EXTENDED POWER UPRATE REVIEW STANDARD

NRR Briefing for

Advisory Committee on Reactor Safeguards

Subcommittee on T/H Phenomena

August 19, 2003

OPENING REMARKS

William H. Ruland

SES Program Champion for Power Uprates

Division of Licensing Project Management

Office of Nuclear Reactor Regulation

MEETING AGENDA (Morning Session)

- Opening Remarks - W. Ruland
- Development of RS-001 - M. Shuaibi
- Containment Review Considerations - R. Lobel
- Mechanical Engineering - K. Manoly
- Plant Systems - J. Tatum
- Risk Evaluation - D. Harrison

MEETING AGENDA (Afternoon Session)

- Materials Engineering - T. Sullivan
- Reactor Systems - S. Peters
- Human Factors - R. Eckenrode
- Power Ascension & Testing - K. Coyne
- ACRS and Public Comments - M. Shuaibi
- Closing – W. Ruland

DEVELOPMENT OF RS-001

Mohammed Shuaibi
Lead Project Manager for Power Uprates
Project Directorate III-1
Division of Licensing Project Management

DEVELOPMENT OF RS-001

- Background
- Purpose of a Review Standard
- Development of the EPU Review Standard
- Contents of the EPU Review Standard

BACKGROUND

- Maine Yankee Lessons Learned
- Template Safety Evaluations
- SECY-01-0124, dated July 9, 2001
- Commission Meeting with ACRS, December 5, 2001
- ACRS Letters on EPU Reviews
- SECY-02-0106, dated June 14, 2002

BACKGROUND (Continued)

- ACRS Meeting, July 2002
- ACRS Meeting, December 2002
- Issued RS-001 for Public Comment, December 2002
- Comment Period, December 2002 to March 2003
- Evaluated Public Comments and Finalized RS-001
- Briefing ACRS on RS-001, August/September 2003

