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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001
March 15, 2000

MEMORANDUM TO: Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Stewart N. Bailey, Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF FEBRUARY 9, 2000, MEETING WITH THE BABCOCK & WILCOX OWNERS GROUP ON INCOMPLETE CONTROL ROD INSERTIONS AT THREE MILE ISLAND (TAC NO. MA7351)

On February 9, 2000, the U. S. Nuclear Regulatory Commission (NRC) staff met with the Babcock and Wilcox Owners Group (B&WOG) to discuss the root cause investigation, recent operating data, actions taken, and future plans in response to the incomplete control rod insertions that occurred at Three Mile Island, Unit 1. The B&WOG is made up of five utilities, Duke Energy Corporation, Entergy Operations, Inc., Florida Power Corporation, GPU Nuclear, Inc. (Amergen), FirstEnergy, and a vendor, Framatome Technologies Group. The B&WOG has seven active reactors at five sites.

After introduction of the meeting participants, the B&WOG started by reviewing the October 1999 meeting on this issue, including the justification for continued operation for TMI-1. The B&WOG described the root cause for the incomplete control rod insertions (IRI) as fuel bowing and excessive guide tube deformation. The contributing factors for IRI include spring holddown force, lateral loads, fuel assembly growth and material creep. The B&WOG discussed the results of data taken following shutdown of several units, including the surveillance tests of control rod drop time, tests of rod drag force, and visual surveillance of assemblies. They also explained their reduction of the data to determine the margin to IRI.

The B&WOG described the corrective actions performed at each unit aimed at reducing guide tube deformation, such as resetting the springs and minimizing "same quadrant shuffle." Potential long-term corrective actions include future improvements in fuel design and the use of an advanced cladding material (M5). They also explained that a mid-cycle shutdown will plastically set the holddown spring due to differential thermal expansion, thereby reducing the holddown force for the rest of the cycle. Since Davis-Besse has had mid-cycle shutdowns for its last two cycles, the B&WOG does not anticipate IRI problems when Davis-Besse shuts down for its next refueling outage.

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The B&WOG concluded that (1) there had been no significant safety issues, (2) corrective actions had been taken to further reduce susceptibility to IRI, and (3) the B&WOG was continuing to monitor plant data and develop analytical tools. The B&WOG also concluded that the analytical models, and their experience in France, demonstrate that their corrective actions will reduce the susceptibility to IRI.

The staff thanked the B&WOG for their presentation. The staff recognized the significant amount of work involved in gathering, evaluating, and presenting the data for this issue. The staff commented that they were interested in further benchmarks of the evaluation models and that they looked forward to the next update.

A list of those attending the meeting is provided as Attachment 1. The slides used by the B&WOG during the meeting are provided in Attachment 2.

Project No. 693

Attachments: 1. Meeting Attendees
2. B&WOG Slides

cc w/atts: See next page

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BABCOCK AND WILCOX OWNERS GROUP

EXECUTIVE COMMITTEE MEETING ATTENDEES

FEBRUARY 9, 2000

NAME	AFFILIATION
Paul Bailey	Duke Power
Jay Verbos	Duke Power
Jimmy Willoughby	Entergy
Barclay Andrews	FCF
John Willse	FCF
Tom Wampler	FCF
Frank McPhatter	FCF
Arthur Copsey	FCF
Gary Williams	FCF
G. Williams	FPC
A. Spillman	Amergen
Gregory Gurican	Amergen
Randy Tropasso	Amergen
Oscar Limpias	Amergen
Bob Jaffa	PECO
Ken Hunt	PECO
Christine Cave	McGraw-Hill
Leslie Collins	ABB CENP
Mike Schoppman	FTI
Kevin O'Sullivan	Utility Resource Associates
Frank Burrow	TVA
Frank Swanger	FirstEnergy
Daniel Kelley	FirstEnergy
Stewart Bailey	NRR/DLPM
Timothy Colburn	NRR/DLPM
Muffet Chatterton	NRR/SRXB
Ralph Caruso	NRR/SRXB

Attachment 1

February 2000 NRC Meeting on Incomplete Rod Insertion

The B&W Owners Group and
Framatome-Cogema Fuels

FRAMATOME
TECHNOLOGIES

Attachment 2

Agenda

- Review of October 1999 meeting
- Recent plant data
- What have we learned
- Corrective actions and future improvements taken by FCF and utilities

Review of October 1999 TMI IRI Meeting

- A significant amount of TMI data was collected and analyzed
- Improvements were made to the TMI Cycle 13 core
- TMI Startup data showed acceptable control rod drop times
- Based on the corrective actions, continuous operation was justified for TMI Cycle 13.
- No safety significance
- TMI will perform drop time testing for all shutdowns when testing has not been performed within four months
- TMI will submit a supplement LER within 18 months evaluating available new data and analyses and determining if additional monitoring is warranted.

TMI IRI Root Cause

Root Cause for the TMI IRI was identified as excessive Guide Tube Deformation

Guide Tube Deformation can be caused by:

- hold-down spring force
- lateral loads
- fuel assembly growth
- creep

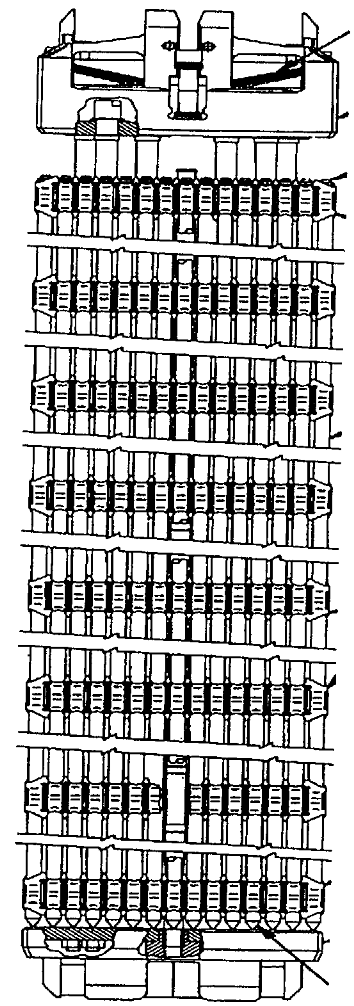
Background on IRI and Guide Tube Deformation

Hold down spring force must prevent FA lift

Spring is "plastically set" during cold shutdown due to differential thermal expansion

Fuel rod clad grows due to irradiation and material creep

Guide tubes grows due to irradiation and material creep



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Immediate Corrective Actions Taken at TMI

Guide tube deformation:	Corrective Actions:
•Hold-down spring force	•Plastically set spring
•Lateral loads	•Minimized "same quadrant shuffle"

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Possible Future Improvements

Guide tube deformation:	Future improvements:
•Hold-down spring force	•Redesign Mark-B10 leaf-spring
•Lateral loads	•Finalize shuffle guidelines
•Fuel assembly growth	•Low growth material (M5™)
•Creep	•Low growth material (M5™)

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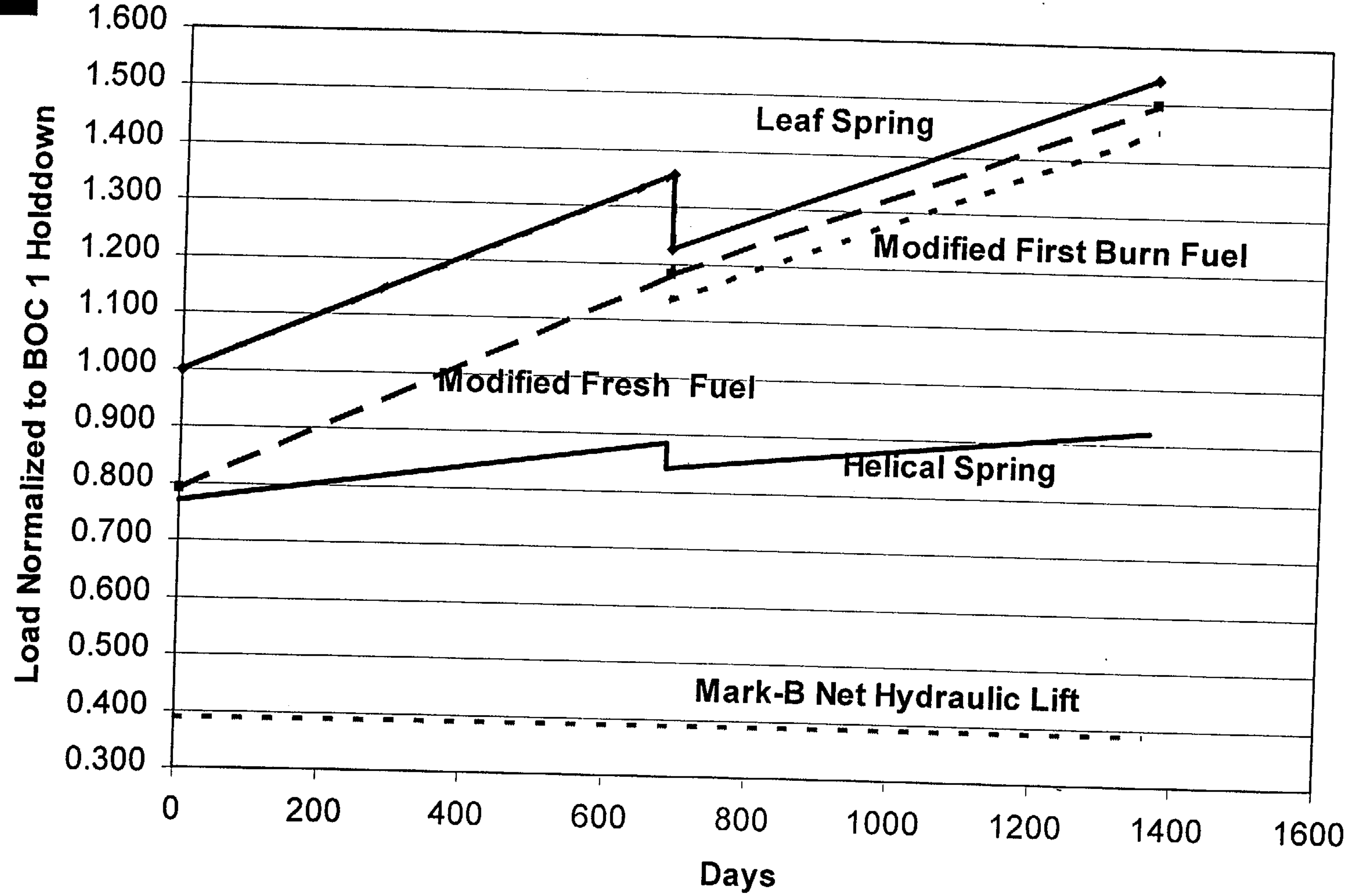
Mark-B Spring Hold-Down: Setting Springs



