



10 CFR 50.46c Proposed Rule Public Meeting: Day 1

April 29, 2014



Meeting Purpose

- Discuss key elements of the 10 CFR 50.46c proposed rule
- Enhance stakeholder understanding of the proposed rule to inform formal comments on the proposed rule
 - Comment period ends on August 21, 2014



Meeting Purpose (cont'd)

- NRC will not be providing formal comment responses to any oral comments made at this meeting
 - Staff will consider oral comments made in developing the final rule and guidance



Meeting Agenda

1. Opening Remarks
2. Proposed Rule Background and Status
3. Optional Risk-Informed Treatment of Debris Under 50.46c
4. Discussion of Specific Request for Written Comment on Risk-Informed Alternative
5. Industry Overview
6. Lunch
7. Overview of 50.46c Proposed Rule
8. Discussion of Specific Request for Written Comment
8. Industry Overview
9. General Discussion
10. Closing Remarks



PROPOSED RULE BACKGROUND AND STATUS



Rulemaking Purpose

- Revise emergency core cooling system (ECCS) acceptance criteria to reflect recent research findings
- Replace prescriptive analytical requirements with performance-based requirements
- Expand applicability to all fuel designs and cladding materials
- Address concerns raised in two petitions for rulemaking (PRMs): PRM-50-71 and PRM-50-84
- Allow an alternative risk-informed approach to evaluate the effects of debris on long-term cooling
 - This objective was added by SRM-SECY-12-0034, “Proposed Rulemaking – 10 CFR 50.46c: Emergency Core Cooling System Performance During Loss of Coolant Accidents (RIN 3150-AH42)” dated January 7, 2013 (Agencywide Document Access and Management System (ADAMS) Accession No. ML13007A478)



Background

- Advance Notice of Proposed Rulemaking Published
 - August 13, 2009 (74 FR 40765)
 - Requested specific comment on 12 issues/questions
- Proposed rule presented to the Advisory Committee on Reactor Safeguards on January 19, 2012
 - Transcript available in ADAMS under Accession No. ML12032A048



Background (cont'd)

- Proposed rule provided to the Commission in March 2012
 - SECY-12-0034, “Proposed Rulemaking
 - 10 CFR 50.46c: Emergency Core Cooling System Performance During Loss of Coolant Accidents (RIN 3150-AH42) (ADAMS Accession No. ML112520186)
- SRM-SECY-12-0034 issued on January 7, 2013



Next Steps

- 75-day public comment period closes on August 21, 2014
- Address public comments
- Develop final rule
 - Due to the Commission in February 2016 (per SRM-COMSECY-13-0006)
- In parallel:
 - Develop GSI-191-related guidance for risk-informed guidance



Related Activity: Fuel Fragmentation, Relocation, Dispersal

- **Commission direction in SRM-SECY-12-0034:**

The staff should complete its research on fuel fragmentation, relocation, and dispersal, and incorporate any necessary changes before requesting Commission approval of the draft final rule. The staff should inform the Commission if this action is not practicable or has unintended consequences. In this case, the staff should provide the Commission an information paper containing additional details fo the anticipated research into fuel fragmentation, the staff's best judgment of the impact the results of that research could have on the proposed rule, and the staff's best estimate of when final conclusions may be drawn from this work.
- **Public meeting on fuel fragmentation, relocation, and dispersal held on March 13 – 14, 2014**
 - Meeting summary available in ADAMS under Accession No. ML14100A131
- **Next Steps**
 - Continue ongoing research activities and develop technical basis and regulatory recommendation



OPTIONAL RISK-INFORMED TREATMENT OF DEBRIS UNDER 50.46c



Commission Direction in SRM-SECY-12-0034

“Regarding Generic Safety Issue 191, the 10 CFR 50.46c proposed rule should contain a provision allowing NRC licensees, on a case-by-case basis, to use **risk-informed alternatives without an exemption request. Accordingly, the staff should modify relevant sections of the proposed rule.”**



Commission Direction in SRM-SECY-12-0034 (cont.)

“In addition, the Federal Register Notice Section VII, “Specific Request for Comments on the Proposed Rule,” should be revised to solicit stakeholder comments on the proposed provision. In the questions for stakeholders, the staff should also inquire as to whether the provision should contain acceptance criteria or if the acceptance criteria should be remanded to regulatory guidance.”



Risk-informed portion of proposed rule

- Optional
- Compares risk from as-built, as operated plant to hypothetical “clean plant” with no debris
- Follows RG 1.174 approach + additional requirements for reporting, changes / errors, and PRA updates
- Written at a high level. Detailed guidance will be informed by South Texas Project (STP) pilot.



