ARKANSAS NUCLEAR ONE, UNIT 2 (ANO-2)

EXTENDED POWER UPRATE (7.5%)

ACRS THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE MEETING

FEBRUARY 13, 2002

TOM ALEXION, PROJECT MANAGER
PROJECT DIRECTORATE IV, SECTION 1
DIVISION OF LICENSING PROJECT MANAGEMENT

BACKGROUND

- Largest PWR power uprate to date

- SG's replaced in fall of 2000
  - Increased mass
  - Increased primary and secondary volumes
  - Increased number of tubes
  - Tubes made from Alloy 690
  - Increased heat transfer area

NRC STAFF REVIEW APPROACH

- Farley 5% power uprate SE (1998)
- Standard Review Plan
- Acceptable codes and methodologies
- Relied on analysis done for SG replacement
- Requests for Additional Information (RAIs)
- Audits/independent calculations in selected areas

PRINCIPLE AREAS OF REVIEW

- NSSS, ACCIDENT ANALYSIS, AND OTHER DESIGN BASIS EVALUATIONS
- EVALUATION OF SSCs
- BOP SYSTEMS & RELATED EVALUATIONS
- HUMAN FACTORS
- RADIOLOGICAL ANALYSES
- RISK ASSESSMENT OF POWER UPRATE

ORDER OF NRR PRESENTATION

- Reactor Systems Review
- Plant Systems Review
- Mechanical & Civil Engineering Review
- Materials & Chemical Engineering Review
- Radiological Assessment
- Risk Assessment of Power Uprate

SUMMARY OF NRR REVIEW

- When the Draft SE was issued, the only open items were in the dose area

- These items have been resolved; the details will be discussed in the presentation by the appropriate review branch

- Therefore, the NRR staff has no open items

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REACTOR SYSTEMS BRANCH (SRXB)

Chu Liang

SRXB REVIEW AREAS

- RCS, ECCS and Shutdown Cooling Systems
- Fuel Performance
- NSSS Design Transients
- LOCA and Non-LOCA Accident Analyses

SRXB REVIEW PROCESS

- Reviewed Application to Current Licensing Basis
- Verify Plant Modifications meet SRP Acceptance Criteria
- Many Transients and Accidents Previously Reviewed at Uprated Power Levels in Amd. 222, dated 09/29/00 (Steam Generator Replacement)
- Revised Transient and Accident Analyses Reviewed to:
  - Assure use of Approved Codes and Methodologies
  - Results meet Acceptance Criteria in SRP

SRXB REVIEW RESULTS

- All Transient and Accident Analyses met SRP Acceptance Criteria
- All Transient and Accident Analyses were Analyzed using Staff Approved Codes and Methodologies
- All Transient and Accident Analyses Inputs are Conservative and Consistent with TS Limits
- Fuel meets all Design Requirements and Limits

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PLANT SYSTEMS BRANCH (SPLB)

Dave Cullison

PLANT SYSTEMS BRANCH

- Reviewed system design/operation requirements impacted by power uprate to assure agency regulations/guidelines are met under power uprate conditions. Nine NUREG-0800, Standard Review Plan sections used as follows:
  - SRP 6.2.5, Combustible Gas Control in Containment
  - SRP 9.1.3, Spent Fuel Pool Cooling and Cleanup
  - SRP 9.2.1, Station Service Water
  - SRP 9.2.5, Ultimate Heat Sink

PLANT SYSTEMS BRANCH

- Continuation of SRP sections used:
  - SRP 9.2.6, Condensate Storage Facilities
  - SRP 10.2, Turbine Generator
  - SRP 10.3, Main Steam Supply
  - SRP 10.4.7, Condensate and Feedwater System
  - SRP 10.4.9, Auxiliary Feedwater System

PLANT SYSTEMS BRANCH

BOP Systems Affected or Impacted by Power Uprate

- No Significant Impact
  - Fuel Pool System
  - Service Water System
  - Ultimate Heat Sink*
  - Containment Cooling*
  - Turbine
  - Main Steam Supply System
  - Steam Dump and Bypass System

*- Reviewed for steam generator replacement at the uprated power

PLANT SYSTEMS BRANCH

BOP Systems Affected or Impacted by Power Uprate

- No Significant Impact (Continued)
  - Condensate and Feedwater System
  - Emergency Feedwater System
  - Other BOP Evaluations
  - Containment Response Analysis*
  - Control Room Uninhabitability
  - Post-LOCA Hydrogen Generation
  - High Energy Line Break (HELB)*
  - Fire Protection Program

*- Reviewed for steam generator replacement at the uprated power

PLANT SYSTEMS BRANCH

Focus BOP Systems

- Fuel Pool System
  - Evaluated administrative controls that ensure current licensing basis maintained
  - RAI to provide more information on the impact on the fuel pool cooling system of the increased decay heat in unloaded spent fuel
  - Found acceptable
- Service Water System
  - RAI to provide more information on impact of power uprate on system
  - Found that no changes to the safety-related portion of the system are required

PLANT SYSTEMS BRANCH

Focus BOP Systems

- Emergency Feedwater System
  - RAI to determine adequate feedwater available
  - Non-related licensing action to reduce CST Technical Specification levels was withdrawn
  - Technical Specification CST levels adequate
  - No significant impact on the system's ability to perform its function

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MECHANICAL & CIVIL ENGINEERING BRANCH (EMEB)

