COMMISSION BRIEFING SLIDES/EXHIBITS

BRIEFING ON MATERIALS DEGRADATION ISSUES AND FUEL RELIABILITY

FEBRUARY 6, 2005

Management Of Materials Issues

Bryce Shriver
President, PPL Generation
Chairman, Materials Executive Oversight Group

NEI

Industry Representatives

- Bryce L. Shriver
- James J. Sheppard, President & Chief Executive Officer, STP Nuclear Operating Company
- Dr. Robin L. Jones, Technology Executive - Materials, EPRI
- Alexander Marion

  Senior Director, Engineering, NEI

NEI

Meeting Objectives

- Summarize the NEI sponsored Materials Initiative
- Discuss progress since the last meeting
- Review regulatory implications

NEI

Materials Initiative Purpose

The purpose is to support safe, reliable and efficient operation of U.S. nuclear power plants through the management of materials issues.

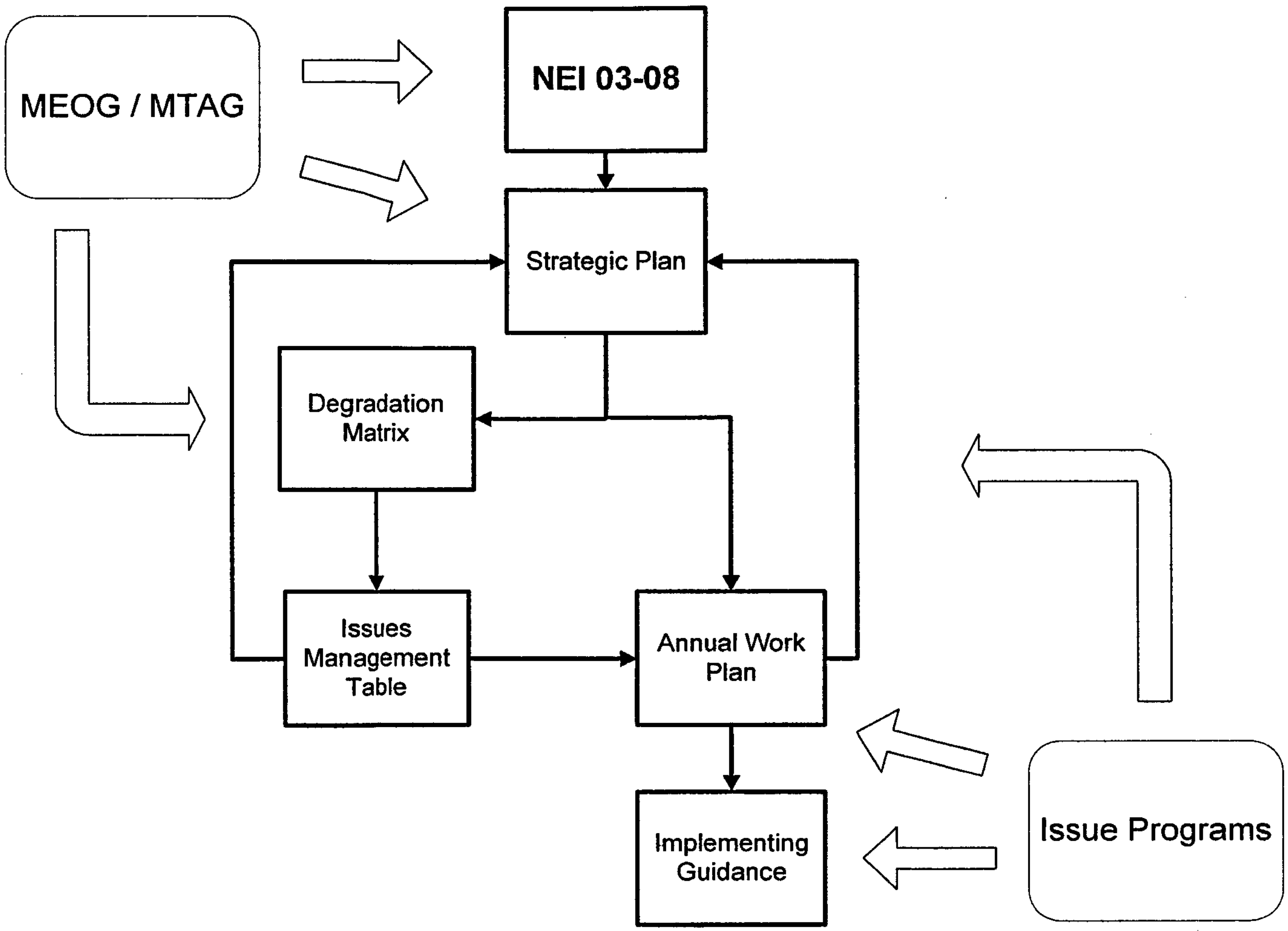
- Coordinate industry sponsored materials research & development
- Prioritize, manage and resolve current and future issues
- Provide accountability to assure materials issues are resolved

