U. S. Nuclear Regulatory Commission

Public Workshop

Extended Power Uprates Lessons Learned

March 19, 2002

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Morning Agenda

- 8:30 – 8:45 Opening Remarks
- 8:45 – 9:30 NRC – Lessons Learned
- 9:30 – 9:35 Break
- 9:35 – 10:20 GE/DAEC/Exelon – Lessons Learned
- 10:20 – 10:25 Break
- 10:25 – 11:10 Westinghouse/ANO-2 – Lessons Learned
- 11:10 – 11:15 Break
- 11:15 – 12:00 Framatome – Lessons Learned

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Afternoon Agenda

- 1:00 – 3:00 Breakout Sessions
- 3:00 – 3:15 Break
- 3:15 – 5:15 Presentations from Breakout Groups
- 5:15 – 5:30 Closing Remarks

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Power Uprate Program

S. Singh Bajwa, Director
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

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Priority of Power Uprates

- High Priority
- Among Most Significant Licensing Actions
- No Unnecessary Delays in Completing Reviews

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Planning/Scheduling

- 6 Months for MUR Power Uprates
- 9 Months for Stretch Power Uprates
- 12 Months for Extended Power Uprates

MUR – Measurement Uncertainty Recapture

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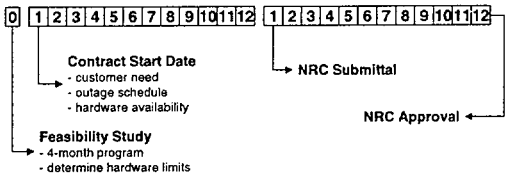
ATTACHMENT 2

Typical EPU Schedule

Licensing Process

- Nominal 12 months for Safety Analysis Report
- Nominal 12 months for NRC Approval



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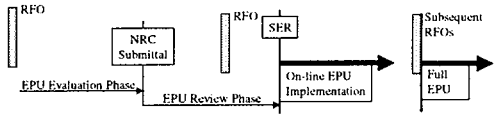
On-Line EPU Implementation

- License and implement power uprate without increase in maximum operating reactor dome pressure
- Permits initial power increase to existing BOP capacity immediately following receipt of OL amendment
- Subsequent BOP mods to achieve full uprate



Implemented at River Bend, DAEC and Dresden 2

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GE Power Uprate: Implementation

Factors involved in selecting power uprate program:

- Potential BOP pinch points
  - License EPU at 120% original rated thermal power
  - EPU staged implementation based on plant mods schedule
- On-line implementation:
  - License uprate without increase in reactor pressure
  - Permits initial power increase to existing BOP capacity immediately following receipt of OL amendment
  - Subsequent BOP mods to achieve target power uprate

Initial PU upon SER independent of BOP mod schedule

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GE Power Uprate: Implementation

Factors involved in selecting power uprate program (cont.):

- Extended Power Uprate:
  - Significant increase in revenues
  - Study finds optimum level, considering hardware mods
  - Phased implementation power level progressive with mods

  Implementation PU ➡ Target PU ≤ License PU

- Electrical Output Optimization – Generator Limit
  - Design thermal power level to support maximum electrical output capability during peak summer conditions
  - Vary thermal power to support constant generation load

  Target PU to support peak capable generation needs

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GE Power Uprate Experience

[redacted]

Extended Power Uprate:	105% Power Uprate:	EPU in Progress:
• KKM (114%)	• Susquehanna - 1, 2	• Brunswick-1,2 (120%)
• KKL (112%)	• WNP-2	• Clinton (120%)
• Hatch-1,2 (113%)	• Limerick - 1, 2	• Browns Ferry-2,3 (120%)
• Monticello (112%)	• Peach Bottom - 2, 3	
• Duane Arnold (120%)	• Fermi 2	**TPO in Progress:**
• Dresden -2,3 (117%)	• FitzPatrick	• River Bend (101.7%)
• Quad Cities -1,2 (117%)	• Brunswick - 1, 2	• Grand Gulf (101.7%)
• Cofrentes (110%)	• NMP-2	• Pilgrim (101.5%)
	• Browns Ferry - 2, 3	• Peach Bottom (101.7%)
	• LaSalle – 1, 2	
	• Laguna Verde	
	• Perry	
	• River Bend	

