Westinghouse Electric Corporation

Energy Systems

Nuclear Services Division

Box 355
Pittsburgh Pennsylvania 15230-0355

January 24, 1997

AW-97-1072

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

Attention: Mr. Frank J. Miraglia

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: "Incomplete Rod Insertions During Cycle 8 - Interim Report on Inspection Plan, Inspection Results and Root Cause," Rev. 1 (Proprietary)

Dear Mr. Miraglia:

The application for withholding is submitted by Westinghouse Electric Corporation ("Westinghouse") pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.790, Affidavit AW-97-1072 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-97-1072 and should be addressed to the undersigned.

Very truly yours,

H. A. Sepp, Manager
Regulatory and Licensing Engineering

Enclosure

cc: Kevin Bohrer/NRC (12H5)

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.

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, 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 Corporation ("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:

Henry A. Sepp

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 24th day
of January, 1997

Janet A. Schwab
Notary Public

Notarial Seal
Janet A. Schwab, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires May 22, 2000
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory and Licensing Engineering, in the Nuclear Services Division, of the Westinghouse Electric Corporation 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 rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Energy Systems Business Unit.

(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 Energy Systems Business Unit 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 "Incomplete Rod Insertions During Cycle 8 - Interim Report on Inspection Plan, Inspection Results and Root Cause," Rev. 1 (Proprietary), for the Wolf Creek Nuclear Station, being transmitted by the Westinghouse Electric Corporation (W) letter and Application for Withholding Proprietary Information from Public Disclosure, Mr. H. A. Sepp to the Document Control Desk, Attention Mr. Frank J. Miraglia. The proprietary information as submitted for use by the Westinghouse Electric Corporation is expected to be applicable in other licensee

submittals in response to certain NRC requirements for justification of RCCA insertions, inspections and evaluation criteria.

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

(a) Establish applicable RCCA inspection and evaluation criteria.

(b) Perform and provide RCCA inspections and evaluations.

Further this information has substantial commercial value as follows:

(a) Westinghouse can sell support and defense of RCCA inspection and evaluation criteria.

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 RCCA inspection and evaluation criteria 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.

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 RCCA inspection and evaluation criteria.

Further the deponent sayeth not.

ENCLOSURE 2

Wolf Creek Nuclear Operating Corporation
Wolf Creek Nuclear Station

Incomplete Rod Insertions During Cycle 8
Interim Report on Inspection Plan, Inspection Results and Root Cause

Westinghouse Non-Proprietary Class 3 - REV I

Wolf Creek Incomplete Rod Insertions During Cycle 8
Interim Report on Inspection Plan, Inspection Results and Root Cause

March, 1996

J. F. Duran
J. Halligan
N. R. Singleton

Preface

Several activities were undertaken by Wolf Creek and Westinghouse to address the incomplete RCCA insertions that occurred at Wolf Creek near the end of cycle 8. These activities included the preparation, review and implementation of a test plan and the formation of a root cause team.

This report includes the test plan, a summary of the test results and a summary of the work and conclusions of the root cause team.

This report was prepared to provide information to support cycle 9 core loading at Wolf Creek.

Contents

1.0 Test Plan

1.1 Cold Drop Tests

PURPOSE - To determine the behavior of the RCCA's in a simulated trip. It is noted conditions will be different due to temperature. This will be a "worst case" since the compression on the assemblies as well as the water density will be higher than operating conditions. Traces on a strip chart are taken to determine the velocity of the RCCA's as a function of axial position. Recoils are to be observed to estimate the amount of drag on assemblies that are fully seated. The behavior of the once burned assemblies are used as a base line for comparison.

TEST ASSEMBLIES - All RCCA locations.

1.2 Drag Test with Upper Internals in Place

PURPOSE - To determine the drag on RCCA's in the fuel assemblies with the drive shaft latched. Traces are taken to show drag as a function of axial position. This data will be compared to drag data taken later in the spent fuel pool to determine the impact of the upper internals on the RCCA drag. Specification F-5.1 is used as a starting point to define "high" and "low" drag.