NEI

Materials Initiative

- NEI 03-08, "***Guideline for the Management of Materials Issues***" effective January 2, 2004 provides:
  - Consistent management process
  - Prioritization of materials issues
  - Proactive, integrated approaches
  - Oversight of implementation

NEI


MEOG / MTAG
NEI 03-08
Strategic Plan
Degradation Matrix
Issues Management Table
Annual Work Plan
Implementing Guidance
Issue Programs

NEI 03-08 Guideline

- Establishes two standing committees
  - Executive Oversight
  - Technical Advisory
- Establishes policy
- Defines roles, responsibilities and expectations
- Provides for an integrated approach
- Establishes implementation

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Strategic Plan

- Comprehensive, integrated view of materials issues
- Framework for prioritizing, planning, coordinating and directing efforts
- Defines high priority materials issues and short & long term technical gaps
- Revision 1 planned first quarter 2006
  - Degradation Matrix and Issue Management Tables

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DEGRADATION MATRIX

- Lists all materials within scope of the Materials Initiative
- Identifies potential degradation mechanisms for applicable materials
- Information obtained from materials experts, laboratory R&D, and operating experience

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Issue Management Tables

- Addresses significance of material degradation on applicable materials
- Defines where materials are used and consequences of failure
- Identifies existing programs/guidance available for effective management
  - Assessment, inspection/evaluation, mitigation, repair/replacement

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Deliverables

- **SG Management**
  - **License Change Package - 5/05**
- **MRP Inspection and Evaluation Guidelines**
  - **Alloy 600 Management Program - 8/04**
  - **Primary system butt welds - 7/05**
- **WOG**
  - **Pressurizer heater sleeves - 4/04**
  - **Boric Acid Corrosion Control Guidelines - 2/05**
- **BWR & PWR Water Chemistry - 12/04**
- **BWR Program Implementation Guide Rev. 1 – 12/05**

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Deliverables

- **BWR VIP**
  - **Steam Dryers – Ongoing**
- **Fuel Reliability**
  - **AOA Guideline Revision 1 - 6/04**
- **Performance Metrics -1/06**
- **Coordination with ASME**
  - **MRP technical basis for Code Case – 9/03**
- **Degradation Matrix & Issue Management Tables 2nd Quarter 2006**

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Changes to Expect

- Proactive industry performance relative to materials degradation
- Industry guidance from Issue Programs will have mandatory and needed actions
- Improved integration/coordination among Issue Programs
- Improved communications on materials issues and related interactions with the NRC

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Regulatory Process

- Implementation of mandatory and needed actions that fall within the scope of 10 CFR 50
  - Primary system components
  - General Design Criteria & Appendix B
- Subject to NRC inspection
- Performance-based approach
- Existing regulations are adequate to assure public health and safety

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Conclusion

- **Actions Taken by Industry**
  - **Proactive, integrated and coordinated**
  - **Accountability to assure plant safety and reliability**
  - **Continuous improvement and feedback**

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Additional Background

ACRONYMS

- AOA – axial offset anomaly
- ASME – American Society of Mechanical Engineers
- BWR – Boiling Water Reactor
- BWR VIP - BWR Vessel & Internals Project
- EPRI – Electric Power Research Institute
- NEI – Nuclear Energy Institute
- MRP – Materials Reliability Program
- PWR – Pressurized Water Reactor
- SG – steam generator
- STP – South Texas Project

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Materials Issue Programs Governed by the Initiative

- EPRI
  - BWR Vessel & Internals Program
  - Materials Reliability Program
  - SG Management program (SGMP)
  - Fuels Reliability Program (as impacted by materials management strategies)
  - Corrosion Research
  - Chemistry Control
  - Non Destructive Examination (NDE)

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Materials Issue Programs Governed by the Initiative

- **NSSS Owners Group Subcommittees**
  - Materials
  - Chemistry
  - Reactor pressure vessel
  - Non Destructive Examinations
  - Steam Generators

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Materials Executive Oversight Group (MEOG)

- **Bryce Shriver (*Chairman*) - PPL**
- **Jim Levine (*Vice-Chairman*) - APS**
- **Joe Sheppard – STP**
- **Chris Crane – Exelon**
- **Bill Eaton - Entergy**
- **Bill McCollum – Duke**
- **Mano Nazar – AEP**
- **Doug Gibson – DTE Energy**
- **Jeff Gasser – SNOC**
- **Greg Wilks – Nuclear Electric Insurance Limited**
- **Joe Donahue – Progress**
- **Jim Klapproth - GE**
- **Nick Liparulo – West.**
- **Gary Mignogna – Framatome ANP**
- **Clair Goddard – INPO**
- **Dave Modeen – EPRI**
- **Alex Marion - NEI**