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SUMMARY

- Generation Capability More Important than Efficiency
- EPU Generic Licensing Approach
  - Facilitates licensing and implementation phases
  - Increase plant uprate capability and flexibility
  - Continuous process improvement
- Constant Pressure Power Uprate Approach
  - Less technical challenges
  - Reduced licensing effort

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Current Status

- 72 Plant-Specific Applications Approved (22 in 2001)
  - 13 Measurement Uncertainty Recapture Power Uprates (12 in 2001)
  - 51 Stretch Power Uprates (5 in 2001)
  - 8 Extended Power Uprates (5 in 2001)
  - Approximately 9800 MWt (3300 MWt in 2001)
- 12 Plant-Specific Applications Under Review
  - 7 Measurement Uncertainty Recapture Power Uprates
  - 1 Stretch Power Uprates
  - 4 Extended Power Uprates
- 2 Generic Topical Reports Under Review

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Looking Ahead

Fiscal Year	Expected Applications	MUR	Stretch	Extended
2002	16	14	0	2
2003	14	5	0	9
2004	5	5	0	0
2005	6	2	2	2
2006	1	0	0	1

- 8 More Power Uprates are Under Consideration
- Expect More Interest as a Result of Existing Potential & Ongoing Work
- NRC Estimates Additional Submittals After FY 2003

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Extended Power Uprates Lessons Learned

Mohammed A. Shuaibi, Project Manager
Project Directorate III-1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

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Communication

- Communicate early and often
- Get clear understanding of any RAIs/concerns and the reasons for the RAIs/concerns
- Keep management informed of status

RAIs – Requests for Additional Information

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Handling of RAIs

- Get questions/concerns to licensee as soon as possible (e.g., e-mail)
- Hold teleconferences to ensure common understanding of the questions/concerns
- Prior to submitting responses to RAIs, check with the reviewers (e.g., teleconference) to ensure that the responses are adequate

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Handling of RAIs (Continued)

- Document RAIs and teleconferences in accordance with NRR Office guidance and procedures
- Make submittals available as soon as possible (e.g., e-mail) after being officially signed and dated

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Exelon

Power Uprate Licensing Process Improvements

NRC Workshop

March 19, 2002

Allan R. Haeger, Exelon Nuclear

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Exelon Nuclear

Introduction

- NRC has been responsive to power uprate submittals
- The process has improved with experience
- Major areas for process improvement
  - Reduce RAI volume
  - Improve schedule predictability
  - Reduce discussions regarding proprietary designation

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Exelon Nuclear

Process Improvements

- Opportunity: Reduce review time by reducing the volume of RAIs
- Potential actions
  - Vendors/utilities review RAI patterns; expand standard submittal shells
  - NRC develop guidance for level of detail required
  - Utilities/vendors maximize dialogue prior to RAI response
  - NRC conduct on-site audits for large volume RAIs

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Exelon Nuclear

Process Improvements

- Opportunity: Improve schedule predictability
- Potential actions
  - Utilities discuss schedules with NRC in advance
  - Utilities limit concurrent major submittals
  - NRC promptly identify difficult areas
  - NRC and vendors work with ACRS to determine remaining areas of focus

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Exelon Nuclear

Process Improvements

- Opportunity: Reduce time spent discussing proprietary designations
- Potential actions
  - Utilities must challenge vendor designations
  - Vendors and NRC continue to meet to resolve remaining issues

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Exelon Nuclear

Conclusion

- Experience is improving the process
- Approval of the constant pressure topical report will place focus on resolving RAI volume and proprietary issues

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Duane Arnold Energy Center
Extended Power Uprate

Implementation – Lessons Learned

Presented by Tony Browning
Principal Licensing Engineer, NMC

Modifications – Lessons Learned

- Team Focused on PUSAR & NRC Submittal
- BOP System Evaluations treated as routine
  - Lack of Design Basis for BOP - evaluations more difficult than Safety-related Systems