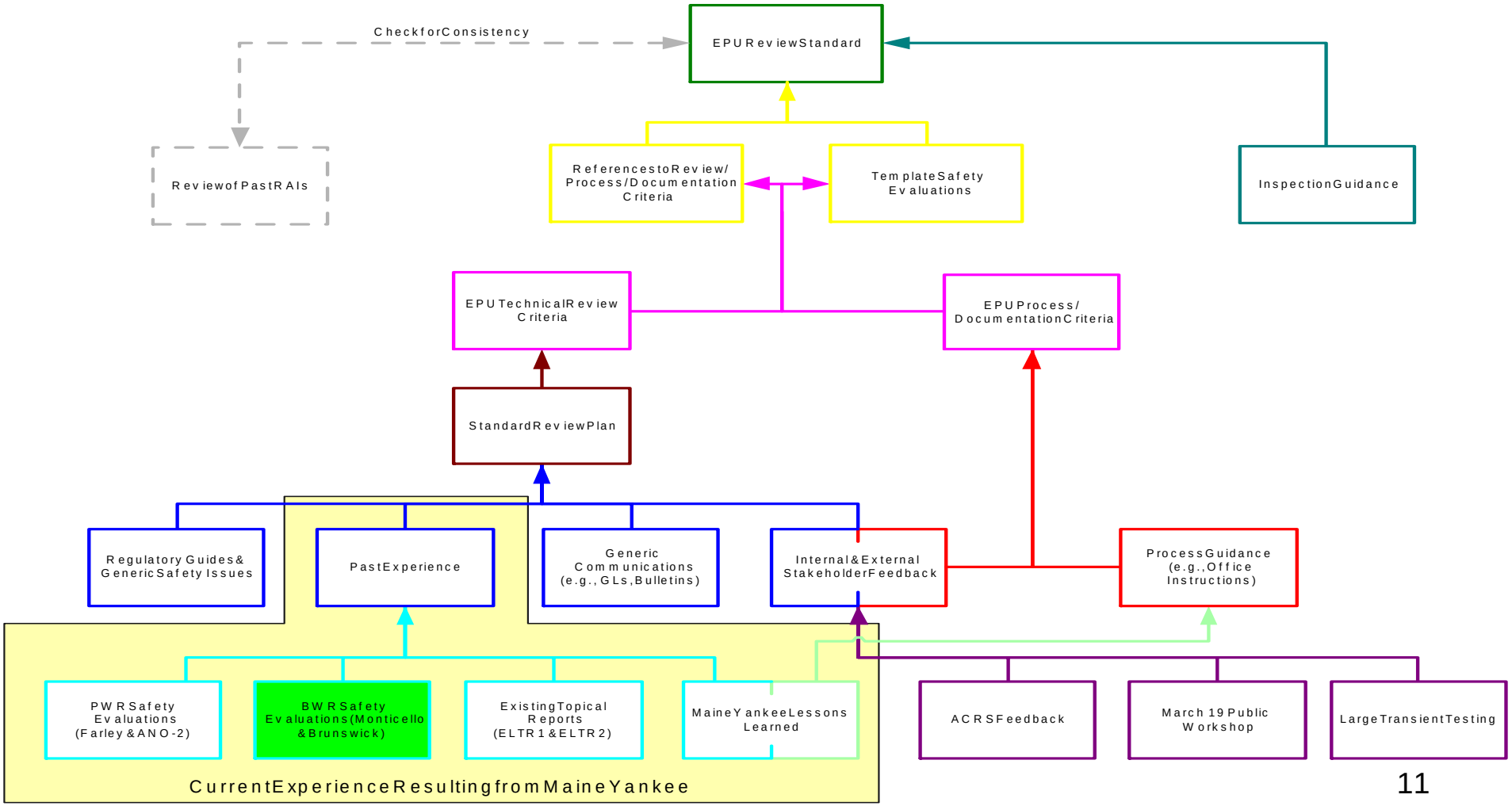
PURPOSE OF A REVIEW STANDARD

- **Provide:**
  - **Comprehensive Guidance**
  - **Mechanism for Retention of Institutional Knowledge**
  - **Technical Review Criteria and Procedural Guidance**
  - **Updated Guidance**

PURPOSE OF A REVIEW STANDARD (Cont'd)

- Increase Effectiveness and Efficiency of Reviews by:
  - Implementing NRR's Vision for Centralized Work Planning
  - Improving Focus, Consistency, Completeness, and Thoroughness of Reviews
- Improve Documentation of Reviews

