Westinghouse
Electric Company

Box 355
Pittsburgh Pennsylvania 15230-0355

May 3, 2000
NSBU-NRC-00-5969

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

Attention: J. S. Wermiel, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

Subject: Westinghouse Fuel Performance Update (Slide Presentation of May 3, 2000), (Proprietary)

Dear Mr. Wermiel:

Enclosed are copies of the Proprietary and Non-Proprietary versions of the presentation material from the Westinghouse/NRC meeting on Fuel Performance held in Columbia, South Carolina on May 3, 2000.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-00-1395 with Proprietary Information Notice and Copyright Notice.

2. One (1) copy of Affidavit, AW-00-1395.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

4601 1/1

Correspondence with respect to any Application for Withholding should reference AW-00-1395 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Copy to:
S. L. Wu, NRR
R. Caruso, NRR
M. S. Chatterton, NRR
S. Bloom, NRR

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Electric Company

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May 3, 2000
AW-00-1395

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Attention: J. S. Wermiel, Chief,
Reactor Systems Branch
Division of Systems Safety and Analysis

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Westinghouse Fuel Performance Update (Slide Presentation of May 3, 2000), (Proprietary)

Reference: Letter from H. A. Sepp to J. S. Wermiel, NSBU-NRC-00-5969, dated May 3, 2000

Dear Mr. Wermiel:

The application for withholding is submitted by Westinghouse Electric Company LLC, a Delaware limited liability company ("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-00-1395 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 10 CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-00-1395 and should be addressed to the undersigned.

Very truly yours,

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Proprietary Information Notice

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC. 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) 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 documents transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies for 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 not withstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond these 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 Company LLC, a Delaware limited liability company ("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, Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 1st day
of May, 2000.

Lorraine M. Piplica
Notary Public

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

(1) I am Manager, Regulatory and Licensing Engineering, in the Nuclear Services Division, of the Westinghouse Electric Company LLC, a Delaware limited liability company ("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 rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR 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 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 10 CFR 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 "Westinghouse Fuel Performance Update (Slide Presentation of May 3, 2000), (Proprietary)," May 3, 2000, for submittal to the Commission, being transmitted by Westinghouse Electric Company (W) letter (NSBU-NRC-00-5969) and Application for Withholding Proprietary Information from Public Disclosure, Henry A. Sepp, Westinghouse, Manager Regulatory and Licensing Engineering to the attention of J. S. Wermiel, Chief, Reactor Systems Branch, Division of Systems Safety and Analysis. The proprietary information as submitted by Westinghouse Electric Company is to provide the material as presented to the NRC staff at the Fuel Performance meeting on May 3, 2000.

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

(a) Correct any problems associated with fuel failures and ensure proper fuel performance of fuel operating in reactors.

(b) Assist customers in improving their fuel performance (zero defects).

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to continue to implement corrective actions to ensure the highest quality of fuel in order to meet the customer needs.

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 technical evaluation justifications 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 the enclosed improved core thermal performance methodology.

Further the deponent sayeth not.

Westinghouse
Fuel Performance Update
(Slide Presentation of May 3, 2000)

May 2000

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Westinghouse NRC Fuel Update Meeting, May 3, 2000 8:30 am

Agenda

1. Fuel Engineering Overview	8:30-9:00
2. Fuel Performance Update	9:00-9:30
3. Top Nozzle Update/Spring Outage Results	9:30-9:50
4. AOA Update	9:50-10:10
5. Break	10:10-10:30
6. Fuel Duty Index	10:30-10:50
7. Zirlo Corrosion Update	10:50-11:05
8. Westinghouse Fuel Duty Experience	11:05-11:30
9. Limited Scope High Burnup LTA Proposal	11:30-11:50
10. Lunch	12:00
11. Plant Tour	1:30
12. Lab Tour	3:00

Westinghouse Fuel Engineering Department Overview

Sumit Ray, Westinghouse

Westinghouse Fuel Engineering Department Overview

Sumit Ray, Westinghouse

Westinghouse Non-Proprietary Class 3

Fuel Engineering

Columbia

Product Engineering

- Fuel assembly design and testing
- Manufacturing support
- Engineering Services & Technology

Pittsburgh

Core Engineering

- Reload core design and licensing
- Reload engineering customer interface
- Engineering Services & Technology

Vision and Objectives

Vision

To provide fuel, services and technology engineered to meet or exceed customer expectations, with continuously improving quality and performance

Key Objectives

- **Safety and Regulatory Compliance**
- **Flawless economical fuel operation**
- **Knowledgeable work force**
- **"Responsive Service Mentality"**

Long-term Quality Improvement Matrix

a, c

New Product Development Process (NPDP)

- **NPDP: A systematic and detailed concurrent engineering process framework for development of new products which improves**
  - **Core Team**
  - **Customer input and involvement**
  - **More robust product & process testing & analysis**
  - **Increased independent review effectiveness**
  - **Trouble-free implementation**
  - **Product follow planning**

Underlying the New Product Development Process is the Application of State of the Art Tools/Methods

- **Goals**
  - **To obtain an understanding of the phenomenological details and their impacts at a detailed level through investment in state-of-the-art techniques**
  - **Apply this technology into the design process**

- **To achieve these goals an integrated test <u>AND</u> analysis approach is needed**

Key Facilities & Technologies Will Support the Future

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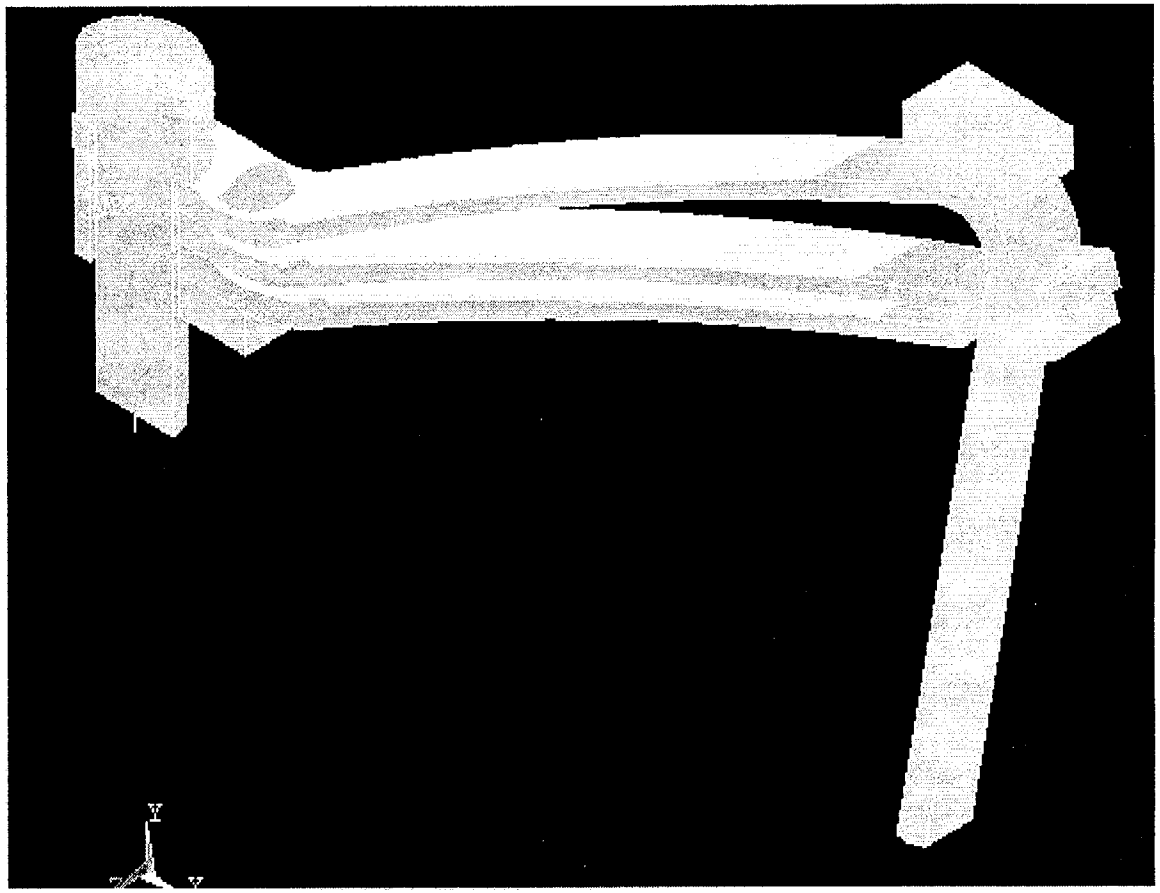
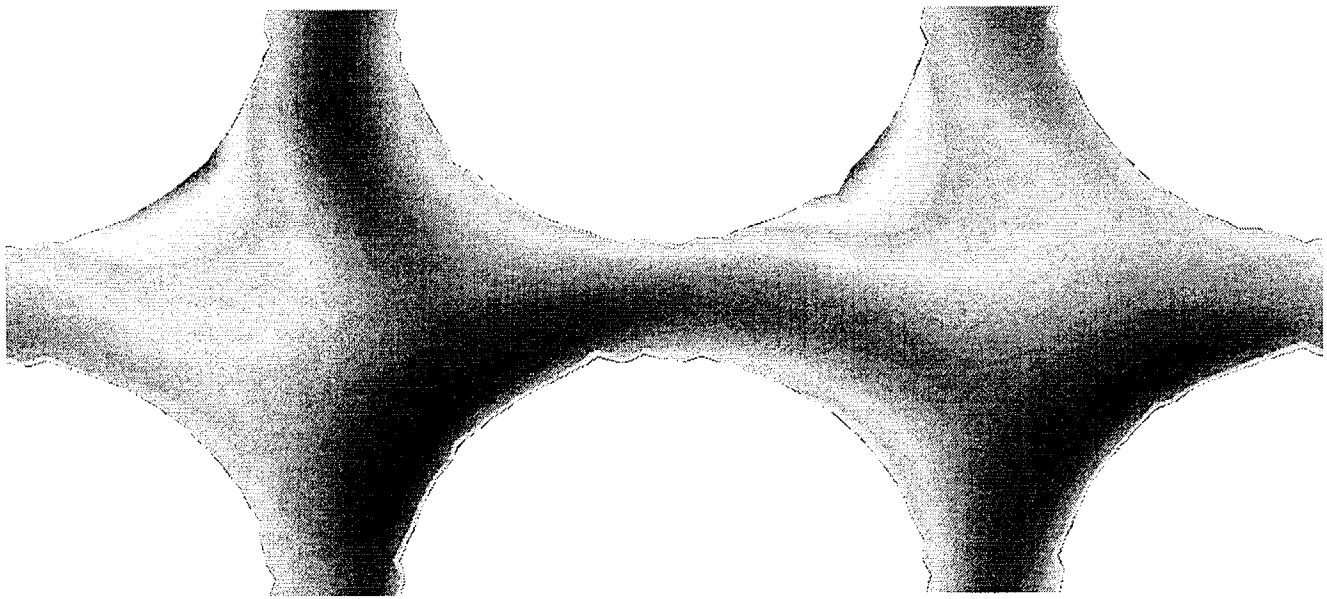
Integrated Solids Modeling & Analysis