Modifications – Lessons Learned

Result – discovered last minute modifications
- Typically related to a "second order effect"
  - Example – FW Heater tube vibration in drain cooler zone

Lesson Learned – *Get an early jump on BOP System evaluations*

Startup Testing – Lessons Learned

- Test Acceptance Criteria – Original 1973 S/U Test Specifications
- Didn't fully incorporate plant operating experience (internal or external)
- Resulted in unexpected test "failures"

Startup Testing – Lessons Learned

- Examples
  - 1) FW flow controllers upgraded in 1996, – didn't have "classical" response assumed in S/U Test Specification
  - 2) One criterion found to be "obsolete"
- Lesson Learned – *Validate basis for test criteria against current system/component requirements.*

Westinghouse

A BNFL Group company

Combined W/CE Fleet Extended Power Uprate Overview and Lessons Learned

John Fasnacht
Manager - Integrated Plant Engineering Services
Westinghouse Electric Corp, LLC.

Presentation Overview

- Overview of Fleet Experience
- EPU Technology and Process
- General Lessons Learned Assessment
- ANO-2 Program
- Questions

Well Developed Fleet Experience

- Combined fleet has successfully achieved 56 uprates equivalent to 2450 MWe
- Recent Activity - 9 plant Appendix K and 6 stretch uprates
- Work in Process/Licensing - 7 plant Appendix K, and 5 stretch/EPU uprates
- EPU Activity
  - ANO-2 — Licensing
  - Beaver Valley 1/2 — Ongoing
  - Point Beach 1/2 — Ongoing
  - Waterford 3 — Ongoing
  - Feasibility Assessment for 4 plants — Ongoing
- Fleet wide remaining potential

EPU Technology for the Future

- Technology platforms for 10% to 20% power uprates
- Systematic review of NSSS fuel, safety analysis, components and systems
- Understanding of key design and licensing basis issues and margins is critical
- Developing new technology to further enhance margins
- Integrated programs and team work

General Lessons Learned Assessment

- Overall communications enhanced
  - Workshops and guidance document
  - Active communication of expectations/responsiveness
  - Communication between LAR and first set of RAIs
  - Copies of RAIs - promoting dialogue, understanding before formal submittal
  - Review pedigree
- Selected considerations for program
  - Experienced review of required elements and detailed work breakdown structure
  - Develop regulatory communication plan
  - Recognize depth of review and information required for submittal
  - Use precedent recognizing that no two plants are alike

Items for Development/Discussion

- Questions regarding current methods and approach
- Internal communications on issues and prior approvals
- Reviewing ongoing/current issues not related to uprate
- Using past precedent and responding to past RAIs vs. additional RAIs
- Overall process is enhanced

Westinghouse Overview of ANO-2 Licensing

- PWR EPU licensing approaching mature process in terms of
  - Breadth of issues
  - Technical issues from NRC or ACRS review
  - Use of existing Licensing basis
  - Handling of Generic industry issues
- Extensive reviews with an appropriate level of detail
  - Experienced Reviewers
  - Familiar with approved methodologies
  - Communication and resolution of technical issues

NRC Workshop
Power Uprate

ANO-2 Power Uprate
Perspectives and Lessons Learned
March 19, 2002
Bryan Daiber
Roger Wilson

Entergy

NRC Workshop
Power Uprate

Roger Wilson

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Presentation Agenda

(1) ANO-2 Uprate Overview
(2) Regulatory Process
(3) ANO-2 Recommendations
- Lessons Learned

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ANO-2 Overview

- Uprate - extended power uprate (EPU), >5%
  - 7.5% Primary: 2815 → 3026 MWt
    - Follows steam generator replacements by 1 cycle
  - 11% Secondary: 958 → 1065 MWe (+107)
    - Replaced high pressure turbine steam path
    - Replaced 4 low pressure turbine stages
    - Isentropic efficiency increase due to advance design

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ANO-2 Overview

- Key design issue
  - T_{HOT} increase versus PWSCC
    - Alloy 600 RV head penetrations
      - Limits uprate amount
      - "Short term" issue
        - Will be resolved in near future
        - Controlled long-term decisions for uprate
- ANO-2 templates used
  - Farley and other BWR submittals
  - Westinghouse topical
  - GE BWR topical

