SOUTH TEXAS PROJECT UNIT 1
BOTTOM MOUNTED INSTRUMENTATION NOZZLE LEAKAGE ISSUE

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BACKGROUND

- April 12, 2003 - Licensee performed boric acid corrosion control (BACC) walkdowns as part of GL 88-05 program. Inspections included a bare metal visual examination of the reactor pressure vessel (RPV) bottom head.

- The licensee's access to the South Texas Project Unit 1 (STP Unit 1) RPV lower head is very conducive to these inspections. Plant design includes an insulating "box" around the lower head with panels that can be opened to permit direct viewing of the bare metal.

- Licensee had performed similar inspections of the lower heads of both STP Unit 1 and Unit 2 previously. The most recent inspection of Unit 1 had been conducted in November 2002 with no evidence of deposits noted.

BACKGROUND

- In April 2003, the licensee discovered deposits characterized as, in total, "about the size of one half of an aspirin tablet" around bottom mounted instrumentation (BMI) penetrations #1 and #46.

- Chemical analysis showed evidence of boron and lithium, indicating the reactor coolant system (RCS) to be the most likely source of the deposits.

- Radiochemical analysis based on cesium isotope dating indicated that the deposits were approximately four years old.

NONDESTRUCTIVE EXAMINATION - SCOPE

- The licensee has conducted extensive nondestructive examination (NDE) on all 58 STP Unit 1 BMI nozzles. Framatome Technologies was chosen as the vendor for the inspections, using a tooling system which had been used previously for BMI inspections in France.

- Performed ultrasonic testing (UT) using axial, circumferential, and zero degree probes from the tube inside diameter (ID) on all nozzles.

- Performed enhanced visual testing (EVT-1) examinations of the J-groove weld surfaces of all nozzles.

- Performed ID eddy current testing (ECT) on some nozzles to confirm UT data.

- Performed "ECT-on-a-stick" examination of the J-groove weld surface of eight penetrations, including #1 and #46.

NONDESTRUCTIVE EVALUATION - RESULTS

- The licensee's NDE results showed:
  - Three axially-oriented indications in nozzle #1. One indication characterized as having a length of ~1.38 inches, extending from above to below the J-groove weld and penetrating the ID of the tube. The other two indications were much smaller and near the root of the weld.
  - Two axially-oriented indications in nozzle #46. One indication characterized as having a length of ~0.98 inches and extending from above to below the J-groove weld. The other indication characterized as having a length of ~0.95 inches and not surface connected.
  - EVT-1 examinations showed signs of extensive grinding on the nozzle and J-groove weld surfaces of many penetrations.

NONDESTRUCTIVE EVALUATION - ADDITIONAL

- The licensee performed additional NDE tests on penetrations #1 and #46, including:

  (1) ECT profilometry on nozzles #1 and #46 to compare as-found nozzle distortions with that predicted from weld finite element modeling to validate predicted weld residual stresses. Preliminary results suggest that the profilometry measurements were consistent with finite element modeling predications.

  (2) Helium pressurization tests on nozzles #1 and #46 to further investigate potential leakage paths in these penetrations. At 150 psi, bubbles were observed on nozzle #1, but not on nozzle #46.

  (3) Phased-array UT from the RPV head outside surface to look for evidence of wastage of the ferritic base material of the head. No evidence of wastage was found.

PRELIMINARY ROOT CAUSE ANALYSIS

- Based on the information currently available, two principal root cause theories are under consideration by the licensee.

(1) The cracking was caused by primary water stress corrosion cracking (PWSCC) which initiated in the nozzle at the toe of the J-groove weld.

- PWSCC of Inconel 82/182/600 observed in other applications
- Consistent with expectations in 1991 Westinghouse report for Sequoyah which assessed potential for BMI cracking
- Inconsistent with the fact that no cracking was observed in other penetrations

(2) The cracking initiated at "discontinuities" (weld lack of fusion, etc.) at the tube/weld interface and propagated to the tube surface.

- Consistent with observed discontinuities in #1 and #46
- Consistent with understanding of general fabrication practices/issues
- Inconsistent with the fact that discontinuities were evident in other penetrations
- No specific mechanism to explain subcritical crack growth

PRELIMINARY ROOT CAUSE ANALYSIS

- The licensee is taking material samples from nozzles #1 and #46 for evaluation. Information from these samples is expected to confirm the degradation mechanism(s) and, potentially, the initiation sites for the observed indications.

- Information from these material samples is expected to clarify whether either of the two principle preliminary root causes is substantiated. Some combination of mechanisms may also be indicated by the information from the material samples.

- Information from the licensee's evaluation of the materials samples will be included in the final root cause report which is currently projected to be completed in late September/early October, 2003.