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Mark-B Data and Analysis

Gary Williams
FCF Team Leader
Mechanical Analysis and Development

FRAMATOME TECHNOLOGIES

Agenda for Mark-B Data and Analysis

- Data taken before TMI IRI observations
- TMI drop times and summary
- Crystal River-3 drop times and summary
- Oconee-2 drop times and summary
- Control rod drag work
- Compare 18-month and 24-month cycles
- Effect of cold shut-down

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Latest Cycle Data for Mark-B Units

Plant	Cycle	EFPD	Outage Date	Max FA Burn-Up
ANO-1	15	473.8	9/11/99	[c,d]
Crystal River-3	11	684.8	10/1/99	[c,d,]
Davis-Besse	11	645.3	4/10/98	[c,d]
TMI-1	12	680.6	9/10/99	[c,d]
Oconee-1	18	435.4	5/20/99	[c,d]
Oconee -2	17	501.8	11/4/99	[c,d]
Oconee -3	17	502.4	10/8/98	[c,d]

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Mark-B Data Taken before TMI-1 IRI Observations

Oconee-3 (502 EFPD)

- No IRI or significant increase in control rod drop time
- Mark-B10 leaf spring
- Type C CRDM

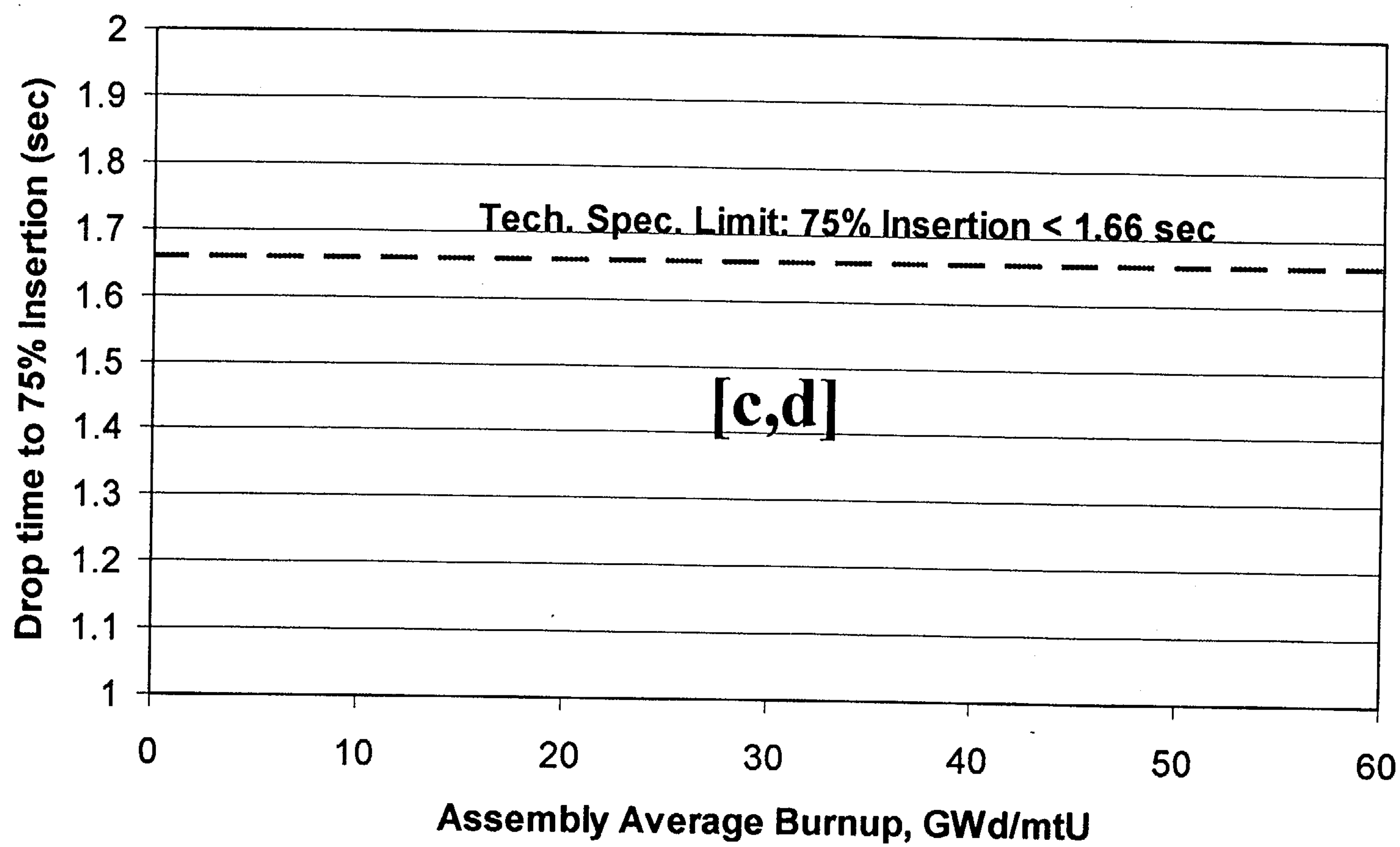
Davis Besse (645 EFPD)

- No IRI
- Mark-B10 leaf spring
- Type C CRDM

ANO-1 (474 EFPD)

- No IRI or significant increase in control rod drop time
- No trends that would indicate future problems
- Helical hold-down spring
- Type B CRDM

Mark-B Drop Time Variation with Burnup

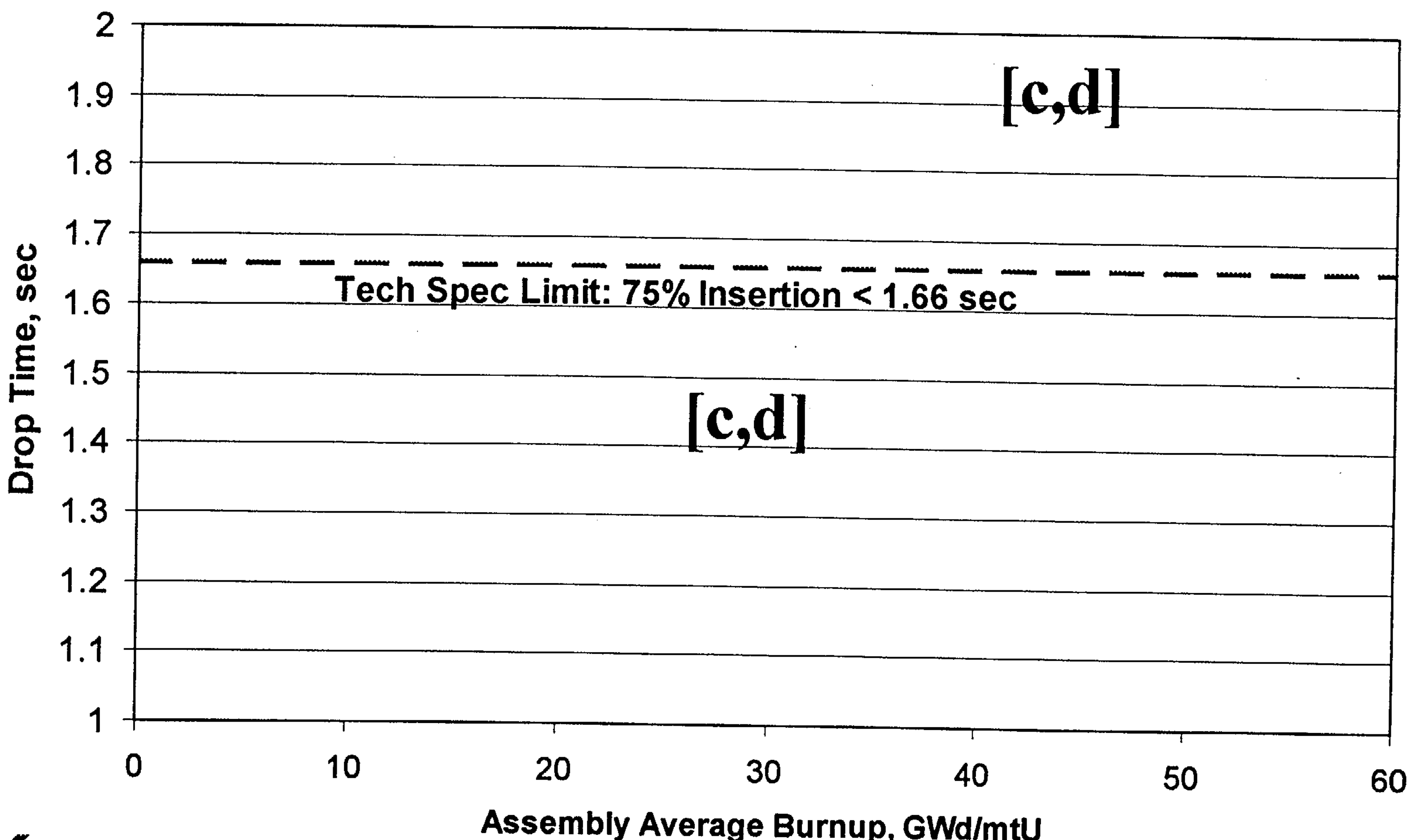


Summary of TMI-1 Data

TMI-1 (681 EFPD, previous cycle ~660 EPFD)

