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

February 6, 1997

MEMORANDUM TO: David B. Matthews, Chief
Generic Issues and Environmental
Projects Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

FROM: Claudia M. Craig, Senior Project Manager Claudia M. Craig
Generic Issues and Environmental
Projects Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF MEETING WITH WESTINGHOUSE TO DISCUSS FUEL CORROSION MODEL

The subject meeting was held at the Nuclear Regulatory Commission (NRC) office in Rockville, Maryland on December 12, 1996, between representatives of Westinghouse and the NRC staff. The purpose of the meeting was for Westinghouse to discuss the reasons for developing a revised fuel corrosion model, the model and its application, and future plans for use of the revised model. Attachment 1 is the list of meeting participants. Westinghouse provided proprietary and non-proprietary versions of the presentation material in an application for withholding proprietary information dated January 17, 1997 (AW-97-1063). Attachment 2 is a copy of the non-proprietary presentation material.

The Westinghouse presentation discussed the background of the issue, the data and trends concerning corrosion, the revised model development and schedule, the preliminary assessment of impacts on design features, and the plans for implementation of the revised code.

Westinghouse discussed the differences in composition of fuel cladding for conventional Zircaloy-4, improved Zircaloy-4, and the new ZIRLO. The data from the mid 1980s indicated an increase in corrosion as burnup increases. This led Westinghouse to take actions including: development of corrosion surveillance programs to expand the database in support of a revised model, introduction of improved Zircaloy-4, which is lower in tin than conventional Zircaloy-4 and therefore has a lower corrosion rate, and modification of the corrosion design model. Even though the improved Zircaloy-4 provides greater corrosion resistance, the improvements in operational efficiency that have also occurred over the past several years, such as longer fuel cycles, higher coolant temperatures, higher power levels, and more aggressive coolant chemistry, have overtaken the extra corrosion margin provided by the improved Zircaloy-4. A comparison of the current model with the data indicated that the model underpredicts corrosion for both conventional and improved Zircaloy-4, particularly at end of life for the improved Zircaloy-4.

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O&M-Meeting
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Therefore, Westinghouse developed a revised model for predicting corrosion rates. Westinghouse compiled a list of potential correlating variables and then selected the ones that gave the best improvements in correlation. These variables were then inserted into the model.

The revised model is currently complete, however, is considered preliminary until final signoff. Westinghouse plans to implement the model in standard designs in April 1997 and plans to extend the model to fuel assembly structural components in August 1997. In addition to the use of the revised model to predict corrosion, Westinghouse plans to use ZIRLO in high corrosion plants that have long cycles. ZIRLO is considered much more resistant to corrosion and will be used as the basis for high burnup programs. Westinghouse estimated that next year 80% of fuel they provide will have ZIRLO cladding.

Westinghouse and the staff discussed the regulatory implications of the implementing the revised model. Westinghouse will keep the staff informed of their progress.

Attachments: As stated

cc w/atts:
Mr. Nicholas J. Liparulo
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Pittsburgh, PA 15230-0355

Mr. Hank A. Sepp
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WESTINGHOUSE / NRC MEETING
FUEL CORROSION MODEL
DECEMBER 12, 1996 AT ROCKVILLE, MD

MEETING PARTICIPANTS

NAME	ORGANIZATION
Claudia Craig	NRC/NRR/PGEB
Francis Grubelich	NRC/NRR/EMEB
H.F. Conrad	NRC/NRR/EMCB
Shi-Liang Wu	NRC/NRR/SRXB
Sumit Ray	Westinghouse CNFD
George Sabol	Westinghouse CNFD
Robert Weiner	Westinghouse CNFD
Vincent J. Esposito	Westinghouse CNFD
John Galembush	Westinghouse NSD
Steve King	Westinghouse CNFD
Howard Menke	Westinghouse CNFD
Larry Phillips	NRC/NRR/SRXP
Muffet Chatterton	NRC/NRR/SRXB
Jack Rosenthal	NRC/AEOD
Eric Weiss	NRC/NRR/SRXB

ATTACHMENT 1

In-Reactor Corrosion of Zircaloy-4 in Westinghouse PWRs

Presentation to NRC

December 12, 1996

Westinghouse / NRC meeting to discuss fuel rod corrosion model

- Purpose of meeting
  - To present the revised Westinghouse fuel rod corrosion model and discuss implementation plans with the NRC
    - Reasons for development
    - Discussion of model and preliminary application
    - Future plans

