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HOPKINS,J.B. Project Directorate III-3

SUBJECT: Forwards addl info re relief request for core flood nozzle weld insps & fracture mechanics analyses.

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OG-1365
April 13, 1994
JHT/94-58

Mr. Jon B. Hopkins
Project Directorate III-3
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Relief from Code Request Using B&WOG Demonstration of Ultrasonics Techniques

References: 1) NRC letter to Duke Power Company dated March 1, 1994
2) Duke Power submittal to NRC, dated November 18, 1993

Dear Mr. Hopkins:

The members of the B&W Owners Group (B&WOG), including Duke Power Company, have completed additional analyses in support of the NDE relief request for core flood nozzle weld inspections. Because the most recent request was for the Oconee Nuclear Station, much of the communication has been on the Oconee docket. Nevertheless, it applies to all of the B&WOG plants. Hence, this information is being transmitted to you in the interest of attempting to close out the issue efficiently from the standpoint of both NRC and B&WOG resources.

Please find attached the information that responds to the NRC's request in Reference 1 for additional information. The attached information supplements that provided in Reference 2. Based on questions raised by the NRC during the 1993 UT demonstration, additional fracture mechanics analyses have been performed and are provided in Attachment B for your information.

We believe this information convincingly demonstrates that the size flaws which were included in the B&WOG mock-up can be detected from the inner diameter of the core flood nozzles and are consistent with Appendix VIII of Section XI of the ASME Code for qualification of NDE personnel and techniques. Furthermore, the fracture mechanics analyses demonstrate that there are sufficient safety margins for granting the requested relief. It is also worth noting that this relief request is beneficial to safety from the standpoint of reduced personnel exposures. Overall, the B&WOG believes this relief request is quite consistent with the types of actions being considered as cost-beneficial licensing actions.

As a follow-up to this submittal, it may be necessary to hold a meeting either in Lynchburg or Rockville.

Please let us know your schedule for reviewing the attached information and whether you believe a meeting will be necessary before granting the requested relief.

If you have questions or need further information, please call Mr. Frank Walters of BWNT (804/385-2208) or me (804/385-2817).

Very truly yours,

J. H. Taylor, Manager
Licensing Services

B&W NUCLEAR TECHNOLOGIES

JHT/bcc

cc: P. S. Walsh/GPUN
D. W. Dalton/DPC
B&WOG NDE Committee Members

INFORMATION REQUESTED by NRC in REFERENCE 1

A. There was a fundamental change in objectives between the 1989 and the 1993 demonstrations. The 1989 demonstration attempted to show equipment capability by selecting electrical discharge machined (EDM) notches with a depth slightly above, slightly below, and well below the Code maximum through-wall depth. The applicable Code was ASME, Section XI, 1974 Edition through the Summer 1975 Addenda, which limited the maximum allowable flaw depth to 5-percent through-wall (independent of the examination method). The 1993 demonstration attempted to show flaw detection capabilities for fatigue-induced flaws according to ASME, Section XI, Appendix VIII, which does not relate to opposite surface flaw depth.

QUESTION **1. What was the basis for this change?**

ANSWER: There was no change in our objectives between the 1989 & 1993 demonstrations.The common objective of both the 1989 and 1993 demonstrations was to demonstrate the flaw detection capabilities of the ultrasonic (UT) examination techniques for opposite surface flaws. Although, different editions of ASME Section XI may have been applicable between these demonstrations, this has no impact on the demonstration objectives, examination techniques or results. As indicated in Reference 3, the demonstration contained two objectives, 1) to demonstrate the effectiveness of the examination technique applied to the 1985 examination for the first interval and 2) the demonstration of refracted longitudinal wave transducers for the capabilities of techniques for the second interval examinations. For the 1993 demonstration the same techniques demonstrated in 1989 were used with additional technology improvements.