- **SolidWorks modeling system implemented**
- **Integration within engineering methods enables rapid, sophisticated stress analyses & 3-D CAD capability**



Computational Fluid Dynamics Analysis (CFD)

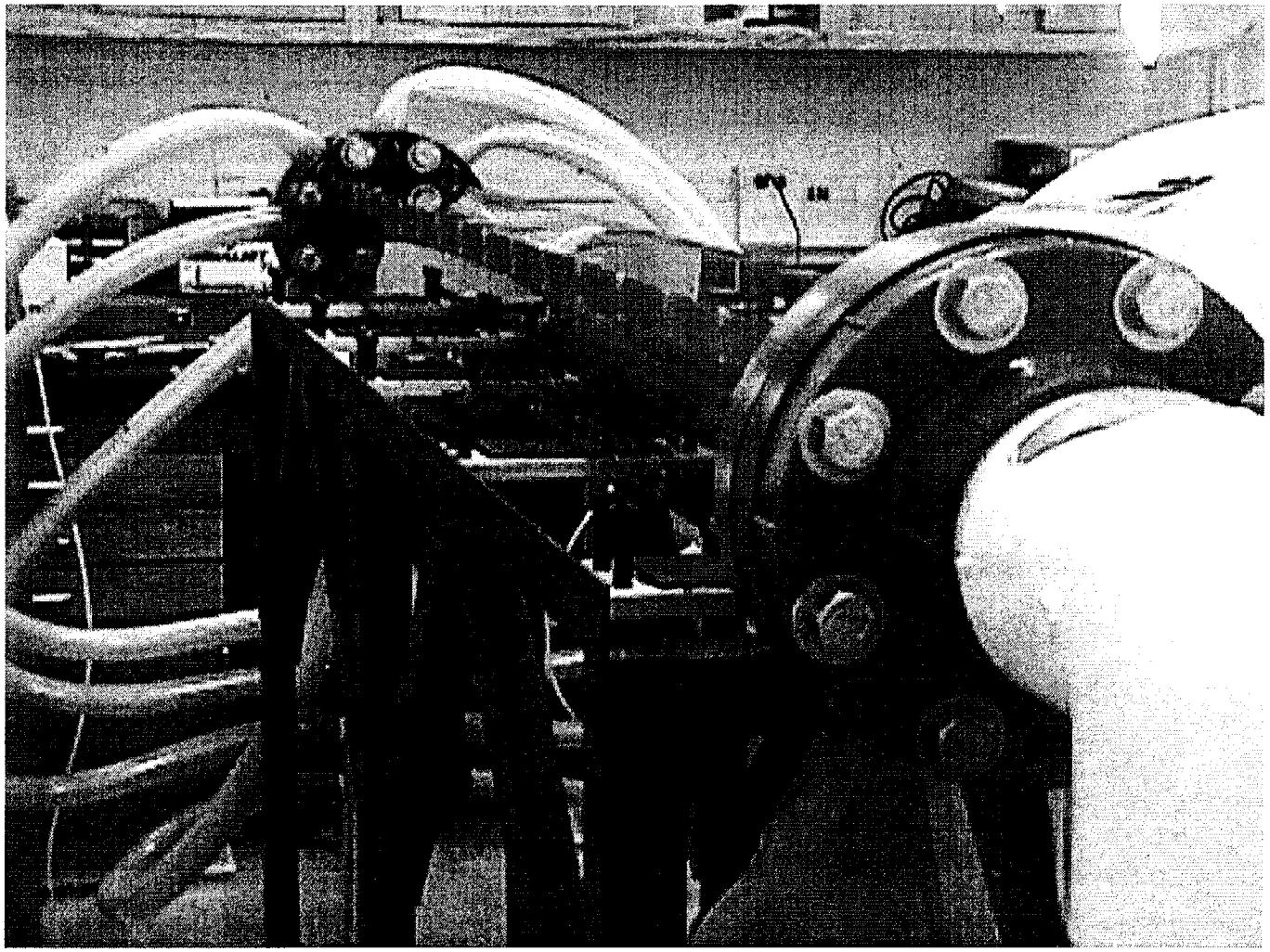
Provides extremely detailed modeling of T&H conditions (Subchannel Temperature Distribution)



Radial Temperature variation by up to 15°F

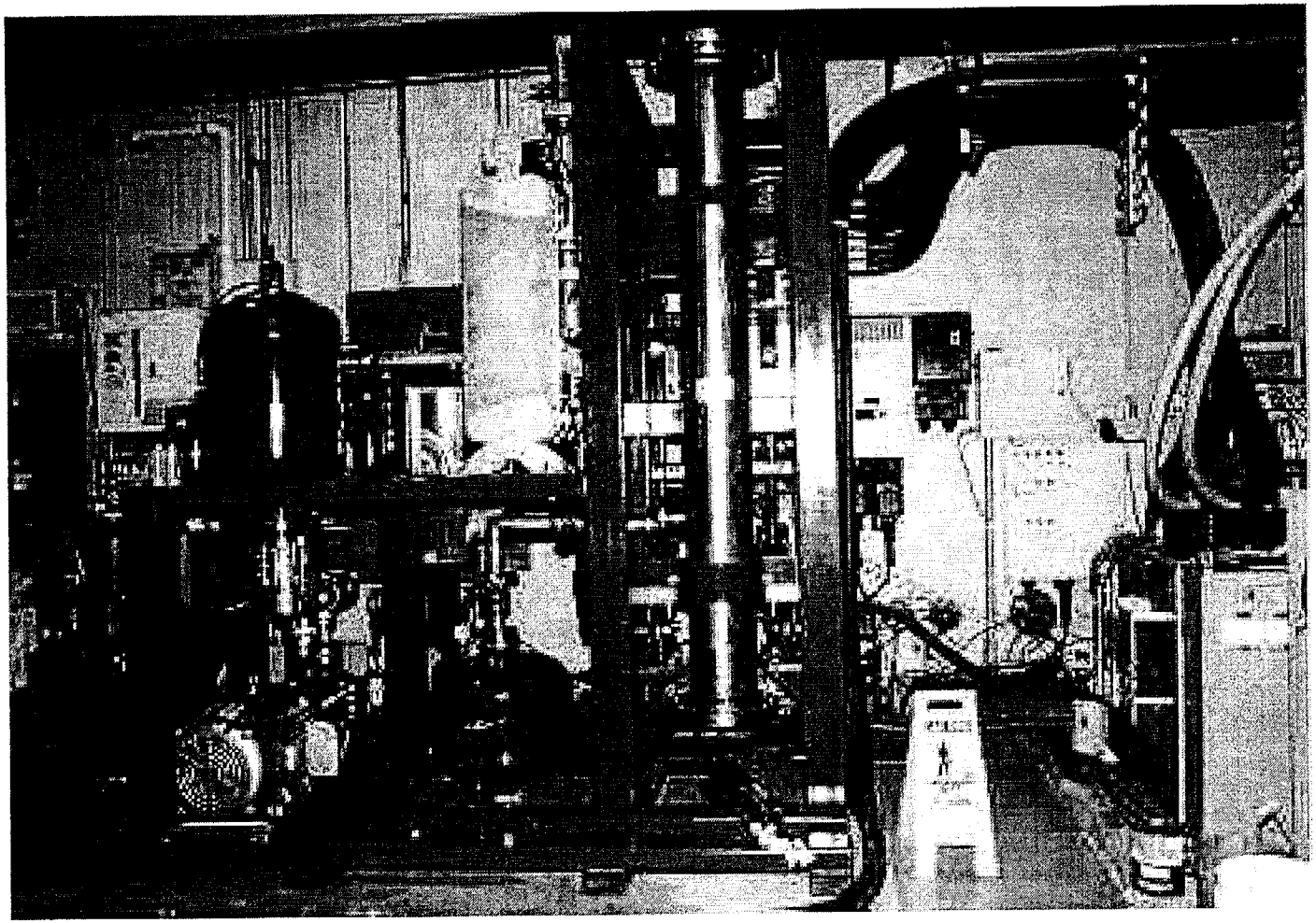
Flow Visualization Test Loop

- Characterizes hydrodynamic flow field produced by mixing grids
- Determines T&H parameters important for thermal and vibration performance
- Supports benchmarking of advanced tools: CFD