Agenda

- Background - Fuel Cladding Corrosion
- Data acquisition and trends in corrosion
- Revised corrosion model development
- Schedule for completion
- Preliminary assessment of impact on design
- Plans for Implementation
- Corrosion margin restoration

W Fuel Cladding and Structural Materials

Nominal Composition %				
	Sn	Nb	Fe	Cr
Conventional Zircaloy-4	1.5	--	0.2	0.1
Improved Zircaloy-4	1.3	--	0.2	0.1
ZIRLO™	1	1	0.1	--

Mid '80s Database and First Indications

Response to Observations of High Corrosion

- Institute corrosion surveillance programs in multiple plants to expand database
- Introduction of Improved Zircaloy-4
  - Low Sn
  - Thermomechanical Processing control, ΣA
  - Tighter control of C, N, Si
- Modification of Corrosion Design Model

Corrosion Database

[ ] (a,b)

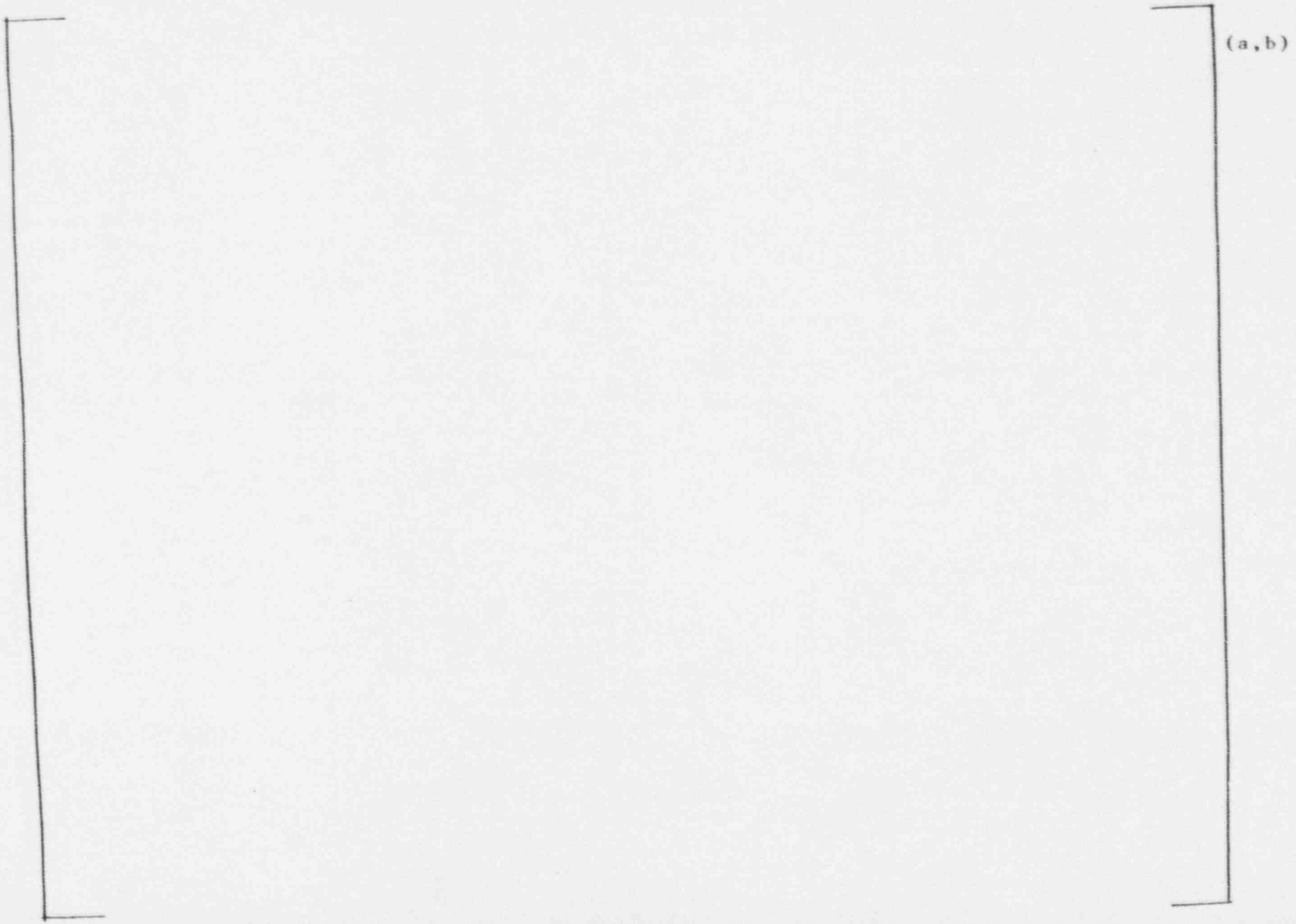
Current Model - Conventional Zr-4

[(a,b)]