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Materials Technical Advisory Group (MTAG)

- Chairman – Bill McCollum - Duke
- Vice Chairman – Bill Eaton - Entergy
- BWRVIP – Robin Dyle - SNOC
- MRP – Mike Robinson - Duke
- SGMP – Forrest Hundley – SNOC
- FRP – Charles Turk - Entergy
- PWR OG – Greg Gerzen – Exelon
- EPRI NDE – Mike Turnbow – TVA
- EPRI Chem – John Wilson – Exelon
- EPRI Corrosion – Craig Harrington – TXU

- At Large Members
  - Joe Donahue – Progress Energy
  - Dennis Weakland – FENOC
  - Tom Jordan – STP
  - Les Spain - Dominion

- MTAG Support
  - EPRI – Robin Jones
  - INPO – Jeff Ewin
  - NEI – Jim Riley

NEI

Defining Significant Nuclear Materials Degradation Issues and Proactive Approaches for Resolution

Robin L. Jones
Technical Executive
EPRI

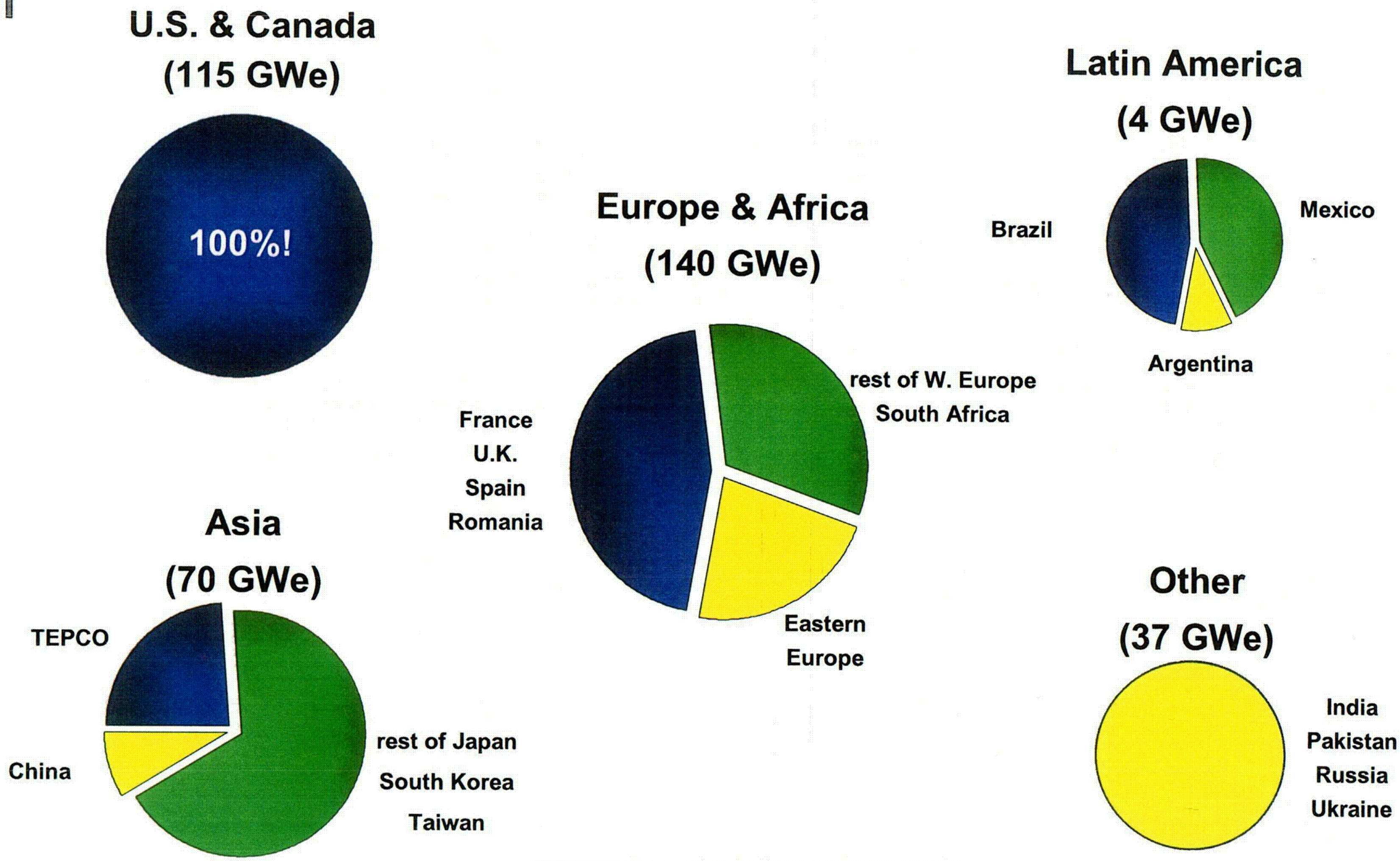
February 6, 2006

EPRI

EPRI's Nuclear Materials R&D Programs

- Seven EPRI R&D programs are governed by the Materials Initiative:
  - BWR Vessel and Internals Program (BWRVIP)
  - Materials Reliability Program (MRP)
  - Steam Generator Management Program (SGMP)
  - Fuel Reliability Program (FRP)
  - Non-Destructive Examination Program and Performance Demonstration Initiative (NDE, PDI)
  - Water Chemistry Control Program
  - Primary System Corrosion Research Program

EPRI Worldwide Membership & Participation



Blue = Full Member
Green = Program Participants
Yellow = no engagement

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Licensees Participating in BWRVIP

U. S. (13 utilities, 34 units)

- Constellation Nuclear, Nine Mile Point LLC
- DTE Energy
- Energy Northwest
- Entergy
- Exelon
- FirstEnergy
- Nebraska Public Power District
- Nuclear Management Co.
- PPL Susquehanna, LLC
- Progress Energy
- PSEG Nuclear
- Southern Nuclear Company
- Tennessee Valley Authority

International (12 utilities, 44 units)

- BKW FMB Energie AG – Switzerland
- Chubu Electric Power Company - Japan
- Chugoku Electric Power Company - Japan
- Comision Federal de Electricidad - Mexico
- Forsmarks Kraftgrupp AB - Sweden
- Iberdrola Generation - Spain
- Japan Atomic Power Company – Japan
- Kernkraftwerk Leibstadt – Switzerland
- OKG Aktiebolag - Sweden
- Taiwan Power Company - Taiwan
- Tohoku Electric Power Company - Japan
- Tokyo Electric Power Company - Japan