TEST ASSEMBLIES - Assemblies are selected based on the following:
a) Failure to fully insert in trip or cold drop
b) Number of recoils
c) Various burnups are included

1.3 Drag Tests in Spent Fuel Pool

PURPOSE - To determine the location of the interference causing the high drag.
Possible Locations - Upper internals
- RCCA
- Fuel assembly
- Combination of the above

TEST SEQUENCE:
a) Drag test RCCA's in current fuel assemblies
b) Drag test RCCA's in reference fuel assemblies
c) Drag test dummy RCCA in selected fuel assemblies

TEST ASSEMBLIES - Fuel assemblies (with RCCA's) are selected based on the following:
a) Failure to fully insert in trip or cold drop

b) Results of drag tests in core

c) Assemblies at various burnups are included

d) Assembly H81 (removed last cycle due to high drag) is included.

The results of the above drag tests may determine the interference is in the upper internals. In this case the internals will be examined. If it is determined the interference is caused by a problem in the RCCA, the following inspections will be conducted.

a) visual inspection of spider and rodlets. If the cause of the high drag can be determined by this visual, additional inspections will not be necessary to determine the root cause. At this point a new plan would be needed to determine a corrective action.

b) If the cause of the high drag is not determined an eddy current inspection will be conducted. At this point a new plan will be needed to determine a corrective action or continue the investigation of the root cause.

If it is determined from the above drag tests that the interference is caused by a problem in the fuel assemblies, the following actions will be taken.

a) All of the fuel assemblies drag tested in the spent fuel pool are to receive :

- a visual inspection of the top nozzle and top nozzle inserts.
- F/A length measurements
- Fuel assembly bow measurements

b) Boroscope inspection of thimble tubes (on selected assemblies)

If the cause of the high drag can be determined from these inspections a new plan would be needed to determine a corrective action. If the root cause has not been determined selected fuel assemblies will be drag tested with the short RCCA standard. The bases for selection is the results of the spent fuel pool drag tests and the value of other assemblies for comparison.

If the short RCCA standard indicates the top of the fuel assembly is the location of the interference, a fuel assembly will be selected (based on short standard drag results) and retested with 22 lock tubes removed. The two remaining lock tubes will be in opposite corners. The data will be put aside for future comparison.

The remaining two lock tubes and the top nozzle will then be removed and the top nozzle inserts inspected. If the cause of the high drag can be determined at this point, a new plan will be needed to determine a corrective action.

A RRTN will then be installed and the drag with the short standard repeated. Using the data from the three drag tests with the short RCCA standard the incremental change from removing the lock tubes and use of the RRTN can be determined. Judgement will be used to determine if this is significant. At this point a new plan may be needed to determine a corrective action or continue the investigation.

