TVA

Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

10 CFR 2.206

JUL 30 2003

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of	)	Docket No. 50-390
Tennessee Valley Authority	)	

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1 – PETITION PURSUANT TO 10 CFR 2.206 – REACTOR COOLANT SYSTEM STAINLESS STEEL CLADDING

By letter dated May 30, 2003, the Union of Concerned Scientists (UCS) petitioned NRC pursuant to 10 CFR 2.206 to take enforcement action against WBN in the form of a Demand for Information (DFI). The petition asks that TVA be required to provide the NRC with information concerning possible corrosion of the reactor coolant pressure boundary. The corrosion is of concern to UCS because the stainless steel cladding for certain areas of the reactor pressure vessel nozzles was removed and not replaced. TVA received a copy of the UCS petition on May 30, 2003 and also received a copy of Mr. Samuel J. Collins' letter to UCS dated July 2, 2003, regarding the petition. TVA was given the option to respond to NRC regarding the petition and we appreciate the opportunity to do so.

Enclosure 1 to this letter provides relevant background information and addresses the specific questions raised by UCS petition. Supporting documentation is also provided in the following enclosures:

Enclosure 2 - Safety Injection (SI) Accumulator Tank 3 Cladding
Enclosure 3 - Chart Reactor Coolant System (RCS) Chemistry - Iron Concentrations

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There are no regulatory commitments in this submittal, and if you should have any questions regarding this letter, please contact me at (423) 365-1824.

Sincerely,

P. L. Pace
Manager, Site Licensing
and Industry Affairs

Enclosures

1. TVA's response to the Union of Concerned Scientists 10 CFR 2.206 Petition - Reactor Coolant System Stainless Steel Cladding
2. Safety Injection (SI) Accumulator Tank 3 Cladding
3. Chart Reactor Coolant System (RCS) Chemistry - Iron Concentrations

cc: See page 3

cc (Enclosures):

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ENCLOSURE 1

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1
UNION OF CONCERNED SCIENTISTS 10 CFR 2.206 PETITION
REACTOR COOLANT SYSTEM (RCS) STAINLESS STEEL CLADDING

On May 30, 2003, the Union of Concerned Scientists (UCS) petitioned the NRC pursuant to 10 CFR 2.206 requesting that NRC take enforcement action against TVA as the licensee of Watts Bar Nuclear Plant (WBN) in the form of a Demand for Information (DFI). Specifically, UCS requested that TVA be required to provide specific information on the possible corrosion of the reactor coolant pressure boundary at WBN due to the existence of defects in the stainless steel cladding applied to the interior surface of the carbon steel reactor pressure vessel (RPV). The cladding provides corrosion resistance against the borated water used as a reactor coolant. Based on recent industry operating experience, the UCS is concerned that the unprotected portion of the RPV nozzles could be subject to unexpected corrosion due to the boric acid in the reactor coolant. Provided below is relevant information on the background of this issue and TVA's specific responses to the questions posed by UCS in its petition. Additional information regarding the cladding on Safety Injection (SI) Accumulator Tank 3, referred to in the UCS petition, is addressed in Enclosure 2:

I. <u>Background - RPV Underclad Cracking Issue:</u>

In the early 1980's NRC identified industry-wide fabrication concerns regarding certain RPVs and requested that inspections be performed to establish the following:

1. To determine if underclad cracks, resulting from certain pre- and post-clad heat treatments used by some European fabricators, were present in the nozzles; and

2. To demonstrate that cladding heat treatments used in the United States did not result in the type of underclad cracks found by a European fabricator.

The WBN RPV, including the inlet nozzles, were manufactured by Rotterdam Nuclear of the Netherlands. This vessel was of the type that could contain the fabrication concerns identified by NRC. Initially, the issue of RPV underclad cracking was discussed among NRC, Westinghouse and TVA in a meeting held on February 22, 1980, at Bethesda, Maryland. In this meeting TVA committed to perform ultrasonic inspections of the RPV nozzles. Information regarding the ultrasonic inspections was requested by NRC in a letter to TVA dated June 18, 1980. TVA responded to NRC in a letter dated August 13, 1980.

