SEPTEMBER 1 1 1978

PPR

Docket Nos. 50-259, 50-260,
50-296 and 50-263

MEMORANDUM FOR: Thomas A. Ippolito, Chief, Operating Reactors Branch #3, DOR

FROM: Richard J. Clark, Project Manager, Operating Reactors Branch #3, DOR

SUBJECT: SWELLING IN G.E. HIGH-DENSITY SPENT FUEL STORAGE RACKS

On Thursday, August 24, 1978, we met with representatives of General Electric Company (GE), Tennessee Valley Authority (TVA), Northern States Power Company (NSP) and Brooks and Perkins Incorporated (B&P) to discuss the swelling noted by NSP in the four GE High Density Spent Fuel Storage racks which were recently installed in the Monticello spent fuel pool (SFP). A list of attendees is enclosed. A previous meeting had been held with the above four organizations on June 5, 1978, to discuss swelling noted in the GE racks during fabrication of the racks for Monticello and Browns Ferry.

By letter dated April 14, 1978, the Commission issued Amendment No. 34 to Operating License No. DPR-22 authorizing Northern States Power Company to increase the storage capacity of the Monticello SFP from 740 to 2237 spent fuel assemblies using high density storage racks supplied by GE. The GE storage racks consist of a number of square tubes fastened together at the corners as shown in Figure 1. The tubes consist of concentric inner and outer square shrouds of Type 304 stainless steel which integrally encapsulate Boral neutron absorber plates. The Boral plates consist of a matrix of 35% Boron Carbide and Type 1100 aluminum, clad on both sides with Type 1100 aluminum. The inner tube of Type 304 stainless steel is 36 mils thick; the outer stainless tube is 90 mils thick. A cut-away sketch showing a typical tube and how they are joined together is shown in Figure 2. The tubes are supplied to GE by Brooks and Perkins, who is also supplying similar tubes (i.e., Boral encapsulated in stainless steel) to Exxon Corporation for proposed use at Salem and Cook and to Nuclear Service Corporation for proposed use at Zion 1 and 2 and Dresden 2 and 3. The method of fabricating the tubes and a picture of a finished tube is shown in Figure 3.

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On July 10 and 11, 1978, Monticello installed two of the new GE racks in their SFP. On August 8 and 9, 1978, two additional racts were installed. Prior to installation in the SFP, every cell in all the racks had been checked with a 5.96" full-length guage. (The nominal inside dimension of the tubes is 6.25".) There was no evidence of any swelling in the tubes. Following installation of the fourth rack in the Monticello SFP, NSP proceeded with neutron attenuation measurements of the tubes and spaces outside the tubes. The source was contained in a pig with a nominal outside dimension of 5.90" and a maximum measured dimension of 6.00". (At one point near the bottom of the pig, the polyethyline shielding was rippled to the 6.00" dimension.) There are a total of 85 tubes in each module plus 84 storage spaces between the tubes. Of the total 340 tubes in the four modules, the pig would not go into 9 tubes. On a tenth tube, the pig hung up near the top, but went down on its own accord. These measurements were made on August 11 and 12, 1978, or within 3 to 4 days after installation of the third and fourth modules. On August 15 and 16, 1978, the ten suspect tubes were rechecked with the 5.96" full length guage; the guage would not fit in any of the 10 tubes. The tubes were also checked with a 5.45" dummy fuel assembly that is the same dimensions as a regular spent fuel assembly. The dummy fuel assembly could not be inserted into 2 tubes, both of which were in the modules that had been unner water about 5 weeks (i.e., the modules installed July 10 and 11, 1978). There were two tubes in the two recently installed modules (i.e., the two modules that had only been under water for 4 days when the swelling was noted) in which the dummy fuel assembly hung-up but slide into the tube of its own weight. GE and NSP are certain that none of the 10 tubes in which swelling was noted had been tubes in which the bladder had ruptured during fabrication so as to wet the boral plates.

On Thursday, August 17, 1978, NSP inspected the swollen tubes with a TV camera and lights. The swelling was confirmed by visual observation. It was noted that the swelling was primarily in the upper half of each tube.