Freon DNB Test Loop

- Performs comparative tests to quantify DNB impacts from various grid design features
- Provides for rapid scoping and design iteration
- Provides high assurance of water DNB result



Comparison of VIPER to Other Test Loops

a, c

Temperature

Pressure

Max Flow Rate in Vessel

Max Reynolds Number

Pump Size

Pump Head @ 3000 gpm

Piping Size

Number of Assemblies

Location

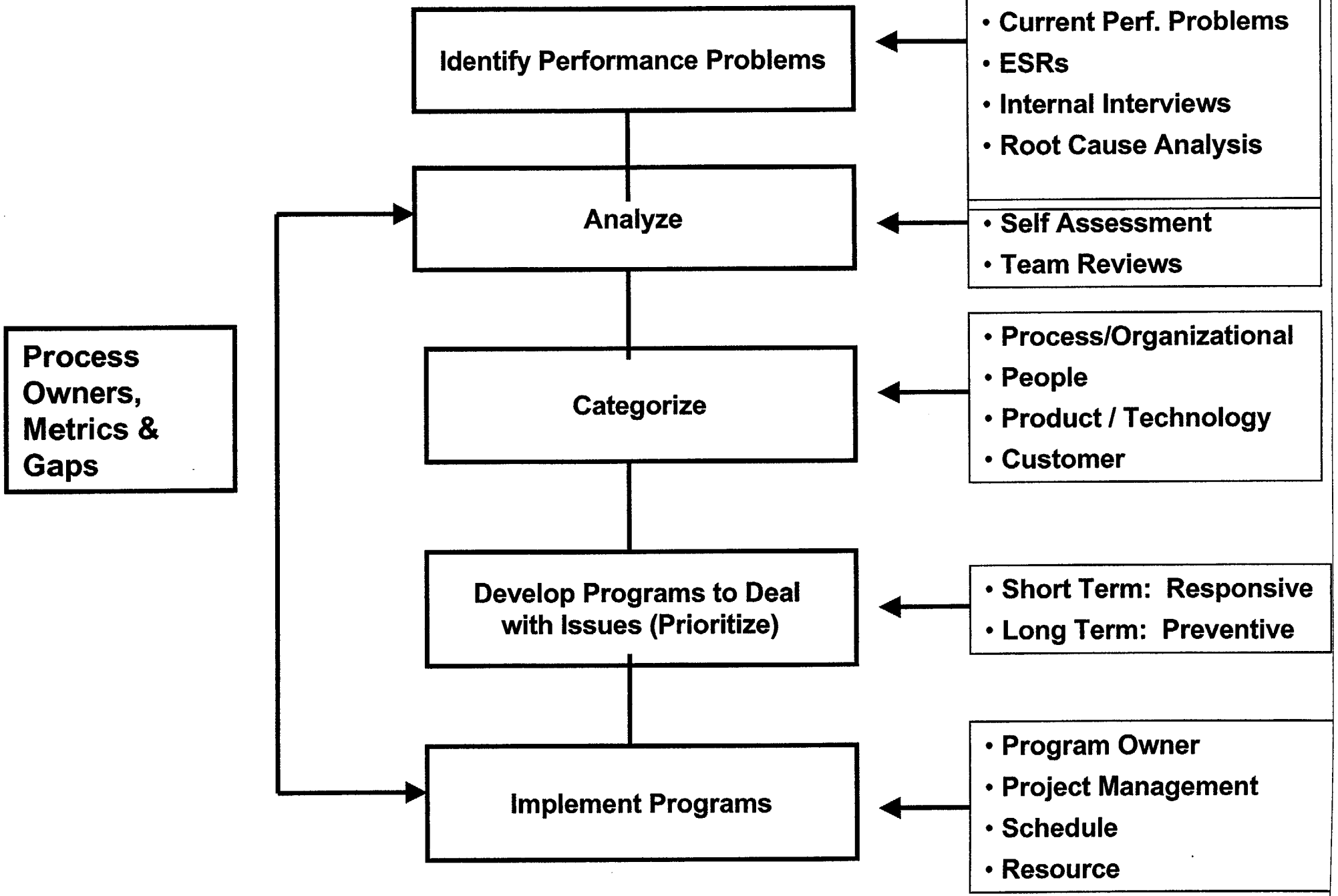
An Increased Emphasis on Plant Fuel Examination is occurring

a, c

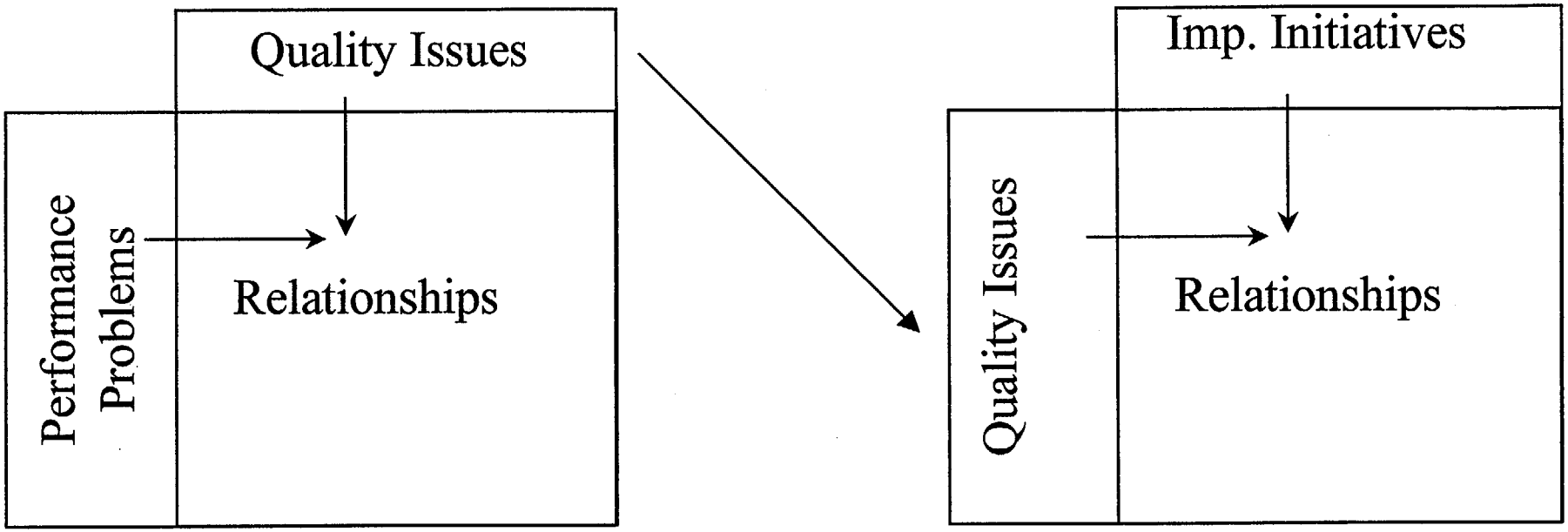
Year 2000 Examinations

a, c

Systematic Quality Approach



Systematic Assessment of Gaps in Quality Improvement Process



- Provides correlation between performance problems and quality issues

- Provides correlation between quality issues and improvement programs
- Identifies gaps

Metrics are being used as part of the assessment of progress, e.g.

