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SUBJECT: Documents acceptance criteria for CRDM nozzle cracks, insp plans to be used during Oct 1994 CRDM nozzle insp at ONS, Unit 2 & crack growth rates used in developing insp plans. Proprietary info encl. Proprietary info withheld.

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DUKE POWER

September 22, 1994

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

Acceptance Criteria for Control Rod
Drive Mechanism Penetration Inspections
Oconee Nuclear Station, Units 1, 2, and 3
Dockets 50-269, 50-270, and 50-287

Gentlemen:

The purpose of this letter is to document the acceptance criteria for CRDM nozzle cracks, the inspection plans to be used during the October 1994 CRDM nozzle inspection at Oconee Nuclear Station (ONS) Unit 2, and the crack growth rates used in developing the inspection plans.

The proposed acceptance criteria for axial flaws in Alloy 600 reactor vessel head penetrations, submitted to the NRC by the Nuclear Management and Resources Council (NUMARC), now NEI (Nuclear Energy Institute), on July 30, 1993, were accepted by the NRC. The proposed acceptance criteria for circumferential flaws in the same submittal, however, were not accepted. The acceptance criteria for axial and circumferential flaws were developed based on the safety assessments prepared by the Babcock & Wilcox, Combustion Engineering, and Westinghouse Owners Groups.

During a discussion with the NRC during a meeting at the B&W Nuclear Technologies offices in Lynchburg, Virginia, on August 17, 1994, it was stated that a circumferential flaw of 2 inches in length on the outside diameter of a CRDM nozzle at ONS would be acceptable. A flaw of 2 inches in length on the outside surface of a reactor vessel penetration is approximately 16% of the OD circumference (based on an OD of 4 inches). Thus, at ONS Units 1, 2, and 3, circumferential flaws whose length, including postulated crack growth during the next operating cycle, does not exceed 2 inches (i.e., 16% of the circumference), are less than 75 percent through-wall, and are in a location consistent with the finite element analysis, would be acceptable.

Duke Power Company (DPCo) plans to use the acceptance criteria based on the wording in the previous paragraphs during the voluntary inspection which will occur during the ONS Unit 2

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refueling outage (EOC-14) scheduled to begin in October 1994. During this inspection at ONS-2, DPCo will notify the NRC of any circumferential flaws that are found during the inspection of the reactor vessel penetrations at ONS Unit 2; however, corrective actions would only be required for circumferential flaws, due to PWSCC, that exceed the acceptance criteria indicated above. Flaws that meet the acceptance criteria would be reinspected in subsequent examinations consistent with the reinspection approach of IWP-2420 of ASME Section XI.

Additionally, the attached preliminary flow charts are currently being developed as a guideline for preparation of the final inspection plan to be used during the inspection at ONS Unit 2. The acceptance criteria for circumferential flaws and the crack growth rates discussed below are incorporated into this flow chart. The flow charts address eddy current (EC) inspection, ultrasonic (UT) inspection, and the repair sequence to be completed in the event that flaws are detected that exceed the acceptance criteria and require repair.

The corrosion crack growth rates used to determine allowable flaw sizes were calculated using Scott's model ("An Analysis of Primary Water Stress Corrosion Cracking in PWR Steam Generators," Presented at the OCED Meeting, Brussels, Belgium, September 16-20, 1991) with an activation energy of 33 Kcal/mole. This crack growth rate model was developed based on industry data for the stress corrosion cracking (SCC) of Alloy 600 steam generator (SG) tubing. This model is considered the most conservative model available for Alloy 600 PWSCC and was used in the safety assessments prepared by the three PWR Owners Groups in 1993.

Scott's crack growth rate equation for 330°C (626°F) is:

$$\frac{da}{dt} = C_o (K_I - K_{I_{sc}})^n \frac{m}{\text{sec}}$$

where

n	= 1.16
$K_{I_{sc}}$	= 9 MPa√m (assumed)
K_I	= applied stress intensity factor, MPa√m
C_o (330°C)	= 2.8e-12

This equation includes a factor of five to account for the effect of cold work on crack growth rate.

