recognized that these criteria were very conservative because they were established at the early stage of quencher development. Since then, extensive quencher test programs were performed resulting in a sufficient data base to justify re-evaluation the SRV load criteria. In response to the request by the Mark II Owners Group and GE, the staff has re-evaluated the SRV loads and established the new acceptance criteria in NUREG-0802. The staff also finds the earlier criteria acceptable. The acceptance criteria in NUREG-0487 supplement No. 1 (for Mark II plants) or the acceptance criteria in an attachment 2 (for Mark III plants) are conservative with respect to the acceptance criteria proposed in Appendices A and B of NUREG-0802, respectively and they are acceptable.

The reporting and/or recordkeeping requirements contained in this letter affect fewer than ten respondents; therefore, OMB clearance is not required under P.L. 96-511.

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Enclosure:
NUREG-0802
Attachments 1 & 2

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ACCEPTANCE CRITERIA FOR QUENCHER LOADS FOR THE MARK III CONTAINMENT

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-21078 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.

T'e 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 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 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 load criteria, which are provided on the attached Table 1, are acceptable. 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[1] 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 operatir 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 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 specified in Item I above are for a particular quencher configuration shown in the topical reports NEDO-11314-08 and NEDE-11314-08. 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 <u>equal to or less than</u> 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 <u>equal to or larger than</u> 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 ..4 of the topical report NEDE-21078.

4. The load profile and associated time histories specified in Figure A5.11 of NEDO-113/4-08 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 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