DEVELOPMENT OF RS-001



CONTENTS OF RS-001

REVIEW STANDARD FOR EXTENDED POWER UPRATES

CONTENTS OF RS-001

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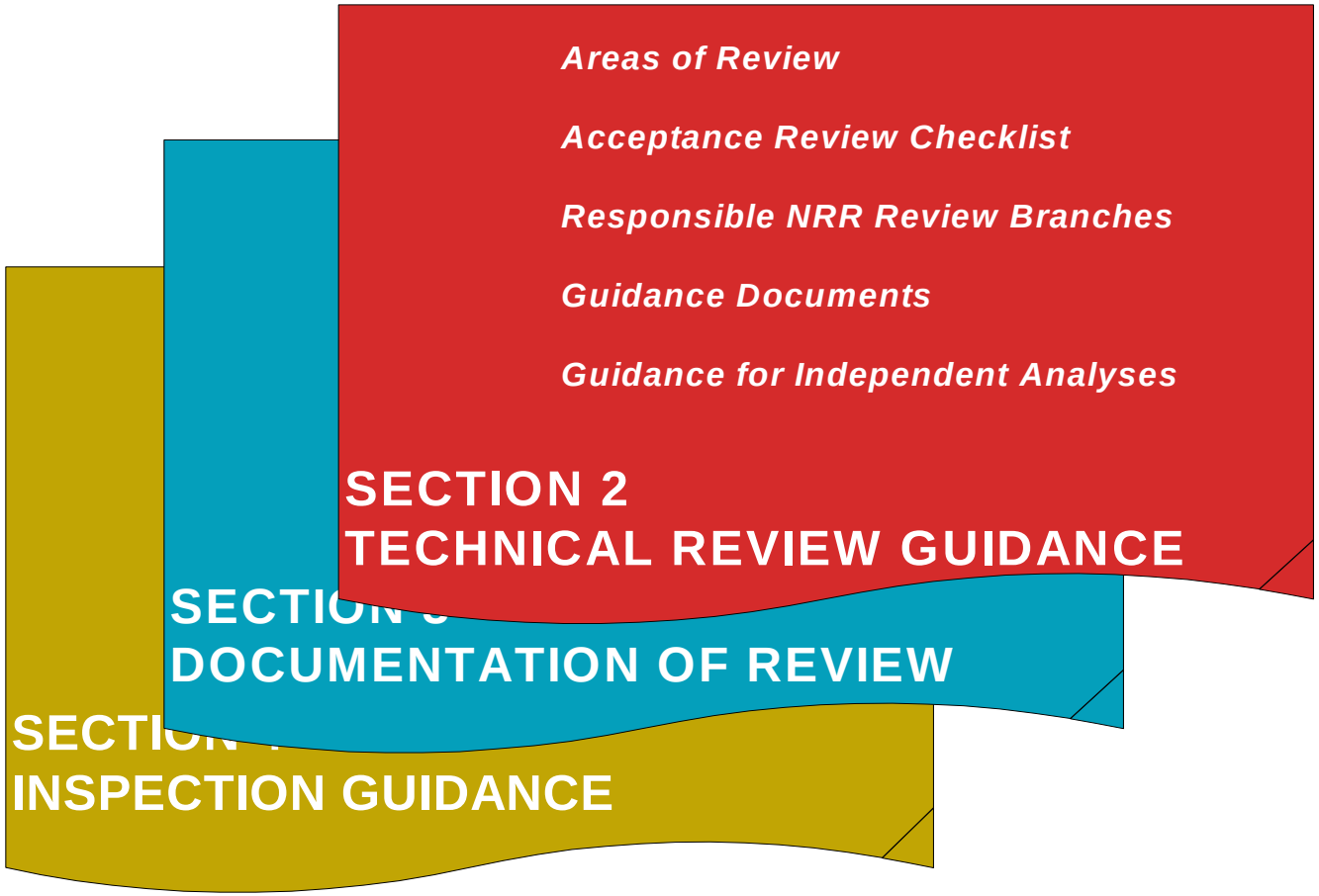
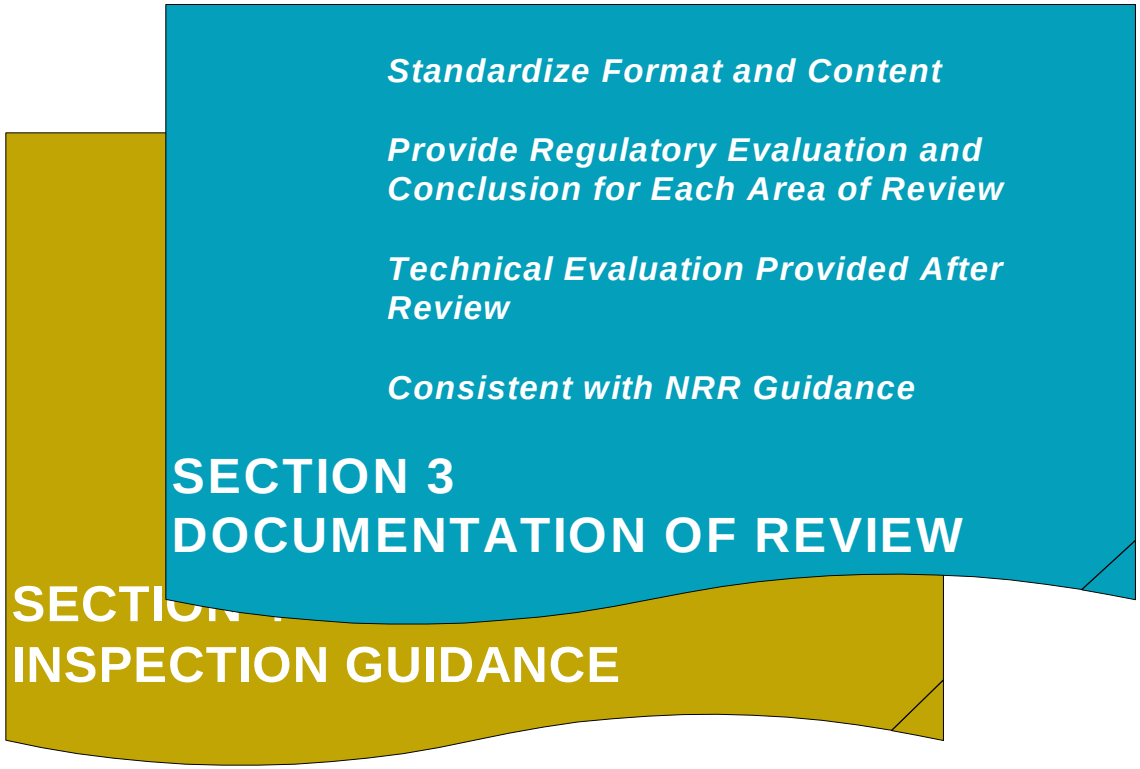


CONTENTS OF RS-001



CONTENTS OF RS-001

Inspection Procedure for Power Uprates

Documentation Highlights Recommended Areas for Inspection

SECTION 4
INSPECTION GUIDANCE

CONTAINMENT REVIEW CONSIDERATIONS

Review Guidance - Matrix 6

BWR Safety Evaluation - Insert 6

PWR Safety Evaluation - Insert 6

Richard Lobel

Containment & Accident Dose Assessment Section

Probabilistic Safety Assessment Branch

Containment Review Considerations

Scope of Review

- Peak Containment Pressure and Temperature Analyses
  - LOCA
  - MSLB
- Subcompartment Analysis
- Combustible Gas Control
- Containment Heat Removal
  - Containment Spray System
  - Containment Fan Cooler System

Containment Review Considerations

Scope of Review - Continued

- Minimum Containment Pressure
  - Input to 10 CFR 50.46 LOCA Analysis
- Net Positive Suction Head
- Environmental Qualification Envelope
- BWR Suppression Pool Hydrodynamic Loads
- BWR Drywell Bypass