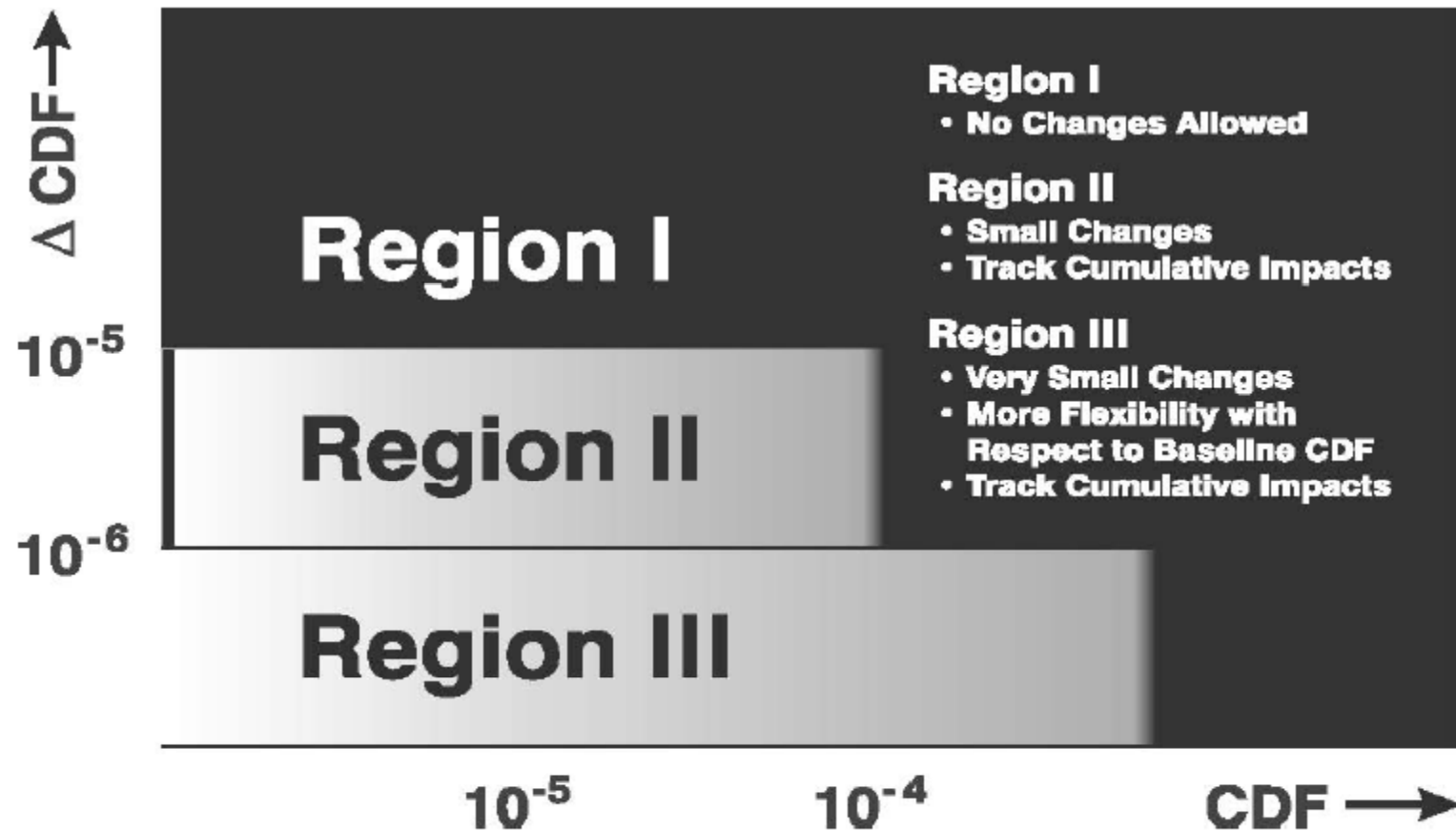
Comparison of as-built, as-operated plant to “clean plant” with no debris

§ 50.46c(e)

The risk-informed approach must:

- (i) Provide reasonable confidence that any increase in core damage frequency and large early release frequency resulting from implementing the alternative risk-informed approach will be small.

