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NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CORE SPRAY PIPING INSPECTION AND FLAW EVALUATION

PEACH BOTTOM ATOMIC POWER STATION, UNIT 2

PECO ENERGY COMPANY

DOCKET NUMBER 50-277

1.0 INTRODUCTION

During the recent refueling outage (2R11) for Peach Bottom Atomic Power Station (PBAPS), Unit 2, crack-like indications were identified in the tee-box cover plate in the core spray internal piping at the 120° reactor pressure vessel penetration. The crack indications are at two symmetric locations (3 and 9 o'clock) in the heat affected zone of the tee-box cover plate. Visual inspection (enhanced VT-1) and follow-up ultrasonic (UT) examinations of the crack indications determined that the crack lengths are 3.4 and 9.4 inches at the 3 and 9 o'clock locations, respectively. The locations and appearance of these crack indications are typical of intergranular stress corrosion cracking (IGSCC).

By letters dated September 26 (two letters) and September 27, 1996, the licensee submitted evaluations of the flaws for NRC review and approval. The results of the licensee's evaluations concluded that sufficient margins exist to operate the plant for one additional cycle with the identified flaw. The staff's evaluation of the scope of the inspection and the inspection results are discussed herein.

2.0 EVALUATION

Scope of Inspection

By letter dated August 6, 1996, as supplemented by letter dated September 12, 1996, PECO Energy Company (the licensee) informed the Nuclear Regulatory Commission (NRC) staff of its intentions to modify the scope and inspection methods for the core spray piping and spargers from the guidelines specified in NRC Bulletin 80-13, "Cracking in Core Spray Spargers," dated May 12, 1980, during the eleventh refueling outage (2R11) at PBAPS Unit 2. This modification allows the licensee to follow the industry guidance contained in the BWR [Boiling Water Reactor] Vessel and Internals Project (BWRVIP) document, "Core Spray Internals Inspection and Flaw Evaluation Guidelines (BWRVIP-18)," dated July 26, 1996.

The licensee stated that the basis for the change to their commitment to the inspection guidance contained in Bulletin 80-13 was to focus additional resources on the areas of the core spray piping which have shown a susceptibility to cracking (e.g., creviced welds). Further, the licensee planned to perform a baseline examination of all accessible core spray annulus piping welds using an enhanced visual resolution testing (i.e., capable of achieving a resolution of 0.0005 inches [0.0127 mm]), EVT-1. During the last refueling outage, 2R10, the licensee performed a baselining CS VT-1 (i.e., capable of achieving a resolution of 0.001 inches [0.0254 mm]) inspection of all sparger piping, nozzles and brackets; and, as such, the licensee did not plan to inspect the sparger piping, nozzles and brackets during this outage as recommended in BWRVIP-18. However, the licensee did plan to perform a CS VT-1 inspection of the mechanical clamp installed during the 1982 outage.

Because the scope and inspection method proposed by the licensee would focus on areas of the core spray piping which are more likely to experience intergranular-stress corrosion cracking and the proposed inspection methods for the core spray internal downcomer piping are more stringent than those recommended in Bulletin 80-13, the staff finds that the scope and inspection methods used for the inspection of the core spray internal piping at the PBAPS Unit 2 plant are acceptable for this outage.

It should be noted that the NRC staff is presently reviewing the acceptability of using BWRVIP-18 generically for all BWRs. While the staff has not identified any major deficiencies in the BWRVIP's technical assessment at this time, neither has the staff made a determination as to its generic acceptability. Therefore, the licensee should be aware that if concerns are identified during the staff's generic review of BWRVIP-18, and if the licensee intends to follow the BWRVIP-18 guidance in the future, the NRC staff may request that the licensee also address these concerns on a plant-specific basis.

Results of Inspection

Since 1980, augmented examinations of the PBAPS Unit 2 core spray piping have been performed in accordance with the guidelines of Bulletin 80-13. One crack-like indication, at the "B" sparger pipe to tee-box joint, was discovered during the fifth refueling outage in 1982, and was repaired by the installation of a mechanical clamp which prevents separation of the sparger pipe from the tee-box. No further indications have been found on the Peach Bottom Unit 2 core spray piping or spargers prior to this outage.

As a result of using the BWRVIP-18 inspection guidance this outage, the licensee was able to perform an enhanced visual inspection of all welds in the core spray piping internal to the reactor pressure vessel in the annular area. The licensee found two crack indications in the tee-box on the Loop B header (120° azimuth) of the core spray system. Follow-up UT examination of the crack indications determined the cracks to be 9.4 inches [23.88 cm] in length from 45.2° to 168.4°, and 3.4 inches [8.64 cm] in length from 231° to 275.6°. The depth of the crack was not measured.

The licensee informed the NRC staff by telephone on September 25, 1996, of the cracking found on the "B" loop core spray tee-box. The licensee believed that the root cause of the cracking was the combined effects of non-symmetrical stiffness along the circumference of the cover plate, the presence of residual stresses, and possible stresses induced during installation. 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 to the rest of the cover plate. The licensee's examination of the cracking supports this premise in that cracking was limited to the heat affected zone of these regions.

