U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Commission Briefing on Reactor Materials Issues

April 28, 2008

Agenda

- Introduction – Jack Grobe, NRR
- Regulatory Activities –
  Michele Evans, NRR
- Research Activities –
  Jennifer Uhle, RES
- Human Capital Resources –
  Jack Grobe

Introduction

- Pressurizer nozzle flaws
- New Code requirements
- Proposed vessel rule
- Extended operation workshop
- Proactive management NUREG
- NDE effectiveness research

Upper Head Background

- Oconee - Spring 2001
  - Circumferential cracking
- Bulletin 2001-01 – Aug. 2001
- Davis-Besse - Spring 2002
  - Head corrosion
- NRC Order EA-03-009 – Feb. 2003
  - Revised in February 2004

Inspections for PWSCC in Upper Head Penetrations

- All baseline inspections complete
- NRC Order EA-03-009 Inspections
  - Susceptibility ranking
  - 1 of ~1500 Low susceptibility nozzles identified PWSCC

Upper Head Replacement

- PWSCC resistant materials
- Half replaced to date
- Anticipate all High and Moderate susceptibility plants will replace heads

Longer Term Approach

- ASME Code Case N-729-1
  - Replace Order
- 10 CFR 50.55a revision to include Code Case
  - Final Rule scheduled May 2008

PWSCC in Butt Welds

- PWSCC in dissimilar metal (DM) butt welds since 2000
- MRP-139 DM butt weld inspection guidelines
- Staff monitoring MRP-139
- Temporary Instruction

Longer Term Approach

- Staff requested ASME Code to develop inspection requirements
  - Code case under development
  - NRC will incorporate code case in 10 CFR 50.55a

Recent Butt Weld Operating Experience

- Wolf Creek pressurizer welds
  - Advanced finite element analyses
- PWSCC in two Babcock & Wilcox plant drop line DM welds
- Retired pressurizer weld inspection

RPV Embrittlement/Aging

- Management of RPV aging is critical to ensuring plant safety
- Four key NRC rules/regulatory guides establish regulatory framework

Current Regulatory Framework

- More than adequate to maintain nuclear safety
- Excess conservatism may impact plant operation and/or plant operating life

Current & Future Actions

- Significant improvement made in our understanding of RPV integrity issues
- Plan to implement improvements through rulemaking

Extended Operation Materials Issues

- NRC/DOE Workshop Feb. 2008
- Aging issues for long-term operation beyond 60 years
- Industry development needs
- Integrated aging management research plan

Proactive Management of Materials Degradation

- PMMD allows for action before degradation is safety significant
- NUREG/CR-6923
- Material susceptibility and knowledge level
- Comparison to industry results

PMMD (continued)

- Review of current research programs
- Collaborative programs with industry but maintain independence
- Enhance coordination
- Prioritize issue resolution

PMMD Implementation

- Database to facilitate updates
- Links to operating experience and research findings
- Knowledge management tool
- International cooperation

Non-Destructive Examination Techniques

- Resolution by prevention or detection and repair/replacement
- Industry initiatives to reduce in-service inspection (ISI) time
- Reliability and effectiveness of NDE techniques are more important

NDE (continued)

- Weld overlays
- High density polyethylene piping
- Program for inspection of nickel-based alloy components
- NDE and PMMD inform NRC's review of Life Beyond 60

Materials Human Resources

- Human Capital
  - Hiring/Retention
  - Training/Knowledge Management
  - Technical Consistency

Acronyms

- PWSCC - Primary Water Stress Corrosion Cracking
- MRP – Materials Reliability Program
- NDE - Non-destructive examination
- RPV - Reactor Pressure Vessel
- ASME - American Society of Mechanical Engineers

Acronyms

- PMMD - Proactive Management of Materials Degradation

Briefing on Reactor Materials Issues

Alexander Marion
Executive Director
Nuclear Energy Institute
April 28, 2008

Industry Panel

- Introductions – Alex Marion, NEI
- Materials initiative – Jeff Gasser, SNC
  - Chairman, Materials Executive Oversight Committee
- Materials issues programs and operating experience – Joe Hagan, FENOC
  - Chairman, EPRI PWR Materials Management Programs Executive Committee

Materials Issues Introductory Comments

- Materials issues continue to be among the top priorities for the nuclear industry
- Materials Initiative approved unanimously by Chief Nuclear Officers in May 2003
  - An NEI Initiative is an industry CNO commitment to establish and implement a defined policy and associated actions
  - Commits the entire nuclear power industry
- Presenters will cover industry activities and utility specific experience

