Indiana Michigan
Power Company
Cook Nuclear Plant
500 Circle Drive
Buchanan, MI 49107
616-465-5901

INDIANA
MICHIGAN
POWER

November 28, 2001

C1101-13
10 CFR 50.90

Docket No.: 50-316

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop O-P1-17
Washington, DC 20555-0001

Donald C. Cook Nuclear Plant Units 1 and 2
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
REGARDING UNIT 2 CONTROL ROD DRIVE MECHANISM VESSEL
HEAD PENETRATION JUSTIFICATION FOR SAFE OPERATION UNTIL
JANUARY 19, 2002

On November 20, 2001, Indiana Michigan Power Company (I&M), the licensee for Donald C. Cook Nuclear Plant (CNP) Unit 2, met with the United States Nuclear Regulatory Commission (NRC) staff to present I&M's justification that Unit 2 was safe to operate past December 31, 2001. In that meeting and in a telephone call on November 21, 2001, between John Stang, NRC Project Manager and Scot Greenlee, CNP Director of Nuclear Technical Services, the NRC informed I&M that additional technical detail concerning the November 20, 2001 presentation was needed by the NRC staff. This letter provides the response to the request for additional information.

This letter contains no new commitments. Should you have any questions, please contact Mr. Ronald W. Gaston, Manager of Regulatory Affairs, at (616) 697-5020.

Sincerely,

M. W. Rencheck
Vice President, Strategic Business Improvements

/dmb

A001

Printed on recycled paper

Attachments

c: J. E. Dyer
MDEQ – DW & RPD
NRC Resident Inspector
R. Whale

AFFIRMATION

I, Michael W. Rencheck, being duly sworn, state that I am Vice President of Indiana Michigan Power Company (I&M), that I am authorized to sign and file this document with the Nuclear Regulatory Commission on behalf of I&M, and that the statements made and the matters set forth herein pertaining to I&M are true and correct to the best of my knowledge, information, and belief.

Indiana Michigan Power Company

M. W. Rencheck
Vice President, Strategic Business Improvements

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 28th DAY OF November, 2001

Margaret M. Sunagel
Notary Public

My Commission Expires 11/2005

MARGARET MARY SUNAGEL
Notary Public, Berrien County, MI
My Commission Expires Nov 23, 2005

bc: P. B. Cowan, w/o attachments
R. W. Gaston, w/o attachments
S. A. Greenlee
S. B. Haggerty, w/o attachments
D. W. Jenkins, w/o attachments
M. W. Rencheck, w/o attachments
E. M. Ridgell, w/o attachments
J. F. Stang, Jr., NRC Washington, DC
T. R. Stephens, w/o attachments

ATTACHMENT 1 TO C1101-13

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING UNIT 2 CONTROL ROD DRIVE MECHANISM VESSEL HEAD PENETRATION JUSTIFICATION FOR SAFE OPERATION UNTIL JANUARY 19, 2002

On November 20, 2001, Indiana Michigan Power Company (I&M) met with the United States Nuclear Regulatory Commission (NRC) staff to present I&M's justification that Unit 2 was safe to operate past December 31, 2001. In that meeting and in a telephone call on November 21, 2001, between John Stang, NRC Project Manager and Scot Greenlee, Donald C. Cook Nuclear Plant (CNP) Director of Nuclear Technical Services, the NRC informed I&M that additional technical detail was needed by the NRC staff. The information provided below responds to the NRC's request for additional information.

NRC Question 1

Please provide the basis for the penetration cracking probabilities provided in Slide 45 of your presentation.

I&M Response to Question 1

The penetration cracking probabilities provided on Slide 45 of the presentation were extracted by linear interpolation from Table 5-3 in Westinghouse Electric Corporation (Westinghouse) report WCAP 14907, Revision 0, "Probabilistic Evaluation of Reactor Vessel Closure Head Penetration Integrity for the Donald C. Cook Units 1 and 2." This WCAP was prepared as a CNP specific report in response to NRC Generic Letter 97-01, "Degradation of Control Rod Drive Mechanism Nozzle and Other Vessel Closure Head Penetrations." The WCAP was subsequently superceded by a generic industry response, and was, therefore, never submitted to the NRC for review. This WCAP was developed by Westinghouse under their Quality Assurance program and is being submitted for your information.

Westinghouse has identified that WCAP 14907 contains proprietary information and should be withheld from public disclosure in accordance with 10 CFR § 2.790. Revision 1 to WCAP 14907 was made by Westinghouse to identify proprietary information and is provided as Attachment 2. An affidavit for withholding WCAP 14907, Revision 1, from public disclosure is provided in Attachment 3.

NRC Question 2

Please provide the referenced report prepared by Electric Power Research Institute (EPRI) containing the qualification methodology for the 1994 eddy current test inspection.

I&M Response to Question 2

The requested report, EPRI Application Report, TR-106260, "Demonstration of Inspection Technology for Alloy 600 CRDM Head Penetrations," was provided to the NRC from EPRI by a separate letter. This report describes a program developed to enable utilities to demonstrate procedures for inspecting Alloy 600 CRDM penetrations. The program was coordinated by utilities and original equipment manufacturers through a Nuclear Utility Management and Resources Ad Hoc Advisory Committee and addresses ultrasonic and eddy current procedures for detecting primary water stress corrosion cracking initiated on the inside surface of penetrations.