Following installation of the second and fourth modules under water, NSP noted bubbles coming up from some tubes. The bubbling was readily observable for 3 to 5 days. The escaping gas was analyzed and found to be rich in hydrogen. None of the tubes that were bubbling showed any indications of swelling when subsequently examined.

Since the modules were installed in the Monticello SFP, the water temperature has been about 80°F. Specific conductance of the water has been less than 1 micromhos and the pH has been essentially neutral.

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There has not been any spent fuel stored in the new GE racks at Monticello. However, the facility is scheduled to shutdown for refueling on October 14, 1978, at which time 121 fuel assemblies are scheduled to be replaced. There are presently 616 spent fuel asemblies in the SFP as a result of five previous refuelings. At the forthcoming refueling, NSP will have to store spent fuel in 112 of the 676 storage spaces in the four new racks.

In the case of the Browns Ferry Nuclear Plant (BFNP), there are four of the new GE racks on site. Browns Ferry Unit No. 3 is scheduled to shutdown on September 8, 1978 for the first refueling of this unit. The entire core of 764 fuel assembiles is scheduled to be off-loaded into the SFP to permit modifications to the control rod drive return line. At the completion of the refueling and maintenance outage, 208 spent fuel assemblies will remain in the BFNP-3 SFP. Since the new fuel is also stored in the SFP, TVA needs storage space for 972 fuel assemblies at the time of shutdown.

TVA has used a dummy fuel assembly to check all tubes in the four racks on-site. No swelling was evident in any tube. GE also checked the racks under fabrication by Chicago Bridge and Iron Nuclear-General Electric (CBIN) at Memphis with a 6.050" guage.

The cause of the swelling in the tubes at Monticello is due to corrosion of the aluminum cladding on the Boral. Whenever corrosion occurs, hydrogen is liberated as the metal surface is oxidized (corroded). All metals exhibit an initially high corrosion rate when exposed to an aqueous environment. If the metal forms a protective corrosion product oxide film, and the film is not removed by chemical or mechanical action, the corrosion rate levels off with time. The Boral sheets in the GE racks are not anodized prior to being encapsulated in stainless steel. If water contacts this non-passivated surface, there is an initially high rate of corrosion (and thus high rate of hydrogen generation) until a protective oxide film is formed. GE estimates that if water enters the encapsulating stainless steel tubes, the initial corrosion of the aluminum cladding generates about a liter of hydrogen until the surface is passivated.

As discussed previously, Brooks and Perkins (B&P) is the only supplier for Boral. B&P supplies the Boral sheets either encapsulated or plain. The shroud (encapsulating) materials offered by B&P include Type 304 stainless steel, Type 6061 aluminum or Type 5083 aluminum. Brooks and Perkins weld the inner and outer tube configurations on a custom made 20 foot longitudinal seam welder. The ends of the shrouds are formed together and this interface is then seal-welded by hand "to assure a leak-tight module". Brooks and Perkins states in their literature that "each full-penetration weld is 100% visually inspected" and subjected to various

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types of NDE testing. The end welds are 100% dye penetrant tested. When NSP inspected the tubes in the Monticello SFP from which bubbles were emanating with the underwater light and TV camera, they noted at least one instance where there was not a juncture between the longitudinal and end-welds. These tubes had passed the QA inspections by Brooks and Perkins at Levonia, Michigan and the QA inspections by Chicago Bridge and Iron and GE at Memphis, Tennessee. According to B&P, the dye penetrant inspection should have detected the lack of closure. With B&P's concurrence, NSP completed the welds using Code qualified welders.

After the tubes were fabricated and inspected at Brooks and Perkins, the tubes were fabricated into racks (modules) at Memphis, Tennessee by CBIN/GE. As shown in Figure 2, an angle is welded onto the sheet metal tubes to join them together. When the initial racks were being fabricated by CBIN, there were instances of burn-through during welding of the angles.