Max Oxide Thickness - Improved Zr-4

(a,b)

Current Model - Improved Zr-4



Improvements for Efficiency Elevate Corrosion Severity

- Longer fuel cycles increase residence time
- Higher coolant temperatures
- Increased power levels
  - Upratings
  - Higher peaking factors
- More sub-cooled boiling
- Greater crud deposition
- More aggressive coolant chemistry strategies
  - Modified chemistry higher Li/B

- Combined corrosion severity rapidly used margin provided by Improved Zr-4

Modeling Approach

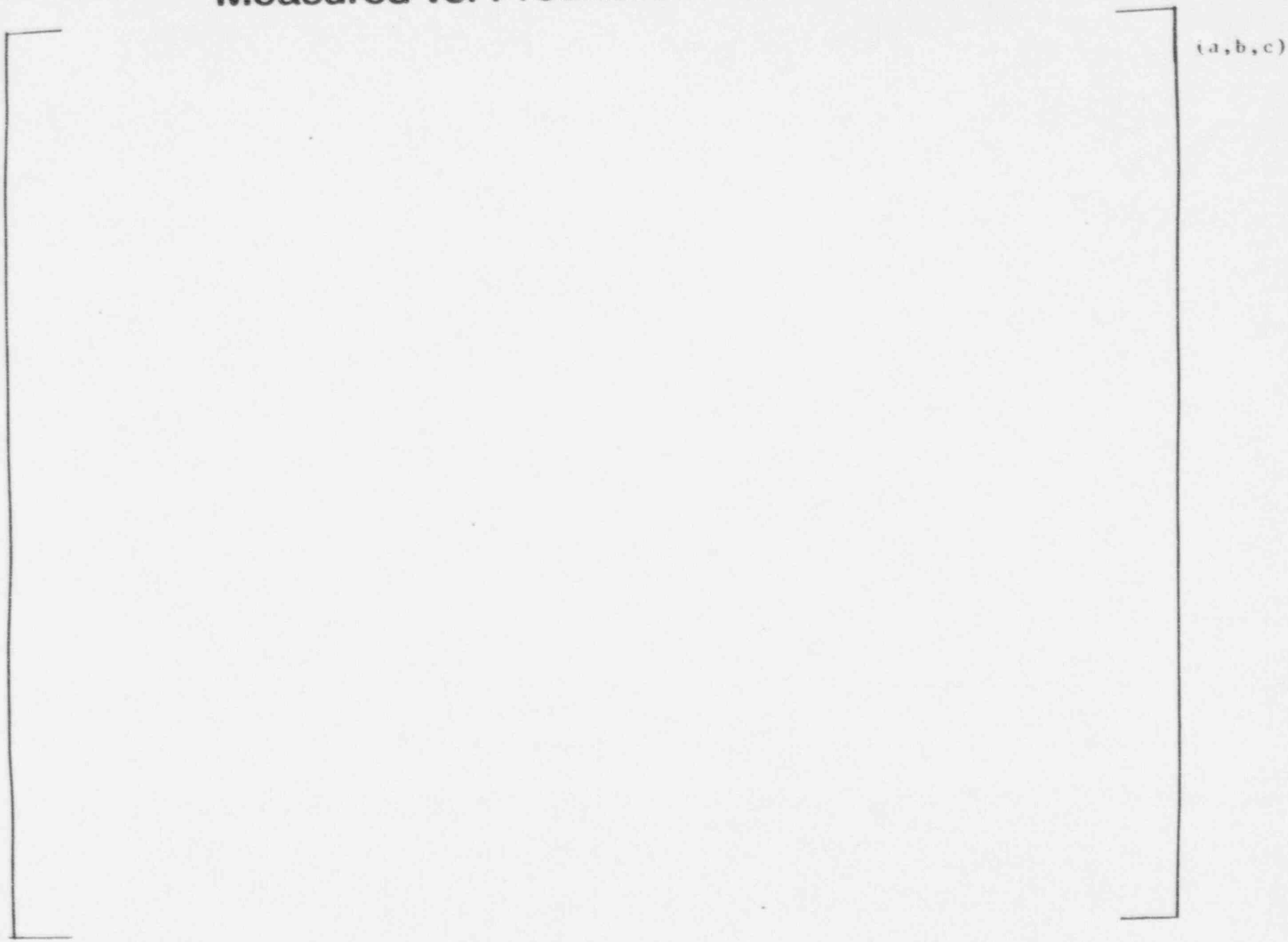
(a,c)