- Two control rods did not fully insert
  - E11 was 26% withdrawn
  - G9 was 7% withdrawn
- Both are leaf spring designs (Mark-B10) with a burnup of approximately 50 GWd/mtU
- Both stayed in the same quadrant for both cycles
- Both showed significant guide tube distortion
- TMI had two long, continuous-operation, cycles

TMI-1 Drop Time Variation with Burnup



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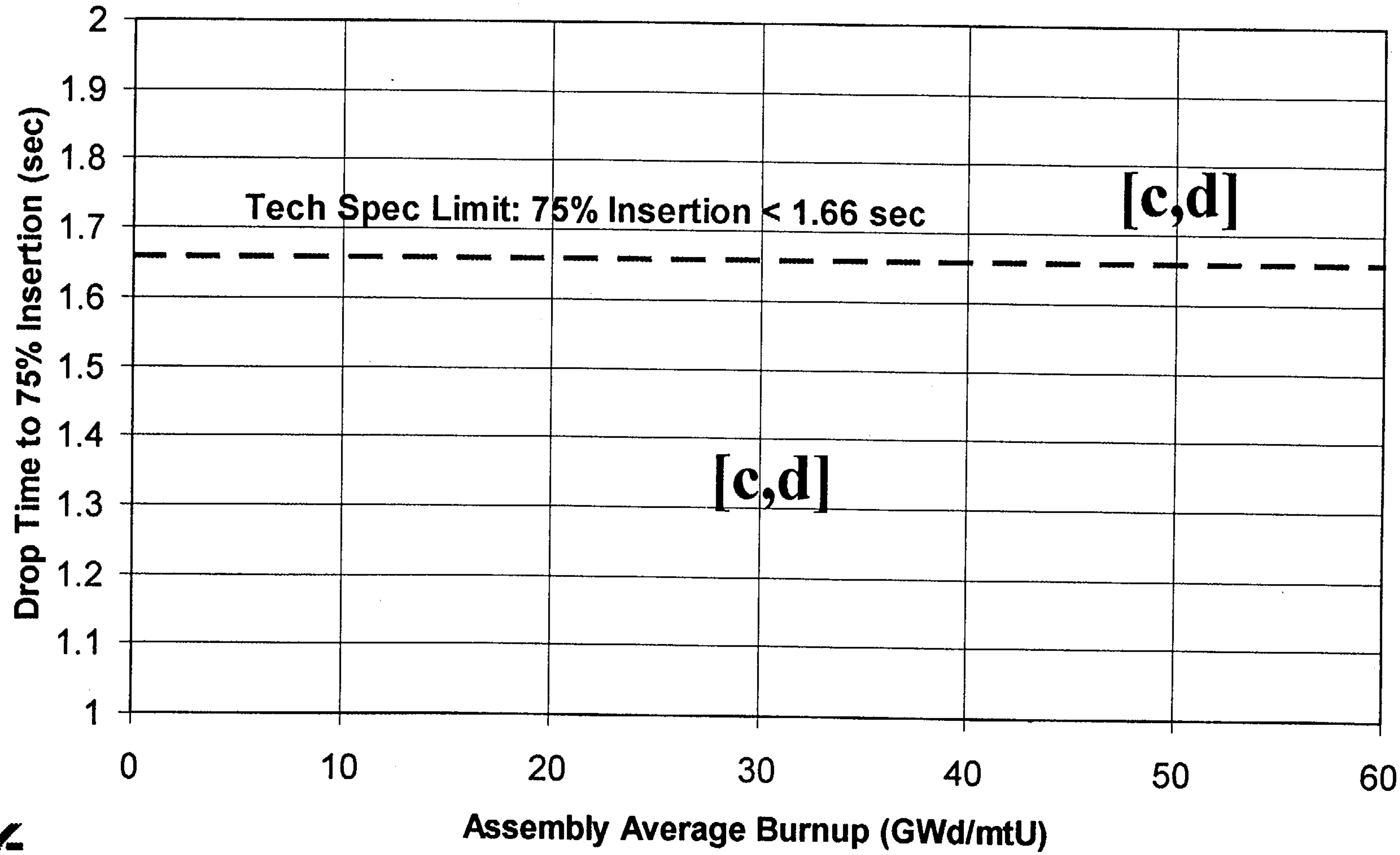
Summary of Crystal River-3 Data

Crystal River-3 (685 EFPD)

- 24-month cycle
- Two fuel assemblies (FA), with old CRDM/thermal barriers, did not meet the 1.66 sec drop time criteria
- A third FA, with Mark-B10 leaf spring design, stopped at 8% withdrawn and slowly fully inserted
- This third FA was measured to have significant control rod drag
- A fourth FA (with an old CRDM/thermal barrier) did not initially meet the 1.66 sec drop time criteria at startup
- After exercising the CRDM, the fourth FA met the drop time criteria

Crystal River 3 Drop Time Variation with Burn-up, EOC 11



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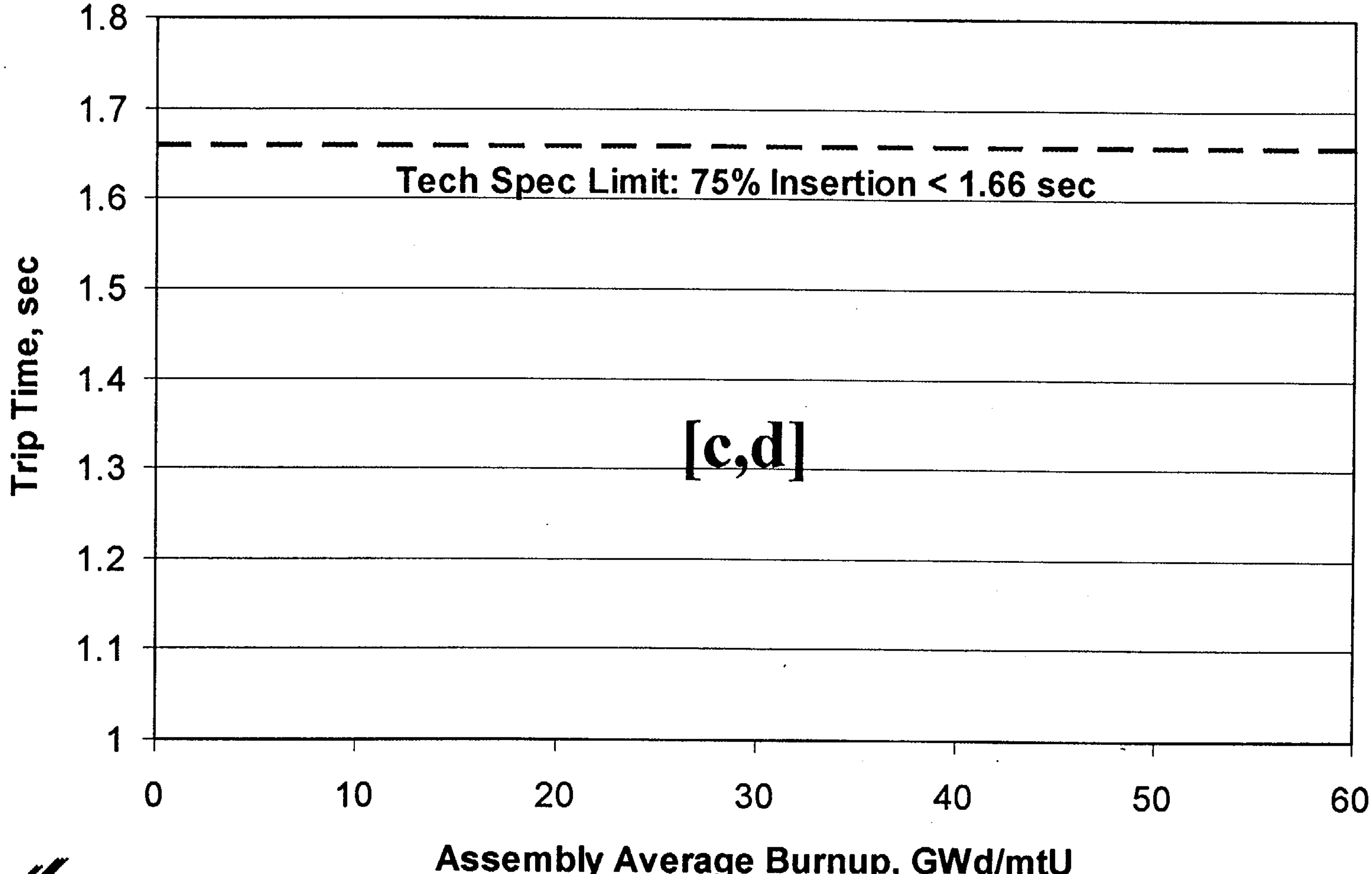
Summary of Oconee-2 Data

