PECO Nuclear

10CFR50.59 Review for NCR PB 96-03414,
Core Spray T-Box Cracks

Peach Bottom Atomic Power Station Unit 2
Revision 0

I. SUBJECT

This 50.59 Review has been prepared in support of the 'Use-As-Is' disposition of NCR PB 96-03414. The subject NCR documents the continued operability of the Unit 2 Core Spray System through the next operating cycle (Unit 2 Cycle 12) with cracks in the T-box cover plate at the 120° Reactor Pressure Vessel (RPV) penetration. The crack indications are at symmetric locations in the heat affected zone (HAZ) of the T-box cover plate as illustrated in Figure 1 (Attachment 1). Visual inspection (enhanced VT-1) and follow up UT examination of the crack indications has determined the cracks to be 9.4 inches in length from 45.2° to 168.4°, and 3.4 inches from 231° to 275.6° when looking at the cover plate face.

Evaluation of the crack indications has demonstrated that the T-box cover plate will maintain its structural integrity through the next operating cycle. The maximum leakage estimated through the cracks is bound by existing core spray system design margins. Therefore, leakage from the T-box cover plate to the annulus region of the RPV will not impact any ECCS/LOCA analysis.

II. Discussion

The 'B' loop core spray T-box is located inside the RPV at the core spray piping penetration into the vessel. The penetration and T-box are positioned at azimuth 120° at an elevation 465 inches above vessel 0" (approximately 9 feet above the top of active fuel). The redundant 'A' loop penetration and T-box are located at azimuth 240°. The T-box function is to divide loop flow to two separate downcomers which provide a flow path for core cooling water through the shroud to the core spray spargers.

The indications in the T-box cover plate were identified during the 2R11 refueling outage in-vessel visual inspections (IVVI). The core spray supply piping welds were examined using guidance from reference 2 in lieu of IE Bulletin 80-13. A 0.5 mil wire resolution visual examination (EVT-1) was utilized at a subject-to-camera distance of 1 to 3 inches in accordance with references 2 & 5. Previous (VT-1) inspection of the 120° T-box cover plate performed during 2R10 (Fall 1994) revealed no indications. The previous inspections utilized a 1 mil wire resolution for visual inspection.

Root Cause

It is believed that the combined effects of non-symmetrical stiffness along the circumference of the cover plate, the presence of weld residual stresses, and possible stresses induced during installation may have caused a higher concentration of stresses at the observed crack locations. This is the likely

explanation of the symmetry observed at the 3 and 9 o'clock positions of the cover plate where the stiffness is greater than the 6 and 12 o'clock positions.

The resulting higher stresses provided for an increase in the probability of intergranular stress corrosion cracking (IGSCC) initiation in the 3 and 9 o'clock positions as compared with the remainder of the cover plate. The UT examination supports this premise in that cracking was limited to the HAZ of these regions with no indication of initiation sites at the 6 and 12 o'clock positions.

The assumption that stress imposed during installation of the core spray piping is a contributing factor is supported by review of the installation procedure (reference 7) and the observed clearance between the 'B' loop piping and the RPV wall at the T-box connection. The measured clearance is <0.1" as compared to a design nominal clearance of 0.5" which was measured on the 'A' loop. However, conclusive evidence is not available based on limited installation records which may have reported any anomalies.

Based on the above discussion, the root cause of the cover plate cracking is believed to be IGSCC initiating and propagating from the areas of highest stress.

Flaw Evaluation

As discussed above, the enhanced VT-1 and follow up UT exarnination have determined the flaw lengths on the cover plate face to be 9.4 and 3.4 inches respectively. The flaw lengths and orientation are considered conservative since they represent the limiting case of multiple UT scans of the cover plate. Based on the thickness of the cover plate and the type of UT examination, all flaws are assumed to be through wall. Therefore, the combined total flaw length in the cover plate was evaluated using a value of 12.8 inches (170°), through wall. The correlation of the ID to OD cracking detected in the cover plate is consistent with the cracking history observed with IGSCC at uncreviced and moderately creviced locations in BWRs.