NRC Question 3

Please provide documentation of vessel head penetration material heat data for Unit 2, and the documentation for the vessel head penetration material heats used for the crack growth data graphs presented in Slides 24 and 26. Additionally, describe how the material was tested if not provided in EPRI TR-109136, "Crack Growth and Microstructural Characterization of Nickel Alloy PWR Vessel Head Penetration Materials."

I&M Response to Question 3

Unit 2 material heat data is found in Table 4-2 on Page 4-8 of WCAP 14118, Revision 4, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: D. C. Cook Units 1 and 2." This WCAP was submitted to the NRC staff on November 5, 2001.

Material heat data used in the crack growth data graphs presented in Slides 24 and 26 is provided in Westinghouse report AEP-01-217, "Tabular Alloy 600 Data from AEP/USNRC Meeting on November 20, 2001", dated November 26, 2001, as Attachment 4. Westinghouse has identified that report AEP-01-217 contains proprietary information and should be withheld from public disclosure in accordance with 10 CFR § 2.790. An affidavit for withholding report AEP-01-217 from public disclosure is provided in Attachment 5.

EPRI TR-109136, "Crack Growth and Microstructural Characterization of Nickel Alloy PWR Vessel Head Penetration Materials," summarizes the results of an extensive testing program to characterize stress corrosion crack growth behavior of Alloy 600 head penetrations in Pressurized Water Reactor environments. The report describes the study of crack growth rate

results on Alloy 600 CRDM head penetrations using fracture mechanics and the method of obtaining the crack growth data.

NRC Question 4

Please provide the documentation for the Cook 2 data point on the crack growth data graph on Slide 24 and the basis for the value "K" that the data point is plotted on. What are the uncertainties and justification of why the Cook 2 data point is applicable in this graph?

I&M Response to Question 4

Westinghouse has prepared letter report, "D. C. Cook Unit 2 Upper Head Penetration Crack Growth Determined from Inspection Data," to respond to this question. This report is provided as Attachment 6.

The crack growth rate and the stress intensity factor, value "K", were recalculated since the meeting of November 20, 2001. Please note that the new calculation shows the Cook 2 data point below the Scott Model curve.

A short qualitative discussion on eddy current and ultrasonic testing uncertainties is discussed at the end of the report.

NRC Question 5

Please provide the results of the 1994 and 1996 Unit 2 vessel head penetration eddy current test.

I&M Response to Question 5

The results of the 1994 eddy current test were provided to the NRC in a letter I&M, dated October 26, 1994, "CRDM Reactor Vessel Head Penetration Assessment." The comparison results of the 1996 eddy current test are provided in the Westinghouse letter report "D. C. Cook Unit 2 Upper Head Penetration Crack Growth Determined from Inspection Data" provided as Attachment 6.

ATTACHMENT 2 TO C1101-13

WESTINGHOUSE ELECTRIC CORPORATION REPORT WCAP 14907, REVISION 1

PROBABILISTIC EVALUATION OF REACTOR VESSEL CLOSURE HEAD PENETRATION INTEGRITY FOR THE DONALD C. COOK UNITS 1 AND 2.

ATTACHMENT 3 TO C1101-13

AFFIDAVIT FOR WITHHOLDING WCAP 14907, REVISION 1, FROM PUBLIC DISCLOSURE

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) contained within parentheses located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.790 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

Westinghouse Electric Company LLC

Box 355
Pittsburgh Pennsylvania 15230-0355

November 26, 2001

CAW-01-1500

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

Attention: Mr. Samuel J. Collins

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: WCAP-14907, Revision 1, "Probabilistic Evaluation of Reactor Vessel Closure Head Penetration Integrity for the Donald C. Cook Units 1 and 2", November 2001.

Dear Mr. Collins:

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-01-1500 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.790 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying Affidavit by American Electric Power Company.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-01-1500 and should be addressed to the undersigned.

Very truly yours,

J. W. Fasnacht, Manager
Integrated Plant Engineering Services

Enclosures

cc: M. Scott, NRR/OWFN/DRPW/PDIV2 (Rockville, MD) 1L

CAW-01-1500

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. W. Fasnacht, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC ("Westinghouse"), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J. W. Fasnacht, Manager
Integrated Plant Engineering Services

Sworn to and subscribed
before me this 26th day
of November, 2001

Lorraine M. Piplica
Notary Public

LORAINE M. PIPLICA
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

Notarial Seal
Lorraine M. Piplica, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Dec. 14, 2003
Member, Pennsylvania Association of Notaries

/cm/0253S.doc

(1) I am Manager, Integrated Plant Engineering Services, in Nuclear Services, Westinghouse Electric Company LLC ("Westinghouse"), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company LLC.

(2) I am making this Affidavit in conformance with the provisions of 10CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company LLC in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in WCAP-14907, Revision 1 (Proprietary), November 2001 for D. C. Cook Units 1 and 2 being transmitted by the American Electric Company letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk, Attention Mr. Samuel J.