Kamal Manoly

EMEB REVIEW AREAS

- Components Evaluated
  - Reactor Vessel, Internals, Nozzles and CRDMs
  - Replacement Steam Generators and Nozzles
  - Reactor Coolant Pumps, Pressurizer and Nozzles
  - NSSS and BOP Piping Systems and Supports
  - Safety-Related Valves (MOVs, AOVs, and SRVs)

EMEB REVIEW AREAS (CONTINUED)

- Scope of Review
  - Methodology, Loads
  - Stresses and Cumulative Usage Factors
  - Acceptance Criteria, Codes and Addenda
  - Functionality and Impact of EPU on GL 89-10 for MOVs, GL 95-07 for Pressure Locking and Thermal Binding, GL 96-06 for Over-pressurization of Piping Segments Penetrating Containment

EMEB REVIEW AREAS (CONTINUED)

- Replacement Steam Generators and Nozzles
  - Finite element analysis of the RCS for design basis loadings using the ANSYS computer code
  - Calculated stresses and CUFs for the limiting RSG components and supports compared against allowables
  - Flow-induced vibration on the U-bend tubing within allowable limits (i.e., maximum stability ratio maintained below 0.75 - less than the limit of 1.0, and peak stresses less than material endurance limit)

EMEB REVIEW AREAS (CONTINUED)

- NSSS and BOP Piping Systems and Supports
  - Finite element analysis performed for revised design loads using Bechtel ME101 Code
  - Calculated stresses compared to ASME Code Section III limits
  - CUFs for Class 1 piping calculated based on 60 years and compared to ASME limit of 1.0

EMEB REVIEW AREAS (CONTINUED)

- Flow-Induced Vibration of Main Steam Piping
  - Main steam remains most sensitive system to FIV
  - SWRI study indicated that kinetic energy is driving force behind FIV
  - FIV decreases as a result of power uprate
  - Piping vibration monitoring during startup, according to OM-3, using hand-held devices and walkdown visual inspection of main steam piping inside and outside containment

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MATERIALS & CHEMICAL ENGINEERING BRANCH (EMCB)

Barry Elliot

Systems, Components, Analyses and Programs Reviewed for Power Uprate

- Fuel Pool Purification System
- Chemical Volume Control System
- Containment Spray System
- Leak-Before-Break Analysis
- Primary & Secondary Water Chemistry Program
- Flow Assisted Corrosion Program
- Neutron Fluence & Reactor Vessel Integrity
- Steam Generator Tube Integrity
- Alloy 600 Program

Alloy 600 Program

- Uprate will increase T_{hot} from 604°F to 609°F
- Increase in T_{hot} will not substantially increase PWSCC initiation and growth rates
- Increase in T_{hot} will increase the Susceptibility Ranking of Vessel Head Penetrations (VHPs); However ANO-2 remains in the moderate range
- Potential for PWSCC to develop in Alloy 600 nozzles will not be significantly effected
- No change in Alloy 600 and VHP inspection program

Neutron Fluence / Reactor Vessel Integrity

- Upper Shelf Energy and RT_{PTS} values meet regulatory screening criteria
- Pressure-Temperature Limits and Low Temperature Overpressure System Setpoints will be modified for Uprated Conditions - separate application
- Reactor Vessel meets regulatory requirements

Steam Generator Integrity

- Alloy 690 tubes more resistant to Stress Corrosion Cracking than Alloy 600 tubes
- Degradation of tubes resulting from deposition of copper was eliminated by removing copper from the secondary side
- Redundancy and analysis of vibrational frequency response of anti-vibration bars minimizes wear
- RG 1.121 analysis ensures structural integrity
- No change in tube inspection program

ARKANSAS NUCLEAR ONE, UNIT 2 (ANO-2)

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PROBABILISTIC SAFETY ASSESSMENT BRANCH (SPSB)
Licensing Section - Dose Assessment

Michelle Hart

Dose Assessment Review

- Regulatory Requirements
  - 10 CFR Part 100
  - GDC 19

- Review Conducted in Accordance with Applicable SRP Sections

Accidents Analyzed

- Power Uprate
  - MHA
  - Control Element Assembly Ejection
  - SGTR
  - Fuel Handling Accident
- Steam Generator Replacement (Sept. 2000)
  - Seized Rotor
  - MSLB
  - Feedwater Line Break

Draft SE Open Items

- GDC 19 Review
- SGTR
- Reactor Building Mixing for MHA

GDC 19 Assessement

- Licensee Developed Action Plan to Address Staff Concerns with Control Room Envelope Unfiltered Inleakage Uncertainty
  - Modifications to be Completed Prior to Startup
- New Licensing Basis Inleakage Value Based on Tracer Gas Testing
- Staff Confirmed Acceptability of Inleakage Assumption for MHA, CEA Ejection, FHA & SGTR

SGTR

- Analysis Was Unavailable for Draft SE
- Staff Had Concerns with Distribution of Iodine Isotopes for RCS in Analysis
- Revised Distribution Provided
- Staff and Licensee in Agreement on Use of Distribution

Reactor Building Mixing Issue

- Return Air to Unsprayed Region Assumed Only From Sprayed Region
- Licensee Provided Clarifying Details of Mixing Model
- Staff Concerns Resolved
  - Staff Performed Independent Assessment of Reactor Building Concentration Values
  - Found Comparable to Licensee Values

Dose Results

All EAB and LPZ Doses meet Part 100 & within SRP Dose Guidelines

All Control Room Doses meet GDC 19 & within SRP Dose Guidelines

ARKANSAS NUCLEAR ONE, UNIT 2 (ANO-2)

EXTENDED POWER UPRATE (7.5%)