Containment Review Considerations

Analytical Methods

BWRs

- Mark I Containment Load Definition Report
- GE Pressure Suppression Containment Analytical Model (NEDO-10320, April 1971)
- GE Mark III Pressure Suppression Containment System Analytical Model (NEDO-20533, June 1974)
- SHEX

Containment Review Considerations

Analytical Methods

PWRs

- COPATTA (Bechtel)
- COCO (Westinghouse)
- LOTIC (Westinghouse)
- TMD (Westinghouse)
- LOCTIC (Stone & Webster)
- CONTRANS (Combustion Engineering)
- GOTHIC (EPRI)

Containment Review Considerations

New Models

- **Necessary to Recover Margin to Accommodate Increase in Power Level**
- **Emphasis on Physical Phenomena Rather than Empirical Correlations**
  - Forced Flow Condensation, Entrainment, Water Aerosols, Droplet Break Flow, Droplet Drop-Out From Atmosphere, Multi-Node
- **Positions Still Being Developed on New Models**
  - Real Effects, Quantification, Conservatism

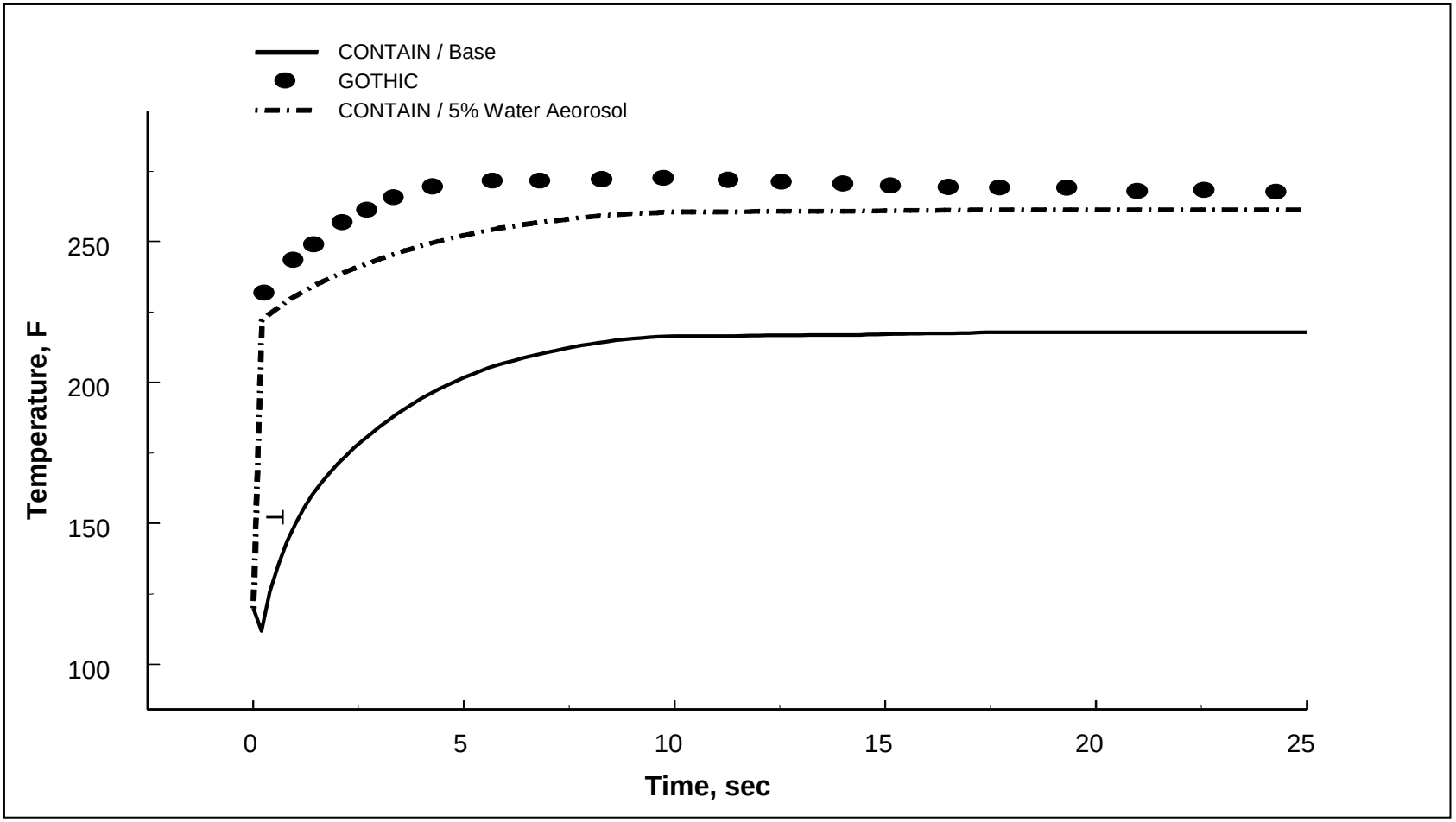
Containment Review Considerations

Independent Calculations

(NRC Uses CONTAIN 2.0)