An evaluation of the T-box cover plate was performed to determine the ligament margins required to ensure structural integrity. Evaluation of the applied loads on the cover plate have determined the cover plate is flaw tolerant. The primary stresses in the T-box cover plate are the result of the pressure differential and flow impingement experienced during core spray injection. Utilizing an applied load based on 133.2 psid, 7,825 GPM (run-out flow) and a safety factor of 2.77, the minimum required plate ligament is 61° at the 6 and 12 o'clock positions for a total of 122° of ligament. This corresponds to a critical flaw size of 17.9 inches (238°). Therefore, when applying a crack growth rate of 5.0E-5 inches/hr in accordance with reference 2, the maximum allowable flaw size to ensure continued operability through the next operating cycle is 14.7 inches (195°). This establishes a margin of 1.9 inches (25°) in addition to the safety factor of 2.77 used in flaw evaluation.

The 2.77 safety factor is a conservative assumption since it applies to a normal/upset condition in which core spray is not expected to inject. Injection of core spray occurs only in a faulted condition where the safety factor is 1.39. When

normal/upset condition in which core spray is not expected to inject. Injection of core spray occurs only in a faulted condition where the safety factor is 1.39. When no safety factor is used in the flaw evaluation (plate failure), the minimum required ligaments at the 6 and 12 o'clock positions are 32° each. This corresponds to maximum allowable flaw size (accounting for crack growth) of 19.1 inches (254°). This illustrates a current margin of 6.3 inches or 84° when not taking into account any safety factor (SF = 1.0).

Specific analysis of the identified flaws lengths and orientation has determined the actual safety factor to be 3.6 (reference 4).

The following table illustrates the margins relative to the flaw evaluation:

	Actual Flaw	Maximum Allowable Flaw Normal/Upset Safety Factor = 2.77 (*Margin*)	Maximum Allowable Flaw Safety Factor = 1.0 (*Margin*)
Total Length (in.)	12.8	14.7 (*1.9*)	19.1 (*6.3*)
Degrees	170	195 (*25*)	254 (*84*)

Leakage Evaluation

Due to the small total area of the indications, any leakage through the cracks will be minimal. Leakage through the end of cycle flaw will be less than 20 GPM which is comparable to the estimated leakage through the T-box vent hole. The original design allowable leakage of 100 GPM will not be exceeded, and the 1,250 GPM margin established by the SAFER/GESTR analysis (Reference 3) provides additional assurance that ability of the Core Spray system to perform its design function will not be compromised. Therefore, crack leakage through the next operating cycle will not impact any ECCS/LOCA analysis.

Generic Implications

Review of generic implications was limited to the 'A' loop 240° T-box. This limited scope is based on similarity in materials, joint configuration, fabrication and loading. Remaining sparger T-box locations were not included based on differences in joint configuration (non-creviced), fabrication and loading. This evaluation has concluded the basis for symmetrical flaws at the 120° azimuth T-box does not fully reflect conditions at the 240° T-box based on the as-left installation clearances (header to vessel wall). This observed difference in the header clearance along with the satisfactory visual inspection of the 240° azimuth T-box cover plate have validated that there are no generic concerns with the 'A' loop of core spray.

III. DETERMINATION

1. Does the activity or discovered condition involve a Technical Specifications change or other Facility Operating (or Possession only) License amendment?

No. Analysis of the cracks, and potential leakage of core spray coolant to the annulus region of the RPV, has confirmed operability of the Core Spray System. This analysis does not necessitate a change to surveillance requirements or limiting conditions for operation of the Core Spray system or other ECCS systems. Therefore, continued operation of the Core Spray system as-is does not require a Technical Specification change or any Operating License amendment.

Technical Specifications 3.5.1 and 3.5.2 and their Bases were reviewed in making this determination.

2. Does the activity or discovered condition make changes to the facility as described in the SAR?

Yes. Continued operation with cracks in the Core Spray 120° T-box cover plate as described above, is considered a change to the facility as described in the SAR. The original design and analyses for Core Spray piping in the vessel provided for welded, flanged or interference fit joints. There was no allowance for cracking in the original Core Spray piping design. However, the T-box continues to meet the structural integrity requirements of TRM Section 3.10 with the evaluated cracking in the cover plate.