NRC observed the ultrasonic inspections performed by TVA and documented their observations in Inspection Report 390/80-28 dated September 23, 1980. TVA further addressed the cladding issue in a letter dated March 20, 1981. NRC later requested information on the cladding issue as part of a question on the Final Safety Analysis Report (FSAR). NRC submitted the FSAR question (Question Number 121.23) in a letter dated January 23, 1982. TVA responded to the question in a letter dated

July 30, 1982, by referring to information provided in its March 20, 1981, letter. NRC reviewed and approved TVA's assessment of the uncladded areas in the RCS cold leg nozzles. NRC's acceptance was documented in NUREG-0847, "Safety Evaluation Report for Watts Bar Nuclear Plant," dated June 1982.

II. Reply to UCS Questions:

Question 1

1. The 1982 determination by TVA and NRC that the unprotected portions of the carbon steel reactor pressure vessel cold leg nozzles would not be exposed to excessive corrosion may not still be applicable in light of recent information about corrosion rates. Has TVA updated the basis for its decision not to repair the cladding defects to verify that safety margins remain intact when recent experience and knowledge about corrosion causes and rate is considered? If so, what is that updated basis? If not what is TVA's rationale for continuing to operate Watts Bar?

RESPONSE

In August 1980 an ultrasonic examination was performed on the WBN Unit 1 RPV nozzles for detection of (cold) cracks under the stainless steel cladding [underclad (cold) cracks]. These cracks were suspected to be in the low alloy steel base metal underneath the stainless steel cladding. Ultrasonic responses (reflectors) from underclad (cold) cracks were reported in the inlet nozzles. Ultrasonic examination did not reveal reportable indications of (cold) cracks in the outlet nozzles.

Westinghouse concluded that the recorded reflectors met the American Society of Mechanical Engineers (ASME) Section XI[1] pre-service acceptance criteria based on a conservative estimate of flaw through wall sizing.[2] In order to validate the flaw depth sizing, Westinghouse recommended that destructive analysis (grinding) be performed.[3] TVA accepted this recommendation and performed grinding on two inlet nozzles (Loop 2 and Loop 3).[4] The results of the grinding validated the Westinghouse predictions. Small portions of the stainless steel cladding were removed as part of this validation effort.

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1 ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components"

2 A component whose ultrasonic (volumetric) examination detects flaws that do not exceed the applicable standards shall be acceptable for service, provided the verified flaws are recorded in accordance with the provisions of the ASME Section XI code in terms of location, size, shape, orientation, and distribution within the component.

3 Westinghouse letter (WAT-D-4195) from M. A. Siano to G. F. Dilworth, TVA, dated November 19, 1980

4 TVA's letter to NRC dated March 20, 1981

As a result of the grinding performed, three areas (one on Loop 2 and two on Loop 3) remained where the austenitic stainless steel clad had been removed. The dimensions of these areas are tabulated below. Westinghouse performed a metallurgical evaluation and recommended that the three areas without cladding be left in an uncladded condition. It was deemed very likely that additional welding to replace the stainless steel clad could have resulted in additional underclad cracks.

Nozzle Number	Size of Exposed Area (inches)	Distance From Safe End (inches)	Total Depth of Removal Area (inches)	Thickness of Nozzle (inches)
Loop 2 - Inlet	1" x 1 ½"	16 ¾"	3/8"	12"
Loop 3 - Inlet	1" x 1 ¼ "	20 ½"	½"	12"
Loop 3 - Inlet	½" x ¾"	29"	3/8"	12"

Note: Dimensions are approximate, depth dimensions from 1993 TVA evaluation (see below).

The technical basis for leaving the three areas uncladded is documented in a Westinghouse Report (WAT-D-4494)[5] which was prepared in 1981. This report evaluated the integrity of the affected nozzles for the life of the plant and concluded that a weld repair was not necessary to ensure integrity.

The primary purpose of the cladding on the inside of the vessel is to minimize corrosion products in the Reactor Coolant System (RCS). Westinghouse evaluated the affects of corrosion on these areas due to water chemistry considering both operating and shutdown conditions. The condition in which the uncladded regions would be exposed during operation is deaerated borated water. For shutdown conditions, the borated water is slightly aerated but is under lower temperature conditions [approximately 140 degrees Fahrenheit (F)]. These two conditions result in very low corrosion rates. The shutdown (worse case) conditions used in Westinghouse's evaluation were assumed at a much higher frequency than actually experienced.