RG 1.174 Risk Acceptance Guidelines



(Figure only shows CDF – licensee must also meet analogous LERF guideline)



Rule is risk-*informed*, not risk-based

§ 50.46c(e)

The risk-informed approach must:

- (ii) Maintain sufficient defense in depth and safety margins
- (iii) Consider results and insights from the probabilistic risk assessment (PRA); and
- (iv) Utilize a PRA that, at a minimum, models severe accident scenarios resulting from internal events occurring at full power operation and reasonably reflects the current plant configuration and operating practices....and is of sufficient scope, level of detail, and technical adequacy...and is subjected to a peer review

Additional work needed to define defense in depth and safety margins in the context of proposed rule.



Changes, Errors, Updates

- § 50.46c(m)(4) Updates to risk-informed consideration of debris in long-term cooling.
 - Following changes and errors, update the debris evaluation model, PRA, and supporting analyses to ensure that the acceptance criteria for the risk-informed approach continue to be met
 - No requirement to report changes or errors provided that risk acceptance guidelines continue to be met
 - Even if no changes or errors have been identified, perform confirmatory review at least once every 48 months



Detailed Guidance

- STP submitted a risk-informed pilot on January 31, 2013
 - Supplemented on June 19, 2013
 - Re-submitted on November 13, 2013 (ML13323A128)
- In parallel with review of submittal, staff will develop and publish draft guidance for the risk-informed approach (est. completion March 2015)
 - SRM-COMSECY-13-0006 (ML13130A167) approved decoupling the publication of the draft guidance from the proposed rule



Detailed Guidance (cont.)

- Final guidance will be issued concurrent with the final rule
 - SRM-COMSECY-13-0006 approved the extension of the final rule due date to February 2016
 - Guidance will be developed based on the pilot plant, STP (operating PWR). In the future, revisions or additions to the documents may be needed to provide adequate guidance for other plant designs (i.e., BWRs, new reactors).



Changes to General Design Criteria (GDC)

- Sump conditions (including debris loading) are input to calculations used to demonstrate compliance with several GDC:
 - Criterion 35 – Emergency core cooling
 - Criterion 38 – Containment heat removal
 - Criterion 41 – Containment atmosphere cleanup



Rule Language Highlights (cont'd)

- Changes would allow certain calculations used to demonstrate compliance with the GDC to treat debris in a risk-informed manner.
- The use of risk-informed methodology is optional and is limited to addressing the effects of debris during the long-term cooling period.



Rule Language Highlights (cont'd)

- Criterion 35 – emergency core cooling: The effects of debris on system safety function with respect to long-term cooling may be evaluated in accordance with all requirements applicable to the risk-informed approach in 10 CFR 50.46c.
- Criterion 38 – Containment heat removal: The effects of debris on safety system function with respect to the maintenance of containment pressure and temperature may be evaluated in accordance with all requirements applicable to the risk-informed approach in 10 CFR 50.46c.
- Criterion 41 – Containment atmosphere cleanup: The effects of debris on safety function following occurrence of the postulated accidents may be evaluated in accordance with all requirements applicable to the risk-informed approach in 10 CFR 50.46c.



DISCUSSION OF SPECIFIC REQUESTS FOR COMMENT ON RISK-INFORMED ALTERNATIVE



#4: Acceptance Criteria for Risk-Informed Alternative

- §50.46c(e) contains only high-level acceptance criteria for the risk-informed alternative.
- **Please provide written comment on whether the detailed acceptance criteria should be set forth in §50.46c or in the associated regulatory guidance.**



#5:Regulatory Approach for Risk-Informed Regulation

- The risk-informed alternative in §50.46c uses numeric risk-acceptance criteria as a matter of compliance.
- **Please provide written comment on whether the risk-informed alternative should require licensees to meet numeric risk acceptance criteria, or risk importance insights, or a combination of numeric risk acceptance criteria and risk importance insights.**



#6: Operational Modes Considered in Risk-Informed Alternative

- §50.46c(e)(2)(ii) would require that the risk-informed approach consider all modes of operation (i.e., full power, low power and shutdown).
- **Please provide written comment on whether the risk-informed approach could generically exclude any plant operational modes from consideration. If so, what are the bases for excluding these operational modes?**



#7: Reporting Criteria for the Risk-Informed Alternative

- §50.46c(m)(4) would provide performance-based reporting requirements for the risk-informed alternative that are similar in concept to the reporting criteria in §50.69.
- **Please provide written comments on whether the reporting criteria should be more prescriptive and establish requirements similar to those for the ECCS model. For instance, should the rule establish values for changes in Δ CDF, Δ LERF, defense in depth, and safety margins that would trigger specific actions?**