The sandwich construction of the tubes was intended to be leak-tight. It appears that the leaks in the tubes at Monticello (evidenced by the bubbing and swelling) was most likely the result of (1) failure to seal the tubes during fabrication at Brooks and Perkins, (2) the welding performed on the tubes during fabrication of the racks at Memphis and/or (3) on stresses induced on the angle welds during transport and handling of the racks.

The tubes in the GE racks are about 14 feet long. Under water, there is a differential pressure of about 6.5 psig between the top and bottom of the tubes due to the hydrostatic head of water. GE estimates that the 36 mil stainless steel tube will withstand about 4.5 psig internal pressure before deforming. If there is a leak at the bottom of a tube which allows water to enter, the hydrostatic head of water prevents the hydrogen from escaping through the same hole until the internal pressure is greater than the hydrostatic head and this pressure is greater than that which deforms the tube. If the wall thickness of the inside stainless steel tubes were increased to withstand more than 6 psig, swelling would not likely occur even if there were a leak in a tube.

The presence of water within the tubes will cause corrosion of the boral (evidenced by the hydrogen generation). The potential extent of the corrosion attack was discussed based on corrosion data submitted by Brooks and Perkins, the experience and test results with Boral in the Brookhaven Reactor and experience with Boral in military and test reactors. The

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staff's main concern was the potential for galvanic corrosion because of the relatively large areas of cathode (stainless) to anode (aluminum) under crevice conditions. NSP and TVA have committed to install corrosion test specimens in the Monticello and Browns Ferry SFP's that will be examined each year to evaluate the corrosion behavior of the Boral. The available corrosion data is adequate to support the conclusion that corrosion and pitting of the Boral is not a safety concern for the near future. The staff is continuing the evaluation of the corrosion behavior of Boral under coupled and crevice conditions for long-term exposures (i.e., 20 to 30 years) to various aqueous environments.

At the conclusion of the meeting, a caucus was held with the NRC attendees and management. Conclusions reached were:

1. To approve GE's proposal to drill a hole in the top of the tubes in the four racks currently in the Monticello SFP and the four racks at Browns Ferry Unit No. 3 to prevent swelling in these racks.

2. To request a commitment from NSP and TVA to store spent fuel for the immediate future only in the spaces adjacent to tubes. NSP stated that it is their intent to store the spent fuel discharged during the fall 1978 outage in the spaces adjacent to tubes until the use of the poison tubes is required for a full core offload or until initiation of Phase II of the rack replacement program. TVA agreed to the same committment.

3. TVA was requested and committed to install corrosion test specimens in the Browns Ferry Unit No. 3 SFP that will be periodically removed and examined to check the long-term corrosion behavior of Boral sandwiched between Type 304 stainless steel.

4. I&E will be requested to review the QA procedures at Brooks and Perkins, CBIN-GE, NSP and TVA with respect to determining whether the inspections can detect if a tube is leak-tight prior to and after fabrication into racks.

5. The design of the GE High-Density Fuel Storage System is being evaluated as a topical report. The need for the tubes to be leak-tight will be evaluated as part of our review.

6. The design and installation of the spent fuel storage racks for Monticello has been approved by NRC; for the four racks, NSP can modify the racks (by drilling the holes in the tubes) under

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Section 50.59. For Browns Ferry, TVA will have to amend their submittal of December 5, 1977, describing the proposed design modification, why the modification is acceptable, and a revised environmental assessment. The revised submittal should describe the proposed temporary rearrangement of racks in the Unit No. 3 SFP (i.e., 4 new high density racks and 39 existing racks rather than 19 new modules as described in the existing submittals, since only 4 of the new modules are presently fabricated and available).