Oconee-2 (502 EFPD)

- No IRI or significant increase in control rod drop time
- No trends that would indicate future problems
- Mark-B10 leaf-spring

Oconee-2 Cycle 17 Drop Time Variation with Burnup



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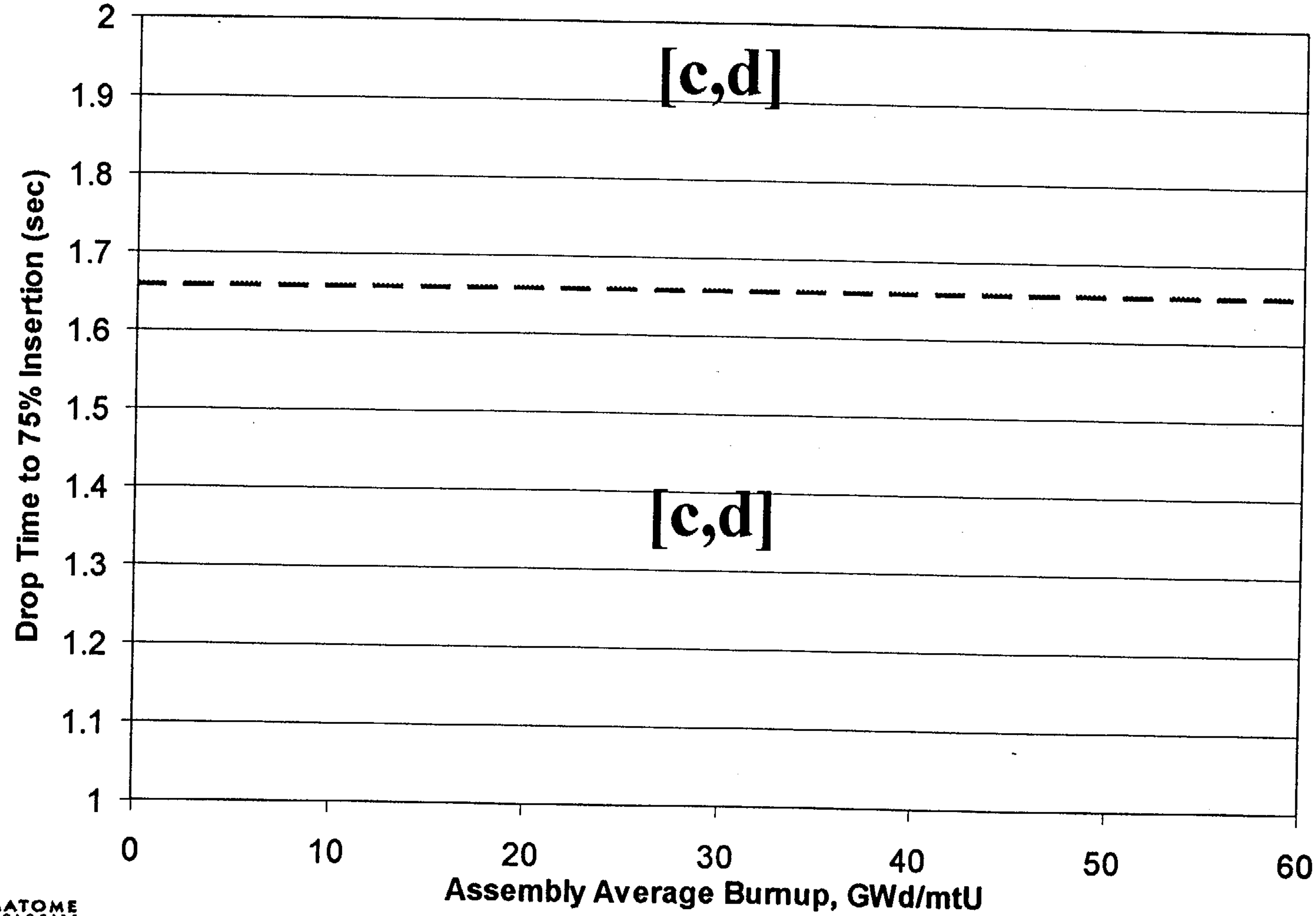
Oconee-2 Drop Time Variation with Burnup

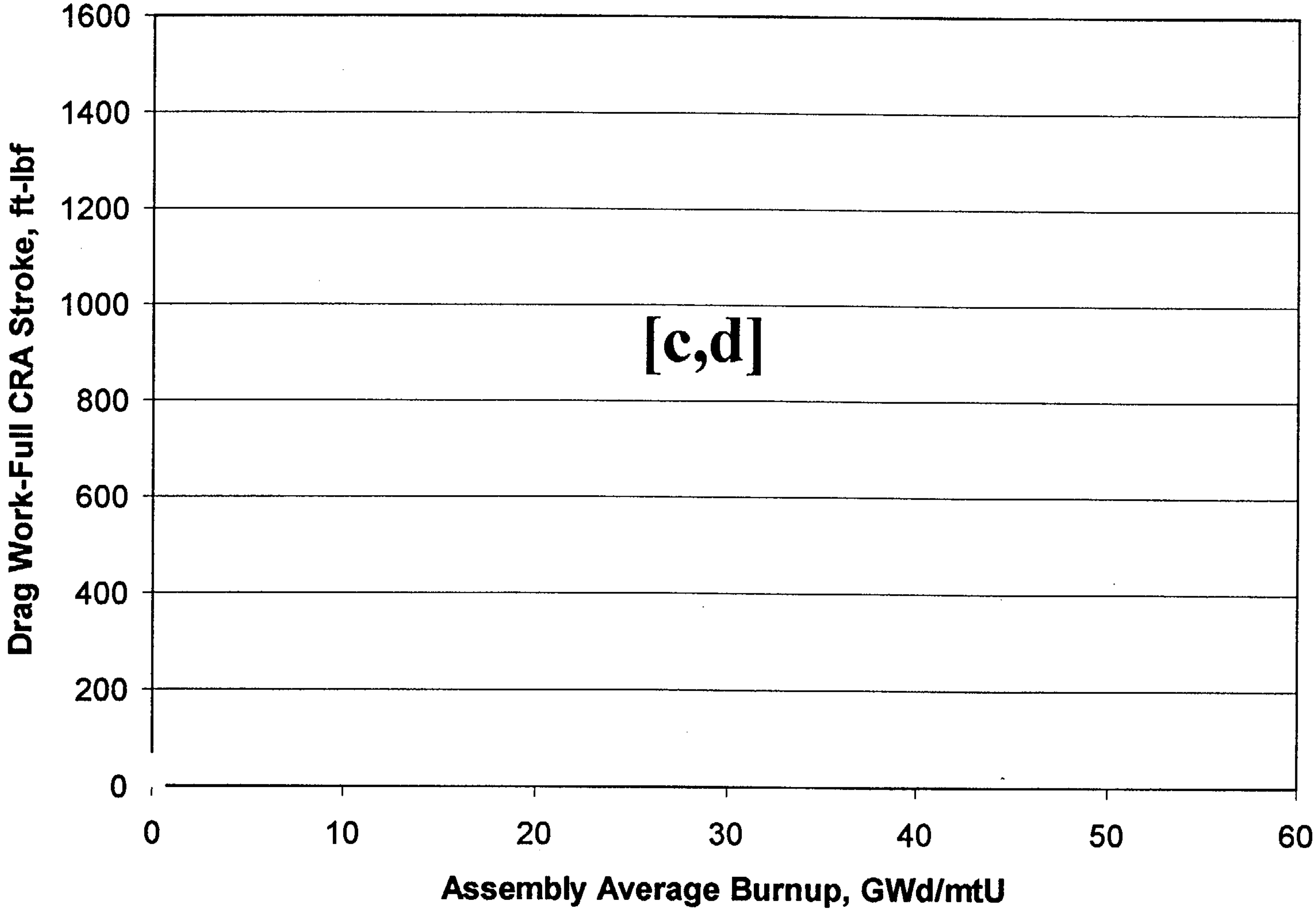


FRAMATOME TECHNOLOGIES

Control Rod Assembly Drag Work

- Integration of mechanical drag force over the length of the GT acting on the control rod assembly (CRA)
  - Slows, and potentially stops, CRA during insertion
- Increases with increased guide tube distortion
- Obtained by analyzing CRA drag profiles
- Used as a measure of margin to incomplete rod insertion

