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SUBJECT: Requests exemption from GDC-4 at postulated pipe rupture locations in reactor recirculation sys. Argument supporting request presented. Related info including MPR Assoc, Inc rept on leak before break analyses encl.

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OCT 17 1986

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Project Director
BWR Project Directorate No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington DC 20555

SUSQUEHANNA STEAM ELECTRIC STATION
POSTULATED PIPE RUPTURES
FILE R-26, R41-2 PLA-2744

Docket Nos. 50-387
50-388

Dear Ms. Adensam:

PP&L has discovered that for postulated double ended guillotine breaks (DEGB's) at certain weld locations in the reactor recirculation system piping of both units of the Susquehanna Steam Electric Station, the resultant jet impingement threatens the capability of certain containment isolation valves to perform their design safety function in what would appear to be a deviation from 10CFR50, Appendix A, General Design Criterion 4 (GDC-4). In response to this discovery, PP&L has performed leak-before-break (LBB) analyses of the welds in question and has determined that DEGB's at these locations are not credible events and therefore PP&L is in compliance with GDC-4. The purpose of this letter is to present all of the facts and arguments concerning this situation. In accordance with 10CFR50.12 and previously established precedent, PP&L is requesting an exemption to GDC-4 at these specific locations. PP&L has provided to NRC I&E Region I justifications for continued operation of the units.

History and Background

During the initial design phase of Susquehanna, analyses were performed by General Electric and Bechtel which indicated no adverse effects to any safety related equipment from postulated breaks at the terminal end pipe-to-safe-end welds in the reactor recirculation system piping. Later in the design phase GE informed PP&L that although their initial assessment indicated no threat to the inboard main steam isolation valves (MSIV's), they had not included the miscellaneous hardware associated with the valves such as limit switches, conduit, etc., in their assessment. PP&L then directed that Bechtel make this assessment. Bechtel performed an analysis which concluded that not only would the miscellaneous hardware not fail as a result of the postulated breaks, it would not even be inside the jet affected zones. In a routine check of the Bechtel analysis, PP&L discovered that the modeling used was incorrect.

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Subsequent reanalysis by PP&L indicated that the miscellaneous hardware was indeed inside the jet affected zones and may be subject to failure.

Attachments 1, 2, and 3 are sketches from the Bechtel calculation for postulated breaks at the N1A, N2K, and N2A nozzle locations, respectively. In this calculation they made several incorrect assumptions and conclusions: 1) That the shadow zones resulting from the broken pipes would envelop the MSIV's closest to the break centerline, 2) that the MSIV's outside the shadowed zones were also outside the jet zones of influence, 3) that the bio-shield doors would have no influence on the jets and finally 4) that the MSIV's were not jet impingement targets. This calculation seems to contradict an earlier analysis where Bechtel concluded that the MSIV's were targets and the jet pressure at the MSIV's was 11 psi.

The combination of assumptions of a "shadowed region behind the broken pipe" and that the outer valves are "not within the jet zone of influence" taken together are not logical since it would follow that there is no area in front of the nozzles where a jet exists. Additionally, they implied that a conical shaped jet was assumed. Since the separations at the breaks are less than one half the pipe diameters, the correct jet shapes should have been fans with their planes perpendicular to the pipe centerlines as described in Section 7.2 of ANSI/ANS-58.2-1980. If the correct fan shaped jets had been assumed, the assumption that the bio-shield doors have no influence on the jets was also incorrect since the breaks are located inside the bio-shield doors where a fan shaped jet would immediately impact the inside diameters of the doors. (Attachments 4 and 5 are detailed sketches of the postulated break at the N1A nozzle. Although the dimensions are different at the N2 nozzles, the relative sizes and positioning in the shield doors are essentially the same.)