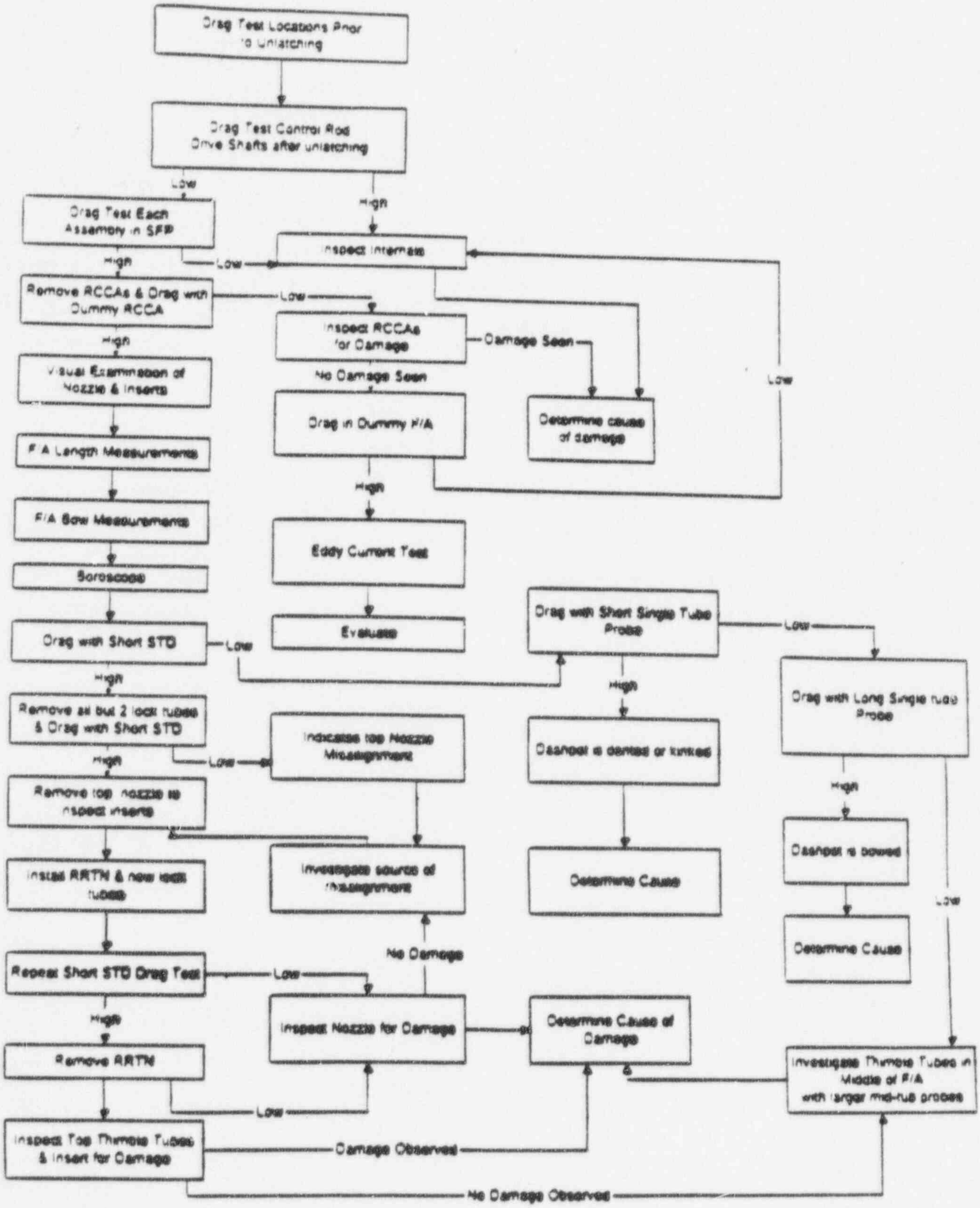
If it was determined by the short standard that there is no problem at the top of the fuel assembly, the focus will be on the dashpot. The thimble tubes of selected fuel assemblies will be probed with a series of single tube probes at various diameters and lengths designed to determine the condition of the dashpot i.e. bowed ,kinked or restricted. The assemblies are selected based on previous drag tests with the full length RCCA's. A control assembly (once burned) will also be tested and the data used for comparison.

If the root cause of the high drag can be determined at this point a new plan will be needed to determine a corrective action. If it is determined the dashpot shows no anomaly, or is only a partial cause, the upper part of the guide thimbles will be investigated. A series of probes similar to the dashpot probes are designed to determine the condition of the guide thimbles (major diameter).

If the root cause can be determined at this point, a new plan will be required to determine a corrective action. If the root cause is not determined, a new plan will be needed to continue the investigation.

The inspection plan logic tree is shown in Figure 1-1.

Figure 1-1 - Wolf Creek Decision Tree for RCCA Insertion Anomaly



2.0 Results of Inspections

2.1 Trip near EOC 8 - 5 RCCA's failed to fully insert. The following fuel assemblies were involved.

Core Position	Fuel Assembly
H02	H16
F06	H50
K06	H53
K10	H59
H08	H38

NOTES: - all involved fuel assemblies are three times burned.
- burn up ranges from approximately 49100 to 51500.

2.2 Cold drop tests - Cold drop tests were performed on all RCCA's
- In addition to the five assemblies above the following three assemblies failed to fully insert.

Core Position	Fuel / ssembly
H14	H11
P08	H03
B08	H32

OBSERVATIONS
- Drag seems to correlate with high burnup
- Assembly H16 (using a hafnium RCCA) stuck at 96 steps.
- The magnitude of the initial recoil bounce and the quantity of subsequent bounces appears to decrease with burnup but the data is more difficult to reliably interpret and appears less consistent than the drag force measurement.

DATA : Summary sheet from Wolf Creek

2.3 Drag Tests With Upper Internals In Place - A total of 27 RCCA's were tested with the upper internals in place, including all of the assemblies that failed to fully insert (except H16, H03, H59 and H53) during the cold drop tests, and various burnups.