The revised corrosion model is:

[ ]

(a,c)

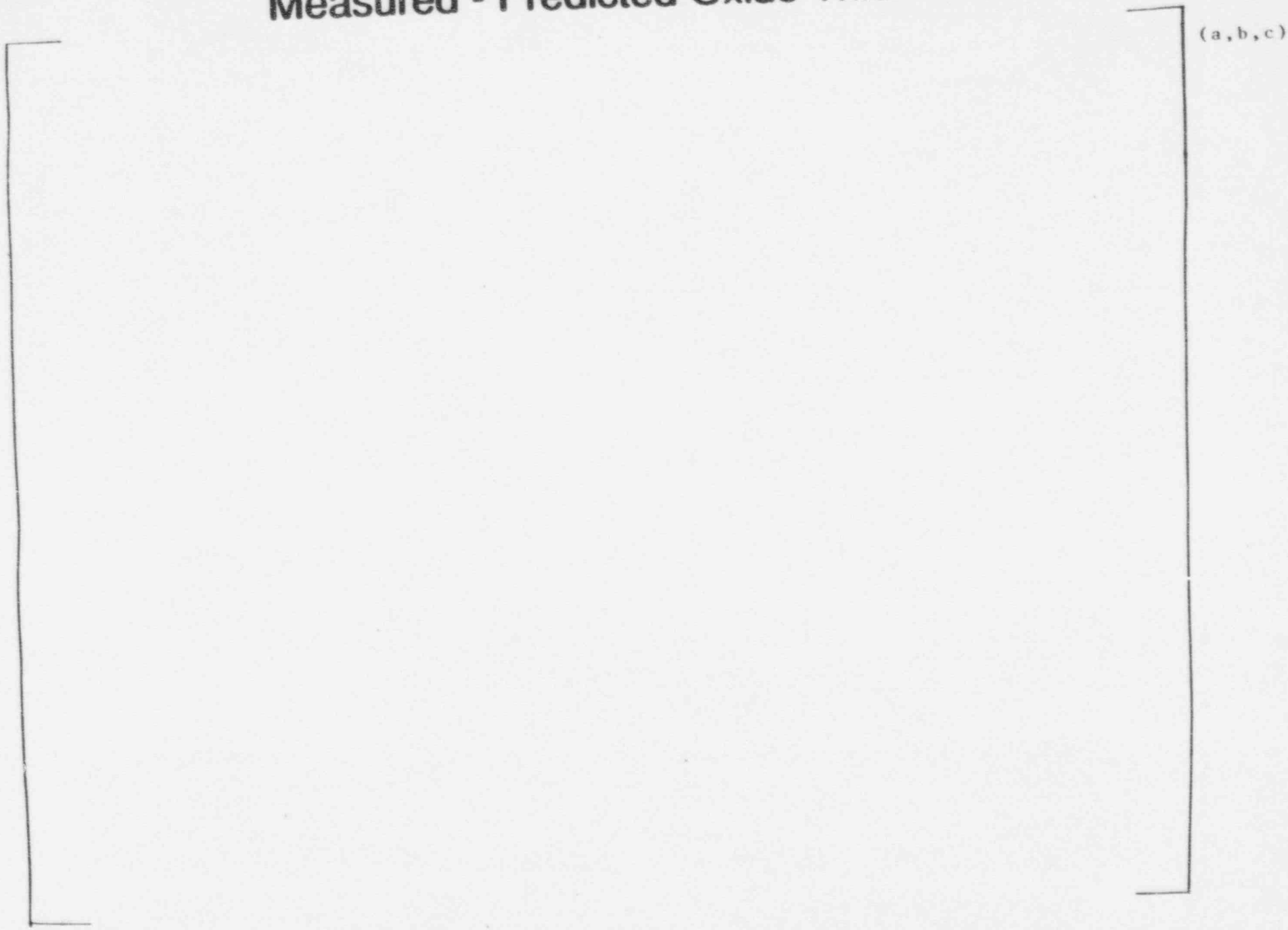
Measured vs. Predicted Oxide Thickness



(a,b,c)