The Integrated Strategic Plan

- The Plan defines a systematic approach to managing materials degradation issues:
  - Identify component vulnerabilities
  - Assess condition (inspect & evaluate)
  - Mitigate initiation and propagation of degradation
  - Repair or replace component as required
- Implementing the Plan involves the identification and prioritization of knowledge gaps
  - Issue Management Tables (IMTs)
  - Materials Degradation Matrix (MDM)

IMT Format

• *Section X — Issue Management Table for YYYYYYY*

Component	Material	Degradation Mechanism	Consequences of Failure	Mitigation Options	Repair / Replace Options	I & E 'Guidance	Gaps, Priority & Basis	Lead Responsibility

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Materials Degradation Matrix

Level 1

PWR						BWR		
PWR Reactor Pressure Vessel	PWR Pressurizer	PWR SG Shell	PWR Reactor Internals	PWR Piping	PWR SG Tubes & Internals	BWR Pressure Vessel	BWR Reactor Internals	BWR Piping

Level 2

PWR Component	Material	SCC SCC					Corrosion/Wear C & W				Fatigue Fat.			Reduction in Toughness RiT					
														Aging	*Irradiation*				
	[1]*Subdivision→*	IG	IA	TG	LTCP	PW	Wstg	Pit	Wear	FAC	HC	LC/Th	Env	Th	Emb	VS	SR	Th_n	Fl
PWR Pressurizer (Including Shell, Surge and Spray Nozzles, Heater Sleeves and Sheaths, Instrument Penetrations)	C&LAS	? e002	N	? e002	N	? e003	Y e004	N	N	Y e005	N	Y e006	Y e007	Y e008	N/A	N/A	N/A	N/A	N/A
	C&LAS Welds	? e002	N	? e002	N	? e003	Y e004	N	N	Y e005	N	Y e006	Y e007	Y e008	N/A	N/A	N/A	N/A	N/A
	Wrought SS	? e012	N	? e012	? e013	? e012	N	N	N	N	N	Y e014	Y e015	N	N/A	N/A	N/A	N/A	N/A
	SS Welds & Clad	Y e016	? e017	Y e018	? e013	? e019	N	N	? e020	N	N	? e014	Y e015	Y e022	N/A	N/A	N/A	N/A	N/A
	Wrought Ni Alloys	N	N	N	? e023	Y e023	N	N	N	N	Y e014	Y e014	Y e015	N	N/A	N/A	N/A	N/A	N/A
	Ni-base Welds & Clad	N	? e024	N	Y e023	Y e025	N	N	N	N	N	Y e014	Y e015	N	N/A	N/A	N/A	N/A	N/A

Level 3

e030	Corrosion-assisted fatigue is a known phenomenon on secondary side (e.g., in the vicinity of girth welds in steam generator shells and in the region of feedwater nozzles) and is not like environmental fatigue described in other areas of this DM. Environmental fatigue research relevant to this specific phenomenon is not ongoing within MRP Fatigue ITG, and is a potential gap.