Collins. The proprietary information as submitted for use by American Electric Company for D. C. Cook Units 1 and 2 is expected to be applicable in other licensee submittals in response to certain NRC requirements as presented in Generic Letter 97-01.

This information is part of that which will enable Westinghouse to:

(a) Determine the nature of potential cracking of the reactor vessel closure head penetrations.

(b) Assist the customer to obtain NRC approval.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for licensing documentation.

(b) Westinghouse can sell support and defense of in-depth probabilistic assessments for all of the reactor vessel closure head penetrations.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar support documentation and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

effort, having the requisite talent and experience, would have to be expended for developing testing and analytical methods and performing tests.

Further the deponent sayeth not.

ATTACHMENT 4 TO C1101-13

WESTINGHOUSE REPORT AEP-01-217

TABULAR ALLOY 600 DATA FROM AEP/USNRC MEETING ON NOVEMBER 20, 2001

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

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Westinghouse Electric Company LLC

Box 355
Pittsburgh Pennsylvania 15230-0355

November 26, 2001

CAW-01-1501

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

Attention: Mr. Samuel J. Collins

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: AEP-01-217, "Tabular Alloy 600 Data From AEP/USNRC Meeting on November 20, 2001", November 26, 2001.

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Very truly yours,

J. W. Fasnacht, Manager
Integrated Plant Engineering Services

Enclosures

cc: M. Scott, NRR/OWFN/DRPW/PDIV2 (Rockville, MD) 1L

CAW-01-1501

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

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J. W. Fasnacht, Manager
Integrated Plant Engineering Services

Sworn to and subscribed
before me this 26th day
of November, 2001

Lorraine M. Piplica
Notary Public

LORAINE M. PIPLICA
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

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(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

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(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in AEP-01-217 (Proprietary), November 26, 2001 for D. C. Cook Units 1 and 2 being transmitted by the American Electric Company letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk, Attention Mr. Samuel J. Collins. The proprietary

information as submitted for use by American Electric Company for D. C. Cook Units 1 and 2 is expected to be applicable in other licensee submittals in response to certain NRC requirements as presented in Generic Letter 97-01.

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(a) Determine the nature of potential cracking in the reactor vessel closure head penetrations.

(b) Assist the customer to obtain NRC approval.

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The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower

effort, having the requisite talent and experience, would have to be expended for developing testing and analytical methods and performing tests.

Further the deponent sayeth not.

ATTACHMENT 6 TO C1101-13

WESTINGHOUSE ELECTRIC CORPORATION LETTER REPORT

D. C. COOK UNIT 2 UPPER HEAD PENETRATION CRACK GROWTH DETERMINED FROM INSPECTION DATA

LTR-SMT-01-72

From: Nuclear Services
WIN: 284-6515
Date: November 26, 2001
Subject: D. C. Cook Unit 2 Upper Head Penetration Crack Growth Determined From Inspection Data

To: D. W. Sklarsky – EC 430G

cc: K. R. Hsu – EC 310
W. R. Rice – EC 520A
S. A. Swamy – EC 307

Attached is the letter report, "D. C. Cook Unit 2 Upper Head Penetration Crack Growth Determined from Inspection Data".

Please transmit this to the customer.

Warren H. Bamford
Structural Mechanics Technology

/pe

Attachment

D. C. COOK UNIT 2 UPPER HEAD PENETRATION

CRACK GROWTH DETERMINED FROM INSPECTION DATA

November 2001

W. H. Bamford

Reviewed by: K. R. Hsu

K. R. Hsu

Approved by: S. A. Swamy

S. A. Swamy, Manager
Structural Mechanics Technology

Westinghouse Electric Company, LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

D C Cook Upper Head Penetration Crack Growth
Determined From Inspection Data

INTRODUCTION

In April of 1996 an eddy current inspection of the outer 5 thermocouple column penetrations (nos. 74-78), and an ultrasonic inspection of the known defects in penetration #75 of D C Cook Unit 2 was accomplished [1]. These five penetrations had previously been inspected during the 1994 Unit 2 outage. The purpose of this inspection was to determine if any new defects were present and if the known defects in Penetration #75 had any growth during the last cycle.

INSPECTION METHODS

Eddy Current Inspection

The eddy current inspection utilized multi-frequency eddy current in the absolute mode. This method consists of measuring the changes in impedance of a coil placed near a conductive or diamagnetic component (reactor vessel head penetration).

Thermocouple (non-sleeved) locations were inspected using a rotating eddy current probe that performs a helical scan as the probe is withdrawn through the attachment weld area. The data was plotted in C-scan format for analysis where each individual scan line is one 360° rotation of the probe. The C-scan plot of the data represents the axial travel of the rotating probe through the penetration.

Ultrasonic Inspection

An ultrasonic Time-Of-Flight-Diffraction (TOFD) technique was used to determine the depth of cracks in the penetration. The TOFD technique makes use of the ultrasonic signals diffracted from the tips of a crack as a means of determining accurately the through-wall extent of the crack. By placing two ultrasonic transducers (one transmitter and one receiver) astride a crack and measuring the time-of-flight of an ultrasonic pulse from the transmitter probe to the defect and back to the receiver, the precise depth of the defect can be determined.