Control Rod Drag Work as a Function of Burn-up



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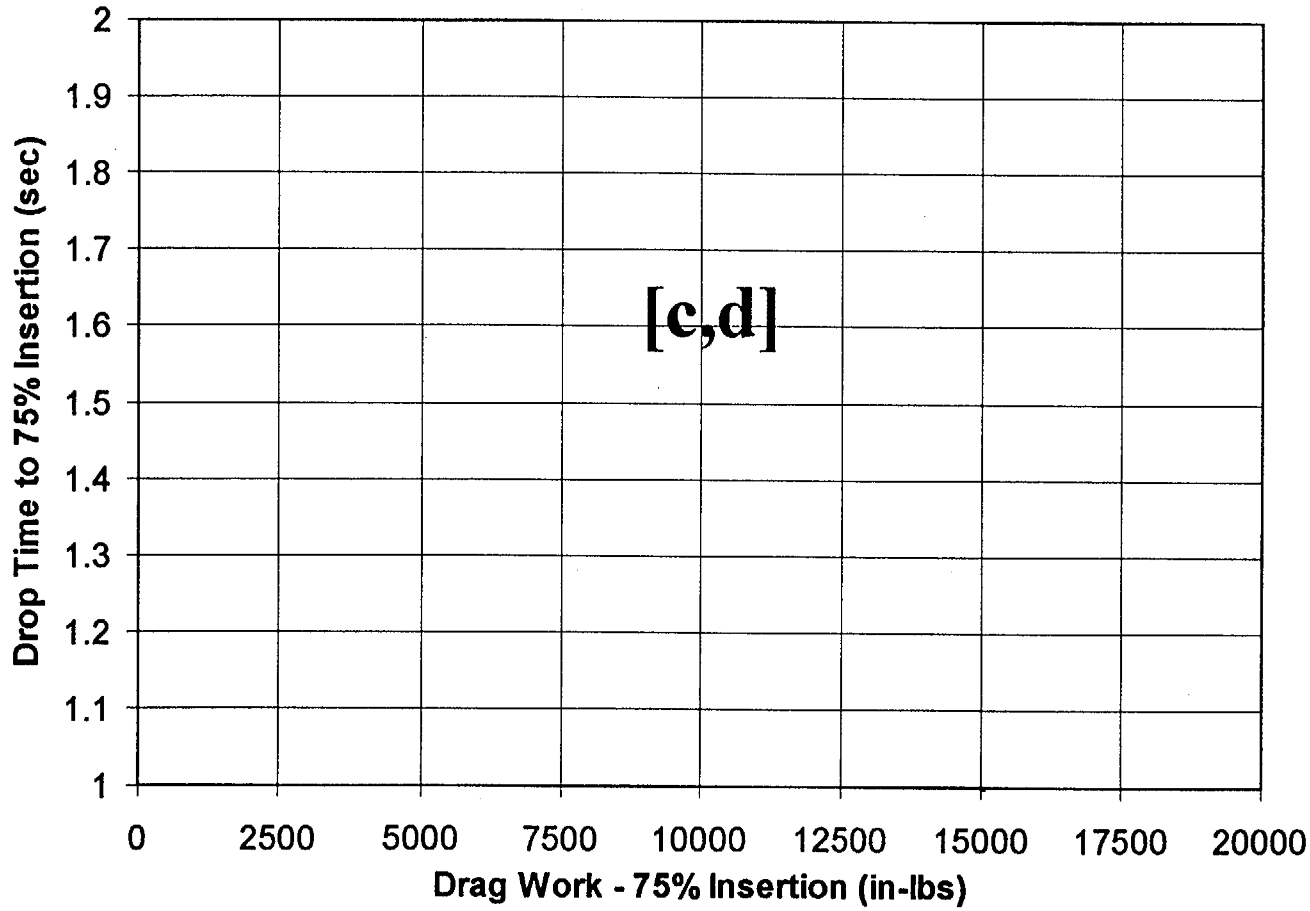
Control Rod Drop Time Variation with Drag Work, TMI-1 Cycle 12



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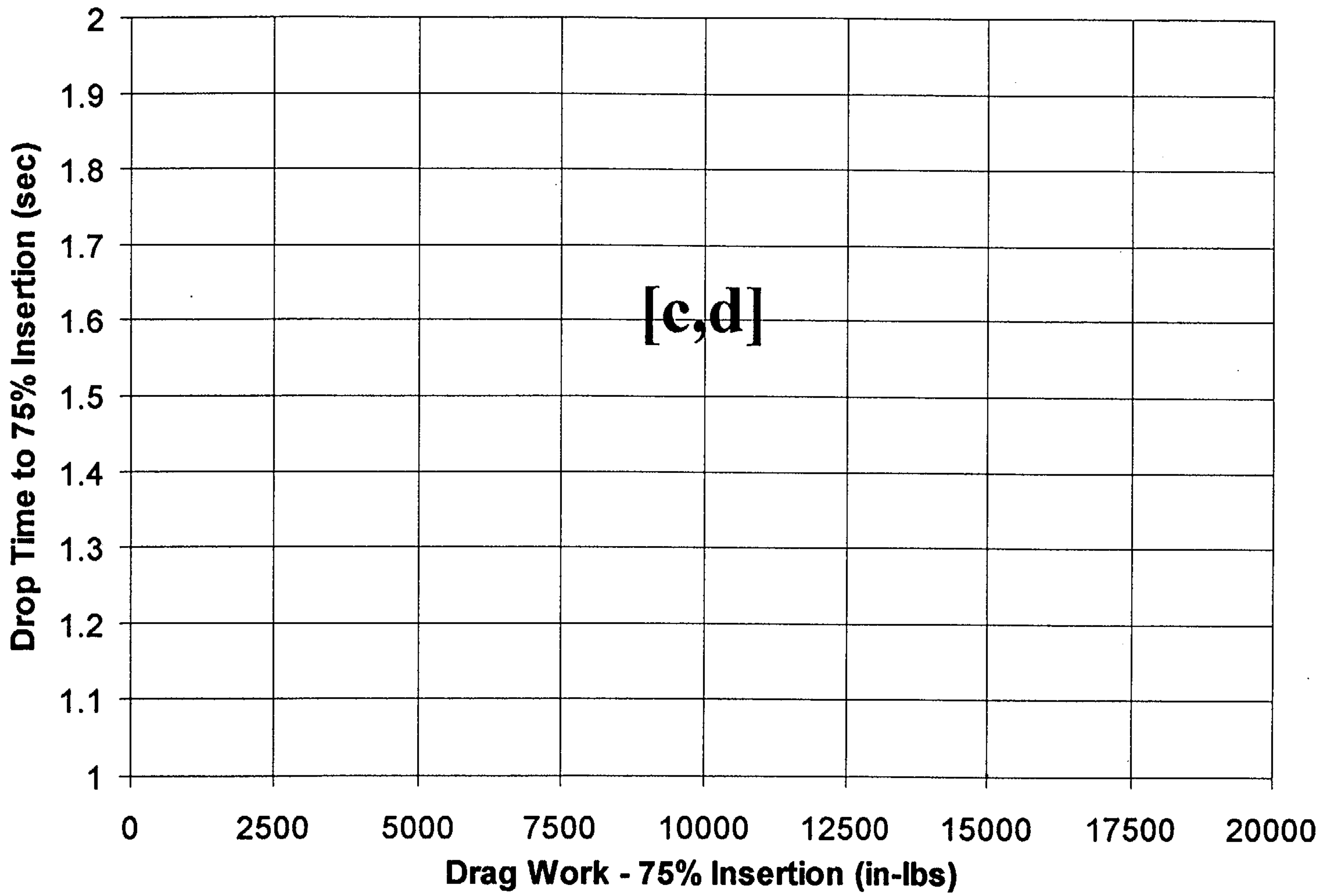
Control Rod Drop Time Variation with Drag Work, CR-3 Cycle 11