Materials Initiative

Jeff Gasser
Executive Vice-President and Chief Nuclear Officer
Southern Company
April 28, 2008

Overview

- Materials Initiative
- Guidance Documents
- Planning for the Future
- Results
- Summary

Background

- NEI executive committee resolution in 2002
- Self assessment of materials programs
- Recommendations
  - Use NSIAC Initiative to establish policy
  - Establish oversight groups
  - Enhance INPO role
  - Enhance communications
  - Provide funding

Materials Initiative

- Provides
  - Consistent management process
  - Prioritization of materials issues
  - Proactive approaches
  - Coordinated approaches
  - Oversight of implementation
- Objective
  - Safe and reliable operation

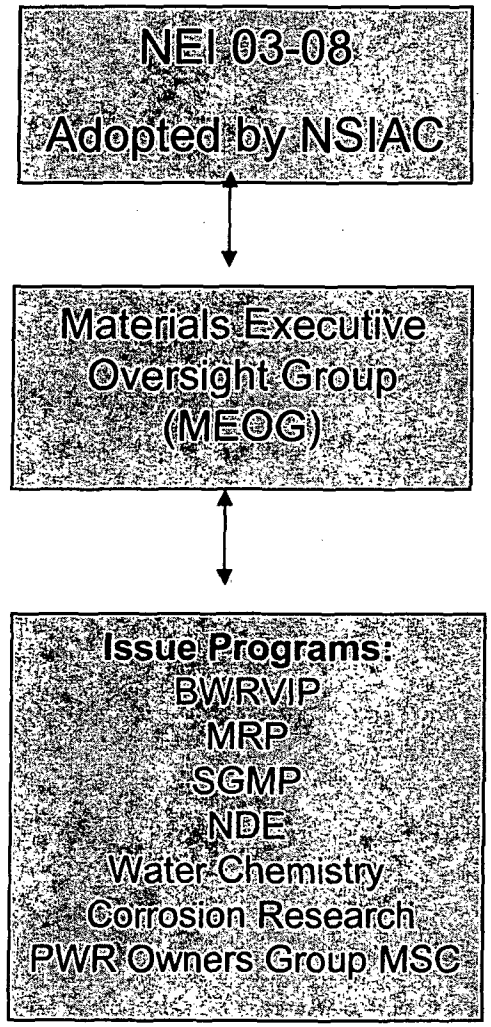
The Initiative is Working

- Industry Codes and regulatory requirements provide high assurance of structural integrity
- Industry documents establish inspection guidance beyond Code and regulatory requirements
- Expectations communicated and understood

Industry Programs Aligned Under the Materials Initiative

- Materials Reliability Project (MRP)
- PWR Owners Group Materials Subcommittee (PWROG MSC)
- BWR Vessel Integrity Program (BWRVIP)
- Steam Generator Management Program (SGMP)
- Non-Destructive Examination (NDE)
- Water Chemistry Control
- Primary Systems Corrosion Research

Industry Materials Organization



Industry Materials Issue Program Scope

- Guideline development
  - MRP
    - PWR reactor vessel and primary system materials
  - SGMP
    - PWR steam generator tubing and tube inspections
  - BWRVIP
    - BWR reactor vessel and primary system materials
  - PWROG Materials Subcommittee
    - PWR primary system materials tactical and operational issues

Industry Materials Issue Program Scope

- Support and research
  - NDE
    - Non-destructive examination equipment and technique development/demonstration
  - Corrosion Research
    - Primary system component corrosion research
    - Irradiation effects
  - Water Chemistry Controls
    - PWR and BWR chemistry control limits and methods
    - Stress corrosion cracking mitigation methods

NEI 03-08 Guideline

- Applies to all programs involving primary system materials.
  - Defines expectations for management of materials integrity
  - Establishes policy
  - Establishes oversight function
  - Defines roles, responsibilities, and expectations
  - Provides for an integrated approach

NEI 03-08 Addenda

- Establishes standards for implementation
  - Materials Management Program Guideline
  - Emergent Issues Protocol
  - Strategic Plan
  - Implementation Protocol
  - Performance Metrics
  - Self Assessment Protocol

Strategic Approach

- Strategic plan defines the key priorities and objectives
  - Defines intermediate and long term strategic issues
  - Identifies critical gaps
- Materials Matrix identifies materials vulnerabilities and level of knowledge
- Materials Issues Management Tables identify open items and establishes priorities

