TENNESSEE VALLEY AUTHORITY
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March 1, 1972

AIR MAIL

Mr. Lawrence D. Low, Director
Division of Compliance
United States Atomic Energy Commission
Washington, DC 20545

Dear Mr. Low:

In response to your letter of December 27, 1971, related to Sequoyah unit 1 vessel cladding and material properties and to Rotterdam Dockyard Company (RDM) welding procedures for the Sequoyah vessels, we offer the following replies to the points raised in your letter.

Item 1

An evaluation of the Sequoyah 1 vessel liquid penetrant inspection of the vessel cladding which has revealed rejectable indications has been conducted by RDM with Westinghouse surveillance.

Evaluation of Cladding Defects

During a required liquid penetrant examination of the Sequoyah 1 vessel cladding, indications of cladding defects were found. These indications were removed; the cladding was repenetrant examined to acceptable limits, repair welded as required for inservice inspection and accepted for shipment to the site.

As part of the evaluation and consistent with 10 CFR 50 Appendix B, Criterion 16, an investigation of the causes of these indications was undertaken at RDM under Westinghouse surveillance. The investigation showed that these indications, which were subsequently found to be intergranular cracks, are associated with low ferrite areas in the cladding. Generally, the cladding contained ferrite ranging from 1.5 to 15 percent as determined by Schaeffler diagram calculations. However, the evaluation showed isolated areas of cladding exhibiting ferrite levels less than 1.5 percent as indicated by Foerster gage surveys.

In determining the mechanism for this condition, the processing history was reviewed. As part of this history, extensive porosity had been observed on Sequoyah 1 cladding and ascribed to contamination in the welding materials plus poor electrical contacts for the welding strip. In the normal fabrication sequence the porosity was removed by grinding. Subsequently, during the hydrostatic testing of the vessel, the cladding was exposed to water containing up to 2.5 ppm Cl for approximately one week.

Based on these considerations of the vessel fabrication history, there are two possible mechanisms by which low ferrite regions could exhibit intergranular cracking, namely, hot tearing or intergranular corrosion. At the present time, it is not possible to distinguish between these mechanisms. However, no matter which was operative, further damage to the cladding should not occur because:

1. The hot tearing mechanism would have been associated with the initial cladding operations.

2. The removal of low ferrite regions and control of water chemistry during plant operation will prevent grain boundary corrosion.

Westinghouse is assured that, with the extensive close followup of the Sequoyah 1 vessel during the latter period of testing, the penetrant examination and subsequent grinding has removed the observed condition. When exposed to the service environment the cladding will not undergo similar chemistry conditions. In the future, both the improved cladding process and close ferrite control will preclude this condition of cracking. For example, ferrite checks are being conducted by using both the Schaeffler diagram and testing with the Foerster gage. Results on a large number of production components have not shown a repetition of the low ferrite zones. In addition, the water used for hydrostatic testing will be upgraded to grade B water instead of grade C which had been previously specified. The following table shows the difference between the old and new specification.

	Current Spec. B	Former Spec. C
Chloride ion, maximum ppm	1.0	25
Fluoride maximum ppm	0.15	2.0
Conductivity, maximum micromhos/cm	20	400
Total solid ppm maximum	---	---
pH range	*	---
Visual clarity	No turbidity, oil, or sediment (For A, B, and C water)	

*Sufficient amounts of ammonium hydroxide (NH_4OH) shall be added to maintain a pH of 10.0 - 10.5 prior to application of test pressure. If a test temperature in excess of 150°F is required or anticipated, between 50 and 300 ppm of Hydrazine (N_2H_4) shall be added to the test solution. Hydrazine target amount shall be 200 ppm.

Inservice Inspection

After grinding out the indications, a study was made to determine the size and depth of divot which would prevent meaningful ultrasonic testing (UT) in the 2T zone on each side of the pressure boundary welds. All the divots which could affect the repeatability of an automated UT scan were eliminated by welding and grinding. Following the weld repair and penetrant testing, a UT check was made and it was determined that the resulting surface was satisfactory for meaningful UT. The divots in themselves did not prevent an adequate manual UT examination of the 2T zones.

Defect Size Evaluation

A fatigue flaw growth analysis (Reference WCAP-7733 and WCAP-7673 Addendum 1) in terms of fracture mechanics parameters showed that the expected growth of the underclad grain boundary separations was 4 mils maximum during the lifetime of the Sequoyah unit 1 vessel. The maximum amount of crack growth occurs in the nozzle shell course region at the intersection of the vessel shell and the outlet nozzle. If a defect in the cladding (nominal 5/32 inch) is superpositioned to line up with the underclad separations, the net effect is a flaw approximately 0.250 inch in depth. The expected growth of the postulated 0.250-inch flaw is 10 mils maximum during the lifetime of the reactor vessel. Again, the maximum amount of growth occurs in the nozzle shell course region.

Since an original flaw size of 250 mils in a reactor pressure vessel is not considered critical and its growth is insignificant during the 40-year plant life, the structural integrity of the Sequoyah unit 1 reactor vessel has not been compromised and the vessel is suitable for the use intended.