ASME Section XI, Appendix VIII was used as guidance for demonstrating the examination's reliability. Although, not specifically addressing the inspection of the outer diameter (OD) surface flaws from the inside surface (ID), the B&WOG believes that Appendix VIII provides a basis and guidance for selecting flaw type, sizes, distribution and criteria for establishing acceptable demonstration results. The need to utilize a document such as Appendix VIII is based on NRC's SER to Duke Power Co. dated May 14,1991 which states "the ultrasonic testing instrumentation and procedures are demonstrated to be capable of detecting and sizing OD surface connected defects, in the circumferential orientation, in a laboratory test block. The defects should be cracks and not machined notches." ASME Section XI, Appendix VIII is the most applicable document that addresses the demonstration of examination reliability. Although, not yet approved by the NRC, this document has been incorporated into the ASME Code.

QUESTION **2. How does the basis relate to the surface examination method requirements contained in ASME Code?**

ANSWER: The intent,as discussed in Reference 2, for using Appendix VIII as guidance for this demonstration was to demonstrate examination reliability for the detection and sizing of flaws within the bounds of the critical flaw size allowed by fracture analysis for a 10 year examination interval. The critical flaw size has been determined to be > 45% through wall, using a 360 degree external circumferential flaw at the point of interest. See ATTACHMENT B for the results of the Oconee 3 fracture mechanics (FM) analysis. The B&WOG never attempted to prove that these UT examination techniques were equivalent to surface examinations, such as liquid penetrant and magnetic particle, as addressed by IWA - 2240 of Section XI. The B&WOG understanding of the intent of Appendix VIII is to provide adequate assurance that the UT procedures and personnel applying the procedures will detect and size flaws that have safety significance and would provide assurance of an acceptable level of Quality and Safety as specified in 10CFR50.55a.

B. There was a change in showing equipment capability between the 1989 and the 1993 demonstrations. Specifically, one mockup in the 1989 demonstration contained ten EDM flaws measuring 0.455- to 1.00- inch long by 2.3- to 5.6-percent through-wall. The ten flaws were located as follows: two in the steel pipe, two in the Inconel butter, two in the stainless steel pipe, and four in the Inconel weld. Two mockups in the 1993 demonstration contained a total of four fatigue flaws that ranged from 7.0- to 12.6-percent through-wall. These four flaws are approximately the maximum through-wall depth allowed by ASME Section XI, 1980 Edition through the Winter 1980 Addenda without further evaluation for flaws initially detected by the surface examination method and subsequently sized by the volumetric examination methods. Three flaws were in steel and one flaw was in stainless steel.

QUESTION **1. What was the bases for this change?**

ANSWER: The demonstration performed in 1989 was successful in demonstrating the detectability of the examination technique for small (length and through-wall) planar reflectors (EDM notches) located in the various mockup materials (REFERENCE 2 and 3). In 1993, the

B&WOG extended the demonstration of the examination techniques capabilities to real flaws (thermal fatigue cracks) as requested in the NRC SER to Duke Power Co. dated May 14,1991. For the purpose of this demonstration, ASME Section XI, Appendix VIII - Performance Demonstrations for Ultrasonic Examination Systems, was utilized for guidance to demonstrate the reliability of the examination techniques and equipment. The flaws were sized and distributed in the mockup in accordance with the ranges of the applicable supplement of Appendix VIII. The supplements used are Supplement 2, for the austenitic stainless Core Flood (CF) safe-end to pipe; Supplement 3, for the reactor coolant (RC) nozzle to pipe weld and Supplement 10, for the CF nozzle to safe-end dissimilar metal welds.

QUESTION **2. How would the flaws in the 1993 demonstration show equipment capability in all three alloys?**

ANSWER: The flaws in the core flood nozzle to safe-end mockup were distributed throughout the three alloys of the mockup. The examination graphic images (1993 demonstration handouts provided NRC) provide evidence of flaw detection capability while scanning from each side of the weld. These images demonstrate that the flaws in each of the materials are detectable while penetrating all three alloys. Flaw #1 illustrates the worse case situation measuring only 0.22 inch through-wall (12.6%) and is located in the ferritic nozzle material, this flaw was detected while scanning from the austenitic safe-end material with the sound beam being directed through the austenitic safe-end material, Inconel weld material, the Inconel buttering and into the ferritic nozzle material.