Materials Initiative Results

- Executive level commitment
- Structured assessment guides priorities
- Improved guidance
- Significant advancements in inspection capability
- INPO review visits
  - Primary system integrity
  - Steam generator management
  - BWR vessel integrity

Materials Initiative Results

- $300M spent addressing materials integrity since 2003
- No challenge to plant safety since the Materials Initiative adopted
- Aggressive inspections finding problems before structural integrity limits are challenged

PWR Primary System Piping Inspections

- PWR nickel-alloy butt weld inspection program
  - Spring 2008 – all plants complete overlays of pressurizer dissimilar metal welds (DMW)
  - 12/31/08 - inspect or mitigate DMW in piping ≥ 4" and ≤14" in diameter and exposed to hot leg temperatures
  - 12/31/09 - inspect or mitigate DMW in piping > 14" in diameter and exposed to hot leg temperatures
  - 12/31/10
    - inspect or mitigate DMW in piping exposed to cold leg temperatures
    - inspect DMW ≥ 2" and < 4" in diameter and exposed to temperatures equivalent to the hot leg or serve an ECCS function
    - inspect DMW ≥ 1" and < 4" in diameter without a requirement for UT exam

Expectations for Industry

- Continue proactive approach
- Implement integrated materials plan reflecting Strategic Plan priorities
- Implement applicable Issue Program guidance
- Support materials Issue Programs
- Support funding
- Perform periodic self assessments

Summary

- Industry executive commitment to ensure structural integrity
- Resolving challenges while maintaining
  - Safety
  - Reliable operation
- Improving performance
- Sharing operating experience
- Communicating effectively with NRC

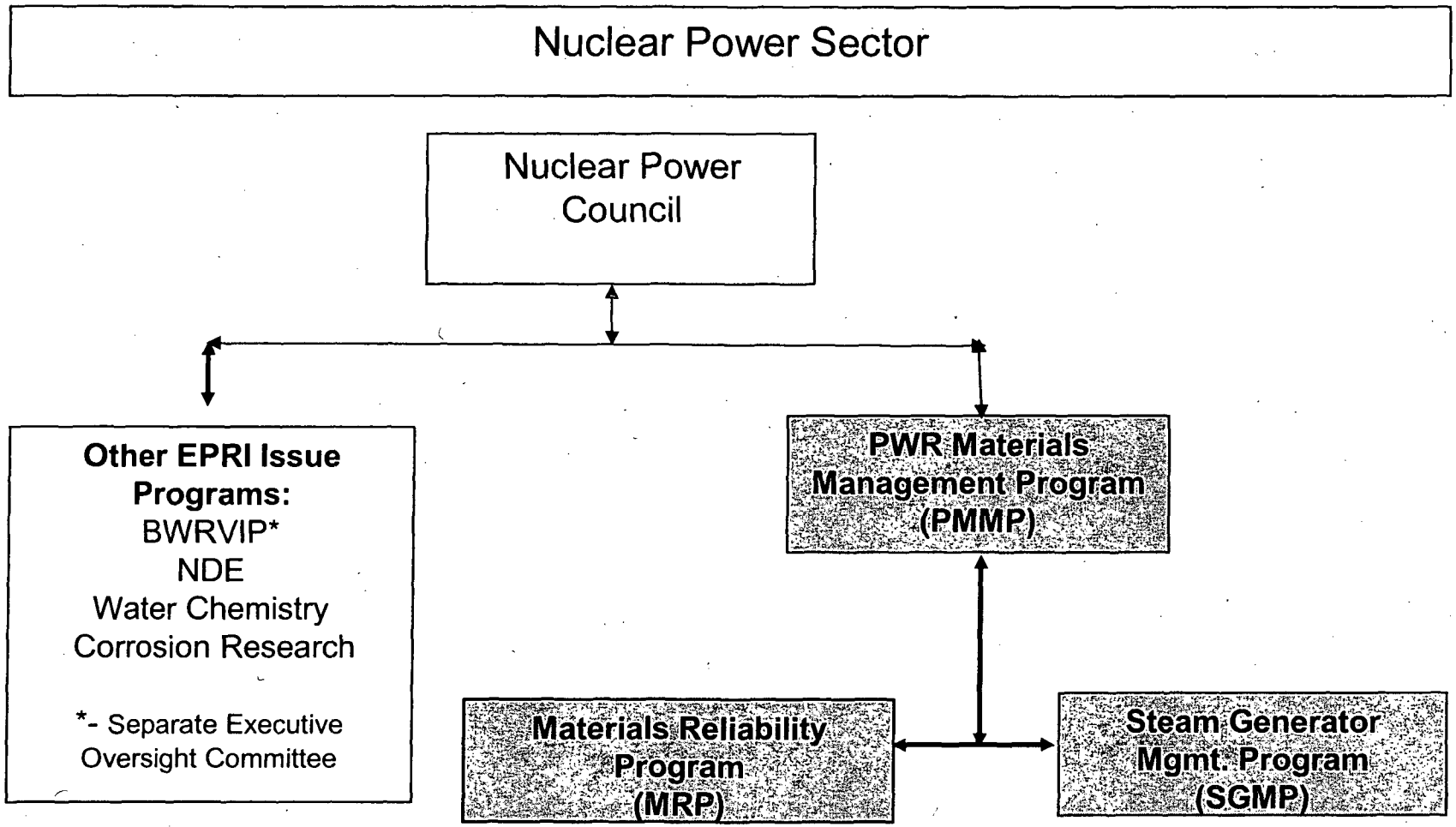
Materials Issues Programs & Operating Experience