Core Position Tested	Fuel Assembly Tested
H06	J35
K08	J29
B10	J56
P06	J63
F14	J50
P10	J64

B08	H32
H14	H11
F06	H50
F10	H45
D12	J32
D04	J08
H08	H38
D02	K06
B12	K46
D14	K22
M02	K15
C09	J28
NC7	J30
C07	J03
J03	J25
L13	J37
N05	J52
N11	J39
L03	J45
H04	H69
H12	H54

Observations - The high burnup assemblies continue to show the highest drag.

- The observed drags do not exceed the weight of the RCCA and drive rod.
- In general, drag decreases with distance from the dashpot
- Chatter appeared on a number of the traces for the "problem" assemblies.

DATA: Summary sheet from Wolf Creek

2.4 Drag Test In Spent Fuel Pool - RCCA's In Fuel Assembly - A total of 16 assemblies were selected for this test, including - all eight that failed to fully insert during cold drops.

- Two additional region 'H' assemblies that showed high drag.
- Four 'J' assemblies with various burnups
- Two 'K' assemblies (control)

FUEL ASSEMBLIES TESTED

Fuel Assembly	RCCA
H16	R27
H53	RS31
H32	RS42
H50	RS19
H11	RS21
H59	RS13
H03	RS11
H38	RS29

J37	RS28
J03	RS23
K46	RS40
J52	RS30
J50	RS09
K06	RS01
H45	RS22
H54	RS18

OBSERVATIONS;

- The data continues to show a correlation between high burnup and high drag.
- Chatter was observed on most of the high drag assemblies.
- It starts above the dashpot on withdraw and stops at about halfway up the F/A
- Observed at the same location on insertion
- The hafnium RCCA showed chatter at a much different frequency and amplitude .
- On assembly H38 and H50, the RCCA did not fully insert by its' own weight.
- In general drag decreases with distance from the dashpot.

DATA: Traces from Wolf Creek & summary data sheets from CNFD.

CONCLUSION: Results are generally consistent with drag tests performed with the internals in place. Drag increases with increasing burnup.

2.4.1 Drag Test with Short RCCA

A drag test was performed using a mock RCCA with 13 inch long rodlets. The tested fuel assemblies are J03, H53, H50, H38, H16, H81, and K06.

OBSERVATIONS ;

- The drag was measured at [ ] a,b,c pounds with the exception of assembly H16 which was [ ] a,b,c pounds. The once burned control assembly (K06) had less drag than the twice and thrice burned assemblies.

2.5 Drag Test of RCCA's in Reference Fuel Assembly
The 16 RCCA's tested above, were drag tested in a new fuel assembly.

OBSERVATIONS - All 16 RCCA's (including the Hafnium) showed a drag of less than [ ][a,b,c] pounds. It was concluded the high drag is resulting from the fuel assembly. No further testing of the RCCA's is required.

DATA: Traces from Wolf Creek and summary from CNFD.

CONCLUSION: Since all RCCA's tested showed low drag, the source of friction must be the fuel assembly.

2.6 Fuel Assembly Length Measurements - Length measurements were conducted on the above fuel assemblies (drag tested) and assembly H81 (removed from core last cycle due to high drag). Additional measurements were taken on the following fuel assemblies: G46, G35, G18, H43, H62, H07, J61, J29 and J46.

OBSERVATIONS:
- The region 'H' assemblies showed higher than expected growth .
- Growth of the fuel rods was less than anticipated .
- The fuel rods were observed to be resting on the top plate of the bottom nozzle (as expected)
- The gap between the fuel rod top end plugs and the bottom surface of the top nozzle adapter appears to be significantly larger than anticipated .

DATA: Video tapes from Wolf Creek, and measurement summary sheets from CNFD.

CONCLUSION: Region 'H' assemblies showed a higher growth than previous experience. Although the fuel assemblies were longer than anticipated, as built reactor core dimensions indicate there was no "solid" interference with internals.

2.7 Fuel Assembly Bow Measurements - Bow measurements were taken on the same 17 fuel assemblies on which length measurements were taken.

OBSERVATIONS: Fuel assembly bow was judged to be within the 'normal' range based on the Westinghouse experience base. Bow tended to be larger on the higher burnup assemblies.

DATA: Video tapes from Wolf Creek, and measurement summary sheets from CNFD.

CONCLUSION: Since these measurements indicate "banana" bow of similar shape and magnitude as previously observed in other plants and fuel types, it should not in itself be a major contributor to the high drag observations.