PROBABILISTIC SAFETY ASSESSMENT BRANCH (SPSB)
Safety Program Section - Risk Assessment

Donald Harrison

ANO-2 EPU

STAFF RISK ASSESSMENT REVIEW

- Licensee Submitted Risk Information for Insights and to Ensure No New Vulnerabilities Created
  - Internal Events
  - External Events
  - Shutdown Operations
  - PRA Quality
- Staff SEs on IPEs and IPEEEs
- Site Review of Fire Analysis and HRA

ANO-2 EPU

OVERALL EPU RISK CONCLUSIONS

- **OVERALL RESULTS**
  - Internal Events CDF ~2E-5/yr ΔCDF ~3E-6/yr LERF ~5E-7/yr ΔLERF ~9E-8/yr
  - External Events (Fires) CDF ~1E-4/yr ΔCDF ~2E-5/yr (Vulnerability Analysis)
  - Shutdown Operations Expect Small Impact
- **LICENSE APPLICATION ACCEPTABLE**
  - Meets Deterministic Requirements
  - No Changes Identified in Management of Risks
  - No New Vulnerabilities Identified
  - Identified Issues Do Not Rebut Presumption of Adequate Protection and Expected Small Risk Increase Does Not Warrant Denial of the License Application

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NRR STAFF CONCLUSION

Tom Alexion

NRR STAFF CONCLUSION

- NRR staff performed extensive review
- No open items
- Application meets applicable regulations
- Acceptable codes and methodologies used
- Reasonable assurance of public health and safety
- NRR staff recommends approval of power uprate

ACRS Thermal-Hydraulic Subcommittee Meeting

Review of ANO-2 Core Power Uprate Request

February 13, 2002

OPEN SESSION

Entergy

Introduction

Rick Lane

Entergy

Introduction

- **Presenters (Entergy)**

  Milton Huff
  Bryan Daiber
  Rich Swanson
  Dale James
  Jamie GoBell

Entergy Support Staff

Doyle Adams
Glenn Ashley
Dennis Boyd
Dan Fouts
Mike Krupa
Tommy Morrison
Dan Spond
Roger Wilson

Westinghouse Support Staff

Joe Cleary
Mehran Golbabai
Karl Haslinger
Kim Jones
Ralph Surman
Tom Watson

Entergy

Introduction

- Project goals
  - Safely uprate ANO-2 by performing analyses and modifying the plant as required to support 7.5% uprate
  - Maintain adequate operating / design margins
  - Use accepted methodology
  - One cycle of operation with several modifications

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Introduction

- Project Team
  - Entergy staff performed the A/E function that included the system evaluations and modifications to support the uprate
  - Utilized some contractor staff augmentation but Entergy engineers had lead oversight

Entergy

Introduction

- Project Team
  - NSSS analyses were performed by Westinghouse, formerly Combustion Engineering (CE). CE is the original equipment manufacturer and fuel supplier
  - Total engineering effort is approximately 130,000 manhours

Entergy

Introduction

- Project Overview
  - 7.5% Uprate of ANO-2
  - Replacement steam generators (RSGs) installed in 2R14 supports increase
  - Containment building design pressure increased in 2R14 supports uprate
- Implementation schedule
  - 2R15 Outage, Spring 2002

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Introduction

- Reactor Design Rating
  - Original reactor core design = 2815 MWt
  - Post 2R15 (Uprated) reactor core design = 3026 MWt (7.5 %)
  - First request for design re-rate

Entergy

Introduction

- Compliance with regulatory requirements
  - Submittal prepared using guidelines from:
    - Westinghouse topical WCAP-10263, "A Review Plan for Uprating the Licensed Power of a PWR Power Plant"
    - Guidance from GE topical NEDC-31897P-A, "Generic Guidelines for GE BWR Extended Power Uprates"
    - SECY-97-042, Section 3, "Power Uprate Review Process"
    - Farley uprate submittal

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Introduction

- Demonstrated compliance with applicable regulations/safety limits
  - Analyses Performed
    - Reactor operating conditions, accidents, and transients
    - Radiological consequences
    - Probabilistic risk
    - Programmatic evaluations

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Plant Changes to Accommodate Power Uprate

Milton Huff

Entergy

Plant Modifications

- Site Modification Approach
  - All modifications accommodate 7.5% power uprate conditions
  - Modifications implemented over four cycles
  - Early implementation of modifications provided validation of performance prior to uprate
  - Majority of major modifications are installed

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Plant Modifications

- Modifications installed to date
  - Replacement steam generators
  - Condenser
  - Moisture separator reheaters
  - High pressure turbine
  - Low pressure turbines

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Plant Modifications

- Modifications Installed to date **(cont'd)**
  - Generator rewind
  - Hydrogen coolers
  - Stator piping
  - Containment cooling fan pitch change
  - Containment chilled water coils for normal cooling

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Plant Modifications

- Modifications to be installed prior to power uprate (Cycle 16)
  - Stator water heat exchanger
  - Isophase bus cooling fans
  - Heater drain pumps

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Plant Modifications

- Setpoint changes
- Equipment / structure re-rates to support power uprate
  - Feedwater heaters
  - Containment uprate
- approved under previous licensing amendment

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Plant Modifications

Conclusion

Balance-of-plant structures, systems and components acceptable for power uprate by either modification or evaluation

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Plant Changes to Accommodate Power Uprate