Joe Hagan
President and CNO
FirstEnergy Nuclear Operating Company
April 28, 2008

Overview

- EPRI PMMP
- Materials Issue Programs
- Operating Experience

EPRI Materials Organization



Future Priorities

- Planned
  - Effect of RCS environment on the performance of materials
  - Damage initiation processes and development of predictive models
  - Mitigation
  - Inspections and Evaluations
  - License Renewal beyond 60 years
- Emergent
  - New plant materials issues, collaboration with ANT
  - Materials degradation operating experience from domestic and <u>foreign plants</u>

Materials Initiative Expectations for Operating Experience

- Clear expectations for communicating operating experience
  - NEI 03-08
- Industry protocols in place for responding to emergent issues

Operating Experience Summary

Davis Besse
Decay Heat Nozzle

- FENOC rescheduled Davis Besse's 2008 refueling to December 2007
  - Pre-emptive weld overlay project included 16 reinforcement welds; 14 on Pressurizer system, two on Decay Heat
- During automated weld overlay process on Decay Heat nozzle, through-wall leakage discovered
  - Weld process halted
  - Problem Solving/Decision Making (PS/DM) Team formed
- Prompt contact with Nuclear Regulatory Commission
  - Consulted with
    - Electric Power Research Institute (EPRI)
    - Institute of Nuclear Power Operations (INPO) and
    - Nuclear Energy Institute (NEI)

Davis Besse
Decay Heat Nozzle

- **Confirmatory Ultrasonic Testing (UT) discovers 1.3 inch axial flaw**
  - Experts attribute flaw to primary water stress corrosion cracking
- **Resolution plan process adopted:**
  - Portion of exposed weld material ground away
  - Automated welding proceeded with nine layers of overlay weld
  - UT exams and Penetrant Testing were successfully completed to verify weld quality and ensure structural integrity

Davis Besse
Decay Heat Nozzle - Lessons Learned

- Prior review of weld history
- Communications protocol
  - Inform all stakeholders promptly
  - Material Reliability Project briefing sheet
  - EPRI, NEI, INPO involvement upfront
  - Direct & repeated dialog with NRC
  - Mutual agreement on going-forward plans
- Industry engagement
  - EPRI Non-Destructive Examination Center support