Richard J. Clark

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ENCLOSURE

ATTENDANCE - MEETING ON SWELLING IN GE

SPENT FUEL STORAGE RACK

AUGUST 24, 1978

Name	Organization
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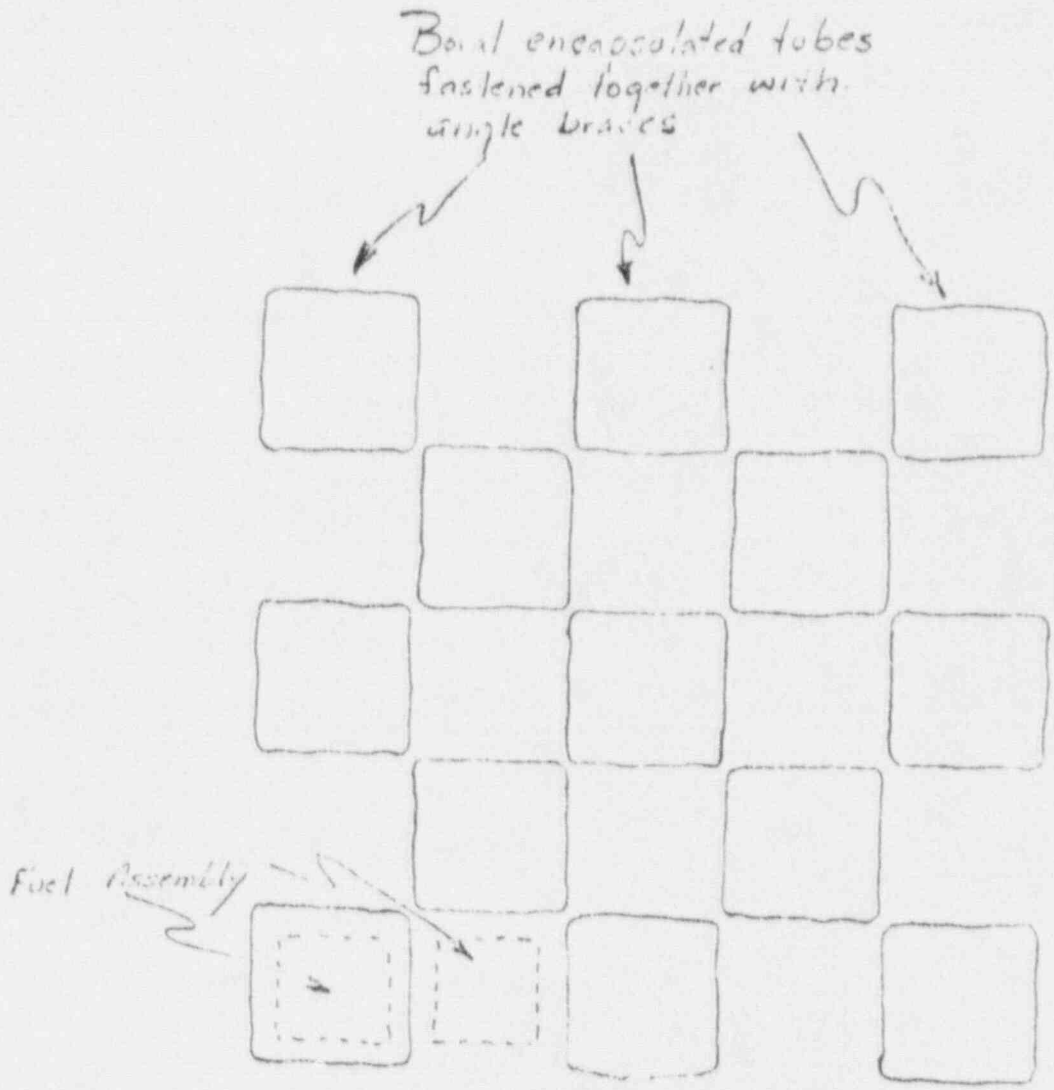
Don Kirkpatrick	NRC
Ed Lantz	NRC
John Zudans	NRC
Bill Russell	NRC
Bart Buckley	NRC
Gary Zech	NRC
Wally Wheadon	GE
Hal Huntley	GE
David Dawson	GE
Ed Grinon	GE
Dennis McCloud	TVA
John Hutton	TVA
John Weeks	Brookhaven National Lab
Leslie Mollon	Brooks & Perkins Inc.
Leon Rafner	Commonwealth Edison
David Nevinski	NSP
Tom Eckhart	Exxon Nuclear



Spent Fuel is stored both within the square tubes and in the spaces between the tubes.