STP UNIT 1 BMI NOZZLE REPAIRS

- The licensee has repaired STP Unit 1 nozzles #1 and #46 using a "half nozzle repair" similar in design to those used to repair other Alloy 600 penetrations.

- The repair was made using Alloy 690 nozzle material and Alloy 52/152 weld material, including the installation of a temper bead weld pad on the outside of the RPV lower head. The RCS pressure boundary weld was moved to the outside surface of the RPV.

- Questions regarding future inspections of the repair, along with inspections of the ferritic base material which will be left exposed to the reactor coolant, are being addressed by the licensee in support of NRC staff review and approval of the repair.

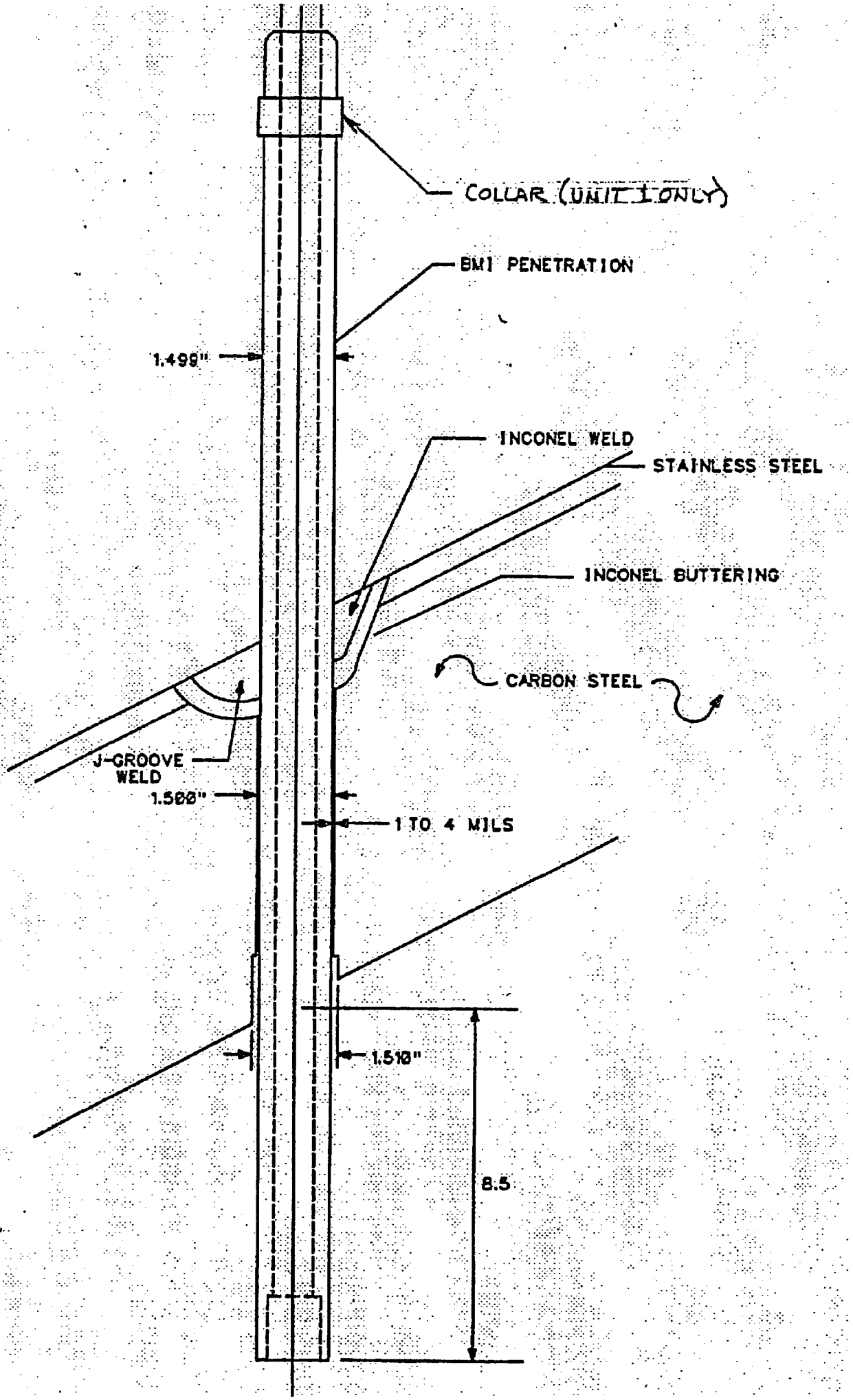
POTENTIAL GENERIC IMPLICATIONS

- None of the available information suggests that STP Unit 1 is unique with regard to being susceptible to lower head penetration cracking.