UFSAR Sections 3.3.4.7, 6.4.3, 6.1, 6.2, 6.3, Table 6.3.1, 6.5.3.3 and Appendix A were reviewed in making this determination.

3. Does the activity or discovered condition make changes to procedures as described in the SAR?

No. Continued operation with the subject cracks in the Core Spray T-box does not require any new procedures or procedural changes. System alignment, operation and testing as described in the SAR are unaffected by this evaluation.

UFSAR Sections 3.3.4.7, 6.4.3, 6.1, 6.2, 6.3, Table 6.3.1, 6.5.3.3 and Appendix A were reviewed in making this determination.

4. Does the activity or discovered condition involve test or experiments not described in the SAR?

No. Continued operation the Core Spray system with cracks in the 120° T-box does not involve any tests or experiments not described in the SAR. When applying conservative crack growth rates for the next operating cycle to the flaw sizes identified in the cover plate, the flaw size is bound by the critical flaw size evaluation performed in reference 1. Therefore, margin exists in the remaining cover plate ligament to ensure structural integrity and system operability through the next operating cycle. There are no additional tests or experiments involving plant systems or equipment required for verification of this analysis.

UFSAR Sections 3.3.4.7, 6.4.3, 6.1, 6.2, 6.3, Table 6.3.1, 6.5.3.3 and Appendix A were reviewed in making this determination.

Since the answer to question #2 is YES, a 10CFR50.59 Safety Evaluation is required.

IV. SAFETY EVALUATION

A. Those accidents potentially negatively impacted by this change include those accidents requiring Core Spray injection into the vessel. LOCA analyses requiring core spray injection have been evaluated in UFSAR Sections 14.6.3 and 14.6.5.

1. May the proposed activity or discovered condition increase the probability of occurrence of an accident previously evaluated in the SAR?

No. The Core Spray system is an accident mitigator designed to prevent excessive fuel cladding temperatures in the event of an intermediate or large pipe break up to and including the design basis double ended shear of recirculation line piping.

UT examination of the cover plate and the evaluation of the applied loads (attachment 2) has validated structural integrity of the cover plate through the next operating cycle. Therefore, there is no potential for loose parts increasing the probability of an accident.

2. **May the proposed activity or discovered condition increase the consequences of an accident previously evaluated in the SAR?**

No. The consequences of an accident previously evaluated in the SAR have not been increased due to the cracks detected at symmetric locations in the heat affected zone (HAZ) of the 120° T-Box cover plate. The flaw sizes identified in the cover plate by UT examination with conservative crack growths assumed through the next operating cycle are bounded by the critical flaw size evaluation performed in reference 1. Therefore, margin exists in the remaining cover plate ligament to ensure structural integrity and system operability through the next operating cycle. The discussion provided in Section II of this safety evaluation provides additional detail on the methodology and assumptions applied in this evaluation.

3. **May the proposed activity or discovered condition create the possibility of an accident of a different type than any previously evaluated in the SAR?**

No. Assessment of potential leakage from the cracks during Core Spray operation was evaluated in terms of the system's ability to mitigate the consequences of an accident, as described above.

The flaw sizes identified in the cover plate by UT examination with conservative crack growths assumed through the next operating cycle are bound by the critical flaw size evaluation performed in reference 1. Therefore, margin exists in the remaining cover plate ligament to ensure structural integrity and system operability through the next operating cycle. Therefore, the potential for an accident caused by release of parts from the Core Spray T-box into the annulus region is not a concern.

B. **Equipment important to safety that is potentially adversely impacted by this change includes the Core Spray System and Reactor Vessel Internals.**

1. **May the proposed activity or discovered condition increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the SAR?**

No. Evaluation of the crack indications has determined that the integrity of the subject T-box cover plate will be maintained through the next operating cycle. Also, an assessment of the cumulative

leakage resulting from cracks has been determined to be minimal such that the existing design basis LOCA analysis is not affected.

The discussion provided in section II of this safety evaluation demonstrates that the 120° T-box cover plate will maintain its structural integrity when applying a safety factor of greater than 2.77 to the stress analysis. This margin provides sufficient basis to determine the possibility of core spray piping failure is not increased.