- **Program status**
  - **Program Health**
  - **Critical Milestones Met (%)**
- **Quality Assurance Program**
  - **Error trends by category (#)**
  - **Cycle time for closure of quality issues (days)**
  - **Error Free team recommendations implemented (#)**
  - **Self assessments (#)**
- **Design Activites**
  - **Design Review Actions (# open and age)**
  - **Design Review Package Review Times (days)**
  - **Viper Loop Capacity**
- **People**
  - **Performance Management Status**
  - **Personnel Addition / Attrition**

Overall Summary

- **We have made significant investments in our testing and analytical capabilities**
- **We have a comprehensive program to collect PIE data**
- **We have developed and are implementing a systematic Quality approach to ensure we incorporate "Lessons Learned"**
- **We have developed technologies & methods that will be building blocks for future development**
- **We are proactively establishing processes, people, and technologies to ensure continuous improvement**

WESTINGHOUSE FUEL PERFORMANCE

Fuel Performance Evaluation

R D Grimoldby
Manager, Product Performance Engineering

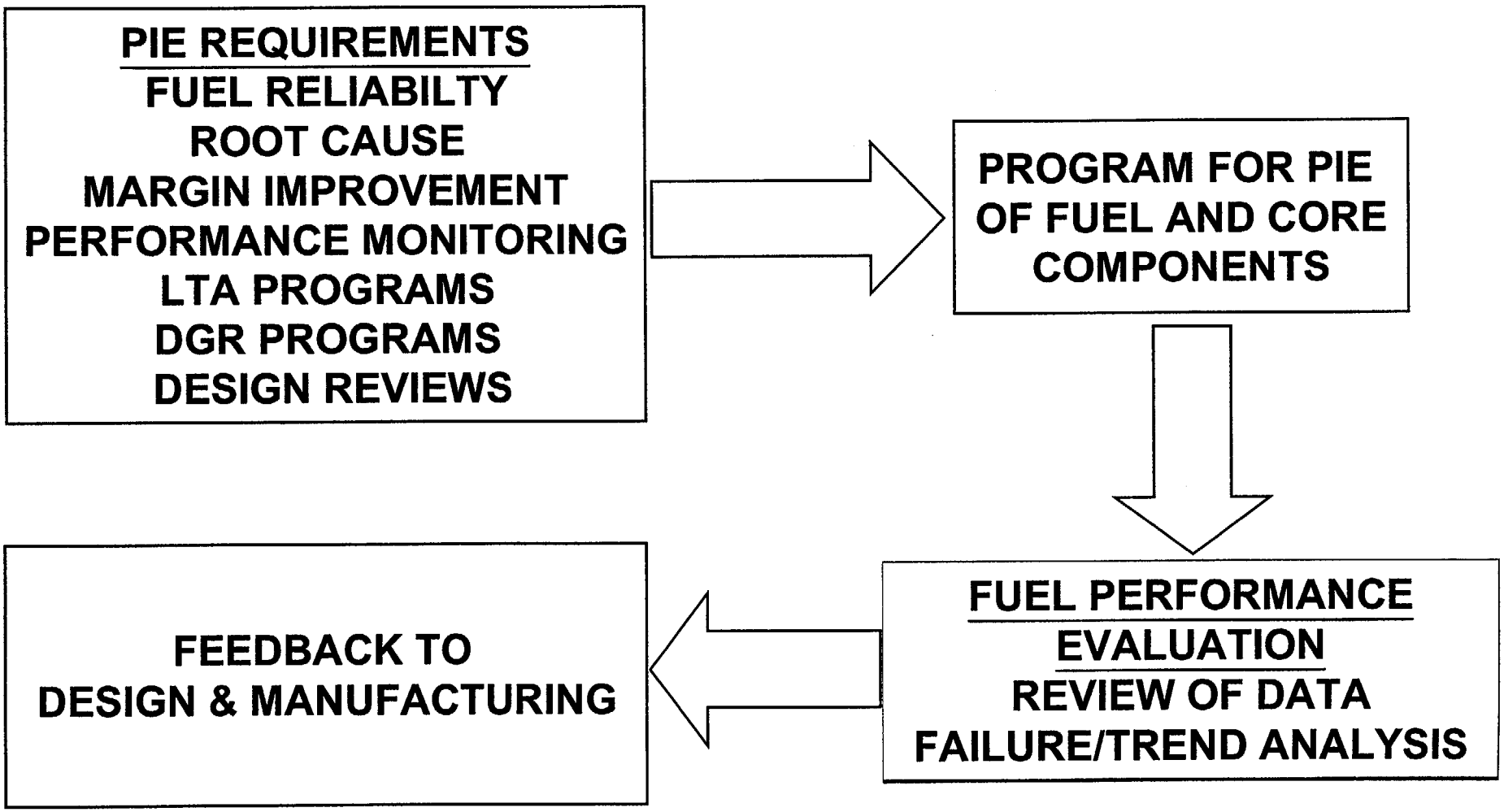
NRC Meeting
3 May 2000

Westinghouse Non-Proprietary Class 3

Agenda

- Fuel Evaluation Process
- Fuel Examination Programs
  - 1999 Accomplishments
  - Spring 2000 Outage Summary
  - PIE Plans for 2000
- Key Observations
  - Fuel Reliability Examination Summary

Fuel Evaluation Process



Flawless Fuel Team Charter

Carry out a systematic review and assessment of all fuel performance data and initiate actions aimed at achieving flawless product performance.

- **Perform a review of all fuel performance and operational data including reports on coolant activity, field anomalies, root cause analyses and field inspections.**
- **Perform failure analyses for the fuel assembly and core component and identify product performance trends.**
- **Make recommendations for product and manufacturing changes and additional performance monitoring.**
- **Manage the follow through on all recommendations.**

Fuel Examination Programs

Leakage Mechanisms Observed in Westinghouse Plants 1995- 2000 (from a population of over 5 million fuel rods)

a, c

1999 Fuel Examinations Summary

- Leaking Fuel Examinations
  - 13 root cause campaigns performed
- Spring Screw Examinations
  - 20 visual inspection campaigns
  - 11 visual & spring scale inspection campaigns

2000 Spring Outage Summary

- Leaking root cause examination
  - 6 root cause campaigns performed
- Spring screw examination
  - 12 spring scale inspection campaigns
  - 8 nozzle replacement campaigns
- Corrosion/Profilometry
  - 2 campaign

Leakage Mechanisms Observed in Westinghouse Plants that Shutdown in 1999-2000 (from a population of over 2.1 million fuel rods)

a, c

No Examinations in 1999-2000

a, c

Effectiveness of Corrective Actions in Westinghouse NSSS

a, c

Year 2000 Fuel Examination Plans

a, c

[ ]

Year 2000 Examinations

a, c

Summary

- Westinghouse objective is flawless fuel performance
- Root cause and corrective actions identified and implemented for observed leakage mechanisms
- Increase emphasis on PIE
  - Determine root causes of leakers
  - Monitor general fuel performance
  - Enhance product margins

Top Nozzle Screw Fracture Update

Meeting With USNRC

May 3, 2000

D. M. Rowland

Spring 2000 Outage: Summary

- Safety case remains valid
- 10 of 12 outages completed
- Fracture rate/heat performance [ ] a, c
- Isolated 1X fracture observed in worst heat
  - No 1X fractures previously identified[ ] a, c
  - One screw fracture identified in highly susceptible heat at 17x17 Plant
- One FA (15x15) had [ ]a, c

Spring 2000 Outage Examinations Update

a, e

[ ]

Spring 2000 Outage Results: Actions Regarding 1X Fracture

- Technical review conducted of current Engineering Position
  - Communication of results to customers

- Review Conclusions
  - [ ] a, c
    major elements of fracture observation
  - Number of 1X fractures extremely small [ ] a, c
  - Fracture was an isolated incident, the tail of a statistical distribution
  - Worst Heat involved; Fuel with this heat nearly out of service domestically
  - Safety Evaluations remain valid

- Inspection Actions
  - [
  -

] a, c

Top Nozzle Spring Screw Fracture: Conditional Acceptance Option

- Westinghouse Safety Evaluation
  - Meets 10 CFR 50.59 Criteria
  - Uses W Integrated Safety Evaluation (ISE) Process
  - Focuses on Key Technical Areas