ONS Unit 2 operates at a temperature (T_{hot}) of 600±5°F (315.6°C). Since it is well known that crack growth rate is strongly affected by temperature, a temperature adjustment for CRDM application is necessary. A temperature correction was obtained from laboratory and field data for SCC growth rates for Alloy 600 in primary water environments. An activation energy of 33 Kcal/mole for crack growth was used to adjust the crack growth rate for the lower operating temperature.

$$C_o(315.6^\circ\text{C}) = C_o(330^\circ\text{C}) * \text{ratio}$$

$$\text{ratio} = \frac{e^{\left(\frac{-Q}{RT_2}\right)}}{e^{\left(\frac{-Q}{RT_1}\right)}}$$

where

$$\begin{aligned} Q &= 33 \text{ Kcal/mole} &= 138.072 \text{ Kjoules/mole} \\ R &= 8.3143 \text{ joules/K-mole} \\ T_1 &= 330.0^\circ\text{C} &= 603.2^\circ\text{K} \\ T_2 &= 315.6^\circ\text{C} &= 588.7^\circ\text{K} \end{aligned}$$

Hence, ratio = 0.5077

$$C_o(315.6^\circ\text{C}) = 1.421e-12$$

Therefore, the temperature adjusted crack growth rate for ONS Unit 2 is

$$\frac{da}{dt} = 1.421 * 10^{-12} (K_I - 9)^{1.16} \frac{m}{\text{sec}}$$

The crack growth rates used in developing Figure 3 (Allowable Flaw Sizes for Axially-Oriented Cracks) of the attached Decision Flow Chart Guidelines are a function of loading (stress), crack size, and geometry. Thus, crack growth does not occur at a fixed rate. In order to facilitate comparison with other work, instantaneous crack growth rates have been calculated. Table A below shows the predicted instantaneous crack growth rates in mm/year for various postulated crack length-to-crack depth (2c/a) semi-elliptical flaws and for various depth cracks in the worst-case CRDM nozzle location. The maximum instantaneous crack growth rate of 2.74 mm/year for the NEI accepted length-to-depth ratio of 2 to 1 corresponds well with the bounding values of 3 mm/year reported in the literature.

Table A


Predicted Instantaneous Crack Growth Rates of a Postulated Axial Flaw on the Uphill Side of a Hillside Nozzle at the Top of the Weld

Crack depth/wall thickness	Instantaneous Crack Growth Rate, da/dt (mm/year)		
	2/1 length/depth ratio	3/1 length/depth ratio	6/1 length/depth ratio
0.25	0.53	1.73	2.74
0.50	1.73	2.21	3.53
0.75	2.74	3.67	5.82

Attachment 1 contains the information proprietary to B&W Nuclear Technologies and DPCo. An affidavit supporting the BWNT proprietary classification follows this letter. The non-proprietary version of Attachment 1 is included as Attachment 2.

If you have any questions or comments regarding the circumferential flaw acceptance criteria, the decision flow chart guidelines, or the crack growth rates discussed above, please contact David Nix at (803) 885-3634 or B&W Nuclear Technologies via Mr. Nix for this information.

Sincerely,

for 
J. W. Hampton
Site Vice President

Attachments

xc w/attachments: L. A. Wiens, Projects Manager
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

xc wo/attachments: Mr. S. D. Ebnetter
Regional Administrator, Region II
U. S. Nuclear Regulatory Commission

Mr. P. E. Harmon
Senior NRC Resident Inspector
Oconee Nuclear Station

Mr. Virgil R. Autry
Bureau of Radiological Health
SC Dept. of Health & Environmental Control
2600 Bull St.
Columbia, SC 29201

AFFIDAVIT OF JAMES H. TAYLOR

- A. My name is James H. Taylor. I am Manager of Licensing Services for B&W Nuclear Technologies (BWNT); and as such I am authorized to execute this Affidavit.
- B. I am familiar with the criteria applied by BWNT to determine whether certain information of BWNT is proprietary and I am familiar with the procedures established within BWNT to ensure the proper application of these criteria.
- C. In determining whether a BWNT document is to be classified as proprietary information, an initial determination is made by the Unit Manager, who is responsible for originating the document, as to whether it falls within the criteria set forth in Paragraph D hereof. If the information falls within any one of these criteria, it is classified as proprietary by the originating Unit Manager. This initial determination is reviewed by the cognizant Section Manager. If the document is designated as proprietary, it is reviewed again by Licensing personnel and other management within BWNT as designated by the Manager of Licensing Services to assure that the regulatory requirements of 10 CFR Section 2.790 are met.
- D. The following information is provided to demonstrate that the provisions of 10 CFR Section 2.790 of the Commission's regulations have been considered:
- (i) The information has been held in confidence by BWNT. Copies of the document are clearly identified as proprietary. In addition, whenever BWNT transmits the

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information to a customer, customer's agent, potential customer or regulatory agency, the transmittal requests the recipient to hold the information as proprietary. Also, in order to strictly limit any potential or actual customer's use of proprietary information, the following provision is included in all proposals submitted by BWNT, and an applicable version of the proprietary provision is included in all of BWNT's contracts:

"Purchaser may retain Company's proposal for use in connection with any contract resulting therefrom, and, for that purpose, make such copies thereof as may be necessary. Any proprietary information concerning Company's or its Supplier's products or manufacturing processes which is so designated by Company or its Suppliers and disclosed to Purchaser incident to the performance of such contract shall remain the property of Company or its Suppliers and is disclosed in confidence, and Purchaser shall not publish or otherwise disclose it to others without the written approval of Company, and no rights, implied or otherwise, are granted to produce or have produced any products or to practice or cause to be practiced any manufacturing processes covered thereby.