Bryan Daiber

Entergy

Plant Modifications

- Fuel Design
  - ANO-2 Cycle 16 (First Thermal Uprate Cycle)
    - Standard 16x16 fuel design
    - 177 total assemblies
    - 80 fresh assemblies being added
    - Changing burnable poison
    - Increasing Tcold 2 °F from Cycle 15
    - Reducing Radial Peaking

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Plant Modifications

- Fuel Design changes
  - Change in Integral Burnable Absorber
    - currently using Gadolinia
    - Cycle 16 will use Erbia
  - Benefit of Erbia
    - More dilute poison, more evenly distributed
    - Less Adverse Response to transients (Control Element Assembly withdrawal events)
    - Better moderator temperature coefficient control
    - Better power peaking

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Plant Modifications

- Comparison to Previous Cycles

Parameter	Cycle 14	Cycle 15	Cycle 16
Burnable Poison	Gadolinia	Gadolinia	Erbia
Reload Batch Size, #	80	68	80
Cycle Length, Effective Full Power Days (EFPD)	557	491	485
Radial Peaking Factor, Fr	1.56	1.56	1.44
Tcold, °F	545	549	551
RCS Flow, % of design flow	104.5	106.5	106.5

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Plant Modifications

Conclusion

Fuel Design Verified to be Acceptable at Uprated Power Conditions

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Boric Acid Makeup (BAM) Tank Concentration

- BAM Tank Limiting Analysis, Consistent with CEN-366
  - Modes 1, 2, 3 and 4 (power operation to Hot Shutdown)
    - Cooldown without letdown
    - Cooldown starts at 26 hours after shutdown coincident with Xenon decay
    - Loss of offsite power assumed
    - Based on End of Cycle (EOC) zero initial boron in RCS
    - Maintain 5% shutdown margin
    - Most negative moderator temperature coefficient (MTC)

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BAM Tank Concentration

- Mode 5 and 6 (Cold Shutdown & Refueling)
  - Cooldown from 200 °F to 135 °F
  - Maintain 5% shutdown margin
  - BAM Tank minimum required level increased slightly, 31% to 36%

- Results
  - More Negative MTC Increases Requirements
  - Margin Added in Conversion to Indicated Level
  - BAM Tank concentrations of 2.5 w/o up to 3.0 w/o removed

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BAM Tank Concentration

Conclusion

BAM Tank Levels
and Concentrations
are Acceptable

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Pressure / Temperature Limits

- Reactor Vessel PT Limits
- October 25, 2001, submittal contained:
  - Specimen analysis of the vessel surveillance specimen removed during 2R14 at ~15.5 EFPY
  - New Technical Specification pressure / temperature limits out to 32 EFPY. Includes power uprate conditions

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Pressure / Temperature Limits

- Fluence Determination
  - Methodology described in BAW-2241P-A, Rev. 1
  - Estimated the fluence based on anticipated power uprate conditions
- Results
  - Opens operating space

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Pressure / Temperature Limits

Conclusion

New PT Curves are Acceptable For Power Uprated Conditions

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Compliance with Regulatory Requirements

Bryan Daiber

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Compliance with Regulatory Requirements

- Analysis Performed
  - Used Approved Methods or Current Methodology
    - Containment, LOCA, Chapter 15 Events
    - New Applications of Approved Methods
      - LBLOCA, Boric Acid Precipitation, Offsite Release, and Control Room Dispersion Factors
- New Methods
  - Feedwater Line Break - Credit low level trip on the affected steam generator

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Compliance with Regulatory Requirements

- Analysis Performed
  - Verified Compliance with all Applicable Regulatory Guidance and Acceptance Criteria
  - Application of NRC Approved Methods have been Verified to be in Compliance with the Limitations and Constraints

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Compliance with Regulatory Requirements

Conclusion

Verified Compliance with all Applicable Regulatory Guidance, Acceptance Criteria and SER Limitations and Constraints

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Plant Margins

- Balance of Plant
  - Reviewed systems for Design Requirements and verified adequate margins
    - Electrical Power - Grid Stability, Main Generator, Transformers, EDGs, and Alternate AC
    - Steam and Power Conversion - Turbine, Main Steam Supply, Water Chemistry, Steam Dump and Bypass System, Condensate and FW, and EFW
    - Auxiliary Systems - SFP, SW, Ultimate Heat Sink, Containment cooling, and SDC
  - Implemented Modifications as Necessary to restore margin

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Plant Margins

- NSSS
  - Reviewed systems for Design Requirements and verified adequate margin
    - Reactor Coolant System
    - Chemical and Volume Control System
    - Safety Injection Systems
    - Shutdown Cooling System
  - No Modifications Necessary

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Plant Margins

- Control Systems
  - Reviewed systems for Design Requirements and verified adequate margin
    - Pressurizer Pressure Control
    - Pressurizer Level Control
    - Feedwater Control System
    - Steam Dump and Bypass Control System
    - Plant Protection Systems (RPS & ESFAS)
    - Plant Monitoring Systems (COLSS and CPCs)
  - Adjusted Setpoints As Necessary

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Plant Margins

- Containment
  - Increased Design Pressure from 54 psig to 59 psig
    - Verified equipment operation
    - Changed pitch on containment fans - require 2 fans
  - Integral flow restrictor nozzle
  - Installed Containment Spray Actuation Signal (CSAS) to isolate FW and Steam
    - Trip hardened relays
- Fuel Design
  - Erbia Poison

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Plant Margins

Conclusion

The Plant was Reviewed and Adequate Margin is Available at Power Uprated Conditions

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Review Issues

Bryan Daiber

Entergy

Anticipated Transient Without Scram (ATWS)

Bryan Daiber

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ATWS

- ATWS Event Response for Uprate Conditions
  - ANO-2 complies with the ATWS rule 10CFR50.62 with its Diverse Scram System / Diverse Turbine Trip (DSS / DTT) and Diverse Emergency Feedwater Actuation System (DEFAS)
  - Power Uprate did not affect the system design functions (hardware, operator interface, system logic, etc.)