- Plant Specific Safety Evaluation based on plant specific design parameters

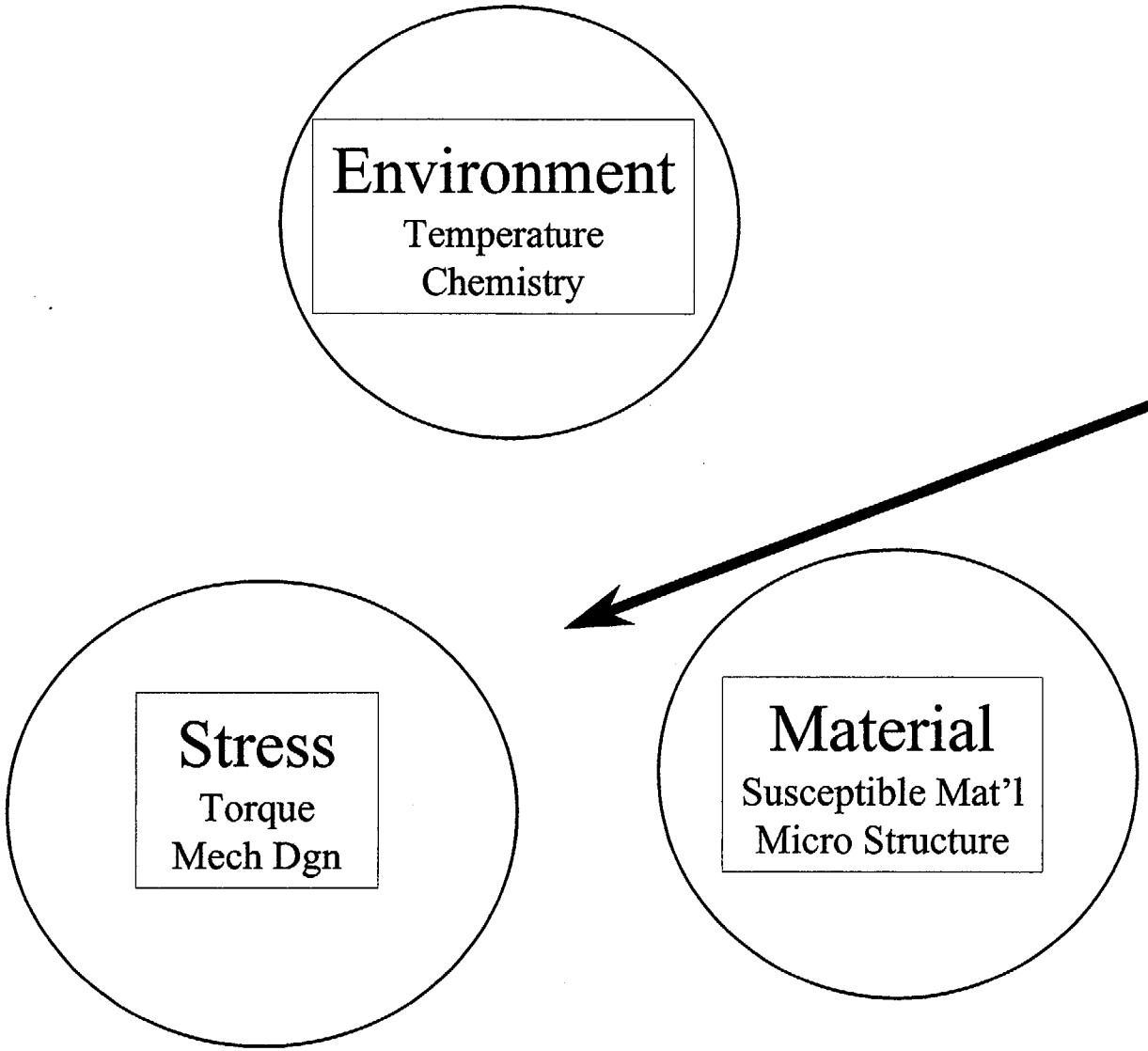
- [ ]a, c

- [ ]a, c

Top Nozzle Screw Fractures: Actions

- Outage Plans:
  - Anticipate screw fractures in [ ]^{a,c}.
  - Identify plant-by plant contingency plans in advance:
    - Repair.
    - Core redesign w/ acceptable replacement fuel.
    - Conditional acceptance.
  - Review and apply, as needed, available W documents on inspection, operation, & safety.
- New Fuel Deliveries:
  - Use [ ]^{a,c} screws for current deliveries, available after [ ]^{a,c}.
  - Plan to introduce [ ]^{a,c}.

Margin Enhancements Implemented



PW-IGSCC requires combination of three conditions

Multi-condition approach selected to enhance margin

Top Nozzle Joint
Margin Enhancement Strategy

a, c

AXIAL OFFSET ANOMALY

NRC / Westinghouse Meeting

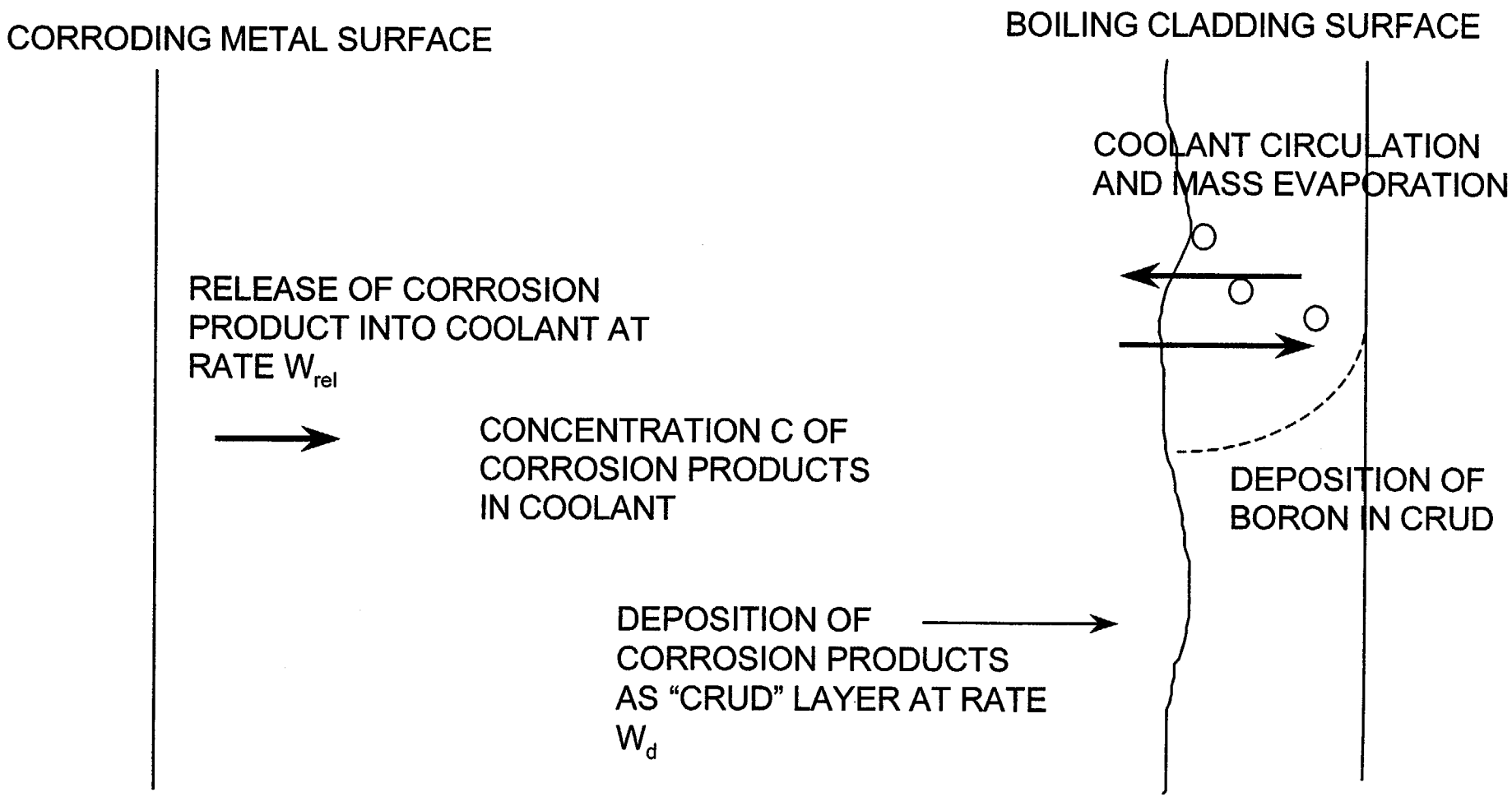
Westinghouse Evaluation of AOA

- Study of basic phenomena
- AOA risk reduction
- AOA management

Crud Deposition and AOA

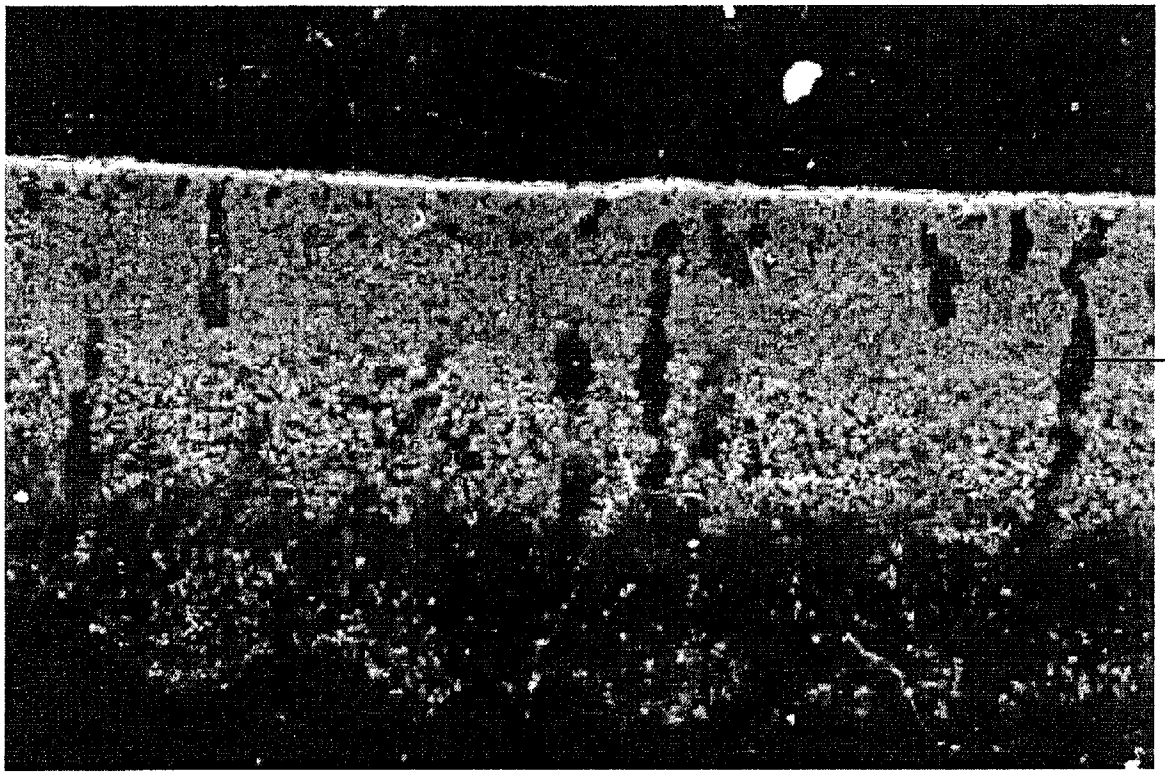
- Corrosion products (nickel & iron) are released into coolant and circulate at concentration C (lb_{metals}/lb_{H2O})
- Subcooled boiling occurs on some assemblies at a rate of m_e lb/ft^2hr
- Nickel and iron oxides deposit at rate proportional to product of m_e, boiling area A_e, and coolant concentration C
- Boron compounds precipitate when deposits and boiling reach critical values