With each scan, two sets of data are collected. The first is a raster B-scan that provides position and depth information. Depth is measured by a comparative technique. The second (weld profilometry) is collected simultaneously with the same probes and uses a pulse-echo C-scan method to detect the presence of the back wall echo. When the probes are over the weld, there is no interface to provide a reflection so the back wall echo disappears. This information is plotted to provide the location and shape of the weld. Because both sets of data are collected simultaneously, position accuracy is very reliable.

ECT INSPECTION RESULTS

Analysis of the data from Penetration 75 was performed with no direct reference to the previous results from 1994 until position information was complete. The results of the eddy current confirmed the presence of the flaws. Their position is shown in Figure 1. Also included is the data from the ultrasonic weld profilometry. The weld profile data is only available for the extent of the ultrasonic scan plan. Therefore, the remaining portion of the weld is extrapolated over 360°.

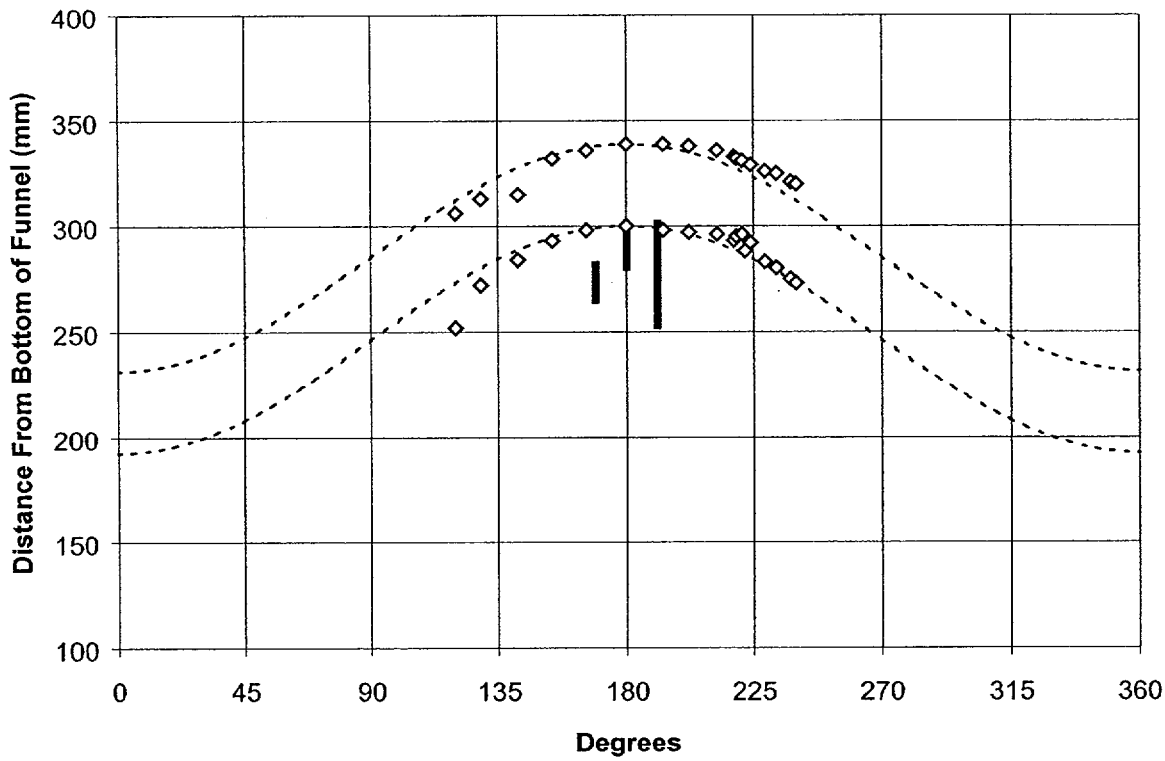

Figure 1
Position of 3 indications in relation to the attachment weld profile.
Actual weld profile shown for UT scan area with the remainder being extrapolated.

UT INSPECTION RESULTS

The ultrasonic scan coordinates were based on the position information from the eddy current inspection. The extent of the indications was measured and a box or "scan plan" was created with a large margin around the cluster. The UT defect sizing procedure outlines the method for defining the scan plan. The area of the scan started above the top of the weld and encompassed the area of the defect cluster, with a generous margin.

The surface position of the flaw is determined by its interference with the lateral wave. This is shown in Figure 2. The ultrasonic weld profile is also shown. Because the defect cluster extent is smaller than the probe separation (PCS), the TOFD technique will not distinguish the individual flaws in terms of their depth. It will only determine the depth of the deepest part of the cluster at any given point. However, it is most likely that the depth profile shown in Figure 3 is that of the longest flaw.