#8: Exemptions Needed to Implement the Risk-Informed Alternative

- The NRC identified that in order to eliminate the need for an exemption to use the risk-informed alternative, changes may be necessary to GDC 35, 38, and 41.
- **Please submit written comments on whether conforming changes to other regulations would be necessary or desirable and include an explanation of why such changes would be needed.**



OVERVIEW OF 50.46c PROPOSED RULE

(All Topics Except Risk-Informed Alternative)



Expanded Applicability

- § 50.46c achieves rulemaking objective to expand applicability beyond “zircaloy or ZIRLO” to all LWRs
 - Eliminates need for exemption requests for new zirconium alloys
 - Addresses petition for rulemaking (PRM-50-71) submitted by the Nuclear Energy Institute



Performance-based Requirements

- § 50.46c defines principle ECCS performance objectives
 - Core temperature must remain below fuel-specific analytical limits
 - Sufficient capability for long-term cooling

AND

- Requires ECCS demonstration using approved evaluation model (either Appendix K or realistic)



Performance-based Requirements (cont.)

For each fuel design:

1. Define **specific** performance requirements and analytical limits which form the basis of “acceptable core temperature” based upon all established degradation mechanisms and unique features
2. Define **specific** analytical requirements which impact the predicted performance of the fuel under LOCA conditions



Performance-based Requirements (cont.)

Current Fuel Designs:

- Based upon extensive empirical database, including recent findings from High Burnup LOCA Research Program, § 50.46c defines specific performance and analytical requirements for current fuel designs

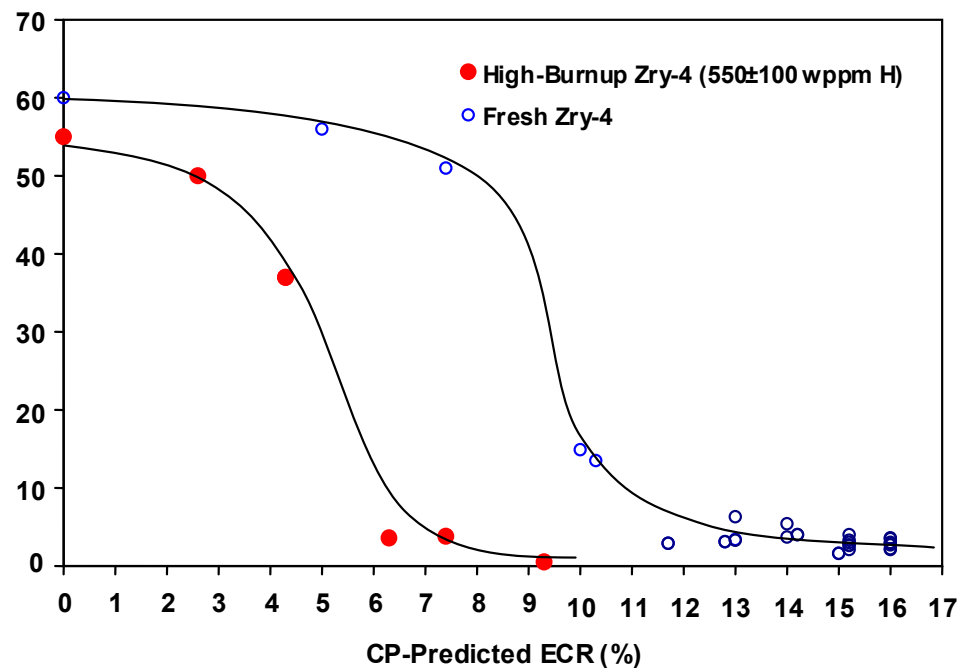
New Fuel Designs:

- Additional research may be necessary to identify all degradation mechanisms and any unique features
- New performance objectives, analytical limits, and analytical requirements would need to be established based upon this research
- Several paragraphs reserved within § 50.46c for future rulemaking on new fuel designs