2.8. Boroscope Inspection - The following assemblies were selected for boroscope inspection; H38, H16, H81, J03, K06.

OBSERVATIONS: Rub marks possibly indicating high drag were observed on H38, H16 and H81. The extent and pattern of rub marks varies with burnup. The marks on higher burnup assemblies tend to form a spiral pattern in the axial direction. The marks on lower burnup assemblies tend to be less pronounced and relatively straight.

DATA: Tapes from Wolf Creek, and summary sheets from CNFD.

CONCLUSION: These observations indicate deformation in the thimble tubes which increase with burnup. This deformation at high burnup has a spiral shape or characteristic.

2.9 Single Tube Probes - The following fuel assemblies were selected for probing the single guide thimbles with the single tube probes: K06, H16, H38, H53, H81, H50, J03.

GO/NO GO tests have been completed on the above assemblies. Also drag measurements have been made on selected assemblies using probe 5 (small probe for upper guide thimble) and the .381 diameter full length probe (simulation of RCCA rodlet).

OBSERVATIONS:

The drag is not predominately due to grid distortion or growth
- Single tube probing shows drag in all region 'H' assemblies.
- Thimbles on the periphery do not show higher drag than thimbles close to the axial centerline.

DATA : Data sheets from Wolf Creek, and analysis summary from CNFD.

CONCLUSIONS:

Since the probes were designed in a combination of diameters and lengths to determine the extent, nature, and shape of any distortion, the following conclusions can be drawn:

- Thimbles are distorted at both dashpot and major diameter elevations. The probes were designed at diameters to test this.

- Thimble tube cross section distortion (such as ovaling) is not a major contributor to the drag on the RCCA rodlets. The probes are designed in a combination of lengths and diameters to detect this.

3.0 Root Cause Evaluation

3.1 Background

On February 19, 1996 a root cause team was organized to determine the root cause of the incomplete RCCA insertion issue. The team included representatives from Wolf Creek, South Texas and several Westinghouse divisions.

The team evaluated three established root cause analysis tools, shown below, to select a method which would be the most effective in evaluating the data which was available at the time.

- Root Cause Analysis (Causal Factor)
- Change Analysis
- Kepner-Tregoe Problem Analysis

The Kepner-Tregoe Problem Analysis technique was selected by the team since the specific cause of the incomplete RCCA insertion was not known at the time the team was convened.

The Kepner-Tregoe Problem Analysis approach consists of the four main phases shown below.

- Describe Problem
- Identify Probable Causes
- Evaluate Probable Causes
- Confirm True Cause

3.2 Summary of Evaluation

The apparent cause of the incomplete RCCA insertion at the Wolf Creek plant has been determined to be fuel assembly thimble tube distortion. The possible contributing and root causes which are considered to be associated with the thimble tube distortion are shown in Figure 3-1. The possible causes that were determined not to be root causes and the bases for these determinations are shown in Figure 3-2.

A plan for confirmation of the root cause(s) and development of predictive analytical techniques is being developed.

At appropriate times in the future the root cause team will meet with the designers to complete the root cause confirmation phase of the Kepner-Tregoe process.

Figure 3-1: Direct Cause of Incomplete Rod Insertion at Wo:f Creek

Direct Cause: Thimble tube distortion

<u>Possible contributing causes</u>

Primary Focus :

Fuel rod (less than expected) to thimble tube (greater than expected) differential growth

Thimble tube to thimble tube differential growth

Secondary Focus :

Fuel assembly bow

Fuel assembly axial growth

Thimble tube wall thickness variation

Thermal creep

Irradiation creep

Thimble tube fixity

<u>Possible root causes</u>

Higher burnup causes atypical growth

Region 'H' assemblies have unique manufacturing or materials issue

Standard Zirc-4 vs. Improved Zirc 4

Thimble tube increased axial compression loading

Residency time

Grid spring orientation

Figure 3-2: Possible Causes That Have Been Discounted For The Wolf Creek Incomplete RCCA Insertion