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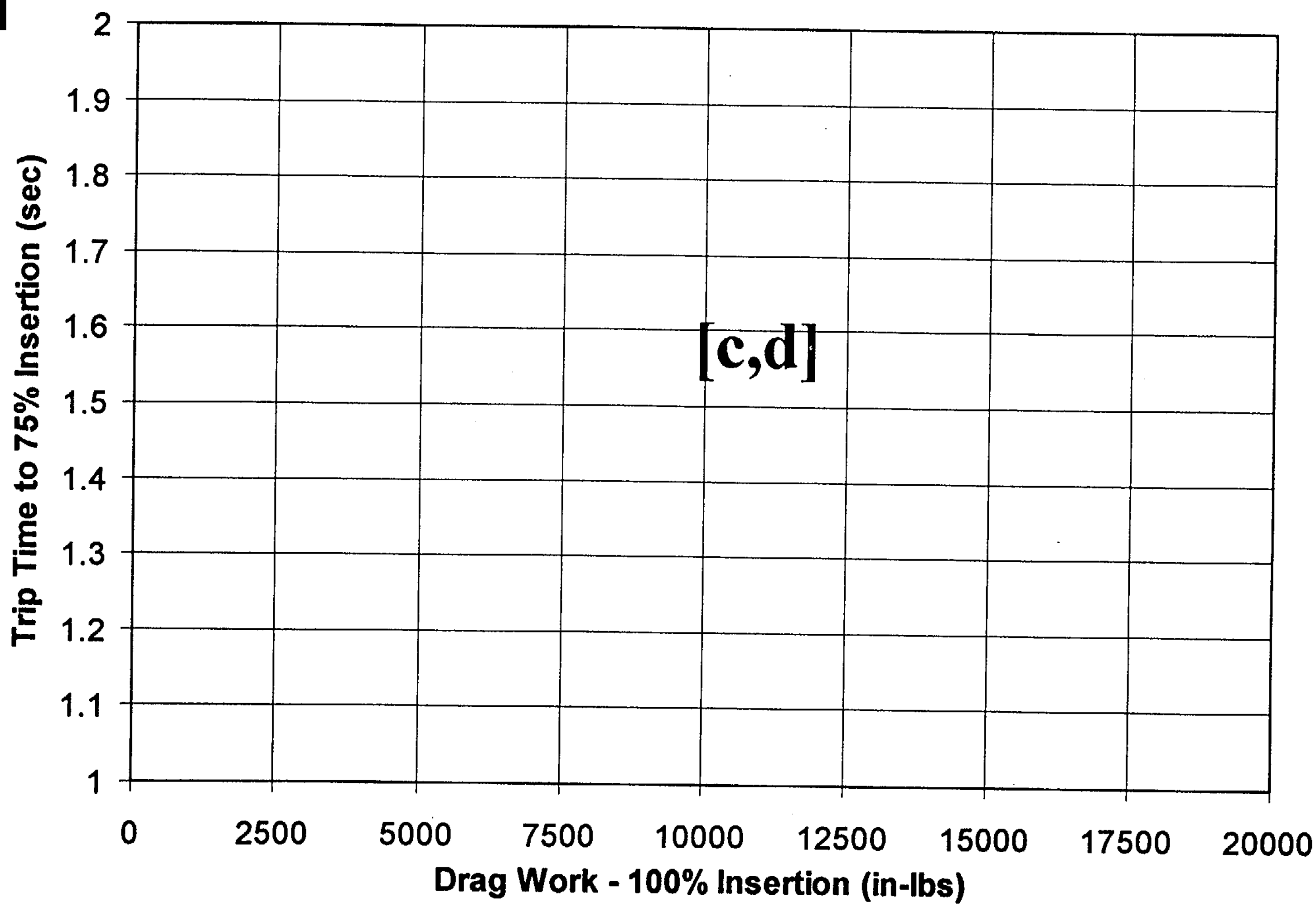
Control Rod Drop Time Variation with Drag Work Oconee-2 Cycle 17 (18-month cycles)



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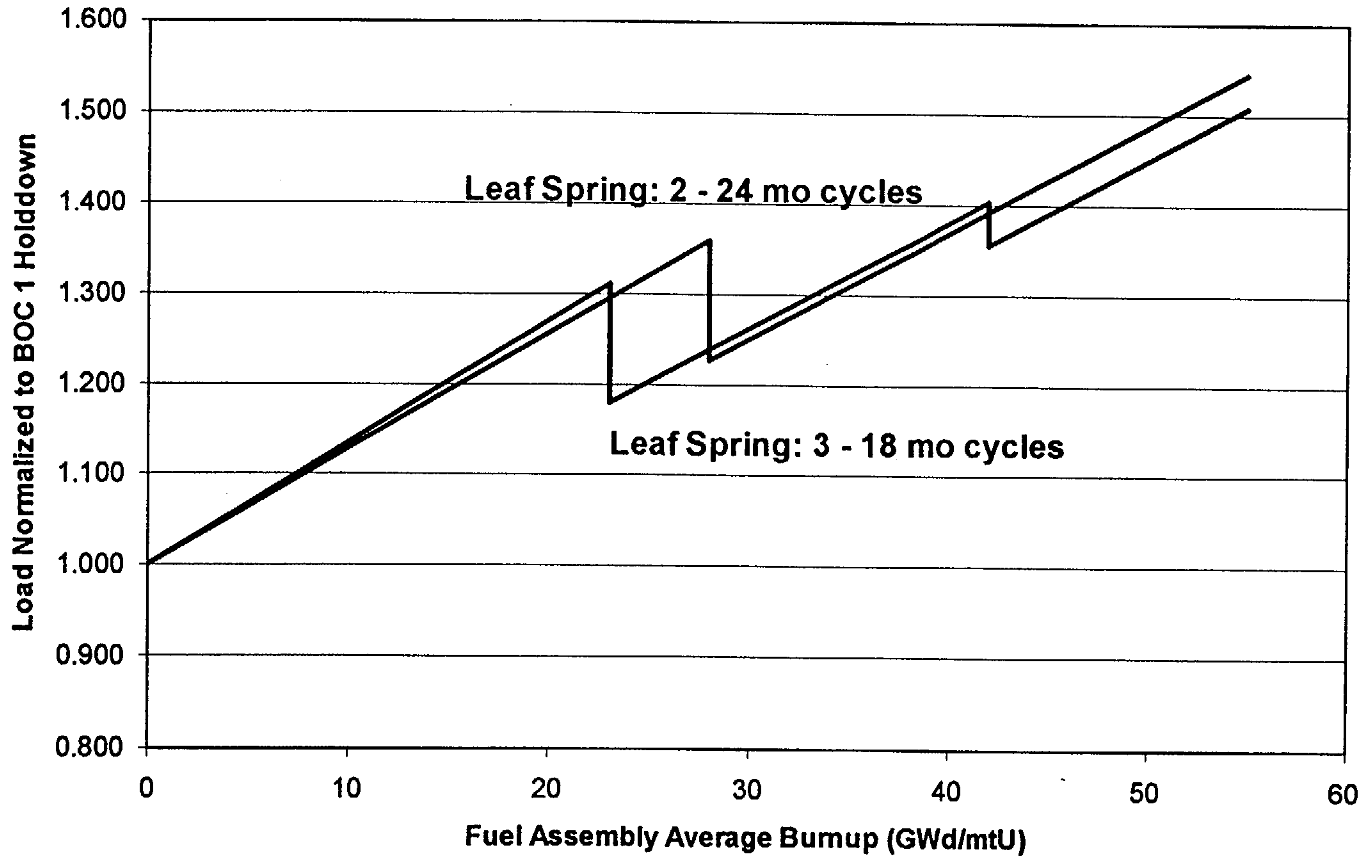
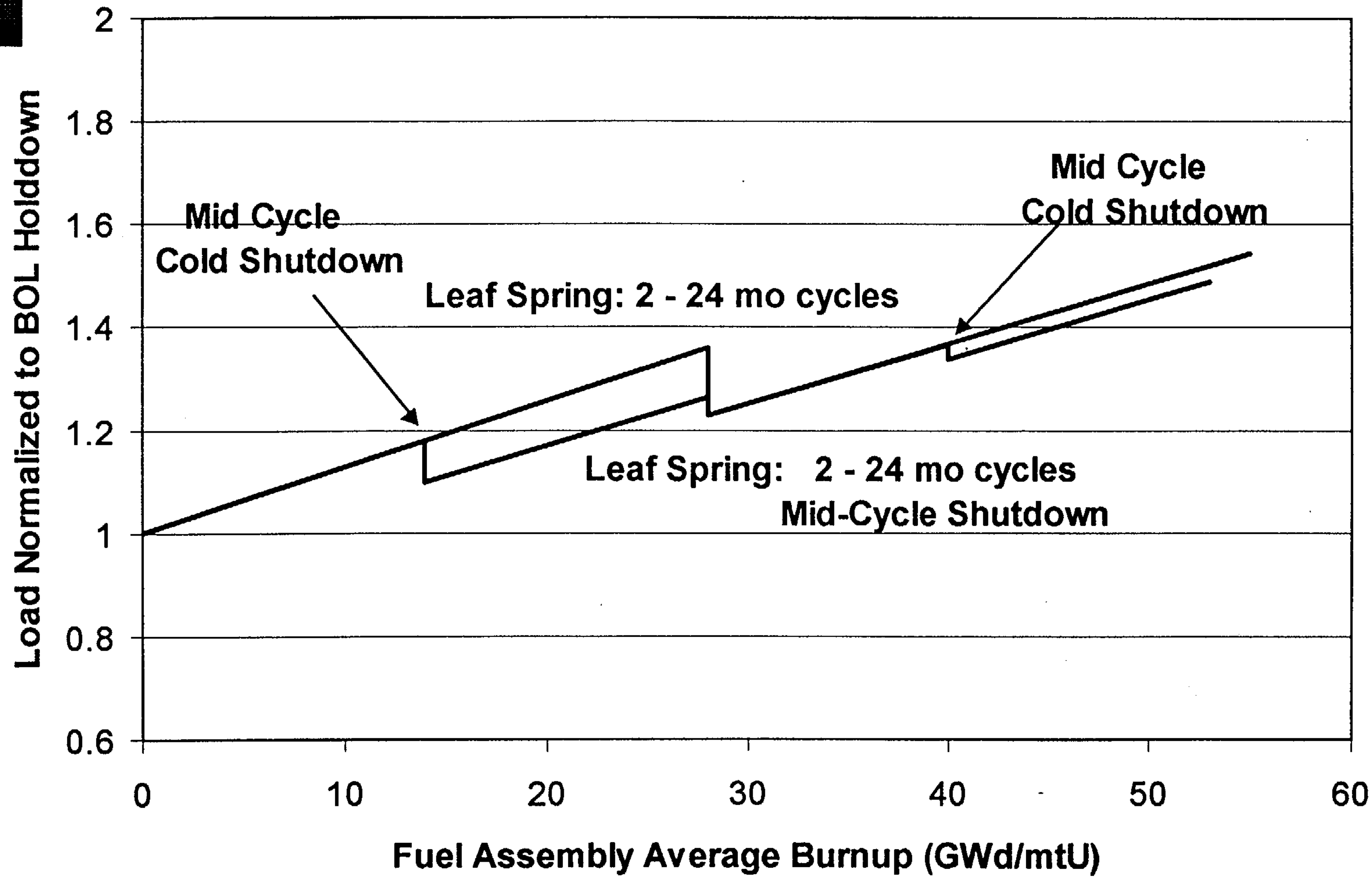
Mark-B Spring Hold Down:
24 Month and 18 Month Cycles