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ATWS

- ATWS Event Response for Uprate Conditions (con't.)
  - DSS /DTT Setpoint Philosophy :
    - Setpoints and response times coordinate with Plant Protection System (PPS) hi pressurizer pressure setpoint to ensure DSS/DTT does not actuate before PPS. Additionally, DSS/DTT must actuate before lifting pressurizer safeties.
    - Existing setpoints and response times were maintained for uprate

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ATWS

- ATWS Event Response for Uprate Conditions (con't.)
  - DEFAS Setpoint Philosophy :
    - Setpoints and response times coordinate with Plant Protection System (PPS) Emergency Feedwater Actuation (EFAS) low SG level actuation function to ensure DEFAS does not actuate before plant protection system (PPS) actuates (i.e., level setpoint < PPS)
    - Existing setpoints and response times were maintained for uprate (Note: Time delay setting changed for SG replacement during 2R14)

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ATWS

Conclusion

ANO-2 Design Regarding ATWS Remains Effective for Uprated Power

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Containment

Containment Response Analysis

- Overview
- Results

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Containment

Overview

- NRC Approved Methods Used
  - Westinghouse - CE Mass/Energy release
  - Bechtel COPATTA code used for containment response
- Results Bounding For Power Uprate
- License Amendment 225

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Containment

Results

- Limiting Single Failure
  - For LOCA - Loss of EDG
  - For MSLB - 0% Power, 1 CS Train Failure
- Limiting Containment Peak Pressure
  - 57.7 psig (both MSLB and LOCA)

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Containment

Conclusion

Peak Containment Pressure is Acceptable

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Operator Training/Impact

Rich Swanson

Entergy

Operator Training/Impact

- Operations oversight
- Review of all modifications and evaluations for impact on operation
- Emergency Operating Procedure impact

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Operator Training/Impact

- Training
  - Simulator changes have been made
  - Two crew training cycles
  - Crews evaluated on the uprated plant prior to outage
- Changes have much less impact than SG Replacement

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Operator Training/Impact

- Controls and Displays
  - Changes minimal or none
    - No physical modifications to control stations
    - No change to format of the Safety Parameter Display System
  - Some display ranges will be re-scaled

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Operator Training/Impact

- Procedures
  - Emergency, Abnormal and Normal Operating
  - No change to type and scope
  - No new procedures
- Emergency Operating Procedures
  - No change to type and nature of actions
  - No new actions

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Operator Training/Impact

- Power Ascension testing
  - Operations involved in development and implementation
  - Test Teams designated to perform testing
  - Experienced

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Operator Training/Impact

- Power Ascension testing
  - Normal testing until 90% of new rating
  - Step up @ 2.5% increments
  - Walkdowns, Control System checks, verify parameters against design
  - All issues will be resolved prior to proceeding

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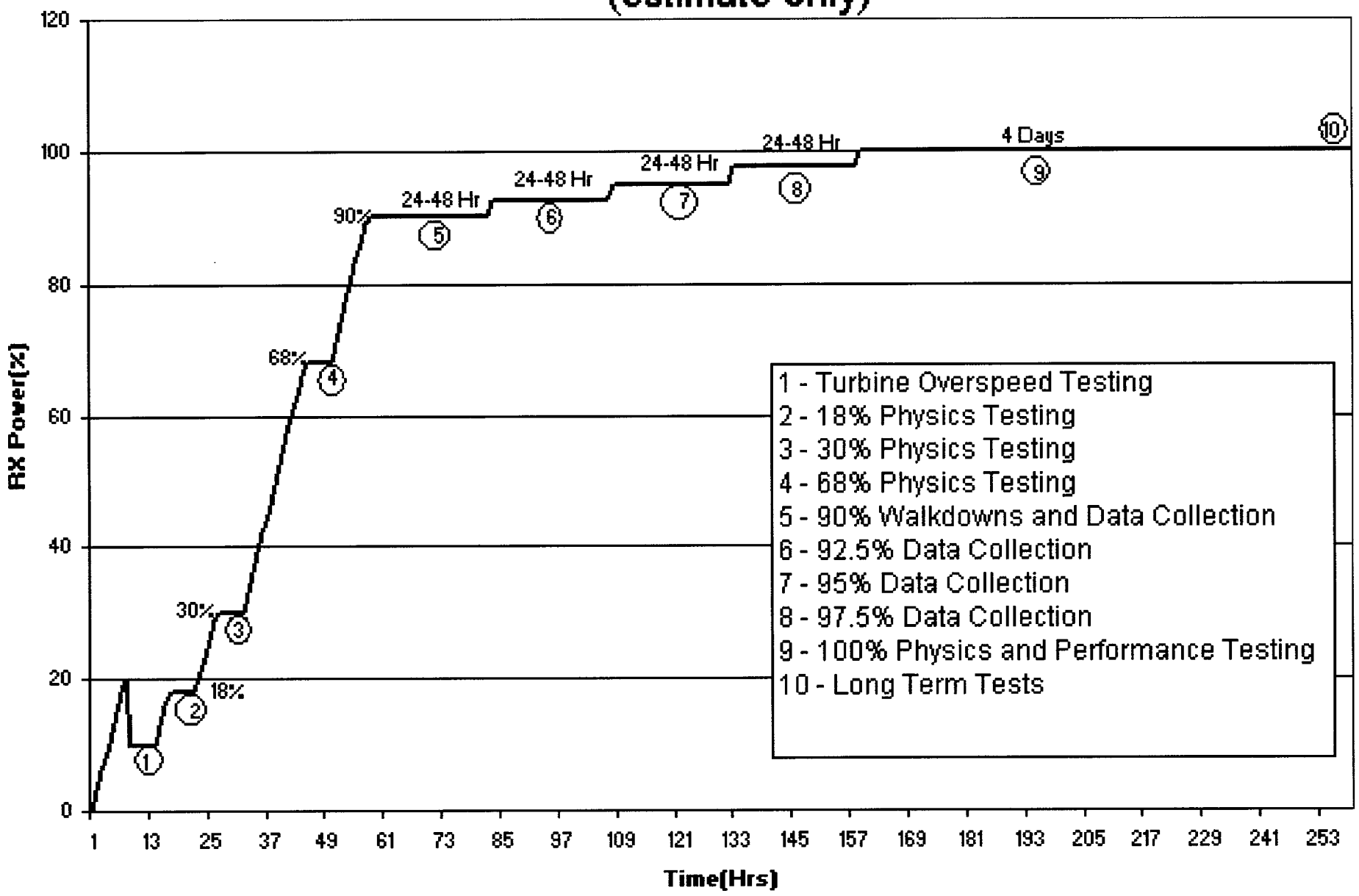
2R15/Cycle 16 Power Ascension Profile
(estimate only)
RX Power[%]
Time(Hrs)
120
100
80
60
40
20
0
1
13
25
37
49
61
73
85
97
109
121
133
145
157
169
181
193
205
217
229
241
253
90%
68%
30%
18%
24-48 Hr
24-48 Hr
24-48 Hr
24-48 Hr
4 Days
1 - Turbine Overspeed Testing
2 - 18% Physics Testing
3 - 30% Physics Testing
4 - 68% Physics Testing
5 - 90% Walkdowns and Data Collection
6 - 92.5% Data Collection
7 - 95% Data Collection
8 - 97.5% Data Collection
9 - 100% Physics and Performance Testing
10 - Long Term Tests