Research Findings

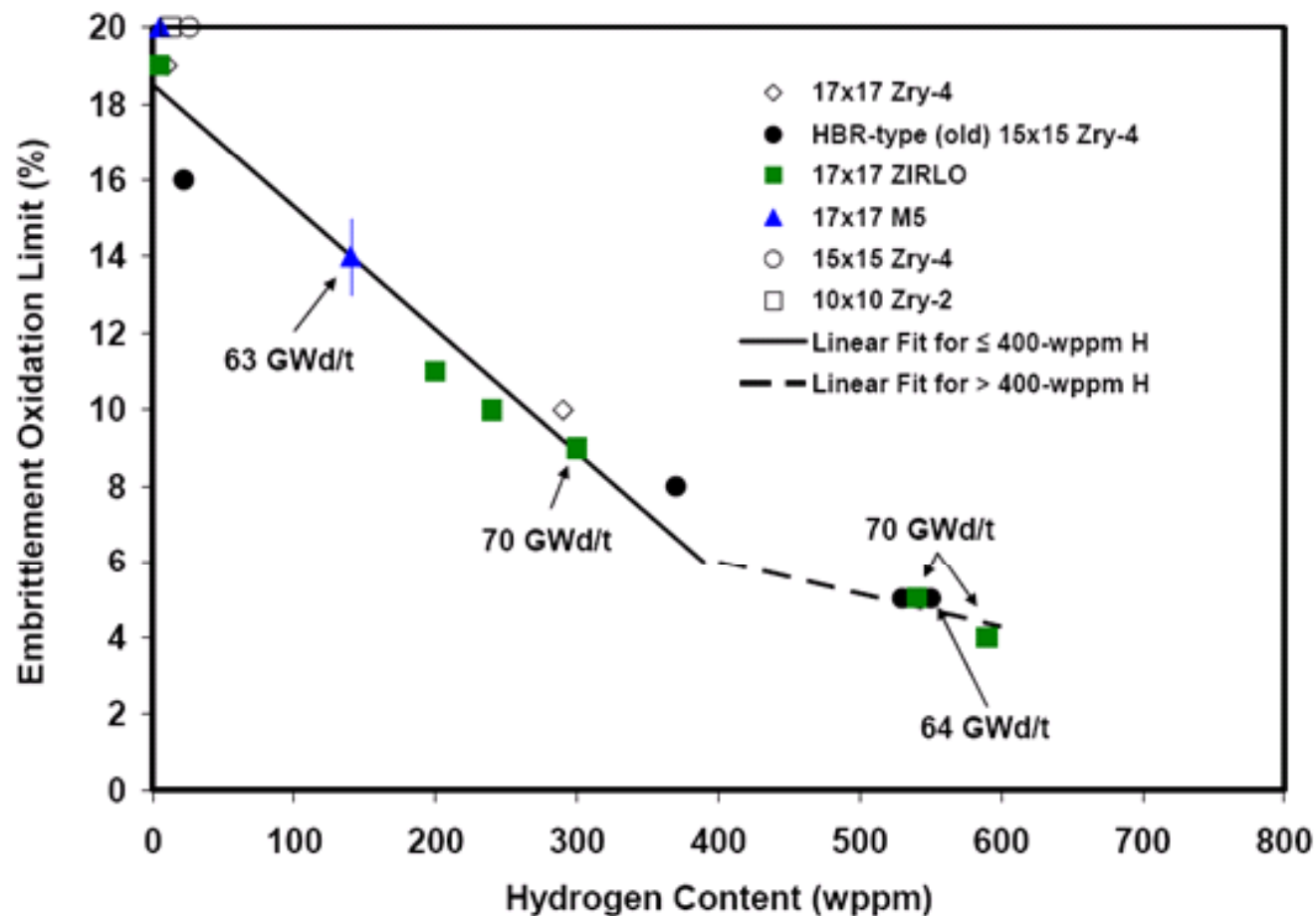
New Embrittlement Mechanism #1:

- Hydrogen-enhanced beta layer embrittlement
 - Pre-transient cladding hydrogen content impacts rate of embrittlement
 - Hydrogen absorption sensitive to alloy composition, fabrication, and in-reactor service



Research Findings (cont.)

- Allowable time-at-temperature reduced from current regulatory requirement (17% equivalent cladding reacted (ECR))





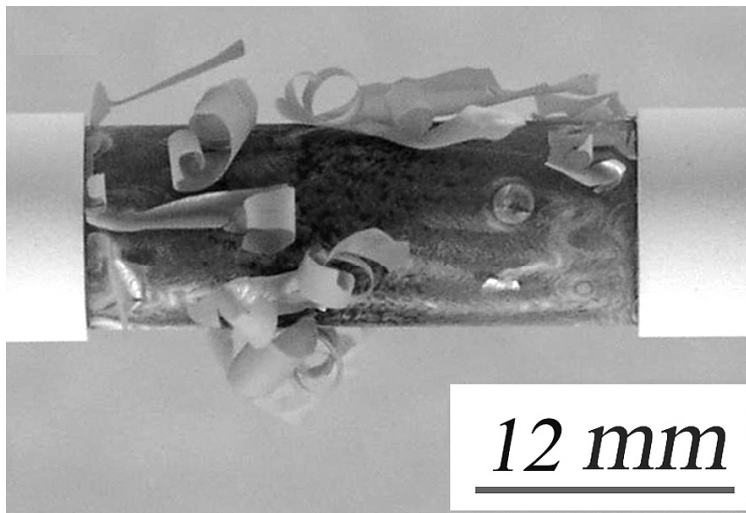
Research Findings (cont.)