Possible Cause	Reason Cause Discounted
Control Rod Drive Mechanisms (CRDMs)	Large clearances between driveshaft and rod travel housing. Drag testing indicated high RCCA/fuel assembly drag following removal of the CRDMs with the reactor vessel closure head.
RCCAs	Successful drag testing of the RCCAs in a fresh fuel assembly
Reactor Vessel Internals Package and CRDM drive shaft	Drag testing of the RCCAs and fuel assemblies in the spent fuel pool were similar to the drag test performed in the vessel
Grid Distortion/Radial Growth	Drag exists with single cylinder probes. Outer thimble drag equal to or less than drag on inner thimbles.
Thimble Tube Ovality	An .008 inch clearance probe passed through some upper thimbles, when a longer, smaller diameter probe would not.
Localized Thimble Tube Diameter Reductions	Wear marks inside thimbles having higher drag were over most of the length of the thimble tube.
Fuel Assembly Top Nozzle Cocking	Not apparent in visual observations, no RCCA insertion degradation apparent early in the drop test traces.
Crud and Debris	Drags – repeatable for several (all tries) excursions. Heavy crud/debris not evident in the thimble tube boroscope examinations. Relatively similar scram/drag results for several assemblies.
Hard Contact of the Fuel Assembly with the Reactor Internals Upper Core Plate	Overall height of the highest fuel assembly was determined to be within the as-built core cavity height.
Reactor Coolant System Chemistry	No basis as causal factor is known

3.3 Description of Problem

The statement of the problem for the root cause evaluation was:

"RCCAs Do Not Fully Insert Into Fuel Assemblies During Rod Drop"

Following the Kepner-Tregoe methods, the information on what, where, extent and when the problem occurs in Wolf Creek data are listed in Figure 3-3 (Fuel Assembly core locations may be taken from Figure 3-4). These results show that

- all RCCAs entered the dashpot prior to stopping during the scram
- the RCCAs stopped after entry into the dashpot (32 steps) on all assemblies during cold drop except H16 which had Hafnium in the RCCA rodlets
- all of the assemblies that had incomplete insertion after trip had incomplete insertion during cold rod drop testing and three additional assemblies that inserted fully during the trip did not fully insert during the cold rod drop testing. Factors that differ between hot and cold reactor conditions include:
  - thermal differential growth between the fuel assemblies and core cavity, resulting in a somewhat higher assembly hold down spring force at cold conditions
  - Primary coolant viscosity, resulting in higher hydraulic friction forces acting on the RCCA and Driveline surfaces at cold conditions
- the assemblies with incomplete insertion had burnups between 49,100 MWD/MTU and 51,500 MWD/MTU.

The Kepner-Tregoe technique next calls for identification of what, where, extent and when the problem did not occur. This is shown in Figure 3-5 which lists the remainder of the fuel assemblies in rodded positions during cycle 8 at Wolf Creek (5 additional 'H', 32 'J', and 8 'K' assemblies) and their burnup at the time of the rod drop tests. It is noted that:

- the burnup of the assemblies was less than or equal to 44,700 MWD/MTU with the exception of assembly H45
- RCCA insertion velocity traces indicated that some resistance also occurred in assembly H45 during the drop test (as evidenced by no recoil of the RCCA at the end of insertion).

In preparation for listing possible root causes, the distinctions felt to be notable between assemblies for which incomplete insertion occurred and other assemblies were listed (Figure 3-6).

Figure 3-3

PROBLEM - GENERAL: RCCA'S DO NOT FULLY INSERT INTO FUEL ASSEMBLIES (F/A) DURING ROD DROP

WOLF CREEK:

IS											
WHAT				WHERE			WHEN				
								RCCA Axial Step Position			
									Cold Drops 2/2-3/96		
F/A	RCCA (2 Cycle Ag)	Trip 1/30/96	Cold Drop 2/2-3/96	Core Loc	Rx Drag Test	RCCA Bank	Event Burnup (K) 1/30/96 (15571 BU) 2/2-3/96	Trip 1/30/96	Drop 1	Drop 2	Drop 3
H16 +	R27 (HI)	X	X	H02	N	C	49.1	30	96	96	N/A
H50 +	RS19	X	X	F06	F	C	51.5	18	18	24	18
H53 +	RS31	X	X	K06	N	C	51.5	18	30	30	N/A
H59 +	RS13	X	X	K10	N	C	51.5	12	12	18	18
H38 +	RS29	X	X	H08	F	D	49.9	18	18	18	18
H11	RS21		X	H14	F	C	49.1	0	12	12	12
H03 #	RS11		X	F08	N	C	49.1	0	6	12	12
H32	RS42		X	B08	F	C	49.1	0	12	12	12
H81**	RS43 (Ag)**		--	SPENT FUEL PIT		--	--	--	--	--	--
Frictional or hydraulic interference											

Extent: Rod deceleration starts at approximately 28" insertion

__NOTES - GENERAL__

3/18/95 - Successful Trip All RCCA Bottom (Cycle BU 4943)

+ Improved Zr-4. All same lot except H38. H38 had 22 T/T and 2 T/T from different lot.