Crud Deposition/Boron Deposition



Crud Deposit Studies

Crud structure supports basic mechanism of boiling in deposit, concentration, and boron precipitation



Side next to cladding

Boiling chimneys

Approximate thickness: 80 microns

Coolant Chemistry Studies

- Collected coolant samples during power operation from several plants with and without AOA
  - "normal" and "abnormal" nickel and iron levels
  - identify source of corrosion product
- Developed recommendations for chemistry operations to reduce AOA risk

AOA risk reduction: core design

- Define a corrosion release rate W_{rel} based on prior operation
- Determine core boiling distribution from core design
- Calculate crud deposit and boron distribution versus time
- Confirm low boron mass on core

AOA risk reduction: chemistry

- Operate plant to minimize corrosion product release (elevated, constant pH)
- Focus on maximum removal of nickel
  - balance dose release targets with need to remove corrosion product inventory
- Operate plant to minimize movement of inventories

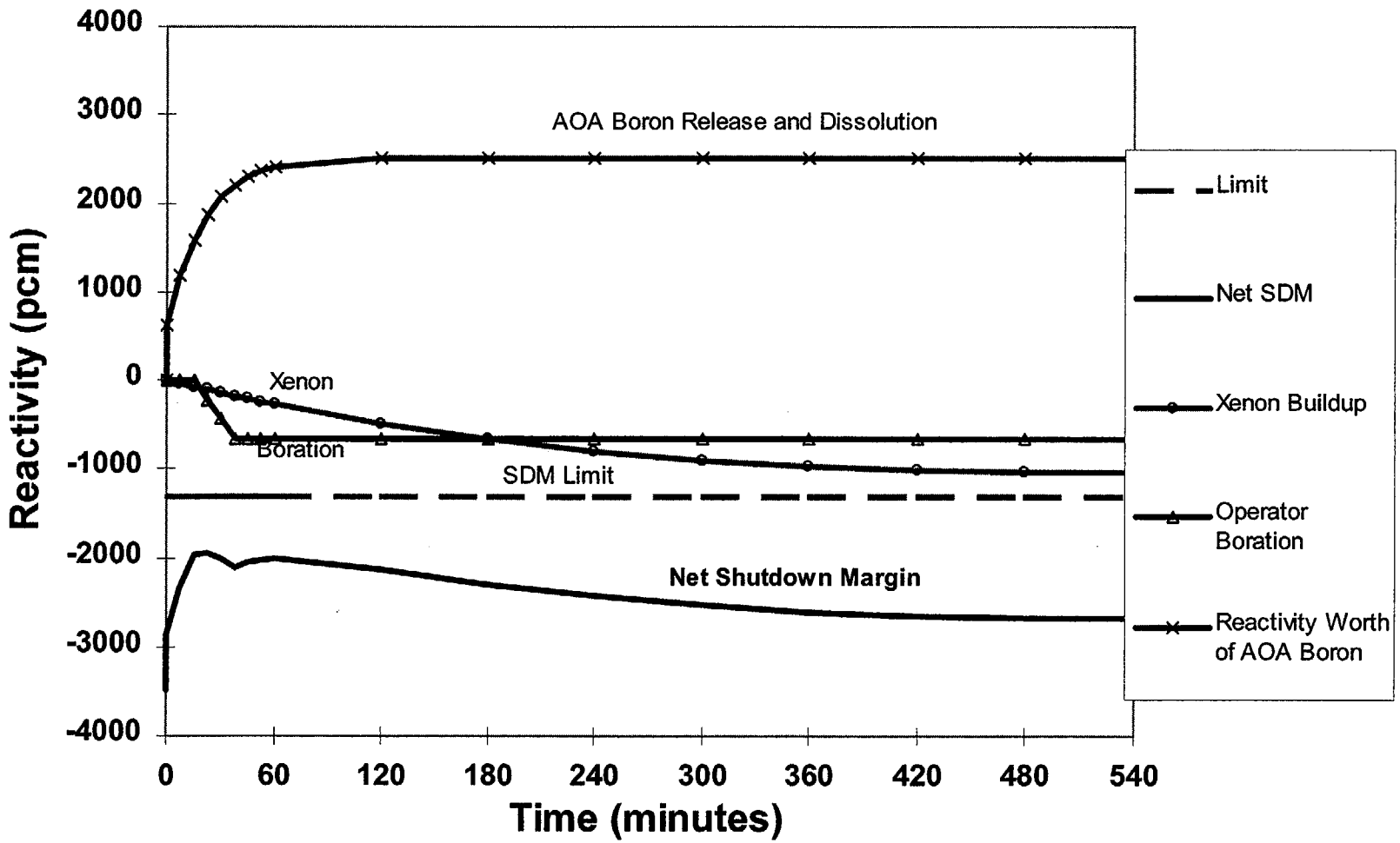
AOA and Shutdown Margin

- AOA erodes shutdown margin
- $LiBO_2$ dissolves after shutdown - boron is neutron absorber
  - increases core reactivity after trip
  - decreases shutdown margin
- Bottom skewed burnup/xenon distribution from depletion with AOA
  - increases flux redistribution after trip
  - decreases shutdown margin
- Conservative assumption: all boron dissolves immediately after trip
  - this assumption was replaced with a more accurate delayed boron model in a recent application

Time Dependent AOA Boron Release

- Large fraction of crud/boron is assumed released immediately after reactor trip
- Remaining boron dissolves from crud
- Positive reactivity from $LiBO_2$ dissolution is offset by xenon buildup (minimum benefit assumed)
- Operator action for RCS boration beginning several minutes after trip also offsets AOA boron dissolution

Time Dependent Boron Release SDM



Status of Westinghouse studies

- Basic studies: Emphasis now on plant conditions which affect source term
- AOA risk reduction: Integrated assessment of core design and plant chemistry
- AOA management: Expect to avoid, but methods available in case

The Fuel Duty Index - A New Measure of Fuel Rod Cladding Performance

W. J. Leech
Westinghouse Electric Company
803-647-3274

Westinghouse/NRC Fuel Update meeting
May 3, 2000

Westinghouse Non-Proprietary Class 3

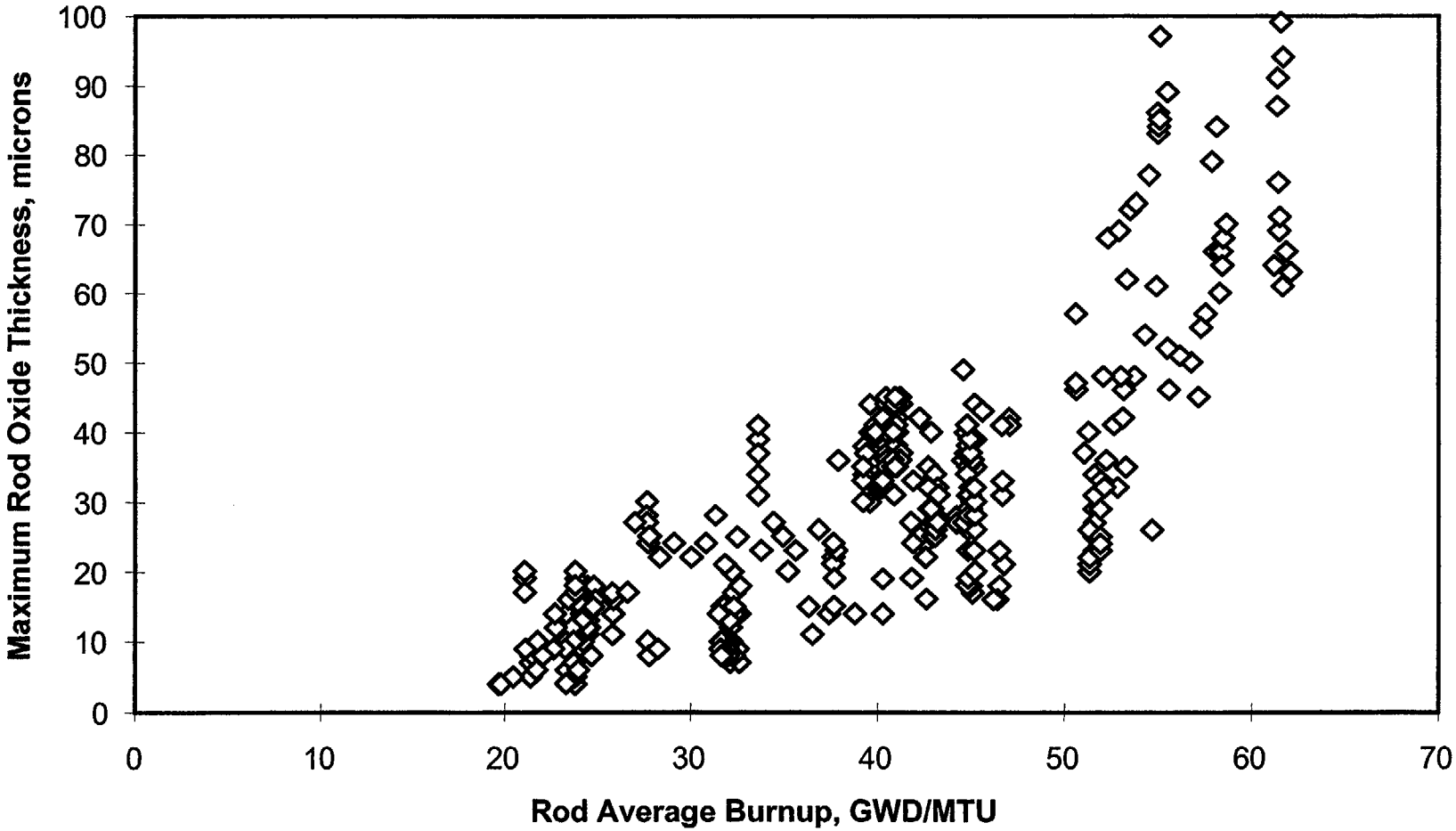
- Fuel rod corrosion data are typically plotted as the maximum rod oxide versus rod average power.