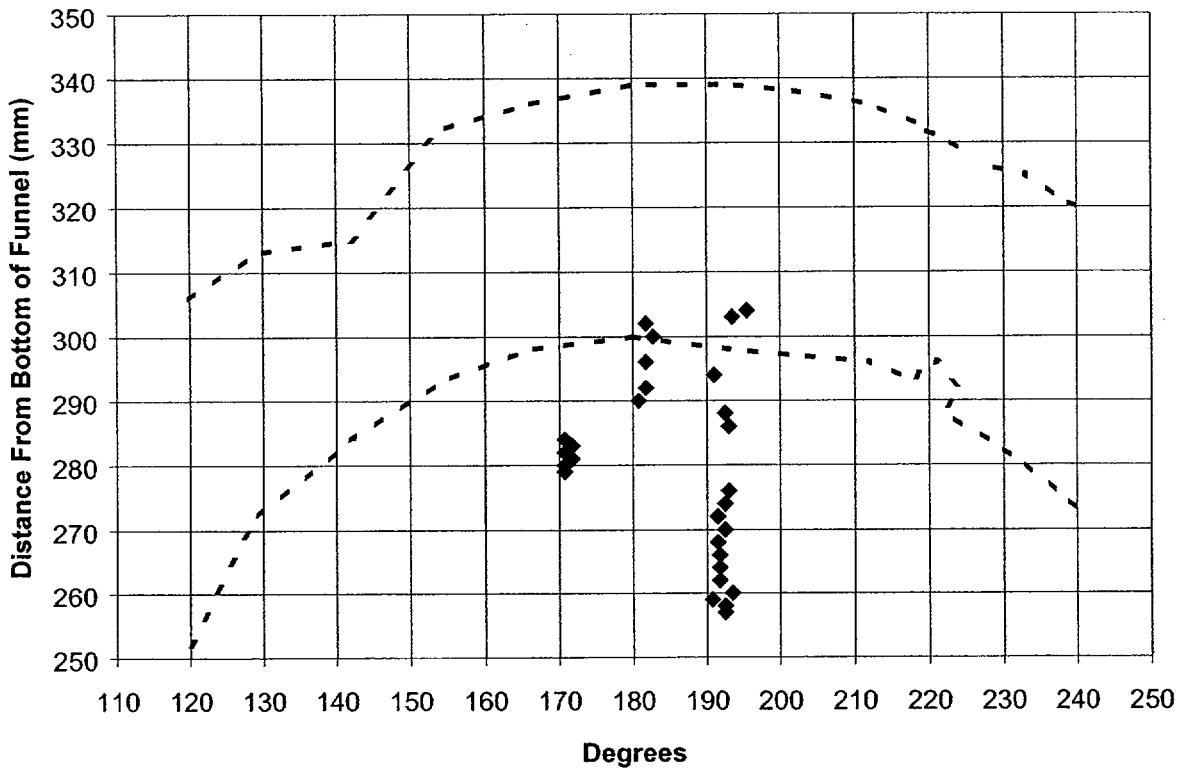

Figure 2

Area of detail of the ultrasonic TOFD plot of attachment weld and defects: 1996 Inspection

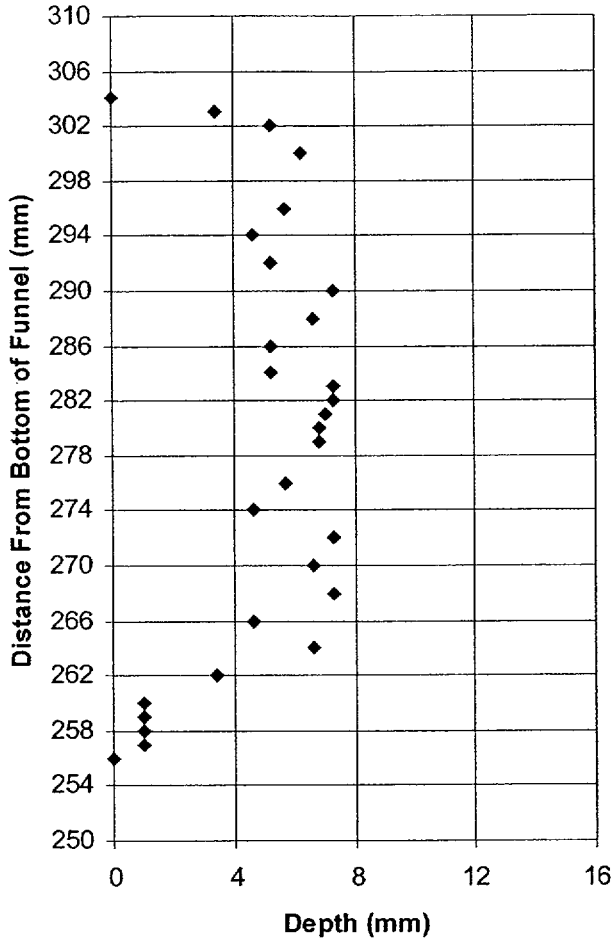

Figure 3
TOFD Depth Profile: 1996 Inspection

INSPECTION SUMMARY

A comparison was first made of the results from the eddy current and ultrasonic TOFD measurements. There is good agreement on circumferential position for all three defects and on the length of indication #1. The axial position of indication #1 is within 3mm for the two techniques. The length estimated by eddy current is the more reliable value.