- Proposed rule language replaces prescriptive 2200°F and 17% ECR limits with a new requirement to test alloys and define the peak cladding temperature (PCT) and integral time-at-temperature (ITT) corresponding to a loss of ductility
- Draft regulatory guide provides an acceptable set of PCT and ITT analytical limits for licensees who elect not to perform testing
- Draft regulatory guide provides an acceptable test procedure for licensees who elect to perform testing

Research Findings (cont.)

New Embrittlement Mechanism #2:

- Degradation of protective oxide layer (breakaway oxidation)
 - Breakaway oxidation results in cladding embrittlement due to hydrogen uptake
 - Susceptibility to breakaway sensitive to alloy composition and fabrication



Alloy	Measured Breakaway Time
Zircaloy-2	>5,000 seconds
Zircaloy-4	5,000 seconds
ZIRLO™	3,500 seconds
M5	>5,000 seconds



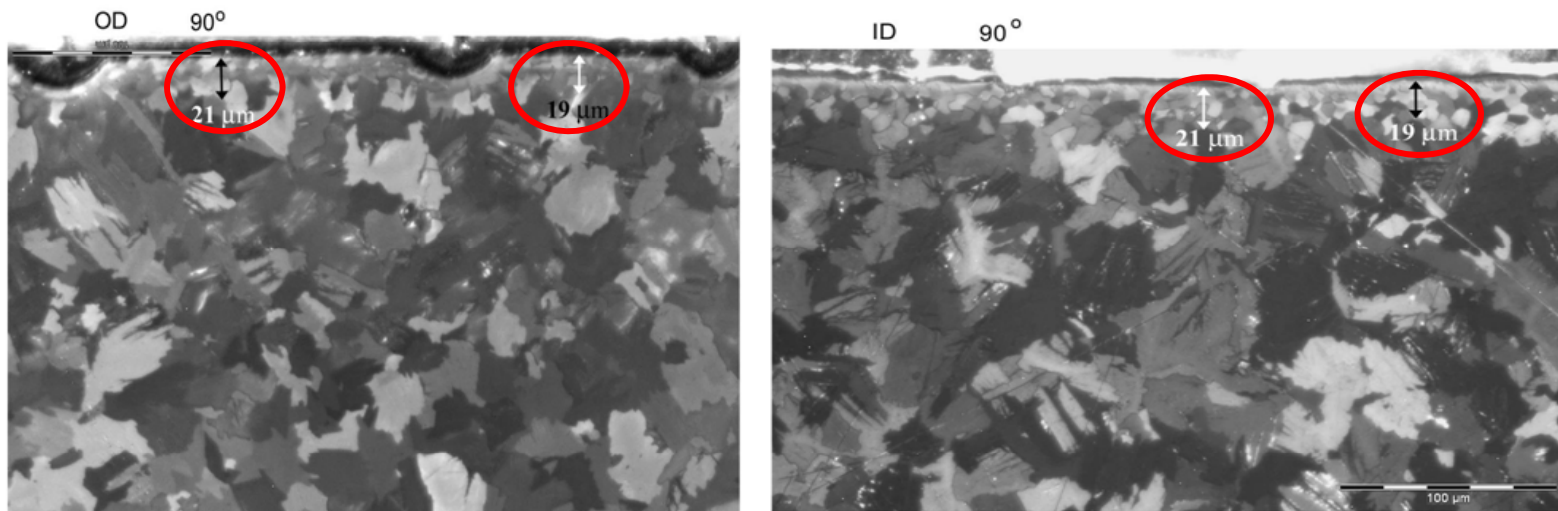
Research Findings (cont.)

- Proposed rule language contains a new performance requirement that addresses breakaway oxidation
 - Alloy specific testing required to define minimum time to experience breakaway phenomenon
 - In addition, a new reporting requirement is added to ensure future performance of cladding alloy
- Draft regulatory guide provides an acceptable test procedure for licensees to perform breakaway testing

Research Findings (cont.)