QUESTION **3. How would the use of the 1993 mockups demonstrate the detectability of random flaws in an actual welded assembly?**

ANSWER: The demonstrated UT examination capabilities, described in question 2, when compared with the results of the FM analysis, ATTACHMENT B, indicate that the UT examination techniques applied to the CF nozzle welds are capable of detecting flaws before they reach a maximum allowable size for the next ten year interval.

C. For the implants used in the 1993 mockups,

QUESTION **1. Were the implants made of the same material as the base metal receiving the implants?**

ANSWER: Yes, they were made of the same material. Refer to Attachment C for a description of the flaw implant process.

QUESTION **2. How were the implants fused to the carbon steel, stainless steel, Inconel butter, and Inconel base metals?**

ANSWER: The flaw implant process as illustrated in Attachment C is performed by first welding a tension bar onto the machined weld preparation. Stress risers are created at the desired crack dimensions. The tension bar is then subjected to cyclic thermal fatigue until failure, thus creating a flaw face on the base material and another flaw face of the base material on the tension bar. The flaw face on the tension bar is then shaped to size, mated to the base material flaw face and seal welded. The remaining weld groove is then filled with standard weld procedures.

QUESTION **3. How were the implant-to-base metal joints examined?**

ANSWER: Upon completion of the crack implant process, the material surrounding the flaw was examined using manual ultrasonic techniques. These examinations were performed to ensure cleanliness of the material surrounding the flaw to allow the proper assessment of the ultrasonic examination capabilities intended to be evaluated using these mockups. In addition to the manual examinations performed during the fabrication of the mockups, the automated examinations performed for the purpose of the 1993 demonstration to the NRC, were used to verify the quality of the flaw and surrounding material, as displayed in the examination graphic images (1993 demonstration handouts).

QUESTION **4. Were there volumetric examinations conducted with implants and blind implants (without cracks)?**

ANSWER: It is the position of the B&WOG, that to properly demonstrate the capability of the examination techniques, supportive evidence justifying any call made for the detection of a flaw be provided. For our purpose the use of the examination graphic images (1993 demonstration handouts) were utilized to support the affirmation of detection capabilities. As displayed in these images there were no signals from the material surrounding the flaws which would indicate the presence of a flaw. Of particular interest, the images of the RC nozzle to pipe weld Mockup (clad ferritic material) consisted of very low material noise levels with high amplitude flaw responses. These images represent the quality of the flaws and the cleanliness of the surrounding base material. The inherent high noise levels of the austenitic stainless and dissimilar metal welds preclude any low amplitude implant signals to unintentionally identify the flaw location.

Based on the position of providing supportive evidence, we believe that the need for blind implants are not necessary to adequately assess the capabilities of the examination techniques.

D. The 1989 demonstration was to the Section XI, 1974 Edition through the Summer 1975 Addenda and the 1993 demonstration was to Section XI, 1980 Edition through the Winter 1980 Addenda.

QUESTION 1. How will the changes in Code requirements be reconciled with prior examinations conducted in <u>anticipation</u> of an acceptable demonstration?

ANSWER: Credit is not being sought for examinations performed to any Edition of the Code prior to the 1980 Edition of Section XI. Examinations performed in recent years and examinations in the near future is the subject for which credit is being sought using the techniques demonstrated in the 1993 B&WOG UT Demonstration.