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Regulatory Process

- Schedule
  - Submittal - 12/19/00
  - RAI response history
    - 15 at end of 9/01
      - Multiple questions in each RAI
    - ACRS review of D. Arnold 9/27/01
    - 27 starting 10/01 (into 3/02)
  - Draft SER issued 1/18/02
  - ACRS subcommittee 2/13/02
  - ACRS full committee 3/7/02
  - License amendment about 4/19/02

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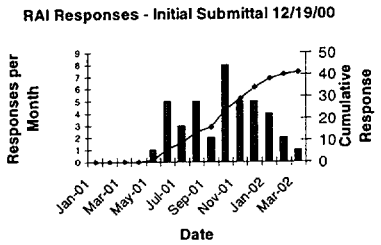
Regulatory Process



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Regulatory Process

- ANO-2 initial submittal
  - Level of detail consistent with FSAR
  - Assumed current licensing basis is maintained
    - Current licensing basis maintained with a few exceptions
      - Control room habitability

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NRC Workshop Power Uprate

Bryan Daiber

Entergy

Regulatory Process

- Analysis methods
  - Used approved methods
  - NRR and ACRS questioned underlying assumptions and applicability to an EPU of some of the approved methods
    - Should be resolved earlier for future licensees

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Regulatory Process

- ACRS directs NRR to probe deeply in key areas
  - NRR performed several confirmatory analyses
    - Containment (LOCA/MSLB)
    - PTS reference temperature calculations
    - RV head crack susceptibility
    - Dose calculations for LOCA, SGTR, FHA and CEA Ejection
    - Atmospheric dispersion X/Q calculations
    - Power uprate PSA assessment
      - Identify areas earlier to allow licensee to support

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Regulatory Process

- NRR probed key areas (continued)
  - Most reviewers familiar with ANO-2 FSAR
    - Verbal interfaces productive
    - Minimized RAIs
  - Reviews were very extensive
  - Many questions were standard
    - Reviewer looking for specific information

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Regulatory Process

- Non-uprate issues
  - NRR included issues not part of uprate
    - Control room habitability
    - ECCS long term core cooling assumptions
    - Exclusion area boundary dispersion factors
    - SG level uncertainties
  - Resolving non-uprate issues was biggest challenge of approval process
    - Preclude these issues; if not, identify known issues earlier

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Regulatory Process

- Probabilistic safety assessment (PSA)
  - Large workload item for licensee
  - NRR and ACRS seem at odds over value added by power uprate updates
    - Better guidelines need to be developed

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Regulatory Process

- Guidelines Needed for PWR Uprates
  - Developed by NRR or industry
    - Additional guidance
      - Reaffirm approved methods
      - Transient testing
      - Environmental impact assessment
      - PSA updates
      - Preclude; else identify non-uprate issues earlier
      - Identify confirmatory analyses earlier
      - Specific questions; generic questions
    - Include in submittal content
      - FAC, EQ, MOV program, fire protection program, human factors
      - ATWS

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ANO Recommendations

- Need full 18 months for EPUs
- Submittals should include:
  - Topics in ANO-2 initial submittal, plus:
    - With NRR guidance
      - Detailed environmental impact (12/10/01 RAI)
      - Operation impacts
      - Testing
    - Include more detail in submittal content
      - FAC
      - EQ, MOV program, fire protection, human factors
      - ATWS

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ANO-2 Overview

Additional Topics

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ANO-2 Overview

- Uprate economics favorable
  - ≈ $35-40M → 107 MWe
  - If accomplished 10 times
    - $350- 400M → 1070 MWe
  - Reduces station operating costs
    - Without staff (payroll) reductions
    - Favorable to company, site and community

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ANO-2 Overview

- Design, Licensing Basis & Config. Control
  - Improved
    - Recent reviews
    - Revised analyses
    - Modifications
    - Many examples