New Embrittlement Mechanism #3:

- Cladding ID oxygen diffusion expedites embrittlement
 - Oxygen ingress from cladding ID reduces allowable time-at-temperature to nil ductility.
 - ID oxygen source sensitive to burnup, power history, and fuel rod design.
- Proposed rule language contains new analytical requirement addressing cladding ID oxygen ingress



Micrograph images of Halden LOCA test specimens of outer cladding surface (left) and inner cladding surface (right) indicating oxygen-stabilized zirconium layers on both surfaces.



Cladding Oxide and Crud

- § 50.46c achieves rulemaking objective to address petition for rulemaking (PRM-50-84 submitted by Mr. Mark Leyse)
- Proposed rule language contains a new analytical requirement associated with the thermal effects of crud and oxide

Implementation Strategy

- Based upon ANPR comments which identified workforce limitations to complete parallel analyses, a staged implementation plan would be the most effective and efficient way to implement 50.46c.
- Plants with the least available safety margin would be required to be in compliance earliest.

Track #1:
Least available margin.



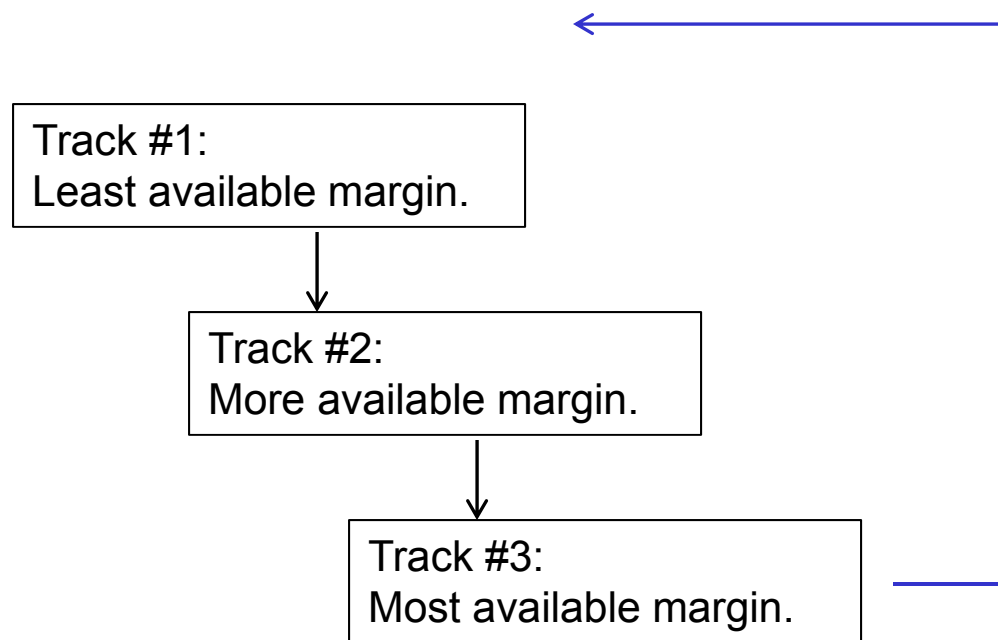
Track #2:
More available margin.



Track #3:
Most available margin.

Strategy (cont.)

- Recognizing that (1) plants with the least amount of safety margin are likely to require the most effort and calendar time to document compliance and (2) a substantial number of plants do not require new LOCA analyses, the implementation plan was revised.





Strategy (cont.)

- Implementation plan designed to achieve the following objectives:
 1. Expedite implementation to as many plants as soon as possible,
 2. Prioritize implementation on plants with less inherent safety margin, and
 3. Balance work load.

Implementation – Existing Fleet

Implementation Track	Basis	Anticipated Level of Effort	Compliance Demonstration
1	All plants which satisfy new requirements without new analyses or model revisions.	Low	No later than 24 months from effective date of rule
2	PWR plants using realistic LBLOCA models requiring new analyses. BWR/2 plants.	Medium	No later than 48 months from effective date of rule
3	PWR plants using Appendix K LB and SB models requiring new analyses. BWR/3 plants.	Medium - High	No later than 60 months from effective date of rule



Paragraph (o)

(o) Implementation

Reactors under Part 50:

- Construction permits issued after the effective date of the rule must comply with the conditions of the rule.
- Operating licenses issued based on construction permits in effect as of the effective date of the rule must comply with the conditions of the rule no later than the date set forth in Table 1 of the rule.