Mark-B Spring Hold Down: Effect of Cold Shutdowns at Davis-Besse



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Oconee 2 PIE Data Collection

- Fuel Assembly (FA) Growth
- FA Bow
- Guide Tube (GT) Plug Gauge
- GT Oxide Measurements
- FA Spacer Grid Oxide & Growth
- Fuel Rod Corrosion & Growth
- Fuel Rod Diameter
- Spring Force Verification
- Control Rod Assembly Drop Times
- Control Rod Assembly Drag

- Results show no anomalous behavior or unfavorable trends

Conclusions From Mark-B Plant Observations

- Plants with 18 month cycles have not had IRI, significant increase in control rod drop times, or undesirable trends
- TMI and Crystal River-3 (24 month cycles) have had increased guide tube deformation that yielded slower drop times and/or IRI
  - Both units had long continuous operations
  - Both units had Mark-B10 leaf springs
  - Both units had same quadrant shuffles

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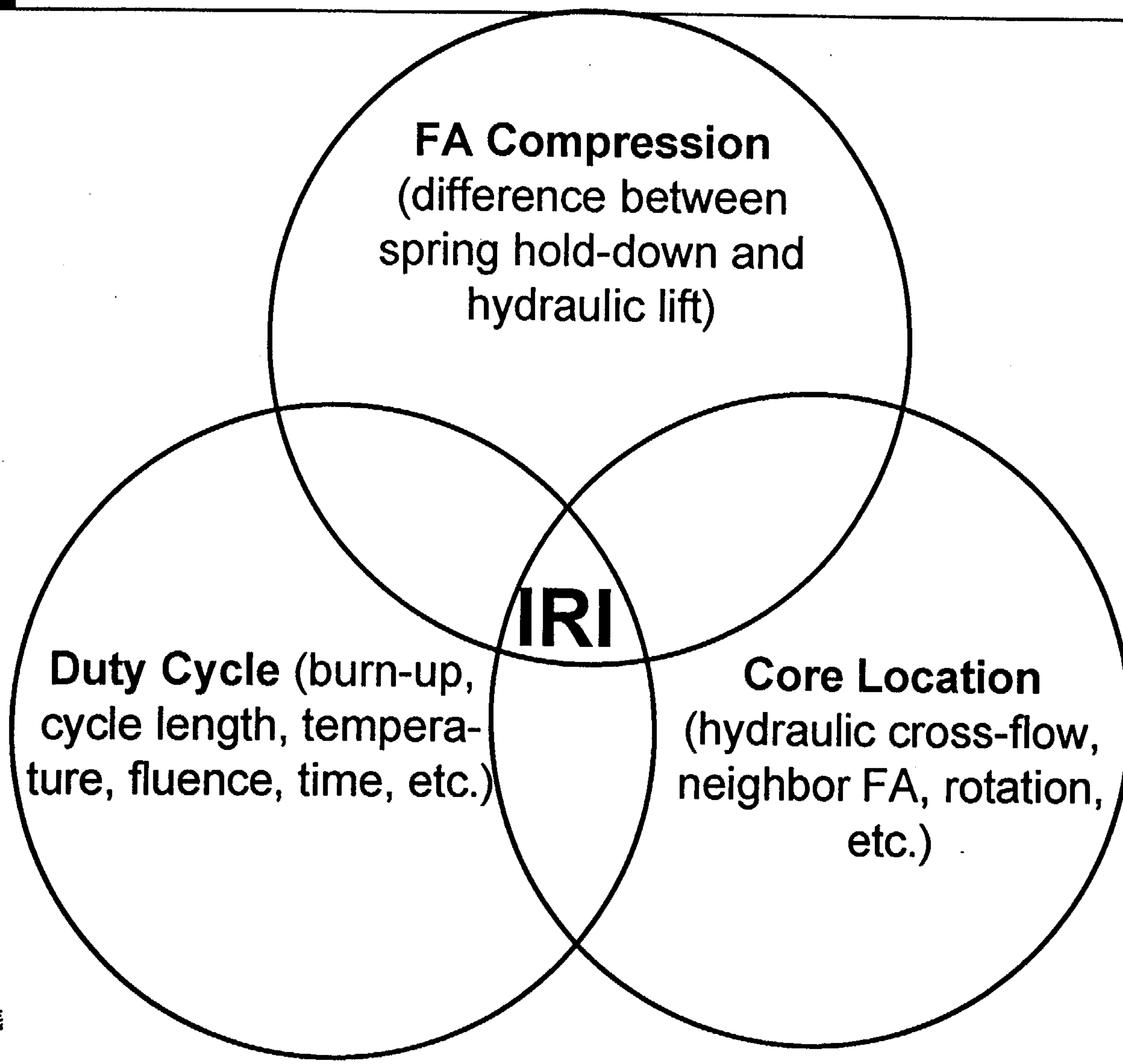
IRI Variables



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Corrective Actions

Bernie Copsey

FRAMATOME TECHNOLOGIES

Corrective Actions Performed at Each Unit

	Set Fresh Fuel Leaf-Spring	Set Burned Fuel Leaf-Spring	Minimize Same Quadrant Shuffle
Recent:			
ANO	**N/A**	**N/A**	**N/A**
TMI	✓	✓	✓
Crystal River	✓	✓	✓
Oconee-2	✓	✓	✓
Future:			
Davis Besse	✓	✓	✓
Oconee-3	✓	**under evaluation**	✓
Oconee-1	**set spring or use redesigned spring**	**under evaluation**	✓

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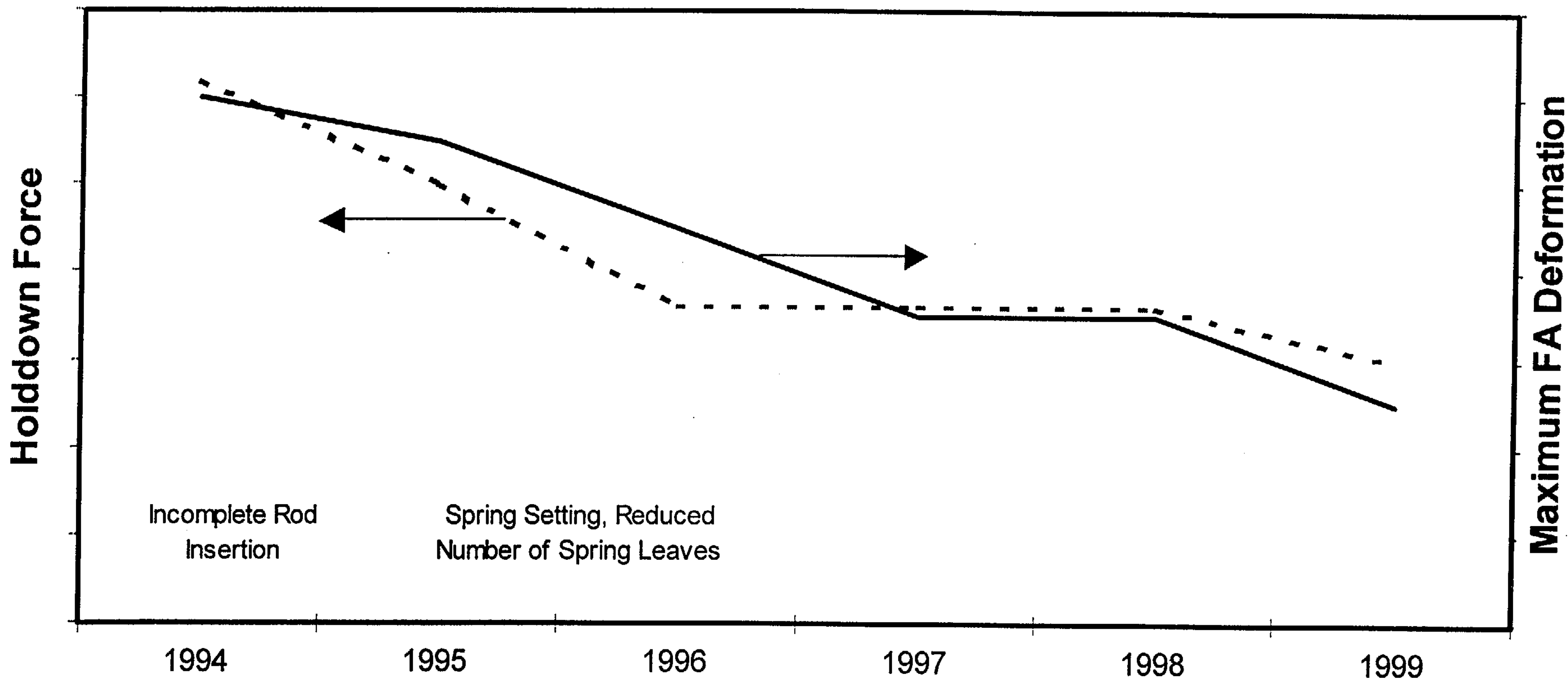
Improvements in FA Deformation at Ringhals