St. Lucie
Pressurizer Nozzle

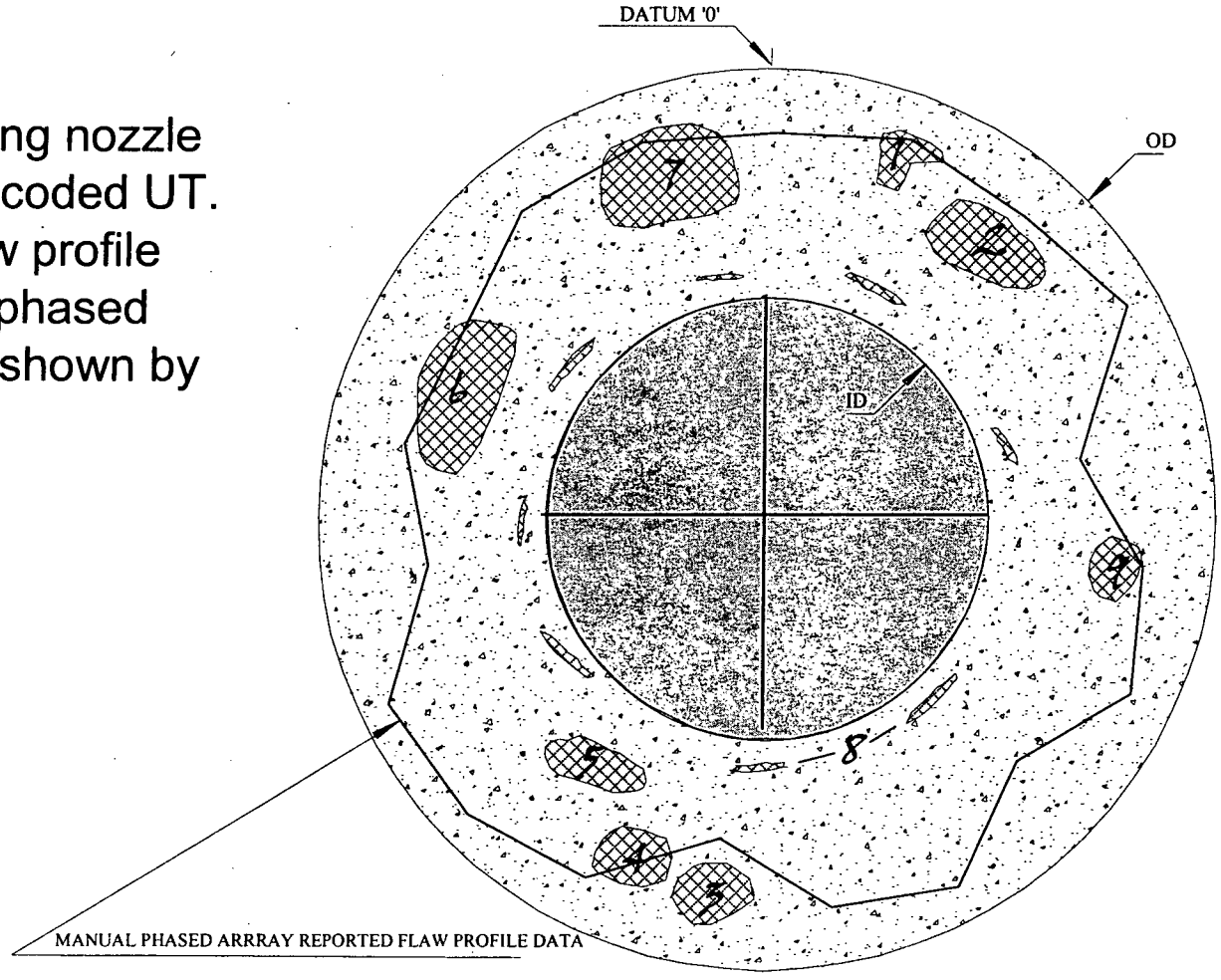
- Studying nozzle from pressurizer replaced in 2005
  - Industry and NRC collaborative research project
- Performed preliminary NDE to determine value for further study
  - Indications considered potential challenge to structural integrity basis
- Industry responded to concern
- Advanced ultrasonic NDE verified fabrication induced defects
  - Further verified with traditional radiography

St. Lucie
Pressurizer Nozzle - Conclusions

- Two separate approaches - NDE and analytical
  - Finite element analysis method remains valid
  - Defects not structurally significant
  - Same conclusion: no safety concern exists
- Rapid and thorough industry response considered a strength

SAFETY NOZZLE 'A'

Sketch showing nozzle flaws after encoded UT. The initial flaw profile after manual phased array NDE is shown by the red line.



LOOKING INTO HEAD

Farley Nuclear Plant

- SNC committed to proactively address nickel-alloy materials issues
- Replaced steam generators 2000-2001
- Replaced reactor vessel heads 2004-2005
- Capital replacement projects improve plant safety and reliability before significant problems can occur

Farley Nuclear Plant Chemical Mitigation

- Both Units have continuously added zinc since 1999 to mitigate PWSCC
  - Farley Unit 1 was first commercial PWR to add zinc to primary side in 1994
- Farley 2 was the only one of five plants with material heat M3935 in reactor vessel head penetrations that did not experience cracking
  - Materials from the Farley 2 and Davis Besse replaced heads are being tested in an Owners Group program to demonstrate zinc addition effectiveness in mitigating PWSCC

Farley Nuclear Plant Unit 2 Pressurizer Surge Nozzle

- April 2007 – First PDI manual UT exam of surge nozzle identified an axial indication.
- Due to complex geometry phased array UT was used to size the indication.
- The axial indication was confirmed and a separate circumferential indication was identified.
- Removal of a boat sample was considered but precluded by the existence of a thermal sleeve, the location and shallow depth of the indications.
- ASME Code analysis showed the as-found nozzle was acceptable through the completed operating cycle.
- Weld overlay of the surge nozzle was performed.