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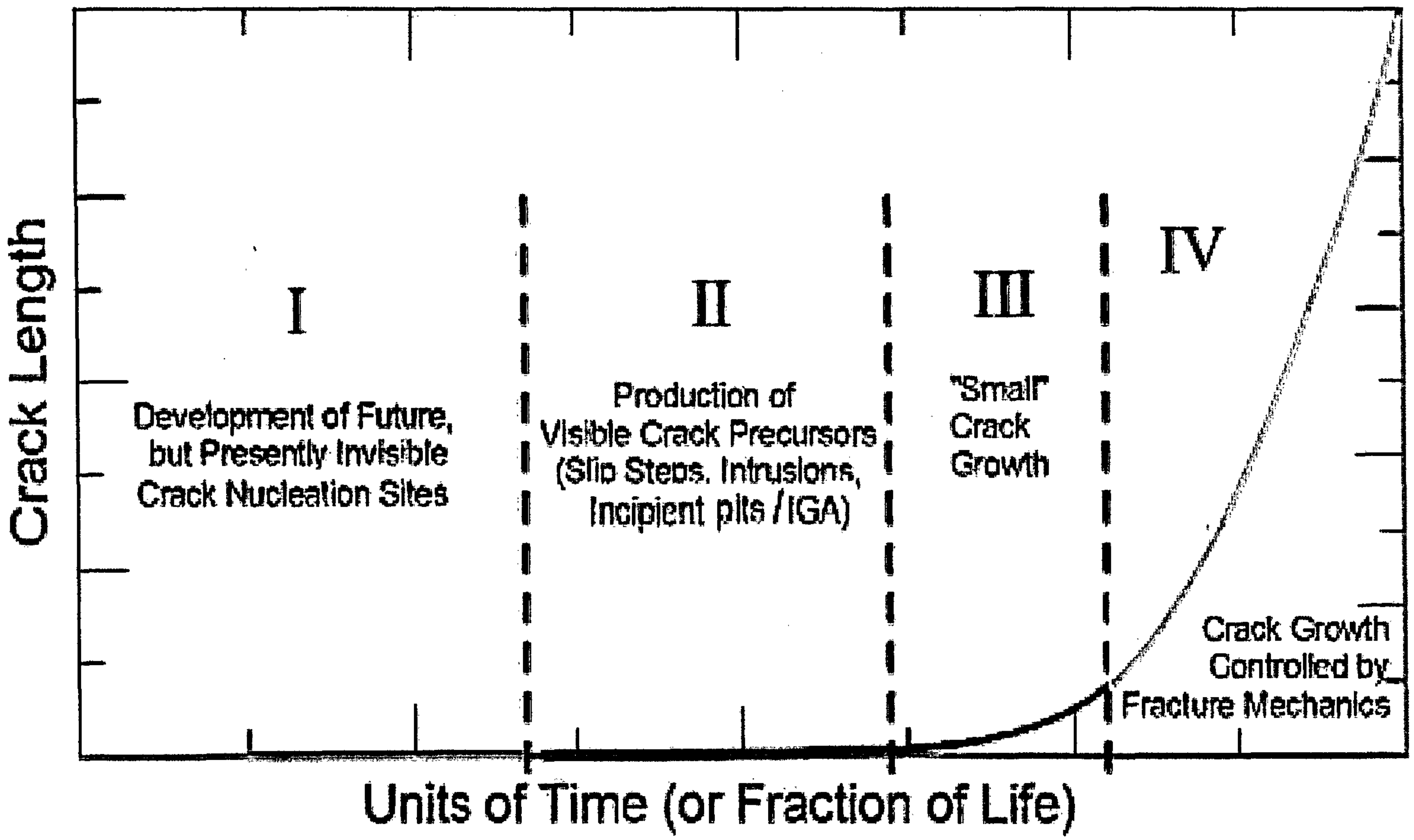
Example from BWR IMT (draft)