With regard to the dimensions of indication #1, both techniques in this inspection give its length to be 48mm (1.89") and the ultrasonic TOFD shows maximum depth to be 7.3mm (0.29"). Compared to the previous result there has been a consistent increase in its overall dimension. Although the amount of increase is within measurement tolerance, it is unlikely that all errors will have compounded to provide an overall increase to both length and depth. The amount of crack growth is also consistent with published crack growth curves, as will be discussed further below.

Comparison of the results from the 1994 inspection shows the apparent circumferential position of the largest flaw has not changed significantly (1994 = 200°, 1996 = 191°). The difference can be attributed to the angular offset of the eddy current probe zero (the angle of the trigger signal during each rotation). The zero point was previously closely estimated using known defects in the calibration block. The position reported here is the more reliable, since the exact angular offset of the eddy current rotating probe was precisely measured prior to scanning. The ultrasonic TOFD scan gave a position of 192.5° that confirms the position as determined with eddy current.

The 1994 inspection results [2] are shown in Figure 4, which is a plot very similar to Figure 3. Note that the maximum depth of the flaw was found to be 6.8 mm, as opposed to the 96 value of 7.3 mm. The total length increased from 45 mm to 48 mm.

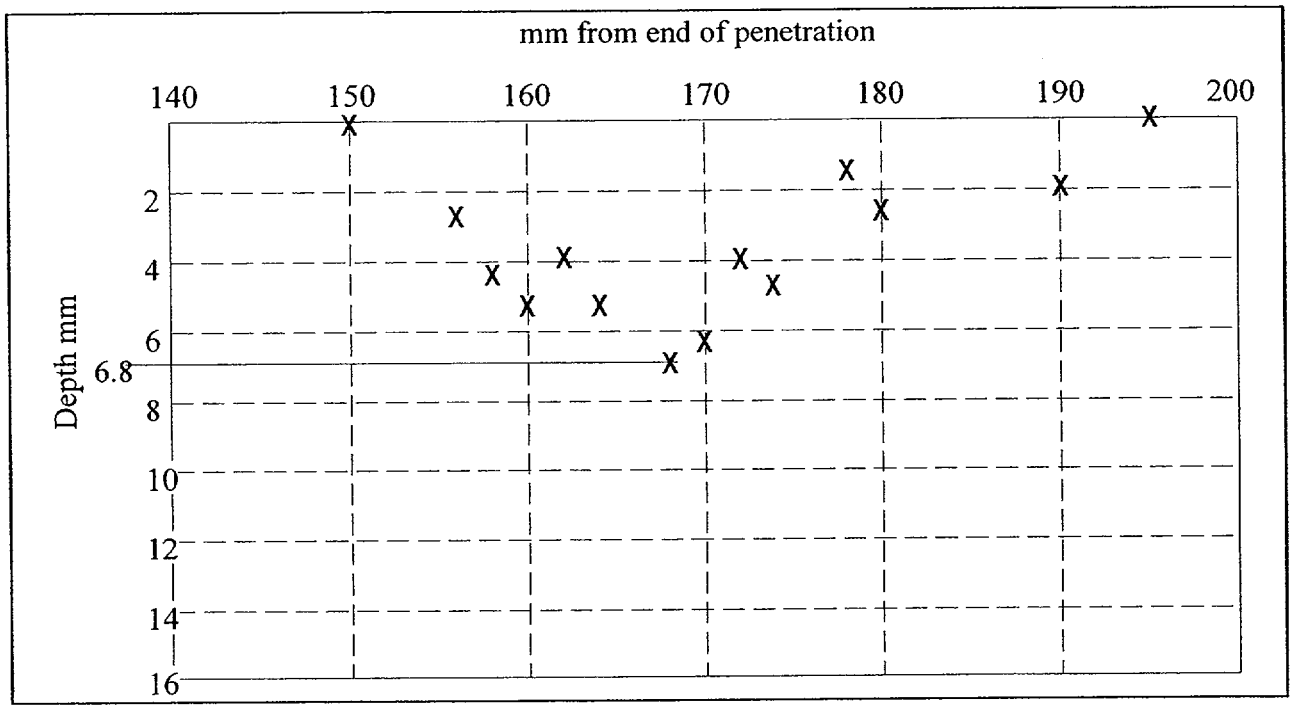

Figure 4
TOFD Depth Profile: 1996 Inspection

CRACK GROWTH IMPLICATIONS FROM 1994 TO 1996

From the two inspections it is possible to imply the crack growth rate which occurred between 1994 and 1996, by simply taking the difference in crack depth, and dividing by the service time, which was nominally 18 months.

This calculation uses the effective full power service time between the two inspections of approximately 14 effective full power months (1.17 EFPY). Two resulting crack growth values can be determined from this evaluation, one for the depth and the second for the length.

Depth growth: 1.37 E-11 m/sec

Length growth: 4.11 E-11 m/sec

The length growth rate calculated above takes into account the fact that the flaw is growing in length from two directions, as the effective growth rate must be divided by two.