- Corrosion is not caused by burnup, and that representation of the data can be confusing and misleading.

- More demanding fuel duties require a closer evaluation to differentiate between cladding corrosion performance and the fuel duty.

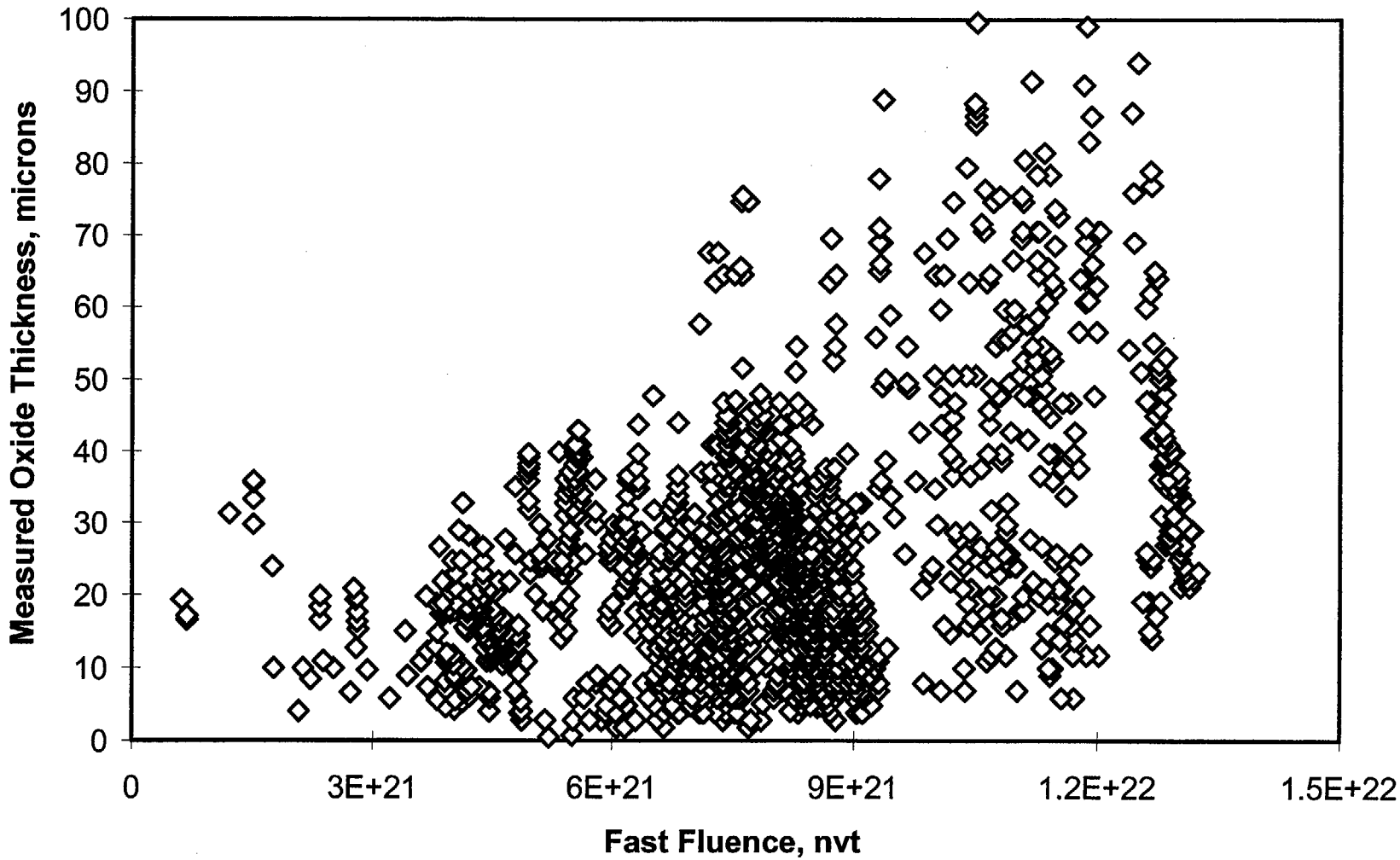
Maximum Rod Oxide Thickness vs. Rod Average Burnup

Apparent correlation with Burnup



Measured Oxide Thickness vs. Fast Fluence

No correlation of oxide and Fast Fluence



Parameters that affect Corrosion

- Primary variable is time at temperature, which depends on;

inlet temperature
core flow rate
core rod average power
axial power shapes
fuel assembly design
fuel rod geometry
number of cycles
length of each cycle
rod power in each cycle
powers of adjacent assemblies in each cycle

A method is needed to synthesize all this information into something meaningful

- Predictions from corrosion models

  May be proprietary

  May require input data not readily available

  Deviations from predictions may be due to model biases

  Do not capture a sense of the duty experienced by the fuel cladding

- Fuel Duty Index (FDI)

Desired Characteristics of a FDI

- Captures the most important effects
- Relatively simple to determine from available information
- Is a valid metric for estimating and comparing cladding performance
- Is not intended to replace predictive models

Definition of the Fuel Duty Index

$$FDI = [((T_{avg} - 580)/100))\times(t/1000)]^2$$

for $T_{avg} \geq 580$

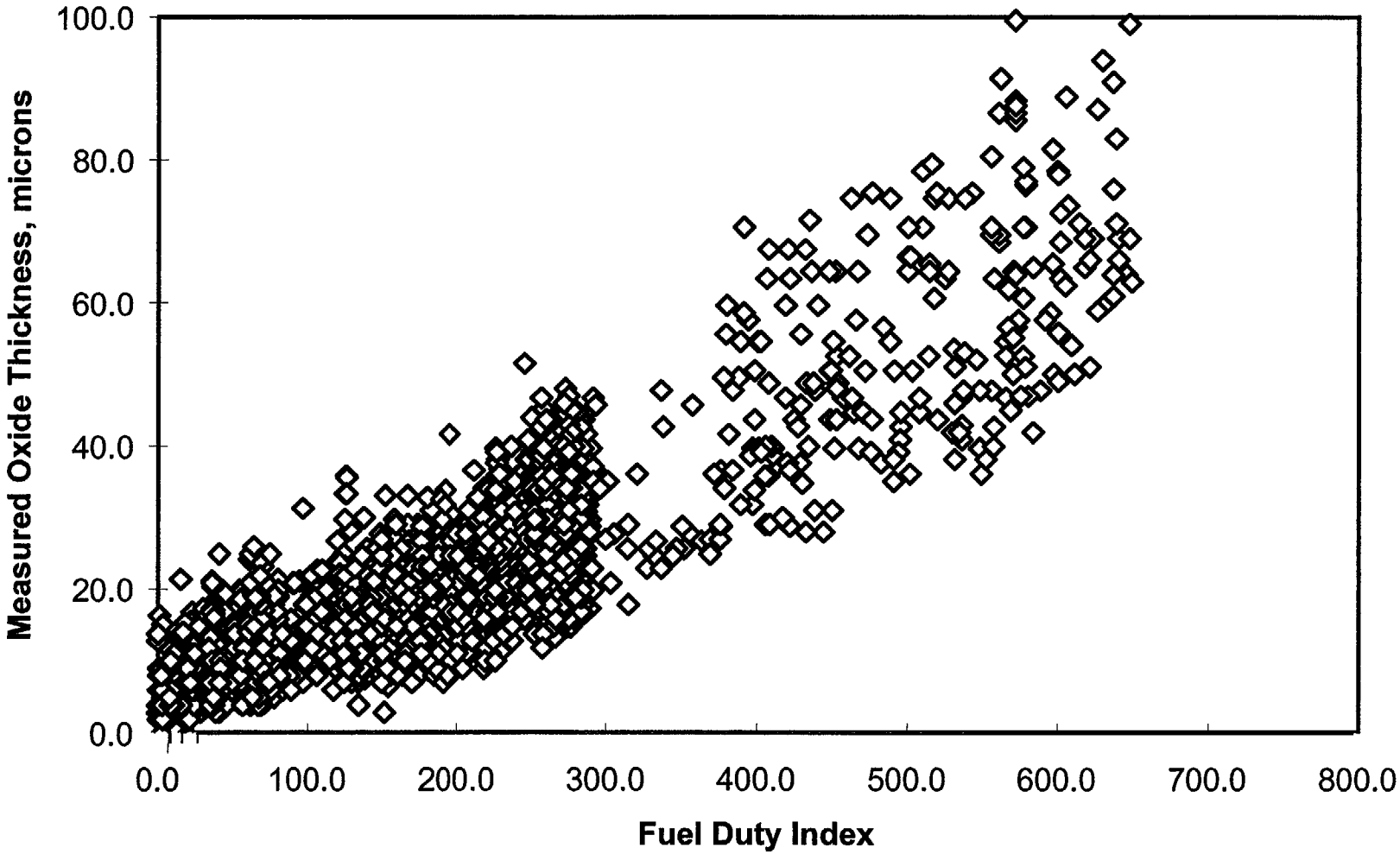
where;