Section 3 — Issue Management Table for BWR ASME Class 1 Piping and Components

Component	Material	Degradation Mechanism	Consequences of Failure	Mitigation	Repair / Replace	I & E Guidance	Gaps, Priority & Basis	Responsible Program(s)
3.1 Reactor Coolant Recirculation								
3.1.1 Recirculation Loop Piping and Fittings & Branch Piping and Fittings *(RHR Suction and Discharge, RWCU)* *(Piping ≥ NPS 4)*	SS (Typ. 304, 304L, 316, 316L, 316NG, 347, 347NG)	IGSCC *(NUREG-0313)* Fatigue *(e105)* Env. Fatigue *(NUREG-6260, e007)*	Loss of Pressure Retaining Boundary	Chemistry Control: BWRVIP-130 HWC: BWRVIP-62	ASME Section XI: IWA-4000 Weld Overlay, IHSI, MSIP (BWRVIP-61)	Fatigue Monitoring ASME Section XI IWB-2500-1: Cat. B-J - Surf & UT Cat. B-P - VT-2 BWRVIP-75: *(Inspection Schedule Relief)*	Resolve environmentally assisted fatigue concerns *(e007)*	BWRVIP Assessment Committee (supported by MRP Fatigue ITG)
3.1.2 Flow Nozzle	SS (Typ. 304, 304L, 316, 316L, 316NG, 347, 347NG)	IGSCC *(NUREG-0313)*	Loss of Pressure Retaining Boundary	Chemistry Control: BWRVIP-130 HWC: BWRVIP-62	ASME Section XI: IWA-4000	ASME Section XI IWB-2500-1: Cat. B-P - VT-2	None	N/A
	CASS (Typ. CF3, CF3M, CF8, CF8M)	IGSCC *(NUREG-0313 R2, > 0.035% C or < 7.5 FN)* Thermal Emb. *(R-52)*	Loss of Pressure Retaining Boundary	Chemistry Control: BWRVIP-130 HWC: BWRVIP-62	ASME Section XI: IWA-4000	ASME Section XI IWB-2500-1: Cat. B-P - VT-2	CASS piping embrittlement - assessment or examination *(GALL XI.M12)*	BWRVIP Assessment Committee

R&D Gap Description	Applicable SR Components
<u>AS-03 – Assess Effectiveness of HWC and NMCA at High Fluences</u> Highly irradiated materials are susceptible to irradiation assisted stress corrosion cracking (IASCC) in the BWR environment. Irradiation damage changes the microstructure and mechanical properties of stainless steel in the vessel and makes it susceptible to IASCC at high fluence levels (typically > $5x10^{20}$ n/cm^2). Although it is reasonable to expect that IASCC should me mitigated by moderate HWC or NMCA, there is little supporting data on irradiated materials at fluence levels expected in BWRs to quantify this effect. The NRC SER on the BWRVIP-14 crack growth model limits it's application to a fluence of <$5x10^{20}$ n/cm^2 . H4 welds in some plants will exceed this limit before end of life. In the absence of additional data, the NRC may not allow inspection relief for highly irradiated welds which are currently not covered by BWRVIP-62. Typically, core shroud inspection costs are approximately $500K per inspection per plant. It is conservative to assume that this task will save at least one inspection per plant. If one third of the US BWR fleet avoids one shroud inspection each (a total of ~10 avoided inspections) the cost savings would $5M. The projected cost savings are far greater than the cost ($1.2M) of the task. This gap is being worked in connection with Assessment Gap AS-01 related to assessment of the impact of high fluence on fracture toughness and crack growth rates. Current activities are ongoing in this area. This program is structured at present in three parts: 1. Develop test data in the Halden research reactor by participating in an internationally sponsored program. The BWRVIP share of this program will be less than 10% of the total cost. This task will be coordinated with the Assessment task on development of a crack growth model for irradiated materials. 2. A new organization called Japan Nuclear Energy Safety (JNES) has been established to provide technical support to METI. JNES is analogous to NRC's Division of Research. Efforts could include establishing bilateral cooperation for information exchange and joint research. It is envisioned that IASCC for BWR and PWR materials will be a major area of focus. Although this is a national program in Japan, it may be possible for EPRI and the BWRVIP to participate in the program, thereby, receiving some or all of the results. 3. The Japanese BWR JOG has also sponsored work on IASCC and has indicated interest in sharing this with BWRVIP. <u>Basis</u>: MDM: e045 BWRVIP: BWRVIP-62, BWRVIP-14, 2006 Work Plan <u>Responsible Program(s)</u>: BWRVIP Assessment <u>Priority</u>: HIGH	**Core Plate:** Rim Hold-down Bolts **LPCI Coupling:** Shroud Attachment Ring **Shroud Assembly:** Shroud Cylinders & Welds, Shroud Ring Segments and welds **Top Guide/Grid Assembly** Grid Assembly, Aligner Pins, Sockets in Top Guide Shroud, Hold-down Devices

Stages in the Development of SCC



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Future Cooperation in Proactive Materials R&D

- Suggested approach:
  - NRC reviews and comments on the knowledge gaps and industry priorities identified in the BWR and PWR Issue Management Tables and works with industry to establish joint priorities
    - This will allow leveraging of NRC and industry funds and will avoid the possibility of developing completely independent (and possibly divergent) R&D programs
  - The Office of Nuclear Regulatory Research and EPRI cooperatively undertake the proactive R&D needed, starting with the highest priority projects