Notwithstanding the above, Purchaser may provide the NRC or any other regulatory agency with any such proprietary information as the NRC or such other agency may require; provided, however, that Purchaser shall first give Company written notice of such proposed disclosure and Company shall have the right to amend such proprietary information so as to make it non-proprietary. In the event that Company cannot amend such proprietary information, Purchaser

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 - d. The information consists of test data or other similar data concerning a process, method or component, the application of which results in a competitive advantage to BWNT.
 - e. The information reveals special aspects of a process, method, component or the like, the exclusive use of which results in a competitive advantage to BWNT.

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f. The information contains ideas for which patent protection may be sought.

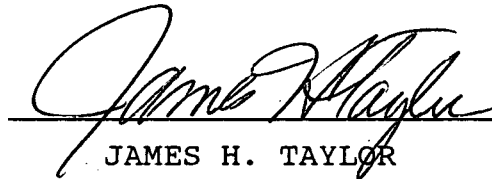
The document(s) listed on Exhibit "A", which is attached hereto and made a part hereof, has been evaluated in accordance with normal BWNT procedures with respect to classification and has been found to contain information which falls within one or more of the criteria enumerated above. Exhibit "B", which is attached hereto and made a part hereof, specifically identifies the criteria applicable to the document(s) listed in Exhibit "A".

- (iii) The document(s) listed in Exhibit "A", which has been made available to the United States Nuclear Regulatory Commission was made available in confidence with a request that the document(s) and the information contained therein be withheld from public disclosure.
- (iv) The information is not available in the open literature and to the best of our knowledge is not known by Combustion Engineering, EXXON, General Electric, Westinghouse or other current or potential domestic or foreign competitors of BWNT.
- (v) Specific information with regard to whether public disclosure of the information is likely to cause harm to the competitive position of BWNT, taking into account the value of the information to BWNT; the amount of effort or money expended by BWNT developing the information; and the ease or difficulty with which the information could be properly duplicated by others is given in Exhibit "B".

E. I have personally reviewed the document(s) listed on Exhibit "A" and have found that it is considered proprietary by BWNT because it contains information which falls within one or more of the

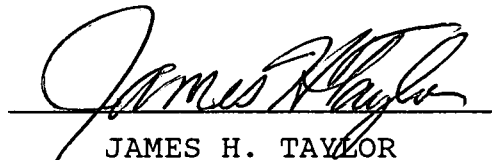
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criteria enumerated in Paragraph D, and it is information which is customarily held in confidence and protected as proprietary information by BWNT. This report comprises information utilized by BWNT in its business which afford BWNT an opportunity to obtain a competitive advantage over those who may wish to know or use the information contained in the document(s).



JAMES H. TAYLOR

State of Virginia)
) SS. Lynchburg
City of Lynchburg)

James H. Taylor, being duly sworn, on his oath deposes and says that he is the person who subscribed his name to the foregoing statement, and that the matters and facts set forth in the statement are true.


JAMES H. TAYLOR

Subscribed and sworn before me
this 16th day of September 1994.


Brenda C. Cardona
Notary Public in and for the City
of Lynchburg, State of Virginia.

My Commission Expires July 31, 1995

EXHIBITS A & B

EXHIBIT A

BWNT Document, "Acceptance Criteria for Control Rod Drive Mechanism Penetration Inspections", Oconee Nuclear Station, Units 1, 2, and 3, Dockets 50-269, 50-270, and 50-287.

EXHIBIT B

The above listed document contains information which is considered Proprietary in accordance with Criteria b, c, and d of the attached affidavit.

Attachment 1

Decision Flow Chart Guidelines

(Proprietary)

PRELIMINARY

PROPRIETARY INFORMATION

NOTICE

THE ATTACHED DOCUMENT CONTAINS OR IS CLAIMED TO CONTAIN PROPRIETARY INFORMATION AND SHOULD BE HANDLED AS NRC SENSITIVE UNCLASSIFIED INFORMATION. IT SHOULD NOT BE DISCUSSED OR MADE AVAILABLE TO ANY PERSON NOT REQUIRING SUCH INFORMATION IN THE CONDUCT OF OFFICIAL BUSINESS AND SHOULD BE STORED, TRANSFERRED, AND DISPOSED OF BY EACH RECIPIENT IN A MANNER WHICH WILL ASSURE THAT ITS CONTENTS ARE NOT MADE AVAILABLE TO UNAUTHORIZED PERSONS.

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