The growth rates determined above were obtained at a temperature of 316°C, and were then plotted with lab data obtained at 325°C, so the growth rates were multiplied by an activation energy correction. The activation energy for Alloy 600 crack growth ranges from 31-33 kcal/mode; therefore, the high end of the range was chosen so the resulting correction would be conservative. Using 33 kcal/node, the correction factor was determined to be 1.5.

Plotting the data with the laboratory data requires determination of the stress intensity factor, K. This calculation was done using the Raju-Newman expression, and using the results of 3-D elastic plastic finite element analysis, which indicate that the stresses in this region are nominally at yield stress. The flaw shape (length/depth) was nominally 6.6, so the value 6 was used. This results in a value of 40.7 MPa $\sqrt{m}$, as seen in Figure 5.

The resulting crack growth rates for plotting at 325°C are therefore:

Depth growth = $\frac{da}{dt} = 2.06x10^{-11}\ m/\sec$ (corrected to 325° C)

Length growth = $\frac{da}{dt} = 6.16x10^{-11}\ m/\sec$ (corrected to 325° C)

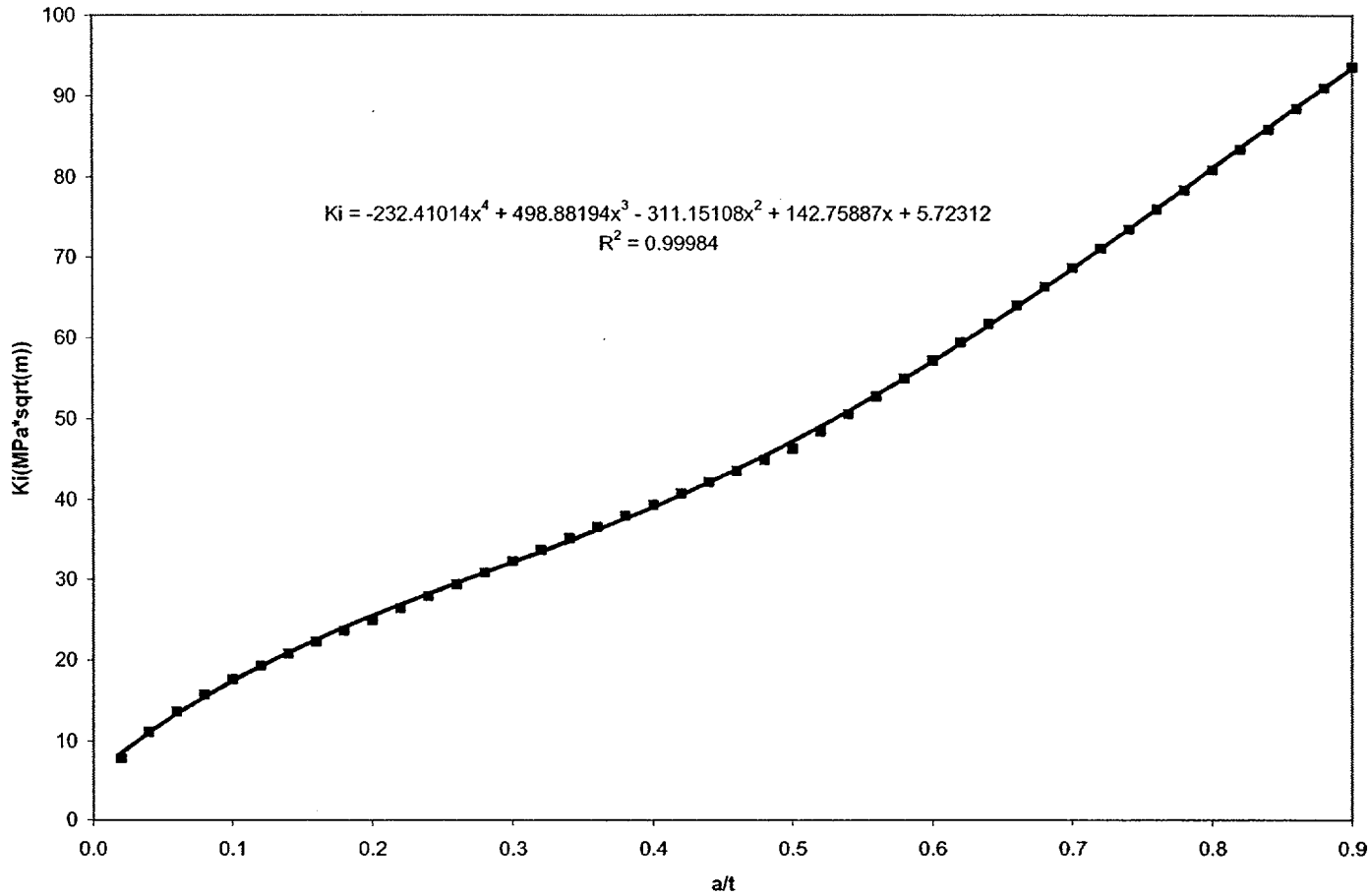

Figure 5
Stress Intensity Factor Calculations for an Axial Inside Surface Flaw
In the D. C. Cook R. V. Head Penetration #75