Item 2

In regard to questions on RDM welding procedures, the following comments apply:

2(a)

Westinghouse has reviewed with RDM their welding procedures 32.04, Revision 6, and 32.05, Revision 4, and the corresponding procedure qualifications wherein specific weld joint configurations were not shown.

RDM admits to the usefulness of attaching a joint configuration sketch to the procedure qualification data sheet and agrees to do so in the future. Although not documented in the procedure qualification data sheets, RDM uses the production drawings to establish the joint geometry and thickness requirements for procedure qualification. This has been verified by the Westinghouse and third party inspectors before accepting the qualification.

2(b)

A review of the welding procedures noted in 2(a) above was conducted regarding preheat temperatures.

The welding procedure combines the minimum preheat temperature and the maximum interpass temperature as the minimum-maximum range for welding. This represents no code violation. In procedure qualification, welding starts as soon as the minimum preheat temperature of 125°C (approximately 260°F) is reached. Since it takes a long time to complete the joint, welding is interrupted at the maximum interpass temperature 260°C (approximately 440°F) and the temperature is allowed to drop, but not below the minimum preheat temperature. This is, in effect, what is done in production and no essential variable has been violated. It should be noticed that the Section IX recommended form for manufacturers' record of procedure qualification tests (Form Q-1) calls for a range in both the preheat and interpass temperatures. These are the data entered by RDM in the procedure qualification data sheet.

Supplementary to the range data now being obtained, RDM has been asked to identify in future procedure qualification data sheets the temperature at which welding starts.

2(c)

The orientation of the bend-test specimens in procedure qualification data sheet J-620 has been reviewed. Reference to transverse and longitudinal side bends is an error in bookkeeping, but the actual work performed was correct. The procedure qualification data sheet submitted to Westinghouse indicates that the side-bend specimens were taken according to Figure Q-7.1 which is the correct figure. This figure identifies transverse specimens only, and all the specimens tested were in accord with the figure. The word "longitudinal" introduced on the procedure qualification data sheet is an error which was made because of confusion with cladding tests which require longitudinal specimens.

Item 3

The relationships between Sequoyah 1 nil ductility transition temperature (NDTT) and the specific Charpy V energy levels at the NDTT have been reviewed. It is realized that there are variations in the Charpy V energy value at the nil ductility transition temperatures. It is for this reason that Westinghouse practice has been to use the higher of NDTT or the 30 ft lb fix temperature. In the case of Sequoyah 1, the NDTT based on drop weight tests has not been limiting and has been at comparatively low temperatures. Since the Charpy V notch tests are conducted at these low temperatures, the values are relatively low leading to values below the 40 ft lb and 50 ft lb indicated as the Charpy V fix in the previously referenced NRL report. In the case of some forgings, SA 508 Class II, and in the case of some plates SA 533, Grade B, Class I, the NDTT has been observed to be at temperatures ranging from +10°F to 60°F. Charpy V fix values associated with these comparatively high NDTT's are normally above 40 to 50 ft lbs.

Consistent with these questions raised, Westinghouse reviewed the quality control surveillance for the toughness tests and are satisfied that the test material location and the test methods and procedures are in compliance. The following practices have been observed on the material tests in question.

A. After the specimen block is marked out on plate or forging, Lloyds checks location and stamps the block.

B. After the block has been cut out, specimen locations are marked out and Lloyds stamps each specimen.

C. Testing of each specimen is witnessed by Lloyds.

Item 4

In the evaluation of the Sequoyah unit 2 closure head transition forgings, RDM performed 3 drop weight tests. RDM obtained 2 no-breaks (NB) at -12°C and 1 "break" at -15°C. E208 (Paragraph 11) states the following as to selection of test temperatures:

"11. Selection of Test Temperatures

11.1 The selection of test temperatures is based on finding, with as few specimens as possible, a lower temperature where the specimen breaks and an upper temperature where it does not break, and then testing at intervals between these temperatures until the temperature limits for break and no-break performance are determined within 10°F (5°C). The NDT temperature is the highest temperature where a specimen breaks when the test is conducted by this procedure. Test at least two specimens that show no-break performance at a temperature 10°F (5°C) above the temperature judged to be the NDT point.

11.2 Conduct the initial test at a temperature estimated to be near the NDT. This temperature and all subsequent test temperatures shall be integral multiples of 10°F or 5°C."

RDM interpreted the NDTT based only on the no-break specimens. It is agreed that to meet all aspects of E208, a NDTT of -15°C should be used. It is assumed that if RDM obtained 2 no-breaks at -12°C, RDM would have obtained 2 no-breaks at the higher temperature of -10°C.

We hope this response to your questions conveys the extent of our evaluation and, where indicated, defines the corrective action taken to assure an acceptable level of quality in the completed

Mr. Lawrence D. Low March 1, 1972

Sequoyah vessels. We will be pleased to provide you with additional information on these items if deemed necessary.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

James E. Watson

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Manager of Power