** High drag BOC Cycle 8 removed to SPENT FUEL PIT

UT probe travel problem, H03, H54, H45

Rx Drag Test: P - Pass
F - Fail
N - No Tests

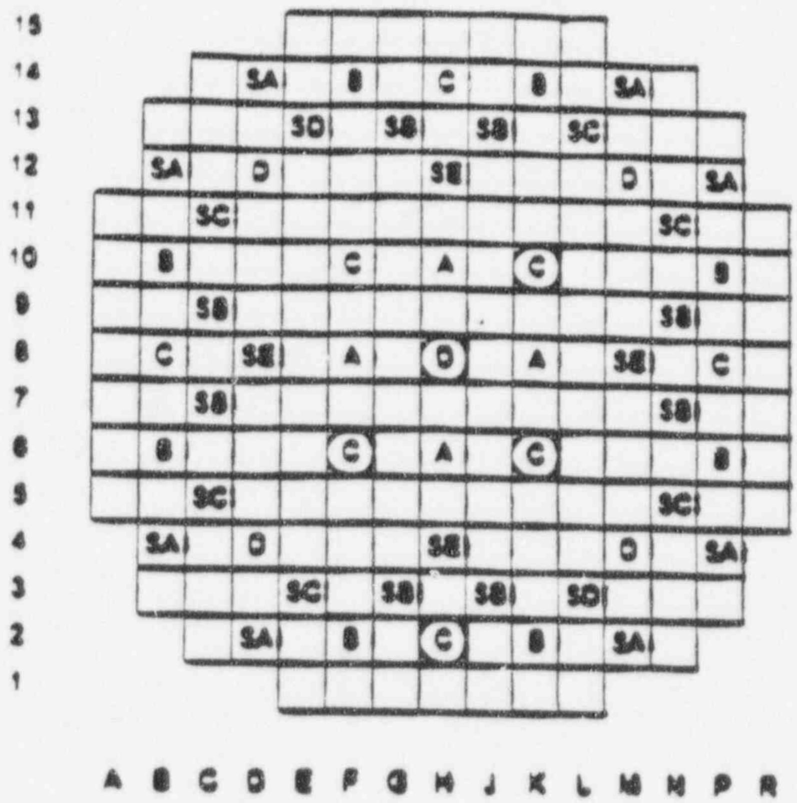


Figure 3-4 - Locations of Rodded Core Locations at Wolf Creek

Figure 3-5

PROBLEM - GENERAL: RCCA'S DO NOT FULLY INSERT INTO FUEL ASSEMBLIES (F/A) DURING ROD DROP

WOLF CREEK:

IS NOT									
WHAT		WHERE			WHEN				
						RCCA Axial Step Position			
							Cold Rod Drops 2/2-3/96		
F/A	RCCA (2 Cycle Ag)	Core Loc	Rx Drag Test	RCCA Bank	Event Burnup (K) 1/30/96 (13571 BU) 2/2-3/96	Trip 1/30/96	Drop 1	Drop 2	Drop 3
H69	RS50	H04	P	SE	44 7	0	0	0	0
H47	RS02	D08	N	SE	44 7	0	0	0	0
H54 #	RS18	H12	F	SE	44 7	0	0	0	0
H56	RS32	M08	N	SE	44 7	0	0	0	0
H45 1 #	RS22	F10	F	C	31 5	0	0	0	0
J series (32)					39 1-44 1	0	0	0	0
K series (8)					15 4	0	0	0	0
A-G series/ prev cycl	Hf-Cycl 1-6				15-31 (Discharge B U)	0			
	Ag-Cycle 7 on					0			
Hard obstruction									

Extent: Is not limited to the dash pot region

NOTES - GENERAL:

1 H45 has no record on rod drop trace but full insertion

UT probe travel problem, H03, H54, H45

Rx Drag Test: P - Pass
F - Fail
N - No Tests

Figure 3-6 - DISTINCTIONS (IS vs IS NOT)