- Substantial Change in Analyses
- New Application of Method for Plant Type or Power Level
- New Type of Analysis
- First-of-a-Kind Method
- Questionable Use of Method
- Questionable Results
- Significant Reduction in Margin

Containment Review Considerations



MECHANICAL AND CIVIL ENGINEERING

Review Guidance - Matrix 2
BWR Safety Evaluation - Insert 2
PWR Safety Evaluation - Insert 2

Kamal Manoly
Civil and Engineering Mechanics Section
Mechanical and Civil Engineering Branch

Mechanical and Civil Engineering

Scope of Review

- Reactor Vessel, Nozzles, and Supports
- Reactor Internal components and Core Support Structures
- Control Rod Drive Mechanisms
- Steam Generator, Nozzles, and Supports (PWR)

Mechanical and Civil Engineering

Scope of Review - Continued

- Reactor Coolant Pump, Nozzles and Supports (PWR)
- Pressurizer, Nozzles and Supports (PWR)
- Reactor Recirculation Pumps and Supports (BWR)
- NSSS and BOP Piping, Components and Supports
- Safety Related Valves (MOVs, AOVs, and SRVs)

Mechanical and Civil Engineering

Technical Areas Reviewed

- Evaluation Methodology and Loadings (including normal, transient and accident loads)
- Calculated Stresses and Cumulative Fatigue Usage Factors
- Acceptance Criteria, Codes and Applicable Addenda

Mechanical and Civil Engineering

Technical Areas Reviewed - Continued

- Functionality and Impact of EPU on Previous Responses to Generic Communication (i.e., GLs 88-11, 89-10, 95-07 and 96-06)
- Impact of EPU on Postulated Pipe Rupture Locations
- Impact of EPU on Dynamic Responses of Structures, and Qualification of Mechanical and Electrical Equipment

Mechanical and Civil Engineering

Flow Induced Vibration

- **Flow Induced Vibration on BWR Reactor Steam Dryers/Separators and Other Reactor Internal Components**

  FW Sparger, Jet Pump, Core Spray Sparger, Core Spray Piping, Fuel Assembly, Dryer Support Brackets, Dryer Guide Rods, Shroud Head Guide Rods, and Instrument Nozzles

- **Flow Induced Vibration on Steam Separators/Dryers Inside PWR Steam Generator (where applicable) and Primary/Secondary Heat Exchanger Tubes (e.g., u-bend tubes)**

Mechanical and Civil Engineering

Flow Induced Vibration - Continued

- Pressure Pulsations due to Increased Recirculation Pump Vane Passing Frequency on BWR Jet Pump Sensing Lines and Jet Pump Riser Brace

- Main Steam Line, Associated Components (including MSIV, PORVs and HPCI and RCIC Isolation Valves) and Attached Piping that may be Susceptible to FIV due to EPU

Mechanical and Civil Engineering

Structural Integrity of BWR Dryer

- Steam Dryer Designed to Maintain its Structural Integrity During a Steam Line Break
- Significant Increase in Steam Flow Rate Due to EPU Conditions
- GE SILs Recommend Visual Inspection of Steam Dryer for any Evidence of Cracking during each Refueling Outage

Mechanical and Civil Engineering

Structural Integrity of BWR Dryer – Cont'd

- In Light of Quad Cities Unit 2 Steam Dryer Failures, Staff will Review Licensee's Actions to Address the Effects of FIV and Acoustic Vibration on Affected Reactor Internal Components

- Staff is Interacting with GE and BWROG to Assess Generic Implications of the Quad Cities Steam Dryer Failures and the Need to Establish Additional Regulatory Actions

Mechanical and Civil Engineering

Pipe Stress Evaluation

- Affected NSSS and BOP Piping Systems, Components and Supports
- Evaluation Methodology, Assumptions, Load Combinations, and Computer Codes
- Flow Induced Vibration due to the Increased MS and FW Flow and Higher FW Temperature for EPU

Mechanical and Civil Engineering

Pipe Stress Evaluation - Continued

- Pipe Stresses and CUFs for the EPU, Acceptance Criteria, Applicable Codes and Standards
- Pipe Support Evaluations for Higher EPU Thermal Loads and the Increased MS and FW Flow
- Pipe Support Modifications (where necessary) to be Completed Prior to Implementation of the EPU

PLANT SYSTEMS

Review Guidance - Matrix 5
BWR Safety Evaluation - Insert 5
PWR Safety Evaluation - Insert 5