The integrity of Core Spray piping between the RPV and the core shroud will continue to be monitored by differential pressure indicating switches DPIS-2-14-043A & B. The indicating switches monitor the differential pressure between each core spray loop at the respective RPV inlet nozzle and pressure above the core plate. Core spray pressure is normally equal to or greater than pressure above the core plate. Failure of the subject T-box cover plate will result in a lower pressure in the Core Spray line which will alarm in the control room.

2. **May the proposed activity or discovered condition increase consequences of a malfunction of equipment important to safety previously evaluated in the SAR?**

No. The flaw sizes identified in the cover plate by UT examination with conservative crack growths assumed through the next operating cycle are bound by the critical flaw size evaluation performed in reference 1. Therefore, margin exists in the remaining cover plate ligament to ensure structural integrity and system operability through the next operating cycle.

Any leakage through the detected T-box cracks has been determined to be minimal, and will not prohibit the "B" Core Spray loop from providing adequate core cooling during a design basis LOCA.

Detection of Core Spray piping failure within the RPV will be maintained as discussed in paragraph B.1. The applicable Technical Specification Action will be entered in the event of a failure indication.

3. **May the proposed activity or discovered condition create the possibility of a different type of malfunction of equipment important to safety than any previously evaluated in the SAR?**

No. The evaluated T-box cracks and any leakage in the crack region for the subject Core Spray loop will not compromise the ability of the Core Spray system to provide adequate coolant flow to the core under design basis LOCA conditions. The flaw sizes identified in the cover plate by UT examination with conservative crack growths assumed through the next operating cycle are bound by the critical flaw size evaluation performed in reference 1. Therefore, margin exists in the remaining cover plate ligament to ensure structural integrity and system operability through the next operating cycle. Therefore, the potential for any equipment malfunction caused by release of parts from the Core Spray T-box into the annulus region is not a concern. Rupture of the Core Spray lines within the RPV has already been considered as part of the Core Spray system design, in that pipe break instrumentation is included.

C. **Technical Specifications Bases for sections 3.5.1, 3.5.2 and UFSAR Appendix C were reviewed for potential reduction in safety .nargin.**

1. **Does the proposed activity or discovered condition reduce the margin of safety as defined in the basis for any Technical Specification?**

No. The margin of safety as defined in the basis for the above listed Technical Specifications has not been reduced. Surveillance requirements for Tech Specs section 3.5.1 state that In-service Testing will be performed to verify systems will provide flow rates required by the respective analyses. The total Core Spray loop flow used to maintain Peak Cladding Temperature margins is 5,000 GPM @ 105 psig reactor pressure. The analysis performed in reference 1 has demonstrated that the subject T-box indications on the "B" Core Spray loop do not affect the ability of the loop to provide the required flow under design basis conditions.

No specific margins associated with the structural integrity of core spray piping inside the RPV are defined in the SAR nor Technical Specifications. However, the analysis described in section II of this document establishes the cover plate will maintain its structural integrity with a safety factor greater than 2.77. This exceeds the minimum safety factor of 2.25 (normal/upset condition) applied to other vessel internals outlined in UFSAR Table C.5.5.

D. Does this activity as proposed involve an unreviewed safety question?

No. Based on the response for Section IV parts A through C of this safety evaluation, continued (one cycle) operation of the Core Spray system with cracks in the 'B' Core Spray 120° T-box cover plate is acceptable, and does not constitute an Unreviewed Safety Question.

E-1 Is a change to the UFSAR necessary?

No. The disposition of this safety evaluation documents that the 'B' core spray loop will continue to function as described in the UFSAR. Documenting indications found in the cover plate for one cycle operation is beyond the detail provided in the UFSAR. Therefore, no UFSAR change is required.

E-2 Is a change to any o. er SAR document necessary? No.