A subsequent PP&L reanalysis was performed on the N1A nozzle location employing the fan shaped jet impacting the bio-shield door I.D. It was assumed that the door remained in place and the mirror insulation was blown away. It was also assumed that, considering the jet having to split on impact with the door, half of the flow would go inward toward the reactor-to-shield-wall annulus and half would go outward toward the MSIV's. Additionally, it was assumed that the half going outward would exit the annulus between the broken pipe and the shield door I.D. and would then behave as a steam/water jet exiting an open ended pipe. Calculations were performed using this model which yielded jet pressures ranging between 4.5 and 7.3 psi at various locations on the MSIV's. This was found to be sufficient to cause failure of several miscellaneous hardware items relating to MSIV position indication and logic permissives for the operation of the MSIV leakage control system. Nonconformance Reports (NCR's) were written at this time and modifications to the design of the miscellaneous hardware were initiated.

Early in the jet reanalysis, MPR Associates, Inc., was contracted to provide expert assistance. Their input allowed PP&L to perform a more refined flow field calculation which had the effect of narrowing the area affected by the jet to the two innermost inboard MSIV's and raising the jet pressure to 36.1 psi (see Attachment 6). At this point, the integrity of the MSIV operators was considered "indeterminant" and NCR's were written accordingly. Analysis of the MSIV integrity was performed by PP&L, and GE was contracted to also

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perform a reanalysis of the valves. Both analyses indicated that the valve operators would fail (at 17.8 psi per PP&L, at 10 psi per GE). The NCR's were revised appropriately.

During this period, concern was also raised for the other locations where the configurations of the piping and bio-shield doors were similar. Walkdowns were performed in both units to identify other safety related potential targets at these locations. These walkdowns identified four additional nozzle locations potentially threatening five additional containment isolation valves in each unit. Detailed fluid flow and integrity analyses were not done at these locations because it was felt a leak-before-break analysis being considered as a solution at the N1A nozzle would envelop these additional locations, making fluid flow and integrity analyses unnecessary. NCR's were written on these other locations because of their "indeterminant" status.

All of the NCR's were dispositioned "use-as-is" until a LBB analysis could be completed based on the inspections that had been performed on the welds, the extremely low probability of failure in the time required to do the LBB analysis, the IGSCC mitigation measures that had been performed, the systemic mitigation effects for the postulated breaks, and the expectation that LBB would be successful. These positions are expanded upon in later paragraphs.

Upon confirmation that the A and D inboard MSIV's would fail, PP&L engineers met with NRC resident inspectors to describe the situation, the mitigating circumstances, and our intended resolution with LBB. MPR Associates, Inc., having successfully performed such an analysis at another BWR, was contracted to perform the analysis for Susquehanna. This analysis was recently successfully completed and forms the foundation of our request for exemption from GDC-4.

Break And Target Locations

The postulated pipe-to-safe-end break locations and the corresponding threatened containment isolation valves are listed in the following table (Attachments 7 and 8 show the locations of the N2 nozzle postulated breaks and targets in Unit 1 and Unit 2, respectively):

Unit	Nozzle No.	Potentially Threatened Valves	Comments
1	N1A	MSIV's B21-HV1F022A & HV1F022D	Confirmed
	N2A	MSIV's B21-HV1F022A & HV1F022B	Indeterminate
	N2B	RWCU Isol. Vlv. G33-HV1F001	Indeterminate
	N2E	Chilled Water Isol Vlvs. HV-18792A1&A2	Indeterminate
	N2K	MSIV's B21-HV1F022C & HV1F022D	Indeterminate
2	N1A	MSIV's B21-HV2F022A & HV2F022D	Confirmed
	N2A	MSIV's B21-HV2F022A & HV2F022B	Indeterminate
	N2E	Chilled Water Vlvs. HV-28792A1&A2	Indeterminate
	N2J	RWCU Isol. Vlv. G33-HV2F001	Indeterminate
	N2K	MSIV's B21-HV2F022C & HV2F022D	Indeterminate

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Resolutions Considered

Three separate resolutions have been considered as our understanding of this situation has evolved: 1) Through refinements in analysis, show that the jet condition at the target is less than that required to damage the target and/or show that the integrity of the target is sufficient to withstand the given jet forces, 2) design and install hardware that would deflect or dissipate the jets and/or harden the targets to withstand the jet forces, or 3) perform a leak-before-break analysis to show that the postulated breaks were not credible.