James Tatum
Balance of Plant Section
Plant Systems Branch

Plant Systems

Scope of Review

- Flood Protection
- Equipment and Floor Drainage System
- Circulating Water System
- Internally Generated Missiles (Outside Containment)
- Internally Generated Missiles (Inside Containment)
- Turbine Generator
- Protection Against Postulated Piping Failures in Fluid Systems Outside Containment

Plant Systems

Scope of Review - Continued

- Fire Protection Program
- Pressurizer Relief Tank
- Fission Product Control Systems and Structures
- Main Condenser Evacuation System
- Turbine Gland Sealing System
- MSIV Leakage Control System
- Spent Fuel Pool Cooling and Cleanup System

Plant Systems

Scope of Review - Continued

- Station Service Water
- Reactor Auxiliary Cooling Water Systems
- Ultimate Heat Sink
- Auxiliary Feedwater System
- Main Steam Supply System
- Main Condenser
- Turbine Bypass System

Plant Systems

Scope of Review - Continued

- Condensate and Feedwater System
- Gaseous Waste Management Systems
- Liquid Waste Management Systems
- Solid Waste Management Systems
- EDG Fuel Oil Storage and Transfer System
- Light Load Handling System

Plant Systems

Fire Protection Program

(SRP Section 9.5.1 + Suppl. Guidance in RS-001)

- **Review Guidance Supplemented to Include Confirmation of Program Elements NOT Affected by EPU**

- **Review Guidance Supplemented to Caution that Revised Fire Analyses May Be Needed When Less Than Full Capability Systems Are Relied Upon**

Plant Systems

Fire Protection Program - Continued

(SRP Section 9.5.1 + Suppl. Guidance in RS-001)

- Review Guidance Supplemented to Caution that EPU May Impact Post-Fire Safe Shutdown Procedures (e.g., Allowable Time for Operators to Take Action)

Plant Systems

Spent Fuel Pool Cooling

(SRP Section 9.1.3 + Suppl. Guidance in RS-001)

- Review Guidance Supplemented with Resolution of GSI-173A

- Review Guidance Supplemented to Identify Bounding Spent Fuel Pool Cooling Scenarios

Plant Systems

Station Service Water and Reactor Auxiliary Cooling Water Systems

(SRP Sections 9.2.1 and 9.2.2 + GLs 89-13 and 96-06)

- Review Guidance Supplemented to Address Validity of GL 89-13 Programs at EPU Conditions
- Review Guidance Supplemented to Address Waterhammer and Two-Phase Flow Conditions for EPU

RISK EVALUATION

Review Guidance - Matrix 13
BWR Safety Evaluation - Insert 13
PWR Safety Evaluation - Insert 13

Donald Harrison
Safety Programs Section
Probabilistic Safety Assessment Branch

Risk Evaluation

Purpose of Review

- **Verify that Risks Associated with Proposed EPU are Acceptable**
- **Determine if “Special Circumstances” are Created**

Risk Evaluation

Scope of Review

- **Internal Events**
  - Initiating Event Frequencies
  - Component Reliability
  - Success Criteria
  - Operator Actions (HEPs)
- **External Events**
  - Seismic Events
  - Fires
  - High Winds, Floods, and Other Events

Risk Evaluation

Scope of Review - Continued

- Shutdown Operations
- PRA Quality

Risk Evaluation

Guidance

- Matrix 13 in RS-001 and Attachments
- RG 1.174
- SRP Chapter 19
- RIS 2001-02

Risk Evaluation

Independent Calculations/Audits

- Potentially Significant Risk Impact Identified
- Questionable Results
- Questions Regarding PRA Quality
- Augment Non-PRA Methods (e.g., Seismic Margins Analysis)
- Special Circumstances Identified Per Appendix D of SRP Chapter 19

MATERIAL AND CHEMICAL ENGINEERING

Review Guidance - Matrix 1

BWR Safety Evaluation - Insert 1

PWR Safety Evaluation - Insert 1

Edmund Sullivan

Materials and Chemical Engineering Branch

Materials and Chemical Engineering

Scope of Review

- Reactor Vessel Materials Surveillance Program
- Pressure-Temperature (P-T) Limits and Upper Shelf Energy (USE)
- Pressurized Thermal Shock (PTS)
- Reactor Internals and Core Support Materials
- Reactor Coolant Pressure Boundary Materials
- Leak-Before-Break

Materials and Chemical Engineering

Scope of Review - Continued

- Protective Coatings Systems
- Flow Accelerated Corrosion (FAC)
- Steam Generator Tube Inservice Inspection
- Steam Generator Blowdown System
- Chemical and Volume Control System
- Reactor Water Cleanup System

Materials and Chemical Engineering

PTS

(PWRs Only)

- Evaluate Effects of Increased Fluence on RT_{PTS}
- Ensure Calculated RT_{PTS} Complies with 10 CFR 50.61
  - Methodology
  - Screening Criteria
- Ensure Structural Integrity of Reactor Coolant Pressure Boundary