Measured - Predicted Oxide Thickness

(a,b,c)



Cladding Model Development Status

- Intermediate Design Review — May 10, '96
- Final Design Review — July 17, '96
- Action Item Completion — In-progress
  - Model is complete and not expected to change, but being considered "preliminary" until sign off.
  - Being used to support fuel design
- Design Review Closeout — Jan. 31, '97
- Design Code Development, Validation — Feb. 28, '97
- Formal Code Implementation — March 31, '97

Assessment of Impact of Model on Design Criteria

- No significant effect on the following criteria

[ ] (a,c)

- Criteria more sensitive to corrosion

[ ] (a,c)

Preparation for Implementation of Revised Cladding Corrosion Model

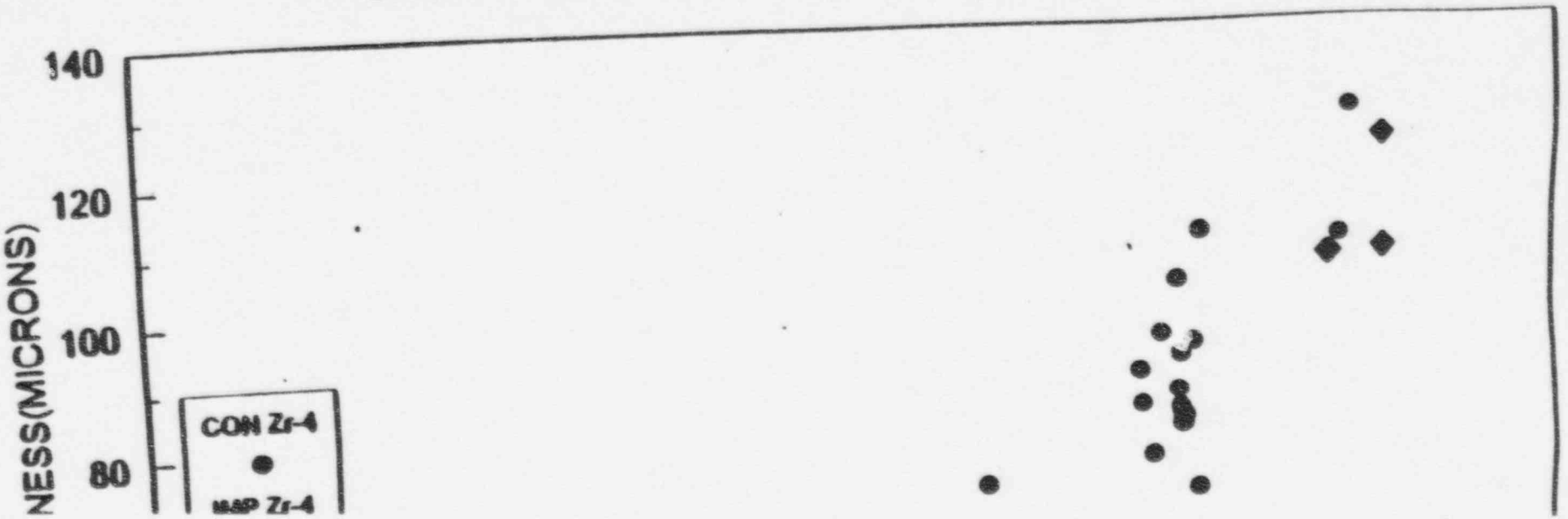
[ ] (a,c)