Operator Training/Impact

Conclusion

The impact of power uprate on Operations training, procedures and response times has been evaluated and found to be acceptable

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Alloy 600

Dale James

Entergy

Alloy 600

- Program currently in place to address cracking of small bore and control element drive mechanism (CEDM) nozzles
- Power uprate results in only slight T_{hot} increase 600°-607° $\Rightarrow$ 609°

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Alloy 600

Small Bore Nozzles

- Hot leg nozzles having slightly higher susceptibility to PWSCC, but no change in safety significance
- GL-88-05 walkdowns conducted each hot shutdown
- Bare metal examinations of hot leg and PZR nozzles
- Replace with Alloy 690 material as leakage identified
- Cracking axially oriented and not safety significant
- Preventive repairs of hot leg RTDs and pressure taps implemented in Fall 2000

Entergy

Alloy 600

CEDM Nozzles

- Preliminary Safety Evaluation performed per Materials Reliability Program (MRP) program document - EPRI MRP Report 48
- Ranking time reduced from 17.1 EFPY to 14.2 EFPY
  (t = 0 measured from March 2001)
- ANO-2 continues to fall within moderate category
- 100% NDE planned for 2R15

Entergy

Alloy 600

Conclusion

- Vessel head penetration susceptibility still characterized to be in moderate category even with power uprate
- Programmatic reviews and inspections ensure that Alloy 600 small bore and vessel head penetrations are adequately monitored at ANO

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Flow Accelerated Corrosion

- FAC affects carbon steel components in the steam cycle where process temperatures exceed 200 °F
- Power uprate results in increased flow rates in certain systems
- Power uprate effects evaluated using CHECKWORKS
- All susceptible systems included in study

Entergy

Flow Accelerated Corrosion

- Most recent inspection results included as baseline
- Worst case operating parameters utilized
- Results indicated minimal impact on predicted FAC wear rates
- Piping systems impacted the greatest by power uprate will continue to be monitored to detect any deviation from predicted wear rates

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Flow Accelerated Corrosion

Conclusion

- Evaluation of power uprate conditions indicate minimal impact on FAC wear rates
- Monitoring and replacement activities will continue to assure potential for FAC failures are minimized

Entergy

Steam Generator Tube Integrity

- Replacement steam generators installed in Fall 2000 specifically designed and analyzed for uprate conditions
- Significant design enhancements incorporated to address previous damage mechanisms
  - Alloy 690 TT
  - Increased heat transfer surface area
  - Full depth hydraulic expansion
  - Stainless steel broached tube support plates
  - Sludge collector
  - Improved u-bend support

Entergy

Steam Generator Tube Integrity

- Regulatory Guide 1.121 evaluation confirmed 40% through wall plugging limit
- 100% eddy current inspection to be performed during upcoming refueling in accordance with EPRI guidelines

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Steam Generator Tube Integrity

Conclusion

- Replacement steam generator specifically analyzed and designed for power uprate conditions
- Inspections will ensure steam generator tube integrity

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Piping Analysis

Jamie GoBell

Piping Analysis

- Scope - initiating changes & boundaries
  - Replacement steam generator (RSG)
  - Power uprate
  - Piping inside containment
  - Piping outside containment