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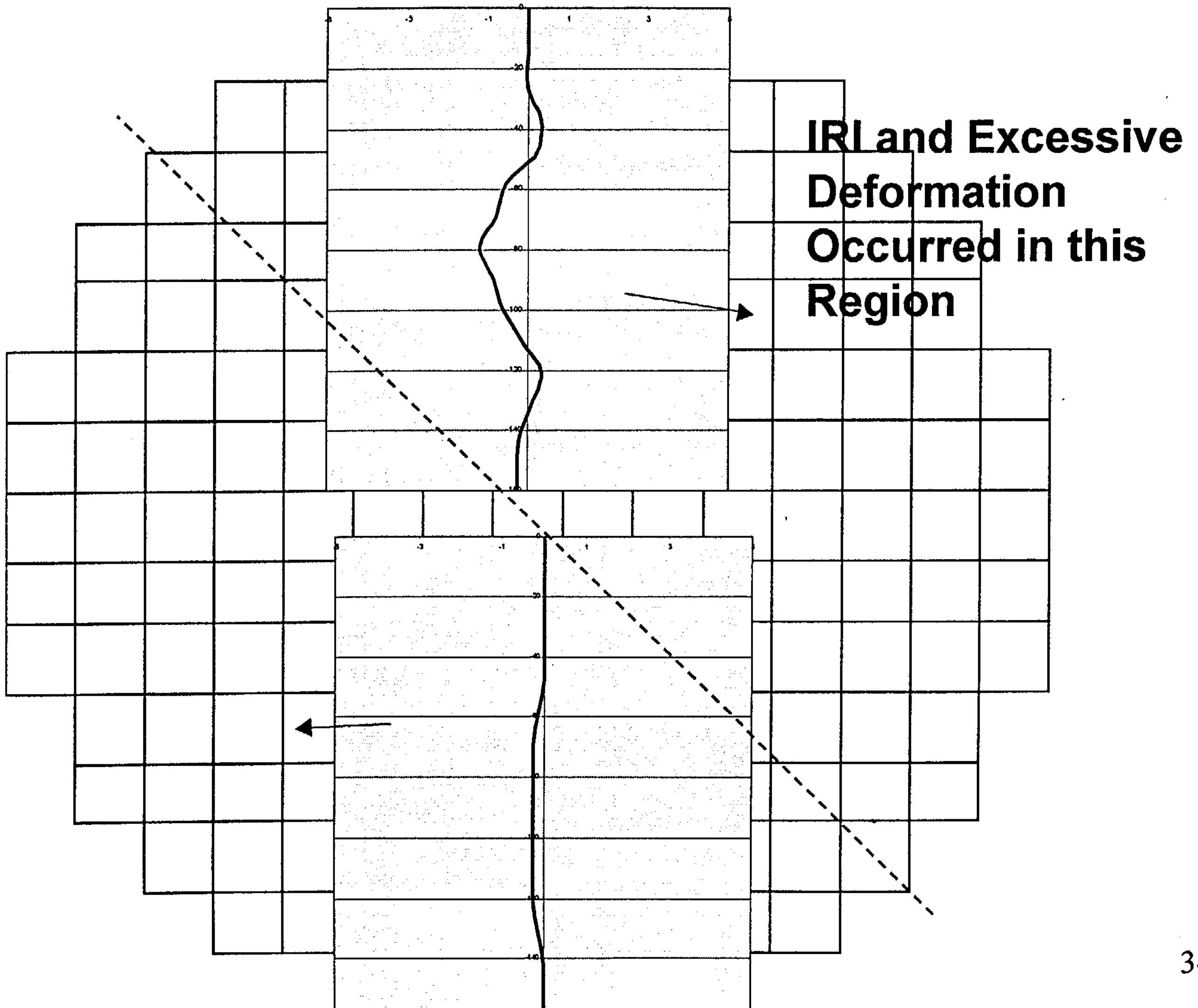
Guide Tube Deformation at TMI is Core Location Dependent



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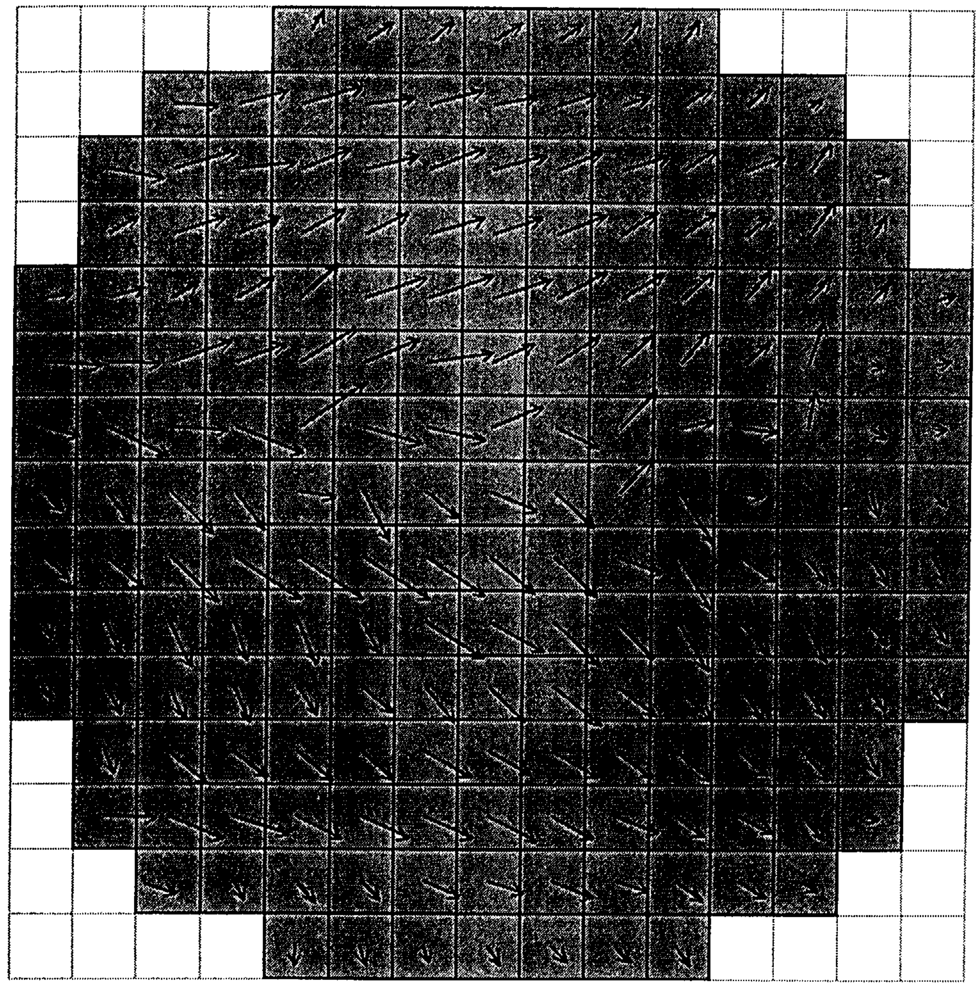
Framatome Also Observed that GT Deformation is Core Location Dependent

- 4-Loop Framatome PWR Units
- Approximately 10 Units Measured
- Guide tube deformation is observed to have the same trend for all plants of the same type



FRAMATOME TECHNOLOGIES

Analytical Models Being Developed

- Single Fuel Assembly Model
  - evaluate guide tube deformation as a function of spring loads, material properties, temperature, etc.
- Core-Wide Fuel Assembly Model
  - evaluate core-wide deformation as a function of FA characteristics
- CRA Drop Model
  - evaluate CRA drop time as a function of CRA drag

Effect of Corrective Action

- Analytical models developed by Framatome show that the corrective actions have reduced susceptibility to IRI
- Framatome France data demonstrates that the corrective actions will reduce susceptibility to IRI

Davis-Besse Corrective Actions

- Planned Corrective Actions
  - Plastic setting of hold-down springs
  - Minimize "same quadrant shuffle"

- Other Beneficial Effects
  - Low growth fuel rod clad material (M5™)
    - Reduced growth-induced hold-down load

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Davis-Besse Tentative Plans

- End-of-cycle drop time measurements
- Additional actions being evaluated
  - CRA drag measurements
    - In Vessel Drag, and/or
    - Spent Fuel Pool Drag

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Planned Future Actions and Events

- Analysis
  - Finite element models
  - CRA drop time models
  - Continued data analysis
- Update TMI LER within 18-months
- Davis Besse will shutdown in April
  - Will provide data on the effect of mid-cycle cold shutdowns
- Mark-B10 leaf spring re-design
  - Improved hydraulic lift methodology
- Advanced material, M5™
  - Clad is currently available, if desired
  - M5™ guide tubes are in North Anna and are going into selected Davis Besse and Sequoyah locations
- Shuffle guidelines will be formalized

Conclusions

- Based on the observed data, there are no significant safety issues
- Corrective actions have been taken to further reduce susceptibility
- We are continuing to monitor data and develop analytical tools

Mark-B Plant Plans for Drop Time Data Acquisition

- Oconee
- ANO
- Crystal River
- TMI
- Davis Besse