The Westinghouse report (WAT-D-4494) also considered corrosion effects due to flow and galvanic corrosion. Corrosion depths were determined based on conservative estimates of laboratory corrosion rates and industry experience. One example of industry experience was Yankee Rowe (Westinghouse Pressurized Water Reactor) which had two clad removed areas in the RPV that were monitored for over 16 years and showed no measurable penetration into the base material. This Yankee Rowe experience is directly related to the condition at WBN.

[5] Westinghouse letter from J. L. Tain to J. A. Raulston, TVA, dated July 15, 1981

Westinghouse concluded that there was no impact to minimum wall thickness requirements. The affected areas are in the heavy section of the nozzle and the small amount of corrosion depth that would occur over the life of the plant was deemed negligible and having no effect on structural or pressure boundary design basis requirements. Given these conditions, no specific fracture mechanics evaluations were performed.

As far as other plant parameters affecting the original evaluation are concerned, no changes made in current operating and water chemistry parameters from the 1981 evaluation would invalidate the original conclusion. Oxygen levels remain low during operation. The refueling periods, when the water is slightly more aerated, are actually now shorter in duration.

Further, TVA has been informally made aware of recent industry repair practices which continue to allow uncladded regions. It is TVA's understanding that Framatome ANP has repaired approximately 80 RPV head penetrations in the last few years due to leaking Alloy 600 nozzles. The Framatome ANP repair results in an area of the RPV head which leaves some exposed low alloy steel. Framatome has evaluated the effect of corrosion due to exposure to reactor coolant and determined the resulting corrosion depth to be insignificant. These evaluations are comparable to the 1981 WBN evaluation and confirm that the evaluation results remain valid.

TVA reviewed the Westinghouse evaluation and agreed with the rationale given and the recommendations provided. The effect of corrosion on low alloy steel due to reactor coolant chemistry is still considered to be insignificant due to the very low oxygen level. The Boric Acid Guidebook[6] validates these low corrosion rates with reference to several other tests conducted world wide. As a result, TVA has concluded that the original evaluation remains valid and that the uncladded areas do not jeopardize the integrity of the RPV nozzles for the life of the plant.

The reactor head degradation experienced by Davis-Besse resulted from reactor coolant leakage to outside the pressure boundary exposing the fluid to oxygen and increasing the corrosion rate. Furthermore, since the metal surface was hot, much of the water evaporated which in turn increased the boric acid concentration. None of these circumstances or conditions are applicable to the small removed clad areas at WBN.

Question 2

The NRC's 1982 Safety Evaluation Report accepted the defects in the stainless steel cladding of the reactor pressure vessel cold leg nozzles without requiring inservice inspections. Although not required by the NRC, TVA may have

6 Boric Acid Corrosion Guidebook, Revision 1: Managing Boric Acid Corrosion Issues at PWR Power Stations, EPRI Report 1000975, November 1, 2001

voluntarily examined one or more of the defects. Has TVA inspected any of the cold leg nozzle cladding defects? If so, when were the inspections conducted and what are the results from the inspections? If not, what are TVA's plans for future inspections of these known cladding defects?

RESPONSE

TVA re-examined the clad removed areas during the fall of 1993. A sketch of each area was made recording the diameter and total depth of each affected region. Comparison of this data to that taken during the 1981 effort shows minimal effect of corrosion during the 12 year timeframe. The Westinghouse report in 1981 recorded the maximum depth into base metal of the clad removed areas as 0.286 inches. This, along with a clad thickness of 0.20 inches (physically measured dimension) results in the total depth in 1981 being 0.486 inches. The 1993 data records the maximum total depth of one-half inch. This would indicate additional corrosion penetration of 0.0140 inches or 0.0012 inch/year during the 12 year period. The piping condition during this 12 year period would have been more corrosive due to higher oxygen exposure than during operation with reactor coolant in the system and very low oxygen.