The licensee performed a flaw evaluation of the two crack indications. For conservatism, the licensee assumed the flaws to be through-wall. The total combined flaw length in the cover plate was evaluated using a value of 12.8 inches [32.51 cm] (170°) through-wall. The licensee performed an evaluation of the tee-box cover plate to determine the ligament margins required to ensure structural integrity of the weld through the next operating cycle. The primary stresses in the tee-box cover plate result from the pressure differential and flow impingement experienced during core spray injection.

Using a safety factor of 2.77, the licensee calculated that a minimum amount of ligament required is 61° at the 6 and 12 o'clock positions (a total of 122° of ligament). This corresponds to a critical flaw size of 17.9 inches [45.47 cm] (238°). Using a staff-approved crack growth rate of 5.0E-5 inches/hr [12.7E-5 cm/hr], the maximum allowable flaw size to ensure continued operability through the next operating cycle was calculated to be 14.7 inches [37.34 cm] (195°). Therefore, with the 12.8 inch [32.51 cm] flaw, a margin of 1.9 inches [4.83 cm] (25°) exists in addition to the safety factor of 2.77. The staff finds the that the licensee's flaw evaluation provides an adequate basis to ensure that the tee-box cover plate with the identified crack indications will remain structurally intact for the next operating cycle.

Because there are four tee-box junctions in the core spray spargers and the licensee was not planning to inspect the sparger tee-boxes this outage, the staff requested that the licensee address the generic implications of the identified crack indications and specifically address the susceptibility of the sparger tee-boxes to the same cracking mechanism. In its September 26, 1996, letter, the licensee provided its evaluation of the generic implications. The licensee found that the there are significant differences between the sparger tee-box and the header tee-box. The sparger cover-to-tee-box weld is a full penetration weld and does not result in crevices where IGSCC may initiate, whereas the header weld is a partial penetration weld that has the potential to yield a small crevice weld. The sparger, including the tee-box, was installed and welded in the shop which provides better control of design and fabrication tolerances and reduces or eliminates fit-up stresses. The header tee-box was fabricated in the field. Lastly, the sparger tee-box operational loads are one-third of those in the header tee-box resulting in lower stresses in the sparger tee-box cover plate. On the basis of the reasons discussed above, the staff finds that the cracking mechanism in the header tee-box is not present or is present to a much lesser degree in the sparger tee-box.

To provide additional assurance that cracking would not occur in the sparger tee-boxes, the licensee performed an enhanced visual inspection (EVT-1) of the "C" loop core spray sparger tee-box and found no recordable cracking indications. This provides further evidence that the licensee's root cause determination is correct. In addition, due to the configuration and location of the core spray spargers, if any further cracking or degradation were to occur between the baseline inspections and subsequent reinspections, this degradation would not prevent injection of coolant inside the core shroud, or inhibit the ability to reflood the inner volume.

Evaluation of Loads

The operational loads on the cover plate of the sparger tee-box consist primarily of loads resulting from impingement of flow and pressure differential across the plate. These loads are approximately one-third less in the sparger tee-box than those in the header tee-box. Estimated loading on the sparger tee-box cover plate from core spray injection is 3235 lbf [14390 N] (4000 gpm at 85 psid) [252.4 liter/sec at 586.0 kPa] vers . 9170 lbf [40790 N] (7825 gpm at 133 psid) [493.7 liter/sec at 917.0 kPa] for the header tee-box. The seismic and thermal loads which could rupture the cover plate were determined to be negligible.

The possible induction of stresses during installation of the core spray piping may have caused a higher concentration of stresses at the observed crack locations. The assumption that the stresses imposed during installation of the core spray piping is a contributing factor to the observed cracking is supported by the observed clearance between the "B" loop piping and the RPV wall at the tee-box connection. The measured clearance is less than 0.1 inch [2.54 mm] as compared to a design nominal clearance of 0.5 inches [12.7 mm] which was measured on the "A" loop. The core spray piping was deformed during installation in the vicinity of the header tee-box cover plate. This resulted in the introduction of additional stresses and a non-uniform stress distribution along the circumference of the header tee-box cover plate. The licensee considers this to be a likely cause for the intergranular stress corrosion cracking (IGSCC) initiation at the 3 and 9 o'clock locations on the header tee-box cover plate. It is the licensee's assessment that the normal stress in the cover plate, imposed during installation, does not contribute to the cover plate blow out or rupture loads since this normal stress would not cause a net section type of failure. The licensee's analysis considers a shear type "blow out" failure of the cover plate in which the flow stress is taken as one-half of the normal stress. The staff concurs with this loading assumption and the licensee's assessment of the cover plate failure loads.

3.0 <u>CONCLUSION</u>

On the basis of its review of the licensee's flaw evaluation, the NRC staff finds that neither the present cracking in the "B" loop core spray tee-box nor its postulated growth through the next operating cycle will prevent the core spray system from performing its intended safety function. Therefore, the PBAPS Unit 2 plant may be operated for the next fuel cycle without repairing the subject tee-box cover plate weld. However, the NRC staff finds that the licensee should reinspect the core spray system at the next scheduled refueling outage. Continued plant operation beyond the current fuel cycle (Unit 2, Cycle 12) will depend on satisfactory evaluation of the reinspection results or by implementing acceptable repairs during the next refueling outage.

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