Figure 1

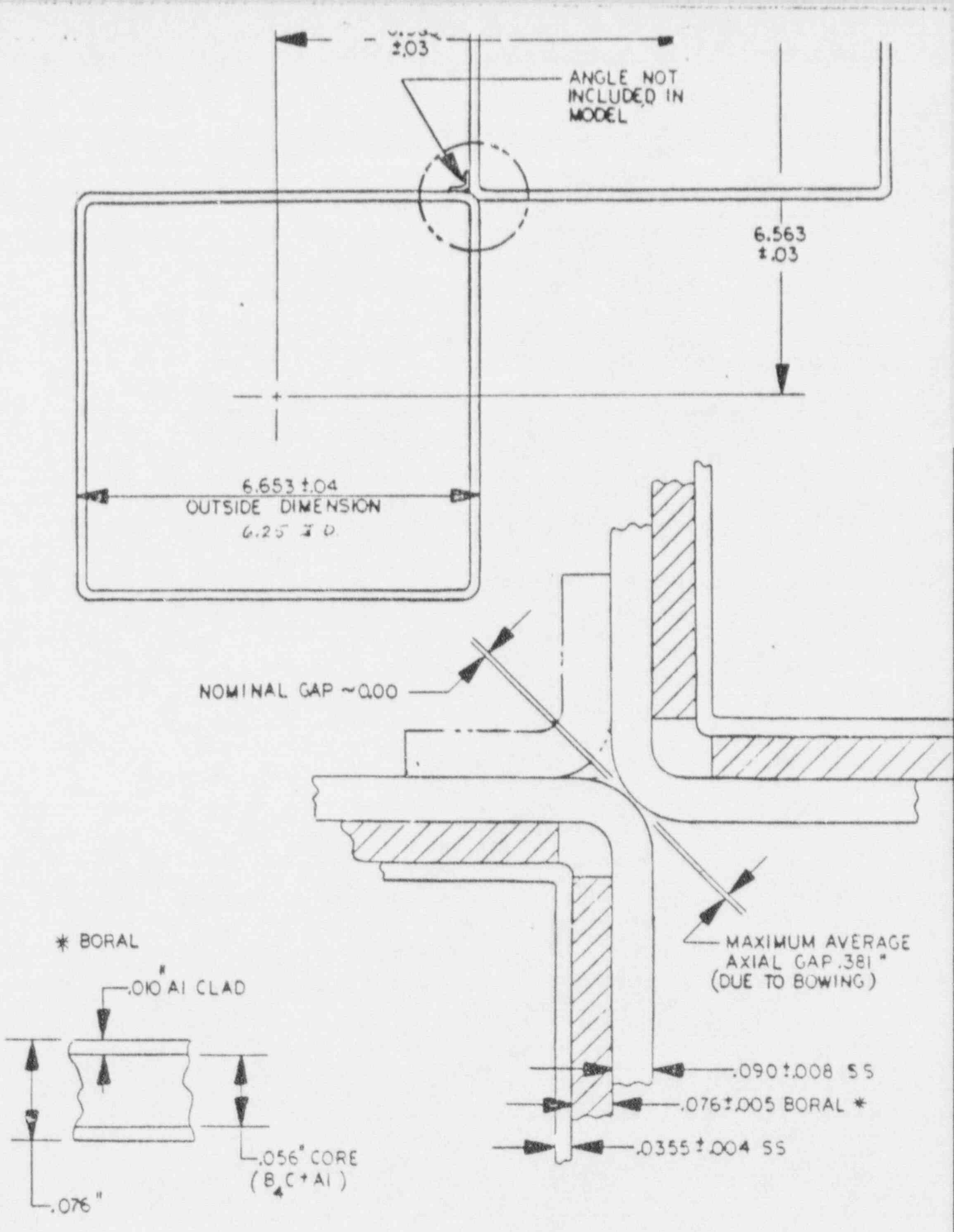


FIGURE 2
STORAGE CELL DIMENSIONS