Prior to receipt of the UCS petition, TVA had scheduled the inlet nozzles for inspection to fulfill a portion of the requirements of the ASME Section XI inservice inspection (ISI) program. These inspections are normally performed on 10 year intervals. The RPV 10 year ISI inspection provides access to the cold leg nozzles once the core barrel is removed. The inspection of the nozzles will be performed using a remotely operated vehicle (ROV). During the ROV examination of the inside radius sections, specific attention will be given to the uncladded areas. This inspection is currently planned for the Cycle 6 refueling outage which is scheduled to occur in the spring of 2005.

Question 3

Watts Bar had its initial startup in the mid 1990s. Thus, the reactor never operated without portions of the carbon steel reactor pressure vessel cold leg nozzles being directly exposed to borated water. Consequently, reactor water chemistry information is unavailable for periods before and after the carbon steel became exposed. Nevertheless, reactor water chemistry data since startup may provide insight on potential corrosion of the carbon steel reactor pressure vessel. What are the data for pertinent reactor water chemistry parameters (e.g. iron concentrations) since startup? Do the chemistry data indicate potential corrosion of the exposed carbon steel nozzle areas?

RESPONSE

While TVA does not typically analyze the reactor coolant system for iron concentration, it does measure certain isotopes which are corrosion products produced in the reactor core via neutron activation of iron. Manganese (Mn) 54, with a 312 day half life, is produced via a (n,p) activation of Iron (Fe) 54 which exists as 5.85 percent of all natural occurring iron. Fe-59, with a 44.5 day half life, is produced via a (n,γ) interaction of Fe-58 which is present in 0.28 percent of natural occurring iron. Since both of these isotopes have relatively long half lives, these activities can be trended to provide an indication of the reactor coolant system iron trend. The graph provided in Enclosure 3 indicates the trend using the above isotopes. Based on this data, the dissolved iron in the RCS is considered to be negligible.

It should be noted that the plant outages are indicated on the graph provided in Enclosure 3. The increase in iron in the reactor coolant during an outage results from chemistry changes in the RCS during the change from plant operation to refueling conditions. Prior to moving fuel, the boron concentration is increased to approximately 2500 ppm boron. This increase in boron to shutdown concentrations and plant cooldown causes a decrease in the coolant pH, which in turn causes an increase in soluble iron corrosion products in the coolant.

An additional indicator of iron in the RCS is a visual inspection of a filtered RCS sample. This sample is performed weekly during power operation. There have been no unusual deposits noted on this weekly filter sample.

Given these several indicators, there are no bases to conclude that the reactor coolant is degrading the uncladded areas in the inlet nozzles.

Question 4

The cladding defects are explicitly described in the NRC's 1982 Safety Evaluation Report, but are not mentioned at all in Section 5.0 of TVA's Updated Final Safety Analysis Report for Watts Bar. Why are the defects mentioned in the SER but not in the UFSAR?

RESPONSE

As indicated in the Section I of this enclosure titled "Background - RPV Underclad Cracking Issue," the cladding issue was addressed as FSAR Question 121.23. The FSAR Question process is outlined in NUREG 0800, "Standard Review Plan," and allowed issues to be addressed between TVA and NRC concerning the review and approval of the FSAR. Information from this process was incorporated into the body of the FSAR only if inclusion of the information was required by Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants LWR Edition," or NUREG 0800.

TVA believes that the text in Section 5.2.3.2, "Compatibility with Reactor Coolant," referred to in the UCS petition could be clarified to reference the three areas [RPV inlet nozzles for Loops 2 and 3 and SI Accumulator Tank 3 (addressed in Enclosure 2)] where the base metal may be exposed to boric acid. TVA documented this in TVA's corrective action program as Problem Evaluation Report (PER) 03-011590-000. The clarification of the UFSAR has been captured as a corrective action for this PER and will result in the updated text being incorporated into WBN's "Living" Updated Final Safety Analysis Report (UFSAR). In addition, TVA has initiated PER 03-012985-000 addressing the need to consider the exposed base metal whenever adjustments to the maximum allowable boron concentrations are made for the RCS or the accumulators.

III. Conclusion:

TVA believes that the RPV nozzle as well as the SI Accumulator Tank 3 cladding issue, (see Enclosure 2) were thoroughly evaluated at the time the issues were initially identified and that no new information or change in circumstances warrants any additional evaluation in these areas. TVA's review of the most current data confirms that no bases exist to conclude that the reactor coolant is having any significant impact on the identified uncladded areas. Accordingly, no NRC enforcement action in the form of a DFI is warranted.