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Piping Analysis

- Methodology
  - Piping inside containment
    - validated original design margins
    - rigorous reanalysis at power uprated conditions
    - seismic, deadweight, containment pressure
    - LOCA loads (branch line pipe breaks, asymmetric compartment pressurization)
    - revised design transients

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Piping Analysis

- Methodology
  - Piping inside containment
    - increased cycles for license renewal
    - maintained or improved original code of record and analytical techniques
    - satisfy code stress and fatigue usage requirements

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Piping Analysis

- Methodology
  - Piping outside containment
    - pressure & temperature changes were evaluated relative to the analysis of record using scaling factors for stress and support/nozzle loads
    - dynamic analysis
    - HELB/MELB, missile hazards, FAC, thermal movement, flaw evaluations, expansion joints

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Piping Analysis

Conclusion

- Few modifications required
  - spring load changes to reduce nozzle loads
  - vibration hardening modifications
- Comprehensive review and analysis
- Piping remains qualified for changes

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ECCS Analysis

Bryan Daiber

Entergy

ECCS Analysis

- LBLOCA, SBLOCA, and Boric Acid Precipitation
  - Methodology
  - Assumptions
  - Acceptance Criteria
  - Results

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LBLOCA

- Methodology
  - Cycle 16
    - New Approved Methodology Applied
    - 1999 EM (evaluation model)
    - CENPD-132, Supplement 4-P, Revision 1

      "Calculative Methods for the CE Nuclear Power Large Break LOCA Evaluation Model", August 2000
  - Cycle 15
    - 1985 EM

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LBLOCA

- Assumptions
  - Power level 3087 MWt vs. 2900 MWt
  - Increased LHR 13.7 kW/ft vs. 13.5 kW/ft
  - Increased Range of Safety Injection Tank (SIT) pressure
    - 500/700 psia vs. 550/650 psia
  - Increased Range of SIT Volume
    - 1000/1600 ft^3 vs. 1350/1600 ft^3

LBLOCA

- Results

Break Size	Peak Cladding Temperature (°F)	Maximum Cladding Oxidation (%)
1.0 DEG/PD	2080	6.2
0.8 DEG/PD	2081	6.3
0.6 DEG/PD	2108	6.9
0.4 DEG/PD	2154	7.8
0.3 DEG/PD	2112	6.9

DEG/PD - Double Ended Guillotine Pump Discharge

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LBLOCA

- Comparison to Cycle 15

Parameter	Criterion	Cycle 15 Results	Cycle 16 Results
Break Size	DEG/PD	0.6	0.4
Peak Cladding Temp, °F	≤ 2200	2029	2154
Max Clad Oxidation, %	≤17	5.4	7.8
Max Core Wide, Oxidation %	≤ 1	0.99	0.99
Coolable Geometry	Yes	Yes	Yes

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SBLOCA

- Methodology
  - Used Current Analysis of Record Methodology
  - S2M
  - CENPD-137, Supplement 2-P-A

  "Calculative Methods for the ABB CE Small Break LOCA Evaluation Model", April 1998.

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SBLOCA

- Assumptions
  - Power level 3087 MWt vs. 2900 MWt
  - Increased LHR 13.7 kW/ft vs. 13.5 kW/ft
  - Increased Range of SIT pressure
    - 500 psia vs. 550 psia
  - High Pressure Safety Injection (HPSI) flow unchanged

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SBLOCA

- Results

Break Size	Peak Cladding Temperature (°F)	Maximum Cladding Oxidation (%)	Maximum Core-Wide Cladding Oxidation (%)
0.03 ft^2PD	1842	3.3	<0.43
0.04 ft^2/PD	2066	10.8	<0.67
0.05 ft^2/PD	1882	10.6	<0.63
0.04 ft^2/PD (1)	2090	12.5	0.73

PD – Pump Discharge

(1) Limiting break size PCT was corrected due to coding error.

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SBLOCA

- Comparison to Cycle 15

Parameter	Criterion	Cycle 15 Results	Cycle 16 Results
Break Size	ft^2/PD	0.04	0.04
Peak Cladding Temp, °F	≤ 2200	1905[(1)]	2066[(1)]
Max Clad Oxidation, %	≤17	6.68	10.78
Max Core Wide, Oxidation %	≤ 1	< 0.50	< 0.67
Coolable Geometry	Yes	Yes	Yes

(1) Same version of code was used in both cases.

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Boric Acid Precipitation

- Methodology
  - Cycle 16
    - New Approved Methodology Applied
    - CENPD-254-P-A, "Post -LOCA Long Term Cooling Evaluation Model", June 1980
  - Cycle 1
- Plant Specific Assessment

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Boric Acid Precipitation

- Analysis
  - New methods more conservative than Cycle 1
  - Power uprate
  - Miscellaneous input update since Cycle 1

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Boric Acid Precipitation

- Results
  - Hot leg injection initiated at 5 hours results in maximum boric acid concentration of 23.3 wt%
  - Less than acceptance limit of 27.6 wt%
  - EOP guidance - 2 to 4 hours to initiate hot leg injection

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ECCS Analysis

Conclusion

ECCS Analysis Results Are Acceptable

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Resolution of Open Issues

Bryan Daiber

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Resolution of Open Issues

- No current open items
- Draft Safety Evaluation notes some open items with respect to the radiological analyses
  - Due to the timing and review process not resolved before issuance of SER
  - These issues have now been resolved

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Radiological Analyses

- Steam Generator Tube Rupture (SGTR), LOCA and Control Room Doses
  - Issue
  - Resolution

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SGTR Dose

- Issue
  - The operator response time was increased from 30 minutes in the License Application to 60 minutes in the Supplements
- Resolution
  - Acceptable results to the NRC staff have been presented in the supplemental information

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LOCA Dose

- Issue
  - The NRC Staff questioned the rate of exchange of air from the sprayed to unsprayed regions in containment due to forced flow.
- Resolution
  - Acceptable supplemental information describing the containment layout with respect to the containment fan intake and discharge has been provided to the Staff.