- Assessments indicate no immediate safety concerns for operating plants

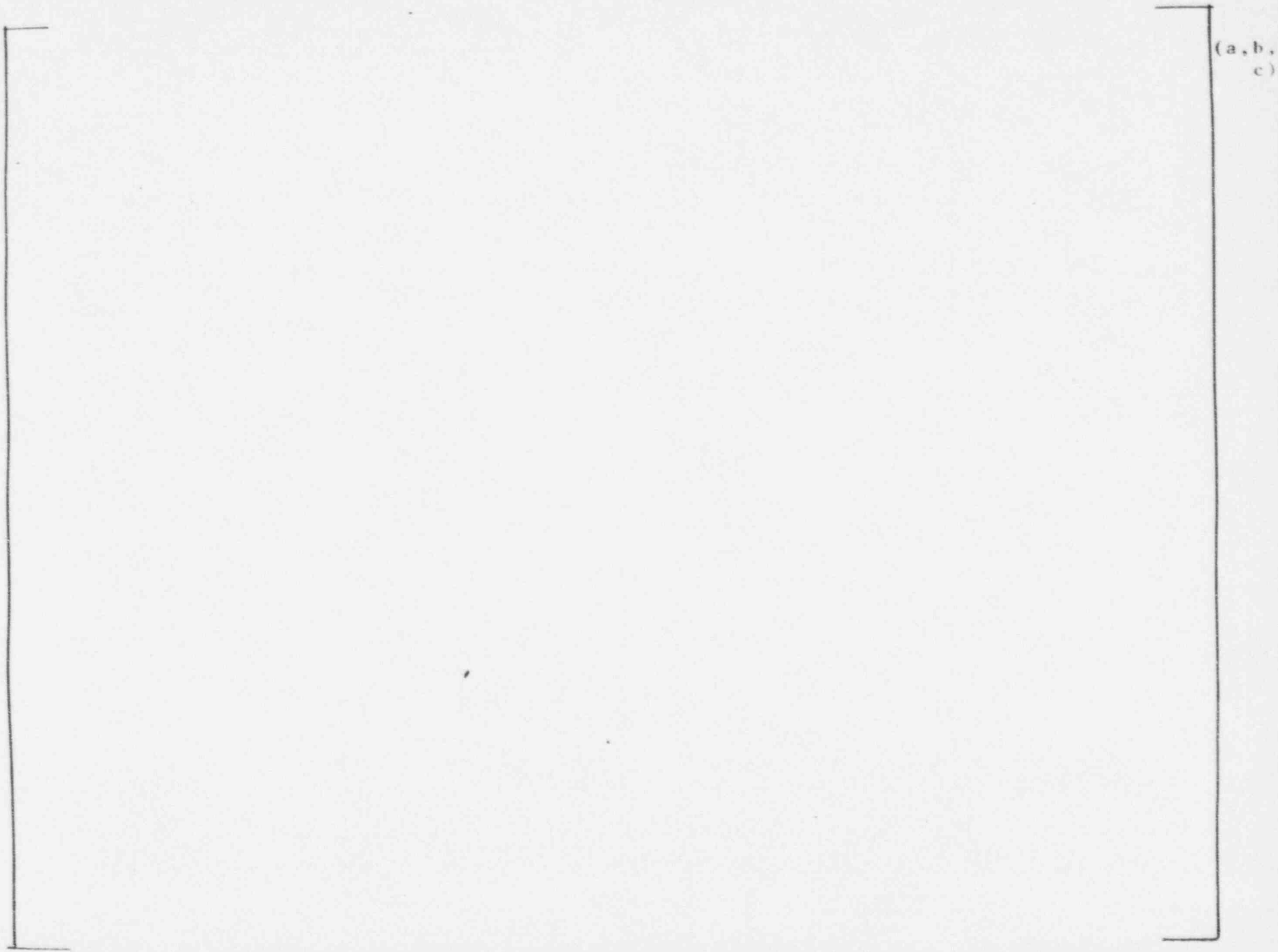
Plan for Implementation of Revised Corrosion Model

- Operating plant evaluations — Feb - May '97
- "Preliminary" model being used for future core designs
- Model implemented in standard design — April '97
- Design with Revised Model will ensure acceptable corrosion margin with Zircaloy-4 cladding
- Assessment for extending new corrosion model to fuel assembly structural — August '97
- ZIRLO usage ensures margin for high duty fuel components

Corrosion in North Anna Unit 1



Measured vs. Predicted Oxide Thickness



ZIRLO™ Implementation

ZIRLO used for the following:

- High corrosion duty plants
  - —high coolant temperature and power
- Cycle lengths > 18 months
  - —e.g., three 24-month cycles
- Basis for High Burnup Program

Summary - Fuel Cladding Corrosion

- Current Model found to underpredict corrosion for Conventional Zircaloy-4
- Benefit with Improved Zircaloy-4 but model still underpredicts end-of-life corrosion
- Revised corrosion model developed for both conventional and Improved Zircaloy-4 cladding
- Revised model will be implemented 1st Q'97
- ZIRLO cladding is being rapidly introduced for high corrosion duty applications