ATTACHMENT B

FRACTURE MECHANICS EVALUATION
for
B&W DESIGNED PLANT OCONEE-3

Summary of Fracture Mechanics Analysis of Postulated Flaws in a Core Flood Nozzle

PURPOSE

The purpose of the fracture mechanics (FM) analysis completed in 1993 on the Oconee - 3 nuclear plant's Core Flood nozzle was to determine the range of possible maximum allowable flaw sizes assuming a fatigue crack growth for the period until the next 10 year RV inservice inspection. The final evaluation then compared the FM results with the 1993 UT inspection results (References 1&2) for establishing anticipated safety margins between the expected minimum detectable defect and the minimum expected allowable flaw size for these conditions.

ANALYSIS CONFIGURATION

The FM analysis was performed on the stainless steel CF Nozzle welds that exists in each B&W designed nuclear plant with the applied stresses obtained from the OCONEE - 3 stress reports and the associated number of design cycles from the applicable functional specification. The fatigue flaw growth analysis was performed considering the normal/upset condition transients expected over the next 10 years. The postulated flaw was a conservative 360 degree part - throughwall circumferential external flaw subjected to an equivalent axial loading.This conservative assumption for the flaw size was used in this analysis only to envelope the NRC concerns about not detecting shallow OD cracks with the present UT technique.

RESULTS

The maximum expected allowable flaw sizes (flaws considered acceptable during the current ISI period) assuming the conservative flaw geometry of a 360 degree external circumferential flaw and that meets ASME Section XI, IWB-3612 for the next 10 year interval is in the range of 45% to 55% of the wall thickness at the locations of the nozzle to safe-end weld and safe-end to pipe weld.

These maximum allowable sizes are well above the minimum demonstrated detectable flaws (7-15%) demonstrated in the 1993 B&WOG UT Demonstration.

It should be noted that while there are uncertainties in all results, the conservative use of a 360 degree external flaw in this comparison could be replaced with more realistic semi-elliptical flaws, if added safety margin was thought to be needed, we believe the point is made without additional considerations.

The details of this FM evaluation can be provided if needed.

ATTACHMENT C

VENDORS DESCRIPTION of the PROCESS
used in the
Fabrication of Flaws
contained in the
B&WOG MOCKUP

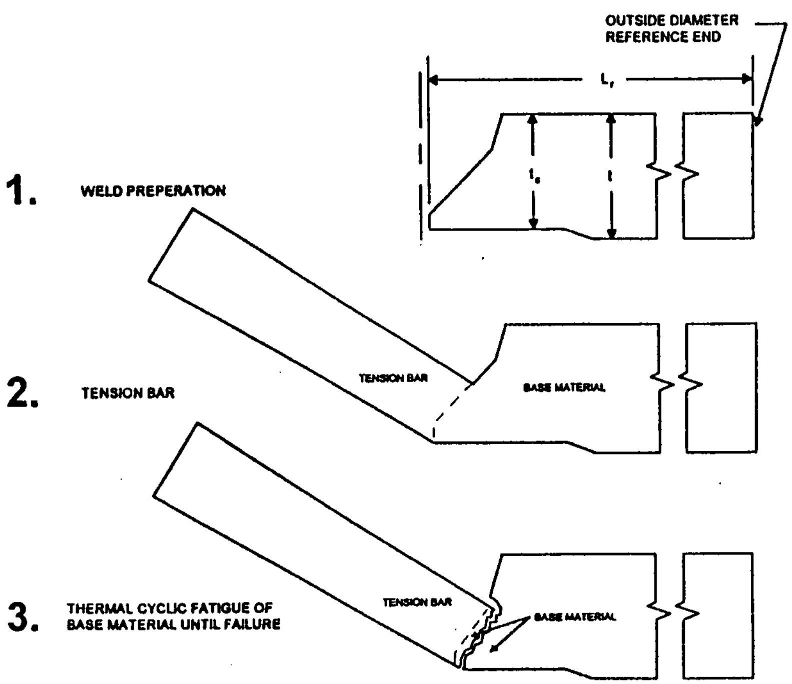
WHAT TYPE OF PROCESS IS USED TO IMPLANT FLAWS IN A TYPICAL APPENDIX VIII PIPING SPECIMEN?