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Control Room Dose

- Issue
  - November 2001 control room envelope integrated inleakage testing showed inleakage of approximately 134 scfm, which is greater than the analysis assumption of 10 scfm.
  - Resolution
  - Acceptable control room doses based on 61 scfm have been submitted to the Staff
  - Commitment made to replace seal on VSF-9 (control room emergency ventilation fan and filter), reduces inleakage by 45 scfm
  - Commitment to prevent pressurization of north wall due to 2VEF-56 fan discharge (switch gear room cooling fan), reduces inleakage by 49 scfm

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Resolution of Open Issues

Conclusion

No Open Issues

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ANO-2 Power Uprate Risk Impact Assessment

Bryan Daiber

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ANO-2 Power Uprate Risk Impact Assessment

- Quantitative impact on at-power risk:
  - Impact on internal events core damage frequency (CDF)
  - Impact on internal events large early release fraction (LERF)
  - Impact on fire vulnerability

- Qualitative impact on at-power risk:
  - Impact on seismic vulnerability
  - Impact on other external events

    (High winds and tornadoes, external flooding, transportation, and accidents at nearby facilities)

- Qualitative impact on shutdown risk

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Current Models

- Started with latest Level-1 plant model
  - 1997 plant model
- Started with latest LERF model
- Started with latest available fire assessment
  - Updated initiating event frequencies
  - Original P2 values
- Started with latest IPEEE (seismic, external events)

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Impact on Internal CDF

- Initiating events & frequencies
- Success criteria
- Component failure rates
- System fault tree analysis
- Operator responses

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Initiating Events & Frequencies

- Reviewed initiating events & frequencies
  - No new initiators identified
  - No increase in initiator frequency
  - No changes required; current model applicable to uprate

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Success Criteria

- Reviewed the Accident Sequence model and success criteria
  - Only one change identified for LBLOCA
    - 2 of 4 HPSI valves to 3 of 4 for uprate
    - long term recirculation
  - CENTS analyses were performed for selected accident scenarios
  - Fault tree top logic updated for LBLOCA effect

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Component Failure Rates

- Component failure rates were reviewed
  - Equipment verified to operate within design limits
  - Modifications were made to improve performance of certain equipment and systems
  - Existing monitoring programs will account for additional wear
  - No adverse effects

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System Fault Tree Analysis

- Plant modifications reviewed for impacts
- System fault trees updated as necessary
  - CSAS actuation logic to main feedwater and main steam isolation valves added to model

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Operator Responses

- Reviewed the operator actions
- CENTS used to quantify the effect of uprate (available time for operator action)
- Incorporated new times into the human reliability analysis (HRA) models

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Level 1 CDF Quantification

- Two PSA models developed
  - pre-uprate, 2A
  - post-uprate, 2B
- Quantified both cases
- Reviewed and Compared results
- Change in CDF (2.7 E-6, 16%)
  - pre 1.70 E-5 /rx-yr
  - post 1.97 E-5 /rx-yr
- Within Region II (small changes)

  Reg Guide 1.174

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LERF

- Started with Level 1 Results from 2A & 2B
- Applied IPE based LERF factors
  - IPE level II assessment is limited scope
  - current level II plant damage state binning factors applied
  - minimal impact to plant damage state binning factors
- Change in LERF (9.3 E-8, 24%)
  - pre 3.87 E-7 /rx-yr
  - post 4.80 E-7 /rx-yr
- Within Region III (very small changes)

  Reg Guide 1.174

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Internal Fire Analysis

- Initiating Event Frequencies
  - Current analysis for combustible loading not affected by uprate
- Component Failure Rates
  - No adverse effect
- Success Criteria
  - No change - minimal impact
- Operator Actions
  - CENTS analysis used to address available time for operator action

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Internal Fire Analysis

- Vulnerability analysis based on EPRI FIVE methodology - screening approach on each fire zone
- Reviewed unscreened zones

  (CDF > 1E-6 /rx-yr)
- No new vulnerabilities or insights identified

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External Events

- Seismic
  - Seismic margin analysis
  - Power level does not affect equipment survivability nor equipment response
  - Power uprate does not modify safe shutdown pathway
  - Seismic risk not impacted

Other External Events
(High Winds/Tornadoes, External Flooding, and Transportation)

- High Winds / Tornadoes
  - No impact due to power uprate
- External Flooding
  - No Impact due to power uprate
- Transportation and Nearby Facility Accidents
  - No impact due to power uprate

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Shutdown Risk

- Qualitative Assessment Using Questions from Standard Review Plan (SRP)19
  - Small decrease in available operator action time during shutdown
  - Maintaining adequate defense-in-depth for shutdown safety functions via the Shutdown Operations Protection Plan (SOPP); minimizes impact of decreased available time
  - No unique or significant impacts

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Risk Evaluation

No unique or significant impacts on:

- Level 1 Internal Events Frequencies
- Component Failure Rates
- IPEEE Internal Fire Analysis
- IPEEE Seismic Analysis
- IPEEE Other External Events Analysis
- Shutdown Risk
- Level-1 CDF
- LERF

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Concluding Remarks

Rick Lane

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