ENCLOSURE 2

Safety Injection (SI) Accumulator Tank 3 Cladding

The UCS petition references TVA's actions on SI Accumulator Tank 3 as a precedent for NRC to require recladding of the RPV inlet nozzles. Actually, NRC and TVA addressed the issue in a manner similar to the RPV nozzles. Flaw indications in the cladding of SI Accumulator Tank 3 were identified by TVA and documented in TVA's Corrective Action Program as Problem Evaluation Report (PER) WBPER920252 dated November 2, 1992. Provided below is an excerpt from the NRC Safety Evaluation (SE) which summarizes the actions taken by TVA:

> "TVA attempted to repair the indications to meet ASME Section III requirements. TVA removed the cladding containing the indications and replaced it with weld metal. However, excavation to remove the indications and shrinkage stresses from welding continually generated new indications in the sensitized cladding in adjacent areas previously free of indications. As a result, TVA decided to finish the weld repair of the excavated areas by adding at least one layer of stainless steel weld material and dispositioning the remaining indications by a fracture mechanics analysis under Section XI of the ASME Code."

Contrary to UCS' assertion that it was not then deemed permissible for TVA to leave defects in some of the cladding of the accumulator tank, the following statement from the SE indicates that some of the carbon steel base metal of the accumulator could be exposed to borated water and provides a basis for why this is acceptable:

> "Many of the flaws extend through the stainless steel cladding, exposing the carbon steel to the borated water environment. Service experience has shown that high concentrations of boron in water can corrode carbon steel. This has happened in boron injection tanks and at the outside of reactor vessel top head regions where the reactor coolant boiled and concentrated. However, there is no mechanism for the borated water to become concentrated in the accumulator. The boron content of the water in the accumulator ranges from 1900 to 2100 ppm, with the nominal concentration specified as 2000 ppm. Therefore, the water in the tank has basically the same chemistry as the primary coolant. The temperature is ambient and oxygen levels are kept to low levels by a nitrogen blanket so any corrosion would occur slowly."

Related to this issue is WBN Unit 1 License Amendment 40 which was issued by NRC revising Surveillance Requirement (SR) 3.5.1.4 and increasing the cold leg accumulator (CLA) boron concentration to a range of 3500 to 3800 ppm. For the higher concentration, the EPRI Boric Acid Corrosion Guidebook was used to estimate the potential impact of this increase on the accumulator. Based on the guidebook, increasing the boron concentration to the order of 3800 ppm will have a negligible effect on the corrosion rate of carbon steel. While the majority of the tests conducted in the handbook are in the range of 2000 - 2500 ppm, one test (conducted by the Moscow Power Institute) was performed at 3000 ppm boron at 590° F. The corrosion rates of this test are quite low and are consistent with the other tests performed. The high corrosion rates discussed in the guidebook result from concentrations in the order of 15,000 ppm. Concentrations of this type generally occur as a result of water dripping onto a hot metal surface which allows the water to boil off and the solution to concentrate.

In order to ensure that future adjustments in boron concentrations are addressed, TVA initiated PER 03-012985-000 addressing the need to consider the exposed base metal whenever adjustments to the maximum allowable boron concentrations are made for the RCS or the accumulators.

As further background information, the following is an outline of the reviews that were performed when the accumulator flaws were initially documented in the TVA corrective action program in 1992:

> NRC initially reviewed the accumulator issue as part of the inspection activities documented in Inspection Report 390/92-38 dated November 30, 1992. The issue was subsequently reviewed by NRC and discussed in Inspection Report 390/93-02 dated February 3, 1993, and documented as Inspector Follow-up Item (IFI) 390/93-02-01. TVA met with NRC on April 14, 1993, to discuss the cladding issue. TVA provided information regarding the issue in letters dated April 16, 1993 and August 3, 1993. Based on this information, NRC issued a Safety Evaluation (SE) dated November 30, 1993, approving TVA's proposed disposition of the cladding issue. The IFI was closed (corrective actions accepted) by NRC in Inspection Report 390/93-84 dated December 21, 1993.

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RCS Chemistry - Iron Concentrations