These resolutions were pursued at the N1A nozzle first since it was the worst case, and the resolutions would likely envelope the problems at the other locations.

The first resolution, jet and valve integrity analyses, was attempted unsuccessfully. These analyses showed such a large disparity between the valve capability and the jet pressure, that further pursuit of this approach was not likely to produce a solution.

In parallel with these analyses, design modifications were looked at conceptually. These included jet deflectors at the source, jet barriers at the targets, target reinforcements, and combinations of these. It became very apparent early on that any of these modifications would involve considerable cost and radiation exposure both for initial installation and for subsequent maintenance and inspection activities. Additionally, because of the congestion in this area, jets could not be deflected without potentially threatening other safety related targets.

For the simplest modifications considered, minimum conservatively estimated installations costs would be approximately $165,000 in 1986 dollars per nozzle at the N1A location. This is for a conceptual design that is not fully developed and that if upon further development would be found to be unworkable, would dictate going to more massive structures which would be expected to be several times more costly. Additionally, considerable costs would also be incurred over the life of the plant due to increased interference with maintenance and inspection activities that are routinely carried out in this area.

The increased radiation exposure that was calculated for this simplest of modifications was in the range of 42 to 53 man-REM per nozzle at the N1A location for initial installation and 67 to 111 man-REM total for subsequent removal and reinstallation of the deflectors that would be required for all ISI inspections over the remaining life of both units assuming the present inspection schedules. As with the case of costs, the associated radiation exposure would be expected to increase if more massive or complex designs were found to be required.

Similar costs and radiation exposure levels would be expected for modifications at each of the N2 nozzles, potentially amounting to a total cost of approximately $1,650,000 and a total radiation exposure of as much as 1640 man-REM for little or no gain in safety. As a result, design modifications

were judged to be impractical and counter to the concepts of maintaining personnel radiation exposure as low as reasonably achievable if another alternative solution were available. Leak-before-break has proven to be this alternative solution.

Leak-Before-Break-Analysis

Performance of Leak-Before-Break analyses was the final alternative pursued. NRC guidelines had been published in NUREG 1061, Volume 3, GDC-4 had been modified to allow LBB in PWR's and was being considered by the NRC for all high energy lines in all commercial nuclear power plants, and precedent had been established in BWR's with LBB being used as justification for interim operation where cracks had been found in recirculation piping welds and in at least one similar case where a postulated line break was found to threaten safety related equipment. In reviewing the NRC guidelines for selecting postulated rupture locations set forth in NUREG-0800, Standard Review Plan, Branch Technical Position MEB 3-1, Section B.1.c (1), we found that "breaks in Class 1 piping (ASME Code, Section III) should be postulated ... at terminal ends" implying that such postulation was not mandatory if such breaks could be shown to be not credible. We, therefore, judged LBB to be a potentially viable alternative for meeting the requirements of GDC-4.

The LBB analyses were performed by MPR Associates, Inc., for all of the welds in question.

Attachment 9 is a report of the analyses performed. This report shows that not only do we meet all of the primary and alternative criteria of NUREG 1061, Volume 3, but that in most cases these criteria are exceeded by very large margins. Additionally, at each juncture of the analyses, very conservative material properties or modeling assumptions were made.

These analyses show that postulated through-wall flaws that would leak at a rate readily detectable by installed leak detection equipment can be accommodated with substantial safety margin against unstable rupture or plastic collapse of the piping. Such flaws would be detected, and corrective action would be taken well before any risk of a DEGB. Therefore, such a break is not considered a credible event at these locations.