(This could be applicable to Watts Bar, Unit 2, and Bellefonte, Units 1 and 2)

- Operating licenses issued prior to the effective date of the rule must comply with the conditions of the rule no later than the date set forth in Table 1 of the rule.
- Operating licenses issued after the effective date of the rule must comply with the conditions of the rule.

(This could be applicable to Clinch River permit process using mPower design.)



Paragraph (o) (cont.)

(o) Implementation.

Reactors under Part 52:

- All applications docketed after the effective date of the rule must comply with the conditions of the rule prior to approval.
(The timing of the final rule may impact near-term applications, e.g. NuScale and mPower)
- Standard design certification renewals after the effective date of the rule must comply with the conditions of the rule prior to approval.
(Applicable to AP1000, ABWR)
- Standard design certification applications pending at effective date of the rule must comply with the conditions of the rule when renewal is submitted.
(Applicable to US EPR and US APWR)
- Combined licenses docketed after the effective date of the rule must comply with the conditions of the rule.
- Combined licenses docketed or issued prior to the effective date of the rule must comply with the conditions of 50.46 at the completion of the first refueling outage after the initial fuel load.
(Applicable to V.C. Summers and Vogtle)



DISCUSSION OF SPECIFIC REQUESTS FOR WRITTEN COMMENT

(All topics except risk-informed alternative)



Specific Request for Written Comment #1: Performance-Based Peak Cladding Temperature (PCT) Limit

- §50.46c(g)(1)(i) maintains the existing 2200°F criterion on PCT for zirconium alloy cladding.
- In place of the prescriptive limit, should the NRC adopt additional performance-based requirements for zirconium alloy cladding to protect against high temperature ductile failure and autocatalytic oxidation?
- Do established testing procedures already exist for demonstrating acceptable high temperature cladding performance and defining acceptance criteria to meet these performance-based requirements?



Specific Request for Written Comment #2: Periodic Breakaway Testing

- §50.46c(m)(3) would require that each licensee measure breakaway oxidation behavior for each re-load batch and report the results to the NRC annually.
- Please submit written comment on the type of data reported and the proposed frequency of required testing.
- Should the licensee be required to report data relevant solely to their reload fuel batch or should the licensee be able to report representative data based on periodic testing?



Specific Request for Comment #3: Analytical Long-Term Peak Cladding Temperature Limit

- §50.46c(g)(1)(v) would require that a specified and NRC-approved limit on long-term PCT be established that preserves a measure of cladding ductility throughout the period of long-term demonstration.
- Should the rule prescribe an analytical limit or performance metric?
- Is preservation of cladding ductility the most appropriate performance metric for LTC?
- Do established testing procedures already exist for demonstrating acceptable long-term cladding performance?



Specific Request for Written Comment #9: Staged Implementation

- §50.46c(o) would establish a staged implementation plan for the proposed rule, with three implementation tracks based upon existing margin to the revised requirements and anticipated level of effort to demonstrate compliance.
- Please submit written comment on the staged implementation plan, track assignments, and/or an alternative means to implement the requirements of the proposed rule.



Specific Request for Comment #10: New Reactor Implementation

- §50.46c(o)(5) – (9) would provide an implementation approach that takes into account design certifications, standard design approvals, manufacturing licenses, and combined licenses and their status in relation to the effective date of the rule.
- Please submit written comment on this implementation proposal, including suggestions for alternative approaches.



Specific Request for Comment #11: Restructuring 10 CFR Chapter 1 with Respect to ECCS Regulations

- NRC seeks comment on whether the ECCS requirements should be moved to the 10 CFR 50.18x series
- Please comment on these structural changes and whether they should be pursued. Please include comments on:
 - The estimated cost for conforming changes
 - Whether the anticipated benefits and efficiencies would outweigh the administrative burden, costs, and complexities



Specific Request for Written Comment #12: Cumulative Effects of Regulation

- NRC seeks comment related to the cumulative effects of regulation (CER). Specifically:
- Are the effective date, compliance date, and submittal dates adequate in light of ongoing CER challenges?
 - If there are CER challenges, how do you suggest the NRC address this situation?
- Are there unintended consequences of the rule?
- Please comment on the draft regulatory analysis (ADAMS Accession No. ML12283A188).



GENERAL DISCUSSION



How to Submit Public Comments on the Proposed Rule

- Follow instructions provided in the Federal Register notice
 - Federal Register notice available on www.regulations.gov under Docket ID: NRC-2008-0332
- Submit comments electronically via www.regulations.gov, Docket ID: NRC-2008-0332
- Please note: Written comments will NOT be accepted during today's meeting.



Questions?

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