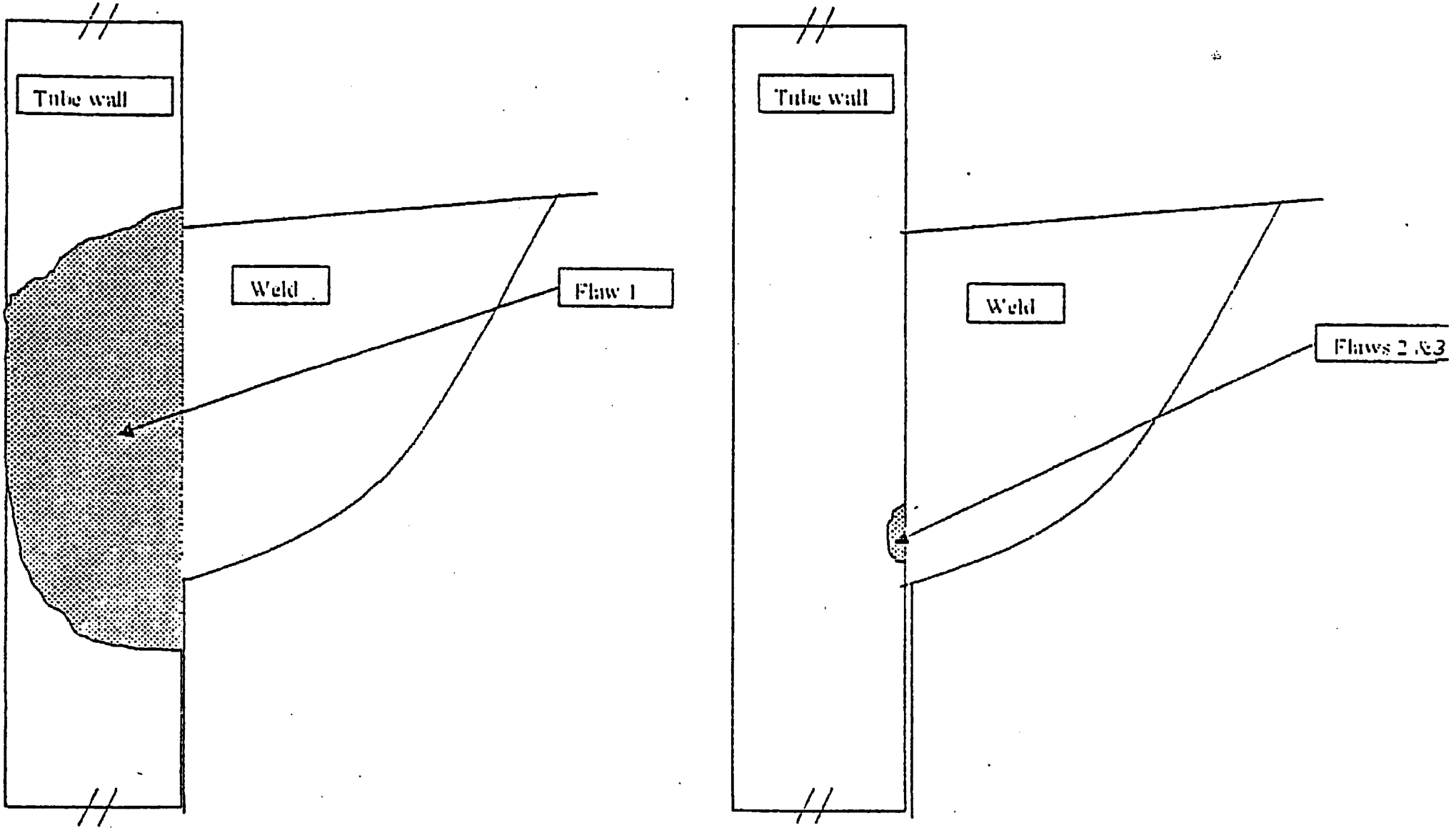
- Based on the "as found" condition of the STP Unit 1 BMI penetration nozzles, the NRC staff has concluded that the risk significance of the situation at STP Unit 1 was minimal.

- However, should the operative degradation mechanism(s) at STP Unit 1 be directly or indirectly capable of inducing large, circumferentially-oriented flaws in RPV lower head penetrations, the risk implications for the U.S. PWR fleet could be significant.

- The NRC staff is in the advanced stages of determining what path we intend to follow with regard to developing generic communication(s) concerning PWR RPV lower head inspections given the information coming out of the STP Unit 1 event.


COLLAR (UNIT 1 ONLY)
BMI PENETRATION
1.499"
INCONEL WELD
STAINLESS STEEL
INCONEL BUTTERING
CARBON STEEL
J-GROOVE WELD
1.500"
1 TO 4 MILS
1.510"
8.5

Penetration #1



Penetration #46