Other Supporting Considerations

Inspections and IGSCC Mitigations

Although the leak-before-break analyses assume a postulated through-wall flaw, each of the welds in question has been inspected, some several times, to insure that flaws even considerably smaller do not exist. Additionally, as described in Section 5 of the report, procedures have been applied at each of the welds to mitigate against the effects of Intergranular Stress Corrosion Cracking (IGSCC). At the N1 nozzles Induction Heat Stress Improvement (IHSI) has been performed, and at the N2 nozzles, the safe ends have been replaced with corrosion resistant material, and the piping has been clad with corrosion resistant material. Attachment 10 is a listing of all the welds and the procedures and

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inspections that have been performed and are planned over the next ten year cycle. Together, these procedures and inspections provide excellent assurance of the integrity of the welds and virtually preclude the development of small cracks, much less such cracks as the ones shown to be safe in the LBB analyses.

Probability Considerations

Even before leak-before-break analyses were applied to these welds, the probability of a large LOCA at one of these locations was estimated to be very low. Such an event would have to be accompanied by a simultaneous failure of one of the corresponding outboard valves (also a very low probability) to produce a situation not described in the FSAR. The combined probability is most severe at nozzles where one motor operated inboard containment isolation valve is threatened and the corresponding outboard isolation valve is also motor operated. In these cases, the combined failure probability is as follows:

Large LOCA probability	=	6.8×10^{-5}/year
MOV failure probability per demand	=	5.6×10^{-3}
Number of MOV outboard valves	=	1
Combined failure probability	=	3.8×10^{-7}/year

At break locations where two air operated inboard valves are threatened and the corresponding outboard isolation valves are also air operated, the combined failure probability is reduced to:

Large LOCA probability	=	6.8×10^{-5}/year
Air operated valve failure probability/demand	=	2.3×10^{-3}
Number of air operated outboard valves/threat	=	2
Combined failure probability	=	3.1×10^{-7}/year

It is therefore concluded that even before LBB considerations, the combined probability of a DEGB at one of the locations in question, combined with a failure of the impacted inboard isolation valves, combined with the random failure of one of the corresponding outboard valves is virtually nonexistent.

Systemic Considerations

Three piping systems which penetrate the primary containment could potentially be affected by the postulated breaks - the main steam system, the reactor water cleanup system, and the reactor building chilled water system. All three of these systems are closed and could reasonably be expected to maintain their integrity post-LOCA, thereby, effectively forming an additional containment boundary. In addition, both the reactor water cleanup system and the reactor building chilled water system are entirely within the reactor building secondary containment. Any leakage from either system would therefore be processed by the standby gas treatment system.

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It should also be noted that the initiating events have been evaluated for their effects on the reactor system. These effects, when conservatively modeled, yield Peak Cladding Temperatures (PCT) of less than 2200°F which produce no significant fuel damage and therefore provide no inventory of radioisotopes for release. However should core damage occur recent, post TMI studies of water moderated reactors, such as SSES, confirm that radioisotopes of significant concern such as Iodine and Cesium can be expected to remain in solution or to plate out on available surfaces to a much higher degree than normally assumed in environmental release calculations. Therefore, it would be expected that releases would be much less than predicted if standard conservative release analyses were performed.

Summary and Conclusions

Through prudent checking of engineering work provided by its contractors, PP&L has discovered threats not previously known to exist to containment isolation valves from postulated pipe ruptures. The ramifications of these discoveries and potential resolutions have been thoroughly considered. PP&L has determined that even not considering the final resolution, the rigorous inspections that have been performed, the low probability of simultaneous independent failures, and the mitigating effects of the system configurations virtually preclude any adverse effects from these discoveries in the time required to generate a final resolution.

The final resolution has been to perform leak-before-break analyses at the postulated break locations in question. Through these analyses, we have shown that double-ended-guillotine-breaks at these locations are not credible events. All other possible alternatives have been considered, resulting in undue hardship and excessive personnel exposure with uncertain results. Based on these analyses and other supporting considerations, it is hereby requested that an exemption from the requirements of General Design Criterion 4 be granted at the postulated break locations described herein for the dynamic effects only of such breaks. Exemption is not requested for the containment pressurization, reactor thermal-hydraulic, or other effects associated with these postulated pipe breaks.

If you have any questions, please contact us.

Very truly yours,

H W Keiser

H. W. Keiser
Vice President - Nuclear Operations

cc: L. R. Plisco USNRC
M. C. Thadani USNRC

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