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November 1, 1977

Mr. Donald K. Davis, Acting Chief
Operating Reactors - Branch 2
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad-Cities Station Units 1 and 2
Evaluation of the Consequence of a
Multiple Subsequent Relief Valve
Discharge on the Mark I Containments
NRC Docket Nos. 50-237/249 and 50-254/265

Dear Mr. Davis:

Enclosed is Commonwealth Edison's evaluation of the potential for and consequence of simultaneous subsequent actuations of multiple relief valves on the torus and torus support system on the Mark I Containments at Dresden and Quad-Cities Stations. This transmittal fulfills the NRC Staff request made at the October 27, 1977 meeting with General Electric and the Mark I Owners Group.

One (1) signed original and 59 copies of this letter are provided for your use.

Very truly yours,

R. L. Bolger

R. L. Bolger
Assistant Vice President

Attachment

EVALUATION OF SUBSEQUENT
SAFETY/RELIEF VALVE ACTUATIONS

The purpose of this transmittal is to report the Commonwealth Edison evaluation of the potential for and consequence of simultaneous subsequent actuations of multiple relief valves on the torus and torus support system on the Mark I Containments at Dresden and Quad-Cities Stations. Provided below is a brief history of the events that have occurred during October, 1977, relative to this issue. This history includes a summary of the report made by General Electric (GE) and the Mark I Owners at the meeting with the Nuclear Regulatory Commission (NRC) Staff on October 27, 1977, as well as the independent evaluation of this issue made by Commonwealth Edison.

The results presented herein have led Commonwealth Edison to the conclusion that the relief valve event determined to be applicable to the Dresden and Quad-Cities Units poses no threat to the integrity of the primary containment boundary. This conclusion is supported by a design basis transient analysis that indicates that the simultaneous subsequent actuation of no more than three (3) valves will occur, as well as operating experience that provides no indication of any deleterious effects from actual vessel isolation transients. Because this evaluation demonstrates that containment integrity is maintained with no resultant effect on public health or safety, the continued operation of Dresden Units 2 and 3 and Quad-Cities Units 1 and 2, is justified.

Moreover, Commonwealth Edison shall within sixty (60) days of the date of this letter implement a relief valve setpoint change that will limit to one (1) the number of valves predicted by system transient analysis to undergo subsequent actuation. This action precludes the occurrence of simultaneous subsequent actuations of multiple relief valves.

Historical Background

Recent investigations by General Electric Company (GE) have resulted in the recognition that for the currently documented system characteristics of the BWR/6 (GESSAR 238) more than one safety/relief valve (SRV) may reopen after the initial pressure transient from the design basis transient isolation event. During discussions with the NRC Staff on this matter on October 6 and 7, 1977, GE was requested to include in the initial report (Reference 1) a preliminary assessment of the impact of multiple subsequent SRV discharges on Mark I Containments. For this preliminary assessment of the Mark I Containments presented in Reference 1, the Monticello plant was used as being typical. This allowed a quick evaluation because extensive data is available for the Monticello plant from the 1976 SRV discharge testing at that station. The result of that assessment as documented in Reference 1 was that the Mark I Short Term Program (STP) acceptance criteria (Reference 2) was satisfied.

Subsequent to the October 11 report (Reference 1), GE, on behalf of the Mark I Owners Group, conducted further evaluations on a plant unique basis. These evaluations have been based upon analytical procedures which adjust the Monticello test results to account for individual plant characteristics. The results of these plant unique evaluations were presented to the NRC Staff on October 27, 1977. The evaluations for the Quad-Cities Units 1 and 2 and Dresden Units 2 and 3 Containments indicated that the STP acceptance criteria is satisfied. This letter further reinforces that conclusion by presenting the results of an independently conducted, more conservative evaluation.

Technical Evaluation

Based on the information presented to the NRC Staff by GE in the October 27 meeting, the highest strength ratio for Quad-Cities Units 1 and 2 was 0.40 and for Dresden Units 2 and 3, 0.41. The maximum shell stresses were reported as 8.3 ksi and 9.5 ksi for Dresden and Quad-Cities, respectively. The details of the methods used by GE were presented in the October 27 meeting and will, therefore, not be repeated in this letter. However, Commonwealth Edison has conducted an evaluation in parallel with that conducted by GE on behalf of the Mark I Owners Group, which includes some additional conservatism in those areas where the NRC Staff expressed concern in the October 27 meeting. The details of that evaluation are presented in Attachment A for Dresden Units 2 and 3 and in Attachment B for Quad-Cities Units 1 and 2. As shown in Attachments A and B, even with the additional conservatisms the STP criteria are satisfied.