EPRI

Rationale for Suggested Approach

- EPRI manages almost all of the U.S. nuclear industry's proactive R&D on materials degradation
- Most of the world's nuclear licensees participate in the EPRI-managed materials degradation programs that are pertinent to their plants
- A mechanism already exists for the Office of Nuclear Regulatory Research and EPRI to cooperate on R&D projects of mutual interest

EPRI

Existing Cooperation Mechanism

- A memorandum of understanding (MOU) between the Office of Nuclear Regulatory Research and EPRI on Cooperative Nuclear Safety Research was signed in October 1997
- The MOU defines the principles of cooperation between the parties and specific projects are defined in separate addenda
  - Management review meetings of all active projects (and new opportunities) are held at least annually
- This mechanism has worked well and the MOU has been extended twice since 1997

ELECTRIC POWER
RESEARCH INSTITUTE

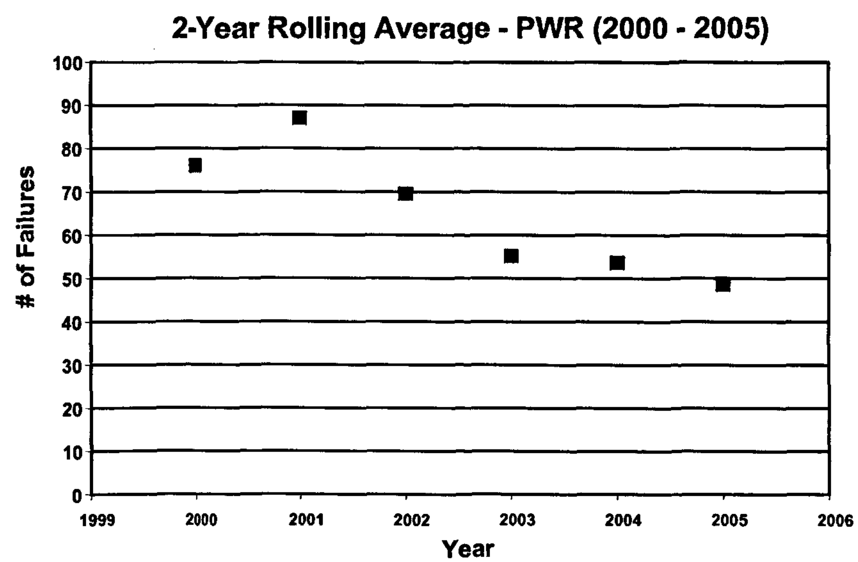
Industry Perspective on Fuel Performance

February 6, 2006

Joe Sheppard
Pres. & CEO,
STP Nuclear Operating Company

Summary Of U.S. Fuel Performance

- Overall number of fuel failures has leveled off with a slightly improving trend
- There has been no repeat of the large number of corrosion related failures that occurred in BWR's in 2003



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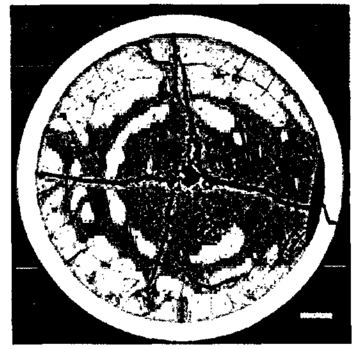
Summary Of U.S. Fuel Performance (cont'd)

- **Major fuel failure mechanisms:**
  - PWR- grid to rod fretting, debris, pellet clad interaction and unknown/uninspected
  - BWR- Debris, pellet clad interaction and unknown/uninspected



- **The quality of fuel pellets, especially the presence of minor surface flaws, is becoming a key focus areas for failures which have occurred after power changes.**
- **BWR channel bowing is becoming a new focus area because it is being observed in all vendor designs**

Continuing Industry Initiatives

- **Industry's Fuel Reliability Program (FRP) falls under the Materials Initiative, NEI 03-08**
- **Fuel Reliability Program continues to focus on:**
  - **Water Chemistry impacts on fuel performance**
  - **Root cause analysis of fuel failures**
  - **Operating experience and benchmark information are collected in fuel reliability data base (FRED)**
- **Results of this analysis is then fed back to vendors and utilities to enable corrective and preventative actions to be undertaken**

Conclusions

- While not a safety issue, U.S. fuel performance continues to have adverse effects on potential radiation exposure, plant generation and economic performance
- Goal of FRP and U.S. Industry is to operate with zero fuel defects
- Due to the care required when handling irradiated fuel, research and root cause results take a long time to develop
- Research and root cause results, however, are starting to bear fruit, which should start to make a positive impact on overall fuel performance
- Cooperative effort between fuel vendors, utilities, and EPRI is dedicated to improving fuel performance, assuring safety and achieving the industry goal