Materials and Chemical Engineering

FAC

(NSAC-0202L-R2)

- Evaluate Effects of Changes in Flow Rates and Thermodynamic Conditions in Piping on FAC Corrosion Rates
- Evaluate Licensee Modeling/Monitoring Programs
- Ensure Structural Integrity of Systems

Materials and Chemical Engineering

Independent Calculations

- RT_{PTS}
- Upper Shelf Energy

REACTOR SYSTEMS

Review Guidance - Matrix 8
BWR Safety Evaluation - Insert 8
PWR Safety Evaluation - Insert 8

Sean Peters
Zena Abdullahi
Reactor Systems Branch

Reactor Systems

Scope of Review

- Fuel System Design
  - Normal Operation and AOOs
    - SAFDLs
  - Non-LOCA Accidents
    - Limited Fuel Failure
  - LOCAs
    - 10 CFR 50.46

Reactor Systems

Scope of Review - Continued

- Nuclear Design
  - Normal Operation and AOOs
    - SAFDLS
  - Reactivity Accidents
    - No RCPB Failure
    - Core Coolability Maintained

Reactor Systems

Scope of Review - Continued

- Thermal-Hydraulic Design
  - Analytical Methodology
  - Thermal-Hydraulic Stability
  - Hydraulic Loads - Core, RCS Components
  - Normal Operations and AOOs
    - Margin of Safety from Fuel Damage
      - DNBR, CHFR

Reactor Systems

Scope of Review - Continued

- **Systems**
  - **CRDM**
  - **RCIC**
  - **RHR**
  - **ECCS**
  - **SLCS**
  - **Overpressure Protection**

Reactor Systems

Scope of Review - Continued

- SRP Chapter 15 Accidents and Transients
  - AOOs, Non-LOCAs, LOCAs
  - Codes and Methodologies
    - Approved for Plant-Specific Applications
    - Implementation Complies with Limitations, Restrictions, and Conditions Specified in Approving SE
    - Assumptions Account for Changes Caused by EPU

Reactor Systems

Scope of Review - Continued

- Other
  - ATWS
    - BWR - Instability
    - PWR - Plants without DSS
  - Spent Fuel/New Fuel Storage
  - Fluence

Reactor Systems

Audits and Independent Calculations

Analyses and Methodologies

- First-of-a-Kind Methodologies
- New Application of Method for Plant Type, Power Level, or Power Density
- Deviations Not Previously Approved
- Applicability Extended Beyond Approved Limits
- Assumptions
- Questionable Results
- Significant Reduction in Margin

HUMAN FACTORS

Review Guidance - Matrix 11
BWR Safety Evaluation - Insert 11
PWR Safety Evaluation - Insert 11

Richard Eckenrode
Operator Licensing and
Human Performance Section
Reactor Operations Branch

Human Factors

Approach for Review

- **Standard Set of Questions Specific to Areas of Interest**
- **Review Guidance**
  - **SRP 13.2.1, “Reactor Operator Training”**
  - **SRP 13.2.2, “Training for Nonlicensed Plant Staff”**
  - **SRP 13.5.2.1, “Operating and Emergency Operating Procedures”**
  - **SRP 18, “Human Factors Engineering”**

Human Factors

Scope of Review

Changes To:

- **Emergency and Abnormal Operating Procedures**
- **Operator Actions Sensitive to Power Uprate**
- **Control Room Controls, Displays, and Alarms**
- **Safety Parameter Display Systems**
- **Operator Training Program and Control Room Simulator**

Human Factors

Sensitive Operator Actions

Describe any new operator actions required as a result of the proposed EPU. Describe changes to any current operator actions related to emergency or abnormal operating procedures that will occur as a result of the proposed EPU.

(i.e., Identify and describe operator actions that will require additional response time or will have reduced time available. Your response should address any operator workarounds that might affect these response times. Identify any operator actions that are being automated or being changed from automatic to manual as a result of the power uprate. Provide justification for the acceptability of these changes.

Human Factors

Reduction in Time Available

- Initial Action Time Screening (ANSI/ANS-58.8)
- Training/Testing Records
- Operating Procedures
- Controls, Displays, and Alarms
- License Examiner Review

Human Factors

Time Response Calculations

(ANSI/ANS-58.8)

Plant Condition	T Diagnosis	+	T Operator	+	n Manipulations
1	(Normal Operations)				
2	5 minutes	+	1 minute	+	n minutes
3	10 minutes	+	3 minutes	+	n minutes
4 and 5	20 minutes	+	5 minutes	+	n minutes

POWER ASCENSION AND TESTING

Review Guidance - Matrix 12
BWR Safety Evaluation - Insert 12
PWR Safety Evaluation - Insert 12