In order to establish the number of relief valves with the potential for simultaneous subsequent actuation a plant specific run of the GE transient computer code was made. This effort resulted in a prediction of a theoretical maximum of three valves for the second actuation on the Dresden and Quad-Cities Units. Therefore, the evaluation presented in Attachments A and B was made for the three valve case. These plant specific transient predictions are judged to be conservative because: 1) startup data compiled by GE on operating BWR's indicates that the transient code over-predicts the number of valves actuating, and 2) operating experience on the Dresden and Quad-Cities Units has revealed no occurrence involving as many as three valves in subsequent actuations.

In addition to the transient analysis which indicated actuation of three valves with the current valve setpoint arrangement (5 valves total, valve A at 1125 psi, valves B and C at 1130 psi, valves D and E at 1135 psi), GE conducted parametric studies to determine setpoint arrangements such that subsequent actuation could be limited to no more than one valve. The optimum arrangement has been determined to consist of a reduction in the relief pressure setpoint of valve A to 1115 psi. This modification in setpoint arrangement results in a prediction by the transient code of only one valve (valve A) lifting in a subsequent actuation. Commonwealth Edison will implement this setpoint change on Quad-Cities Units 1 and 2 and Dresden Unit 3 within 60 days. Dresden Unit 2 will implement the setpoint change prior to the rise to power from the current refueling outage.

<u>Summary</u>

In summary, it has been determined on the basis of design basis transient analyses applicable to Dresden Units 2 and 3 and Quad-Cities Units 1 and 2, that the simultaneous second actuation of relief valves is limited to only three valves. For this three valve design case, the criteria established as a part of the Mark I Containment Short Term Program are satisfied. Furthermore, Commonwealth Edison shall within sixty (60) days of the date of this letter implement a relief valve setpoint change that will limit to one (1) the number of valves predicted to undergo subsequent actuation. Since the one valve case is less severe than the three valve case for which the technical basis is provided in Attachments A and B, a structural assessment will not be documented for the one (1) valve case. Moreover, it has been concluded on the basis of the three valve case that containment integrity is maintained within margins approved as a part of the Mark I Containment Program. The continued operation of Dresden Units 2 and 3, and Quad-Cities Units 1 and 2, is justified, therefore, because the relief valve subsequent actuation loads do not exceed approved acceptance criteria and have no deleterious effect on the health or safety of the public. For these reasons, it is the judgment of Commonwealth Edison that no additional short term action is required.

References: 1 - Glenn G. Sherwood (GE) letter to Norman C. Mosely (NRC), dated October 11, 1977. Subject: Reportable Condition under 10 CFR 21. Attachment: Five page report entitled, "Potential Reportable Condition Relief Valve Control System".

2 - Appendix A, entitled, "Computation of Structural Element Capacity", of Mark I STP report (NUTECH report No. MK1-02-012) entitled, "Description of Short Term Program Plant Unique Torus Support Systems and Attached Piping Analysis", Revision 2, dated June 1976.

Attachment A

DRESDEN UNITS 2 AND 3
EVALUATION OF THREE VALVE SIMULTANEOUS SEQUENTIAL SRV ACTUATION

Actuating Valves (three total)

Valve A - relief set pressure = 1125 psi
(azimuth = 22.5° Dresden 2 & 3)

Valve B - relief set pressure = 1130 psi
(azimuth = 112.5° Dresden 2 & 3)

Valve C - relief set pressure = 1130 psi
(azimuth = 292.5° Dresden 2,
247.5° Dresden 3)

Maximum Torus Support Column Compression Loads

Outside column = 527 (SRV) + 298 (dead weight water and steel) + 64 (seismic) = 889 kips

Inside column = 414 + 248 + 47 = 709 kips

The SRV column loads given above are for three valves (A, B, and C) simultaneous second pop. They are derived by extrapolation of Monticello SRV test results. Column load due to the multiple valve actuation are computed by assuming that loads from individual valves add directly (SRSS not used). The "hot pop" factor used is 2.02 and has been derived from Monticello test data by computing the average hot pop factor and adding one standard deviation. The "plant unique factor" to convert Monticello test results to Dresden plant are those developed by GE and are based on analytical models of the SRV clearing event and an integration of the resulting pressures of the torus wetted surface.

Torus Up-Lift Potential

Dresden 2 and 3 have pin connections at the base of the torus support columns which provide restraint against uplift. Therefore, forces on the column due to the negative pressure phase of the SRV loading function can be computed by the same method used for compressive loads. As in the case of column compression, direct addition is used for multi-valve effect. Hot pop factor for upward load phase (average plus one standard deviation) is 1.60.

Outside column = + 264 (upward due to SRV) - 298 (downward dead weight) = -34 kips (compression)

Inside column = + 207 - 248 = -41 kips (compression)

As seen from the above, tension forces do not develop in the torus support columns, therefore, torus uplift is of no concern.

Maximum Torus Shell Membrane Stress

Monticello outside fiber shell stress at mid bay, 45^{o} up from bottom of torus of 3.4 ksi for a single cold pop in the test bay is multiplied by the following factors to obtain the estimated maximum clean shell membrane stress for the Dresden torus for 3 simultaneous subsequent actuations.