V. REFERENCES

1. GENE-B13-01805-104 Revision 1, "Safety Assessment of Core Spray T-Box Indications Peach Bottom Unit 2", September 25, 1996
2. EPRI TR-106740, "BWR Core Spray Internals Inspection and Flaw Evaluation Guidelines (BWRVIP-18)", July 1996.
3. NEDC-32163P Class III, January 1993, "Peach Bottom Atomic Power Station Units 2 and 3 SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis"
4. Letter from M.L. Herrera (GENE) to V. Nilekani, "Peach Bottom Unit 2 Core Spray Loop B Tee-Box Flaw Evaluation", September 26, 1996
5. GENE SIL No. 289 Revision 1 Supplement 2, "Cracking in Core Spray Piping", January 5, 1996
6. Technical Specifications 3.2.1, 3.5.1 and 3.5.2
7. GE Nuclear Energy Division 22A2233AB Rev.3, "General Instructions for Reactor Assembly", November 13, 1973 (PECO Doc. No. M-1-U-429)
8. Technical Requirements Manual Sections 3.3, 3.10
9. UFSAR Sections 3.3, 3.6, 6.1, 6.2, 6.3, 6.4, 6.5, Appendices A, C & K
10. NCR PB 96-03414

VI. ATTACHMENTS

1. Figure 1, Peach Bottom Unit 2 Core Spray T-Box Cover Plate Cracking, 120° azimuth
2. Letter from M.L. Herrera (GENE) to V. Nilekani, "Peach Bottom Unit 2 Core Spray Loop B Tee-Box Flaw Evaluation", September 26,1996

VI. APPROVALS

Prepared by: Michael K Delaney
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Date: 09/26/96

Peer Review: Paul R. Ram
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Date: 9/26/96

Approval: Gary L Stuhler
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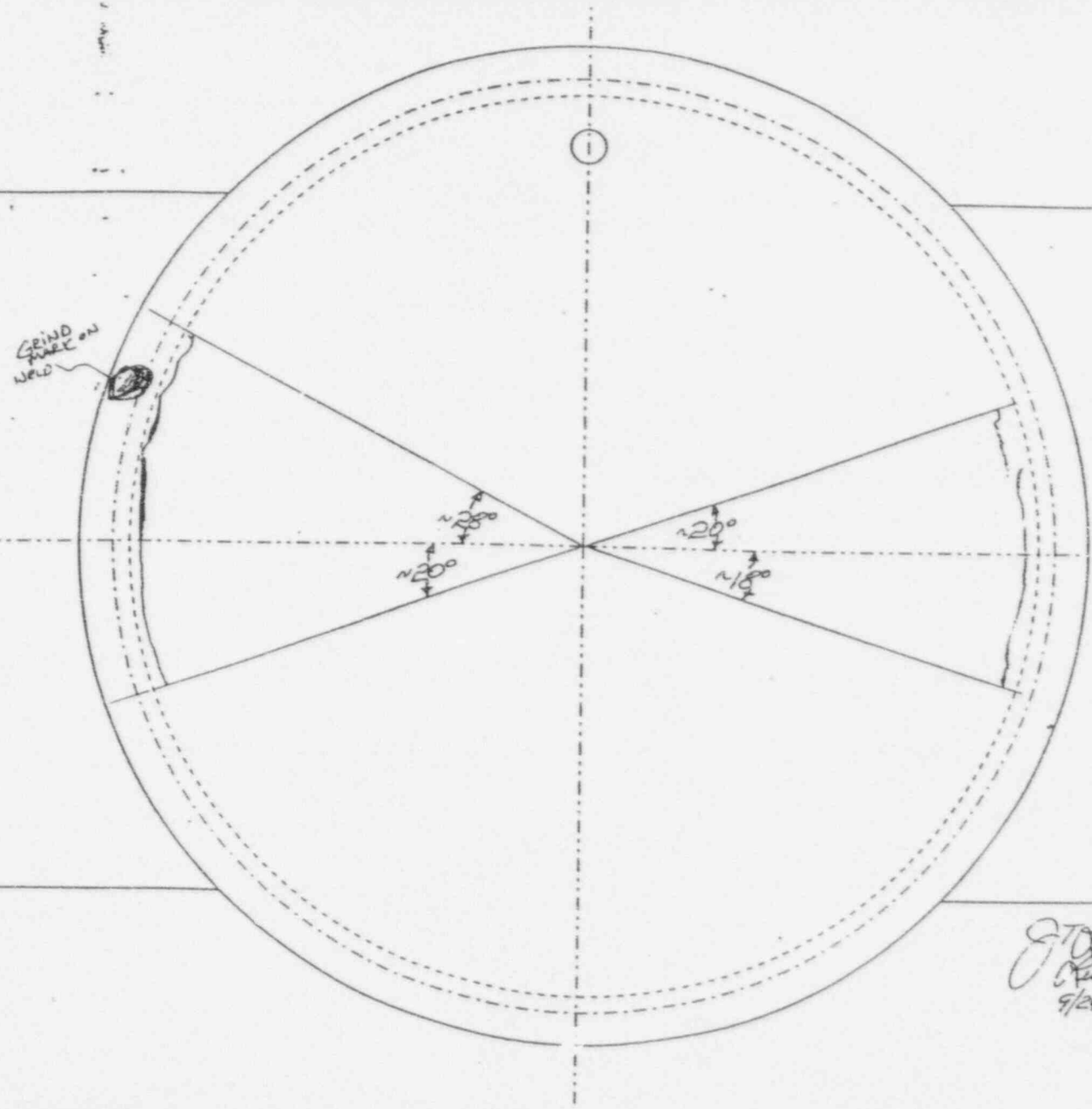
Date: 9/26/96