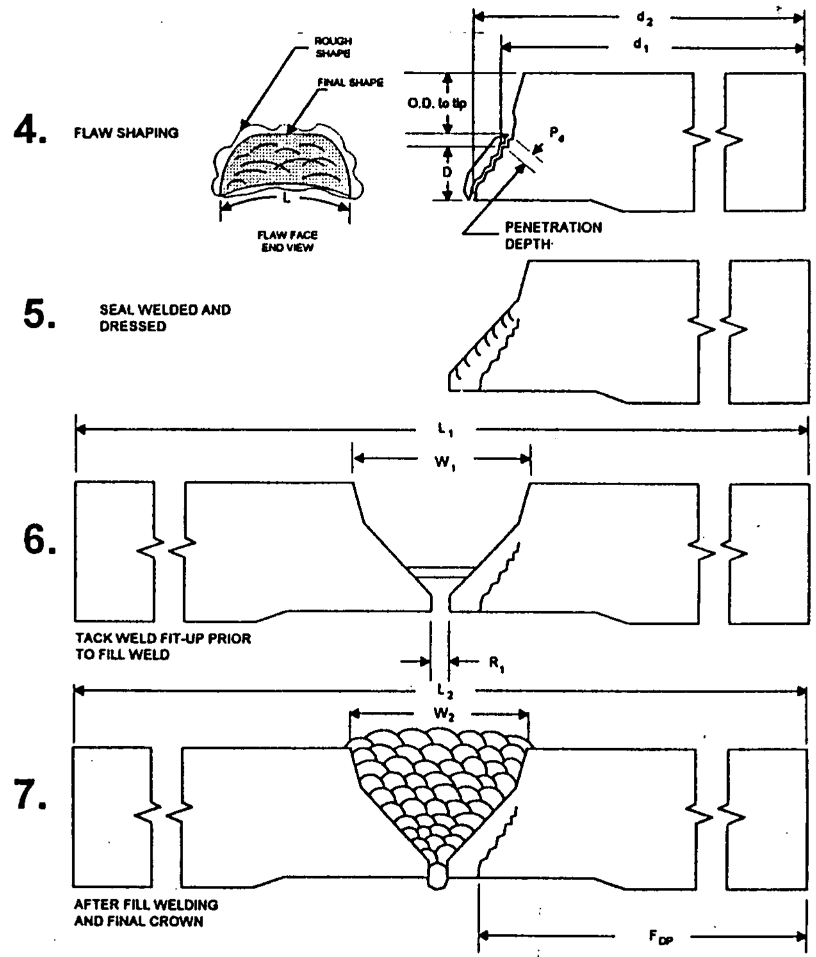
- A unique process of heating/cooling while under tension is used to initiate a thermal fatigue crack at a location that will later become the HAZ. The number of cycles is controlled to obtain the desired crack "roughness."

- The thermal fatigue crack is caused to initiate in base material, thus allowing UT energy to impinge directly on the flaw face.

- After taking careful physical measurements to establish flaw location, the implant is seal welded in place. The remaining weld groove is then filled with a standard welding procedure.

- During the flaw manufacturing process, *PH D*iversified takes into account the **various geometric conditions** that must be present; i.e., type of cladding, nozzle radius, weld crown, counterbore, mismatch, diametrical shrink, etc.





*PH D*IVERSIFIED REFERS TO TWO KINDS OF APPENDIX VIII SPECIMENS. WHAT ARE THEY?

- Practice specimens are designed to replicate typical plant components that will require a UT examination in accordance with Section XI. These flawed specimens are essential for in-house training and UT procedure development.

- Qualification specimens are identical to practice samples (except for the degree of confidentiality) and will be use to conduct performance demonstration in accordance with the user's Appendix VIII program.