Kevin Coyne/Robert Pettis
Quality and Maintenance Section
Emergency Preparedness and
Plant Support Branch

Power Ascension and Testing

Scope of Review

(New SRP 14.2.1)

- Initial Plant Testing Potentially Invalidated by EPU
- Plant Modifications Necessary to Support the EPU
- Programmatic Aspects Related to Test Program
  - Control
  - Scheduling
  - Sequencing

Power Ascension and Testing

Considerations

- **Initial Plant Testing Invalidated by the EPU**
- **Modifications for Previous EPUs Performed Under 10 CFR 50.59**
- **System/Component Performance Adequately Covered**
  - **Technical Specification Testing**
  - **Quality Assurance Programs**

Power Ascension and Testing

Review Methodology

(Power Ascension Testing - Original Licensing)

- **Identification of Initial Testing Invalidated by the EPU**
  - **Initial Tests Performed at 80% Power or Greater**
  - **Initial Tests Performed at Lower Power Level if Invalidated**

- **All Tests Identified by Above Criteria Must be Performed or Dispositioned in EPU Application**

Power Ascension and Testing

Review Methodology – Continued

(Modification Testing)

- **Demonstrate the Performance of SSCs Important to Safety Meeting All of the Following:**
  - **Performance of SSC is Impacted by EPU Modification**
  - **SSC is Used to Mitigate AOO in Plant's Licensing Basis**
  - **SSC Supports a Function that Relies on Integrated Operation of Multiple Systems and Components**

- **Integral Testing Should be Performed if SSC Cannot be Adequately Tested by Overlapping Individual Components or System-Level Tests**

Power Ascension and Testing

Review Methodology - Continued

(Programmatic Evaluation of Proposed Testing Plans)

- Incremental Approach to Maximum Power Level
- Monitoring of Important Parameters
- Test Acceptance Criteria
- Contingency Plans

Power Ascension and Testing

Review Methodology - Continued

(Review of Proposed Test Exception)

- Previous Operating Experience
- Introduction of new Thermal-Hydraulic Phenomena
- Introduction of new System Interactions
- Conformance with Limitations Associated with Analytical Methods
- Testing Guidance in Vendor Topical Reports
- Risk Implications

ACRS AND PUBLIC COMMENTS

Mohammed Shuaibi
Lead Project Manager for Power Uprates
Project Directorate III-1
Division of Licensing Project Management

PUBLIC COMMENTS

- Draft RS-001 Issued December 31, 2002
- Public Comment Period Closed on March 31, 2003
- Received Three Comment Letters
  - STARS (March 28, 2003)
  - NEI (March 31, 2003)
  - Framatome ANP (May 2, 2003)

Public Comments

Summary

- Backfit/Plant-Specific Licensing Bases
- Burden of Completing Matrices
- Need for Independent Calculations
- Use of Precedent
- Impact on NRC Approved Topical Reports
- Control of Future Changes to RS-001
- Pilot Initial Use

Public Comments

Summary - Continued

- NRC Management Oversight
- Acceptance Review (“Sufficient Detail”)
- Evaluate Resulting Review Cost/RAI Savings
- Need for Review of Non-Licensed Plant Staff Training
- Stand-Alone References Section
- Establishing Standard Application Format
- NRC Fee-Billing Practices

ACRS COMMENTS

- ACRS Reviews Extended Power Uprates
  - Historical Threshold Established as > 5 Percent
  - Staff Proposal to Link ACRS Review to Plant Design Capacity

- Letters on Past EPU Reviews
  - Duane Arnold (October 17, 2001)
  - Dresden and Quad Cities (December 12, 2001)
  - Clinton (March 14, 2002)
  - ANO-2 (March 14, 2002)
  - GE CPPU Topical Report (April 17, 2002)
  - Brunswick (May 10, 2002)

ACRS Comments

Summary

- Documentation
- Communication with Inspection Staff
- Criteria for Independent Calculation
- Standard Review Plan
- Integral Testing
- Transition Reload Safety Analyses
- Need for More Detailed Thermal/Hydraulic Models

ACRS Comments

Summary - Continued

- **Important Areas**
  - **Reduction in Time Available for Operator Actions**
  - **Irradiation-Assisted Stress Corrosion Cracking of Internals**
  - **Flow-Accelerated Corrosion**
  - **Fatigue of Feedwater Piping**
  - **Containment Response**
  - **Local Power Oscillations**
  - **ATWS and ATWS Recovery**

ACRS Comments

Summary - Continued

- Use of Human Reliability Models Not Approved by the NRC
- Ability of PRAs to Model Margin Reduction
- Level of Review of Risk Information/PRA Quality
- RG 1.174 Interpretation Issues

CLOSING REMARKS

William H. Ruland

SES Program Champion for Power Uprates

Division of Licensing Project Management

Office of Nuclear Reactor Regulation