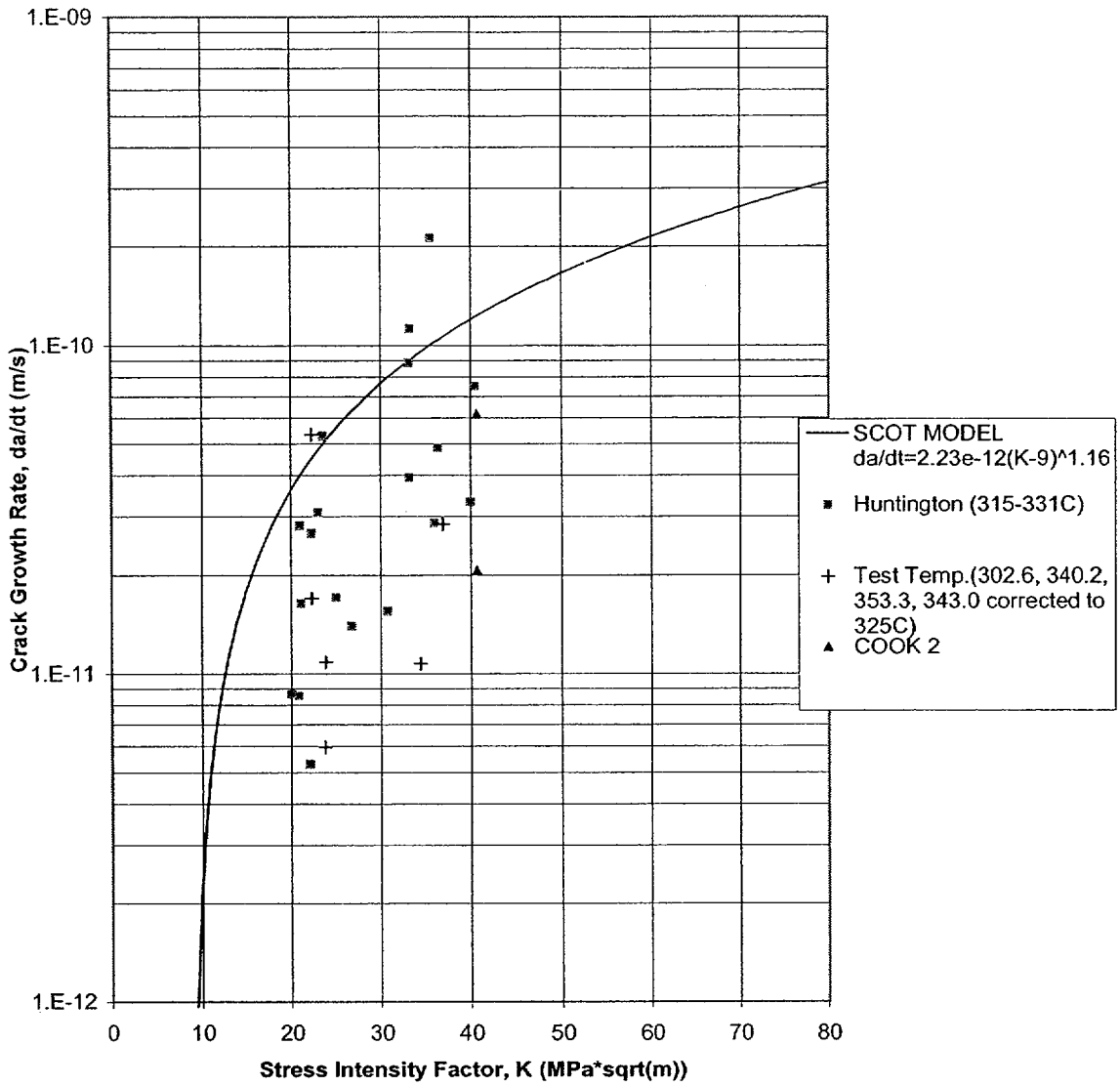

Figure 6
D.C. Cook Unit 2 Service Induced Crack Growth Compared with Lab Data for Huntington Alloys Materials

DISCUSSION

The results from the DC cook Unit 2 crack growth are compared with a number of laboratory test results in Figure 6. Note that both values fall within the scatter of the lab data on all the heats of Huntington Alloy materials. The results are bounded by the modified Scott Model, as developed in references [3] and [5].

$$\frac{da}{dt} = 2.23x10^{-11}\,(k-9)^{1.16} m/\sec \text{ (at 325° C)}$$

The crack measurement uncertainty was not specifically assessed herein, but it can be seen that two independent measurements, about 18 months apart, resulted in nearly identical results. The length measurements could be considered somewhat more reliable, because they were confirmed with both ECT and UT, but the depth measurements by UT were confirmed to be accurate by blind tests at the EPRI NDE Center.

These results confirm that the projected growth in the DC Cook Unit 2 head penetration is conservatively predicted by the modified Scott Model.

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5. Bamford, W.H., et al, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: D. C. Cook Units 1 and 2". Westinghouse Electric WCAP 14118, Rev. 4.

ATTACHMENT 5 TO C1101-13

AFFIDAVIT FOR WITHHOLDING WESTINGHOUSE REPORT AEP-01-217 FROM PUBLIC DISCLOSURE