T_{avg} = time averaged oxide surface layer temperature, ^oF

t = Total irradiation time, hrs

Measured Oxide Thickness vs. Fuel Duty Index

Oxide thickness correlates with FDI



ZIRLO™ Corrosion Update

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Westinghouse/NRC Fuel Update Meeting
May 3, 2000

Introduction

- There is an aggressive program to collect data at FDI ranges [ ]^{a,c}
- This data will be used to continually improve our models and as necessary we will update the NRC
- Data collected to date indicate that design limits are being met

ZIRLO™ Corrosion Program Update

- Monitoring of ZIRLO™ corrosion is based on a systematic program to obtain field data
  - Obtain Corrosion Measurement Data over a range of fuel duties
  - Evaluate vs Previous Experience
  - Ensure safety conclusions continue to be validated
  - Revise model as required and implement in design

ZIRLO™ PIE Programs

- Data from over 500 rods, burnups to 66.3 GWD/MTU
- FDI values to 650
- Data collected from 8 plants and 16 cycles

Plant A **Cycles N, N+2, N+3**

Plant B **Cycles N, N+1**

Plant C **Cycle N**

Plant D **Cycle N**

Plant E **Cycles N, N+1, N+2**

Plant F **Cycle N**

Plant G **Cycle N**

Plant H **Cycles N, N+1, N+2, N+3**

Observations

- Measurements from Plants A - G show good agreement with the design model

- Measurements from over 80% of the assemblies in Plant H are in good agreement with predictions

- Measurements from 3 assemblies in Plant H with burnups of 49-52 GWD/MTU were in the range of [ ]^{ac}, and are [ ]^{a,c} than predictions , but well within design limits

a,c

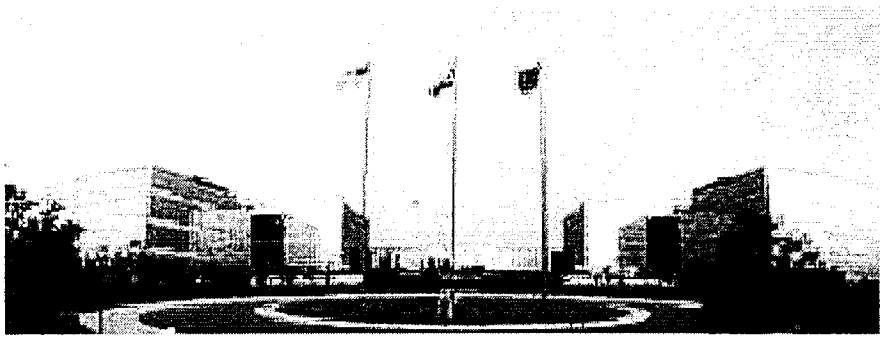
Actions

- Assess new data versus corrosion model
  - most data consistent with expectations, some measurements higher than expected
- Assess rationale for data points
  - multi-cycle high boiling duty is suspected
  - if true, this is very limited in actual operation
- Evaluate and collect additional data
- Revise ZIRLO™ corrosion model if necessary

Summary

- Westinghouse is conducting an aggressive program to collect data at FDI ranges of [ ]a,c
- This data will be used to continually improve our models and as necessary we will update the NRC
- Data collected to date indicate that design limits are being met

Westinghouse Fuel Duty Experience



Brian Beebe

May 3, 2000

Outline

- ⌘Trends In Operating Strategies
- ⌘L^4P Assembly Life Cycles
- ⌘Last 2 Cycles Fuel Duty Data
- ⌘Loading Pattern Risk Assessment

Loading Pattern Types

a, c

Core Thermal Power

a, c

Core Average Enrichment

a, c

Core Average Burnup

a, c

Operating Full Power Days

a, c

Peaking Factor Limits

a, c

Miscellaneous

- Burnable Absorbers
  - Discrete vs integral
    - handling, maintenance, let-down, hold-down
- Coast-downs and Economics

General Characteristics

- Feed Characteristics, 18 Month
  - % of core, 2, 3 and 4 loop
    - Typical aggressive peaking factors - [redacted] a, c
    - Very high peaking factors - [redacted] a, c
  - Checkerboard vs ring patterns
  - 12, 15, and 21 month cycles
  - Center assembly benefits
    - 2 and 1.5 assembly per cycle benefits

Current Cycle Schemes

- 2, 3 and 4 Loop Cores L4P Averages
  - Interior checkerboard dominant
    - 40% feed, 40% once, 20% twice
    - Assembly life cycle is in-in-out (except center)
    - Cycle BUs and Power Sharing Data:

a, c

Planned Cycle Scheme

a, c

Planned Cycle Scheme

a, c

Last 2 Cycles Fuel Duty Data

Cycle Discharge BU

a, c

Last 2 Cycles Fuel Duty Data

Highest 10 BU

a, c

Introduction To LPRA

- Why is it necessary
  - Increased fuel duties
  - Decreased operating margin
  - New operating issues
- Who is involved
  - Core design engineer
  - T/H engineer
  - Fuel rod design engineer
  - Utility
- What is involved
  - Loading pattern review during LP development
  - Determination of risk(s) on candidate LP
  - Customer discussions regarding risk potential

Items Assessed In The LPRA

a, c

Calculational Process

- Not a Safety Calculation
  - Provides a quantitative basis to discuss with the customer and determine if actions are necessary
- For all categories:
  - Calculate key values of previous cycle
  - Calculate key values of current cycle
  - Compare key values
  - Determine increase/decrease of cycle to cycle comparable risk
    - Does not determine overall magnitude of risk

Quadrant Power Tilt

a, c

Summary

- Trends In Operating Strategies
  - Increased MWt, W%, EFPDs and Design Limits
- L^4P Assembly Life Cycles
  - Smaller feed numbers
- Last 2 Cycles Fuel Duty Data
  - Higher discharge BUs
- Loading Pattern Risk Assessment
  - Proactive strategy to determine change in risk to various operating issues early in LP stage

High Burnup LTAs

Presented by:
W. H. Slagle

High Burnup LTAs

- Currently, the Westinghouse licensed fuel burnup limit, as specified by the Fuel Criteria Evaluation Process (FCEP), WCAP-12488-A, is 62 GWD/MTU. LTAs that would reach burnups beyond this level would be classified as high burnup LTAs.

- NEI, EPRI, and the industry are currently working on perspective guidelines for fuel rod design criteria and associated safety analyses that can be used to demonstrate acceptability of high burnup fuel.

- Intermediate burnup step increases have been discourage by the NRC since this process would consume extensive regulatory review for each vendor applying for incremental increases.

High Burnup LTAs

- Upon completion of the generic guidelines that are being proposed by the industry, NRC concurrence of these guidelines will be necessary.

- Regardless of the regulatory process, or the generic guidelines that are determined to demonstrate acceptability, real fuel data will be needed to justify the ultimate design criteria and acceptance criteria.

- As noted during the recent ANS meeting in Park City, the NRC has stated the need for data. This data is not just data at the high end of the burnup limit being sought, but must encompass data from the current burnup limits to the ultimate requested limits. This intermediate high burnup data will substantiate fuel performance behaviors for each of the design criteria that will be applied.

High Burnup LTAs

- A proposed approach by Westinghouse to the NRC for obtaining the intermediate high burnup data through LTA programs is to make the LTA programs more attractive to the individual licensee.

- Typically, LTAs are highly characterized and are monitored throughout their life. A second approach would be to use region average as-built data to pre-characterize fuel assemblies that could be driven to intermediate high burnup stages to allow selective data to be obtained. The type of data that could be obtained through this approach would be corrosion measurements, crud measurements, and axial and radial growth measurements.

- The more detailed, highly characterized, LTAs would still be essential for the confirmation of first principle fuel performance behaviors.

High Burnup LTAs

- The proposed approach would be to permit utilities to pursue limited LTA programs from a [

  ] [a, c]. The benefit to this approach is that it would be more of an incentive to the utilities to support the effort of obtaining intermediate high burnup data.

- The true high burnup, highly characterized LTA programs are seldom shown to have any fuel management economic benefit. In fact, many times fuel management suffers with these types of programs.

- An example of this approach can be illustrated by examining ZIRLO™ corrosion data versus burnup.

High Burnup LTAs

a, b, c

High Burnup LTAs

- The advantage to this proposed approach is that the utilities are more likely to agree to LTA programs and the data that could be obtained would substantially add to the database, thus, increasing the likelihood that data scatter would be a question in validating the much higher burnup data.