Farley-1 Pressurizer Heater Sleeves

- October 2007 visual inspection identified very small (pinhead size) white residue at the heater sleeve to bottom head annulus on two heaters
- Physical characteristics of the residue were not like a typical boric acid deposit
  - chemistry sample indicated boron and cesium-137
- Heaters were removed, NDE performed to verify no through wall defects
- New heaters were installed
- Contingency plan developed for future heater exams

Hatch-1
Control Rod Drive Return Line Nozzle

- Performed weld NDE data review as a result of operating experience
  - Resulted in additional weld examination
- Indication on one control rod drive return line nozzle weld
- Circumferentially oriented defect
- NDE Center confirmed
- Weld repaired with overlay

SNC Lessons Learned

- Pro-active response to operating experience
- Conservative decision making
- Prompt communications with industry
- Prompt communications with NRC
- Document operating experience
- Follow through with lessons learned

Overall Summary and Conclusions

- Industry response to ongoing and emergent issues is effective
- Conservative decision making evident in field applications
- Proactive sharing of experience and lessons learned
- Experience input to industry guidance documents and program priorities

Acronyms

- NEI - Nuclear Energy Institute
- NSIAC – Nuclear Strategic Issues Advisory Committee
- RCS - Reactor Coolant System
- PWR - Pressurized Water Reactor
- BWR – Boiling Water Reactor
- DMW – Dissimilar Metal Welds

Acronyms

- BWRVIP – Boiling Water Reactor Vessel Internals Project
- MRP – Materials Reliability Project
- NDE – Non-destructive Examination
- SGMP – Steam Generator Management Program
- APWG – Action Plan Working Groups
- ANT - Advanced Nuclear Technology
- UT – Ultrasonic Testing
- PDI – Performance Demonstration Initiative

Back-up Slides

Background

- NEI Executive Committee Resolution
  - Fully support industrywide effort to improve management of materials issue
- Self-Assessment of Materials Programs
  - Driven by recent plant events
  - Develop a more proactive process

Backround

- **Self-Assessment**
  - Identify barriers or gaps in current materials programs
  - Integrate industry programs
    - SG Management (SGMP)
    - PWR Materials Reliability (MRP)
    - BWR Vessel & Internals (BWR VIP)
    - Fuel Reliability Program (FRP)
    - Chemistry, Corrosion and NDE
    - NSSS Owners Groups

Background

- **Self-Assessment Conclusions**
  - **Limited coordination of industry efforts on materials issues**
  - **Limited ability to enforce implementation of industry guidance**
  - **Limited verification of implementation**
  - **Inadequate participation and support of Issue Programs (IP)**
  - **NSIAC Initiative warranted**

Background

- **Self-Assessment Recommendations**
  - Create executive-level and technical oversight groups
  - Establish policy on the management of materials issues
  - Use the NEI Initiative Process
  - Expand INPO's role
  - Enhance communications
  - Define regulatory interface

Materials Initiative

- Approved by NSIAC in May 2003
- Each licensee will meet the intent of NEI 03-08, Guideline for the Management of Materials Issues
- Initiative effective January 2, 2004
  - Includes $12M for 2004-2005 to fund high priority materials issues in addition to the $47.5M currently budgeted by Issue Programs for 2005

Materials Executive Oversight Group (MEOG)

- Jeff Gasser (*Chairman*) – Southern Company
- Joe Sheppard – STP
- Chris Crane – Exelon
- Joe Donahue - Progress Energy
- Mano Nazar – AEP
- Joe Hagan - FENOC
- Mike Robinson - Duke
- Greg Wilks - NEIL
- Jim Klapproth - GE
- Nick Liparulo – West.
- Gary Mignogna – AREVA
- Rick Jacobs – INPO
- Dave Modeen – EPRI
- Alex Marion - NEI