10 CFR 50.55a Review For:
NCR PB 96-03414
U2 CST-Box Crack
ATTACHMENT 1
Pg. 1 of 1



J T Lindberg
Reviewer
9/20/96

PBAPS Unit 2
Core Spray Tee-Box Az 120 Deg
Left Side Angle Approx. 48 Deg.
Right Side Angle Approx. 38 Deg.

VISUAL EXAM

4

ATTACHMENT 2
10CFR50.59 REVIEW FOR:
PB UNIT 2 C.S. T-BOX CRACKING
PAGE 1 OF 2

GE Nuclear Energy

General Electric Company
175 Curtner Ave, San Jose, CA 95125

September 26, 1996

Vijay Nilekani
PECo Energy

Subject: Peach Bottom Unit 2 Core Spray Loop B Tee-Box Flaw Evaluation

An evaluation of the UT detected indications in the cover plate of the Peach Bottom Unit 2 Core Spray Line tee box has been performed. This letter presents the results of this evaluation.

Based on the UT results, the indication locations are summarized below.

Indication	Azimuthal Location
1	43.18° to 168.37°
2	231.02° to 251.96°
3	255.68° to 275.61°

All indications were assumed to be through-wall. Due to the proximity of indications 2 and 3, these were combined into a single flaw. Thus, the evaluation was performed considering two flaws, one from 43.18° to 168.37° and the second from 231.02° to 275.61°. Crack growth from each end was added to each indication length. For a 25 month period and a crack growth rate of 5×10^{-5} in/hr, the crack growth from each indication end is 0.91 inch. With crack growth, the azimuthal locations for the two indications become:

Indication	Azimuthal Location
1	30.98° to 180.57°
2'	218.82° to 287.81°

Based on discussions with Vijay Nilekani, Jim Stanley of PECo and GENE NDE inspection services personnel, the flaw lengths and orientations are conservative since they represent the most limiting scans of the cover plate.

The evaluation was performed assuming ductile shear failure. The applied loads during the core spray injection are 7702 lbs due to the pressure difference (133.2 psi) and 1468 lbs due to the flow impingement (7825 gpm).

ATTACHMENT 2
10CFR50.59 REVIEW FOR:
PB UNIT 2 C.S. T-BOX CRACKING
PAGE 2 OF 2

A safety factor of 2.77 was applied to the calculation which corresponds to normal and upset conditions although core spray injection occurs during a faulted event when lower safety factors and higher allowable stresses are permitted. A factor of 2 was applied to the material flow stress to consider shear failure. A Z factor of 1.2 was applied due to the weld procedure used in welding the cover plate to tee box.

The resulting safety factor (for the detected indications and assuming no new crack initiation) was calculated to be 3.6 which exceeds the required safety factor applicable to the normal and upset event of 2.77. Using the faulted condition criteria results in a safety factor of 4.2 which exceeds the required faulted safety factor of 1.39.

Please contact me if you have any questions.

Regards,

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