1. Burnup (greater than 49K vs. less than 45)
2. Bank (D + C vs. all others (SE))
3. Region 'H' assy's only affected (but not all)
4. Region 'H' assy's affected/region 'G''s not affected (?) - similar BU

3.4 Possible Root Causes and Evaluation of Causes

Possible root causes developed by the root cause team are listed in the first column of Figure 3-7. This table was initiated before the implementation of the inspection plan in Section 2 was begun. To eliminate or support these causes, results from Wolf Creek inspections and tests, and the successful rod drops at the beginning of cycle 8 were used as well as judgement and experience. Key Wolf Creek inspection and test results used by the root cause team in eliminating possible root causes are described in Section 2.0. From these results, some of which are reflected in Figure 3-7, the root causes listed in Figure 3-2 were eliminated and the remaining root cause - thimble distortion - remained.

Figure 3-7 - Kepner-Tregoe Evaluation of Probable Causes

POSSIBLE CAUSES	DOES NOT EXPLAIN	EXPLAINS ONLY IF
1. F/A 1st Mode Bow (banana)	Incomplete RCCA insertion (Historical database shows even ~600 mils banana bow will not impede rod scrams to the extent observed)	In combination with another possible cause such as AS@ bow, debris, etc
2. F/A 2nd Mode Bow ("S")	(Experiences at Ringhals indicates that larger AS@ bows can affect scram times)	
3. F/A Mid-Elevation Twist	Same as (1) (twist will manifest as banana bow except that cross assembly rods will have bows in opposite directions)	Same as (1)
4. Top Nozzle Cocking	Successful scram on 3/18/95 (no interference indicated in first ~28" of drop trace)	Something caused lock-up after 3/18/95
5. RCCA Rodlet Distortions		
a. Rodlets Kink	Successful scram on 3/18/95	Between 3/18/95 & 1/30/96 something happened to cause kinks in rods that are not bottoming
b. Rodlets Swelling	Deceleration in upper thimble on Ag rods (HI RCCAs with known swelling at other plants did not show similar drop traces)	In combination with another possible cause
c. Bow	Same as (1) (rodlets very flexible)	Same as (1)
6. Thimble Tubes Ovalization/Local Distortion	(Large ovalization would be required since the clearance in the upper thimble tubes is large)	
7. Blocked Thimble Tubes Flow Holes	Calc. Note conclusion indicates that blocked thimble tubes would not cause increase in drags observed in the reactor or spent fuel pit	
8. Debris	Smooth rod drops/rods settling in - no hard stops (repeated after several excursions)	
9. RCCA Spider Distortion	Successful scram on 3/8/95 (RCCA assembly did not have excessive drag in a fresh fuel assembly)	Trip on 3/8/95 caused distortion
10. CRDM Thermal Sleeve/Funnel Interference	Drag test after head removed	
11. Upper Internals/Top Nozzle Misalignment	Successful scram on 3/18/95 (should have been bad from BOC if this mechanism applies)	
12. Guide Card Wear	Drag test after head removal (if this was the mechanism the drag would have been low since the RCCA rodlets are no longer hydraulically loaded against their interfacing parts)	
13 Thimble Tube Wear Through	Same as (12)	

14.	CRUD		
a.	Upper Internals	Elevated drag forces after removal of upper internals (CRUD does not build-up in wear areas)	
b.	Thimble Tubes	(Crud buildup appears normal from boroscopic I.D examinations)	
c.	RCCA Rodlets	RCCA drag was normal in a fresh fuel assembly	
15.	RTN Connection	Rod drop traces which do not show drag at beginning of drop	
16.	Crushed Fuel Due to Missing "S" Holes	No problems with start-up & 3/18 scram (fuel would have been damaged at BOC)	
17.	CRDM/Drive Rod Interference	Drag test after head removal	
18.	CRDM Drive Rod Bow	Successful drag tests of 5 drive rods after head removal (driveshaft clearance is greater than RCCA clearance)	Drive rod bow sufficient to cause drag when coupled to RCCA
19.	Broken Leaf Spring	Rod drop traces which do not show drag at beginning of drop (inspection shows no apparent spring damage)	

3.5 Confirmation of Root Cause

Based on the present knowledge of the problem, a program of additional inspections, tests and analyses is being developed.

The primary intents of this program are:

- To improve the understanding and enable quantification of the sources of the forces that are significant to cause thimble tube distortion

- To refine tools for prediction of thimble distortion and their ɾ ɘct on