Materials Degradation Issues and Fuel Reliability

Feb. 6, 2006

Jennifer Uhle, RES
Jack Grobe, NRR
Frank Akstulewicz, NRR

Proactive Management of Materials Degradation

- Resolving degradation issues before they become a concern by
  - Preventing the degradation or
  - Monitoring, mitigating and repairing it

2004 Commission Direction To NRC Staff

- Continue program to predict future degradation and take necessary action
- Develop research programs using risk-informed insights
- Pursue collaborative research programs
- Evaluate regulatory treatment

NRC Program to Predict Future Degradation

- Identifying mechanisms and susceptible components
- Evaluating in-service inspection effectiveness
- Determining the safety significance
- Verifying repair and mitigation effectiveness

Identification of Mechanisms

- Conducted a study using several international experts
  - Identified possible degradation mechanisms and susceptible components
  - Appraised the state of knowledge
- Final report available June 2006

Collaborative Research Program Development

- Proactive resolution requires extensive knowledge
- Feasible through collaboration to prevent unnecessary duplication
- Research plan
  - Mechanisms
  - Detection and monitoring
  - Mitigation and repair

Status of Collaborative Efforts

- **Domestic**
  - Met with industry January 2006
  - Meeting planned to define specific areas of collaboration
- **International**
  - 2005: 2 meetings held (USA, Japan)
  - 2006: 2 meetings planned (USA, Europe)

Summary

- NRC is working to identify and resolve materials degradation issues before they become safety-significant
- NRC is using risk-informed insights to prioritize work
- NRC is pursuing collaborative research efforts

Use of Research Results

- Three related programs
  - Proactive Materials Degradation Assessment
  - Inservice Inspection and Monitoring Capabilities
  - Risk associated with failure
- Evaluate results to determine need for regulatory action and to prioritize resources

Staff Requirements Memorandum

- **Industry initiative - framework for management of materials issues**
- **Staff Requirements Memorandum from Nov. 8, 2004 Commission Meeting**
  - **Regulatory treatment of industry's mandatory and needed action categories**

Recent Regulatory Action

- Industry revised Steam Generator Program Guidelines in 2005
- Industry implementation mandatory
- NRC action - Steam Generator Program Guidelines covered by performance-based technical specifications

Recent Regulatory Action

- Westinghouse Owners Group issued report on management of boric acid corrosion in April 2004
- Industry implementation mandatory
- NRC action - Inspection Procedure revised to address updated expectation for boric acid corrosion control following Davis-Besse

Recent Regulatory Action

- Material Reliability Program issued report on butt weld primary water stress corrosion cracking in August 2005
- Industry implementation mandatory

Recent Regulatory Action

- **NRC action – Initiated action to change requirements to include enhanced butt weld examination frequency**
  - **Contacted ASME to revise Code to reflect new examination expectations**

Conclusions

- Regulatory treatment of materials issues depends on several factors
- Range of regulatory vehicles have been used
- Some industry materials initiatives do not need regulatory treatment

Requirements And Oversight

- Technical Specifications
- Fuel Design Reviews
- Periodic meetings with fuel vendors

Current Fuel Reliability Statistics

Current Statistics	**PWR**	**BWR**
Number of plants	69	35
Number of plants with fuel defects	16	7
% of plants with fuel defects	23	20
Number of fuel assemblies with defects	59	14
Fuel assembly defect rate in 2005 (per thousand assemblies)	**3.9**	**0.6**
Fuel assembly defect rate in 2004 (per thousand assemblies)	**2.5**	**1.1**

BWR Failure Mechanisms

Failure Mechanisms	2003	2004	2005
DEBRIS	3	8	5
Pellet Clad Interaction-SCC	4	5	4
CRUD / CORROSION	63	3	0
GRID-TO-ROD FRETTING	- -	- -	- -
FABRICATION	1	0	0
INSPECTED / UNKNOWN	8	10	5
Total Fuel Assemblies With a Fuel Defect	**79**	**26**	**14**

PWR Failure Mechanisms

Failure Mechanisms	2003	2004	2005
DEBRIS	6	0	5
Pellet Clad Interaction-SCC	1	0	1
CRUD / CORROSION	0	0	0
GRID-TO-ROD FRETTING	37	29	31
FABRICATION	1	0	0
INSPECTED / UNKNOWN	24	9	22
Total Fuel Assemblies with a Fuel Defect	**69**	**38**	**59**

Conclusions

- Number of failures is not of significant safety concern
- No significant trend was observed
- Staff will continue to monitor this area

Summary

- NRC will continue to monitor fuels and materials degradation issues, and take appropriate action
- NRC is enhancing its ability to predict materials degradation
- There are a range of regulatory vehicles used in addressing materials issues
- Number of fuel failures is not of significant safety concern