$F_1 = 1.49$ = Highest observed ratio of stress at the bottom of the shell to stress 45^{o} up, from Pilgrim SRV test. (Data to compute this ratio is not available from Monticello test)

$F_2 = 2.9$ = Highest observed ratio of stress intensity at mid bay 45^{o} due to subsequent actuation to stress intensity due to cold pop. (i.e., hot pop factor)

$F_3 = 1.71$ = Multi-valve factor derived by direct addition of effects of individual valve actuations.

$F_4 = 0.97$ = Ratio of diameter-to-thickness ratio for the Dresden torus shell to the diameter-to-thickness ratio for the Monticello torus shell.

$F_5 = 1.087$ = Dresden plant unique factor as determined by GE.

Therefore, the maximum shell membrane stress at mid bay is conservatively estimated to be:

$$3.4 \times 1.49 \times 2.9 \times 1.71 \times 0.97 \times 1.087 = 26 \text{ ksi}$$

Strength Ratios

Outside Torus Support Column	:	889/3300 = 0.27
Inside Torus Support Column	:	709/3000 = 0.24
Outside Column-to-Shell Connection	:	889/4051 = 0.22
Inside Column-to-Shell Connection	:	709/3463 = 0.20
Outside Column Pin Connection	:	889/1970 = 0.45
Inside Column Pin Connection	:	709/2513 = 0.28

QUAD-CITIES UNITS 1 AND 2
EVALUATION OF THREE VALVE SIMULTANEOUS SEQUENTIAL SRV ACTUATION

Actuating Valves (three total)

Valve A - relief set pressure = 1125 psi
(azimuth = 22.5° Quad-Cities 1 and 2)

Valve B - relief set pressure = 1130 psi
(azimuth = 112.5° Quad-Cities 1 and 2)

Valve C - relief set pressure = 1130 psi
(azimuth = 292.5° Quad 2, 247.5° Quad 1)

Maximum Torus Support Column Compression Loads

Outside column = 598 (SRV) + 287 (dead weight water and steel) + 74 (seismic) = 959 kips

Inside column = 470 + 241 + 56 = 767 kips

The SRV column loads given above are for three valves (A, B, and C) simultaneous second pop. They are derived by extrapolation of Monticello SRV test results. Column load due to the multiple valve actuation are computed by assuming that loads from individual valves add directly (SRSS not used). The "hot pop" factor used is 2.02 and has been derived from Monticello test data by computing the average hot pop factor and adding one standard deviation. The "plant unique factor" to convert Monticello test results to Quad-Cities plant are those developed by GE and are based on analytical models of the SRV clearing event and an integration of the resulting pressures of the torus wetted surface.

Torus Up-Lift Potential

The connection at the base of the torus support columns for Quad-Cities provide no resistance to upward displacement of the column base plate. An evaluation for uplift potential similar to that presented in Attachment A for Dresden would indicate a tendency for a tension force of approximately 13 kips to develop in the outside column. The inside column remains in compression through the negative pressure phase of the loading. However, since the outside column indicated net tension, the single degree of freedom up-lift model was used to confirm that torus up-lift is of no concern for the SRV three valve hot pop loading. The single degree of freedom model predicts uplifts for the three valve hot pop case less than those reported in the short term program for pool swell. Therefore, it can be concluded that torus up-lift is within STP acceptance criteria.

<u>Maximum Torus Shell Membrane Stress</u>

Monticello outside fiber shell stress at mid bay, 45° up from bottom of torus of 3.4 ksi for a single cold pop in the test bay is multiplied by the following factors to obtain the estimated maximum clean shell membrane stress for the Quad-Cities torus for 3 simultaneous subsequent actuations.

$F_1 = 1.49$ = Highest observed ratio of stress at the bottom of the shell to stress 45° up, from Pilgrim SRV test. (Data to compute this ratio is not available from Monticello test)

$F_2 = 2.9$ = Highest observed ratio of stress intensity at mid bay 45° due to subsequent actuation to stress intensity due to cold pop. (i.e., hot pop factor)

$F_3 = 1.71$ = Multi-valve factor derived by direct addition of effects of individual valve actuations.

$F_4 = 0.98$ = Ratio of diameter-to-thickness ratio for the Quad-Cities torus shell to the diameter-to-thickness ratio for the Monticello torus shell.

$F_5 = 1.234$ = Quad-Cities plant unique factor as determined by GE.

Therefore, the maximum shell membrane stress at mid bay is conservatively estimated to be:

$$3.4 \times 1.49 \times 2.9 \times 1.71 \times 0.98 \times 1.234 = 30 \text{ ksi}$$

Strength Ratios

Outside Torus Support Column	:	959/2386 = 0.40
Inside Torus Support Column	:	767/2386 = 0.32
Outside Column-to-Shell Connection	:	959/2165 = 0.44
Inside Column-to-Shell Connection	:	767/2165 = 0.35