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Extended Power Uprate

Martin Parece
Manager, Project Development
Engineering & Licensing

FRAMATOME ANP

Features of the B&W-Designed PWR

Parameter	Value
Number of Loops	2 (2 x 4)
Steam Generator Type	Once-Through
Current Rated Thermal Power, MWt	2544 – 2772
Number of Fuel Assemblies	177
Typical Fuel Cycle Length, Months	24
Reactor Coolant System Flowrate, gpm	352,000 (TDF) 390,000 (Act.)
Operating Pressure, psia	2170
Operating Avg RC Temperature, F	579 - 582
Operating Steam Pressure, psia	925
Steam Exit Superheat, F	55 – 62
Feedwater/Steam Flow, Mlb/hr	10.8 – 11.7

FRAMATOME ANP

Extended Power Uprate Status

> Currently performing NSSS and BOP engineering & analysis to increase Davis-Besse rated power from 2772 MWt to 3014 MWt.

> Target uprate for Spring 2004.

> Other B&W-plant owners considering extended power uprates. No definite plans set. Expect most to do EPU by 2010.

FRAMATOME ANP

Using Experience to Set The Scope

> Reviewed Industry Topical Reports on EPU.

> Reviewed EPU and Calorimetric Uprate Submittals.

> Factored in Heavy Component (RSG) Licensing Experience.

> Framatome ANP Turnkey EPU Projects in Europe.

> Performed Uprate Feasibility Studies With Utilities.

> Set The Scope.

FRAMATOME ANP

Simplified EPU Work Breakdown Structure

> Determination of Operating Conditions
> Fuel Analysis
> Core Mechanical Analysis
> UFSAR Accident Evaluation
> Post-Accident Containment Evaluation
> Evaluate NSSS Structural
> Evaluation of NSSS Components
> Review of Attached Piping
> Review and Update Licensing Documents
> Plant Setpoint Review
> Evaluation of Plant Systems
> Procedure Reviews
> Plant Programs

FRAMATOME ANP

Lessons Learned - NSSS

> Maximum Power of Approximately 3014 MWt

> Limited By Fuel Design Parameters
- Maximum Axial Peaking Limits
- 24 Month Cycle Design
- LOCA PCT & kW/Ft Limits
- Requires Advanced M5™ Cladding

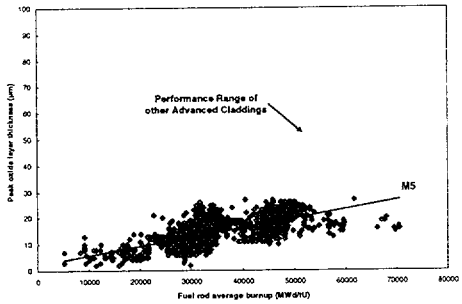
> OTSG Limiting NSSS Component

> Minor Changes to Accident & Containment Analyses

> Some Changes to AFW & ECCS

FRAMATOME ANP

M5™ Provides PWRs with the Lowest Corrosion Rate Available



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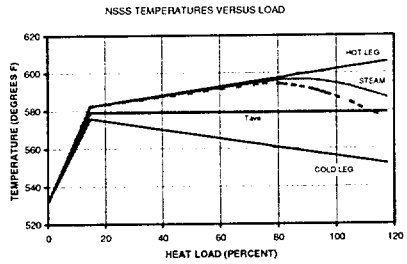
Effect of Tube Plugging On OTSG Superheat



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BOP Lessons Learned

> Usual Suspects Are Limiting For EPU
- HP/LP Turbines
- Generator
- Moisture Separator Reheaters
- Condenser Tubing
- Heater Drain Pumps
- Feedwater Pumps
- Condensate Pumps
- Ultimate Heat Sink

> In Most Cases, Cost of Secondary Plant Upgrades Will Determine The Uprated Power Value

FRAMATOME ANP

Summary

> B&W-Designed NSSS EPU Limited to ~3014 MWt

> Cost of BOP Upgrades Sets Target Value

> FENOC and FRA-ANP Uprating Davis-Besse to ~3014 MWt

> Other B&W Plant Owners Considering EPU. No set plans.

> FRA-ANP Prepared to Support All Fuel Clients For EPU.

FRAMATOME ANP