GORDON A. CLEFTON
Senior Project Manager,
Engineering and Operations Support

1201 F Street, NW, Suite 1100
Washington, DC 20004
P: 202.739.8086
gac@nei.org
nei.org

NUCLEAR ENERGY INSTITUTE

August 21, 2014

Ms. Annette Vietti-Cook
Secretary
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTN: Rulemakings and Adjudications Staff

Subject: Comments on "Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria" (Docket ID NRC–2008–0332) (*Federal Register* Notice 79FR16106)

Project Number: 689

The Nuclear Regulatory Commission (NRC), through the *Federal Register* Notice (79FR16106) and Docket ID: NRC–2008-0332, issued for public comment the rulemaking package for "Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria." The Nuclear Energy Institute (NEI)[1], on behalf of the industry, provides the attached comments for NRC consideration.

Our overarching concern with the proposed rulemaking package is that the industry cost to implement the rule is not commensurate with the safety benefit. A 2012 NRC safety assessment[2] confirmed, on a plant-specific basis, the safe operation of the U.S. commercial nuclear fleet. This safety assessment was supported by reports submitted by the BWROG[3] and the PWROG[4] that documented no safety issue exists and that the plants have a sufficient margin of safety to the proposed oxidation criterion. The safety

[1] The Nuclear Energy Institute (NEI) is the organization responsible for establishing unified industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all entities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel cycle facilities, nuclear materials licensees, and other organizations and entities involved in the nuclear energy industry.

[2] NRC ECCS Performance Safety Assessment And Audit Report, February 10, 2012 (ADAMS ML12041A078).

[3] BWROG-TP-11-010 (Rev.1), Evaluation of BWR LOCA Analyses and Margins Against High Burnup Fuel Research Findings, June 2011 (ADAMS ML111950139).

[4] PWROG Letter Report OG-11-143, 10CFR50 46(b) Margin Assessment Report, April 29, 2011; (ADAMS ML11139A309).

assessment also outlined an appropriate set of actions to be taken that would confirm plant safety in the interim until a revised rule is implemented. Thus, the safety benefit provided by the transition from operation under the current rule, with significant margin of safety, to operation under the proposed rule is minimal.

The industry cost to implement the proposed rule is estimated to be on the order of $1 million per unit. This makes it imperative that less impactful methods, such as that proposed in the 2012 NRC safety assessment, be considered as acceptable alternatives to the requirements of the proposed rule. NEI believes that the Regulatory Analysis, included as part of the rule package, significantly underestimates the costs to implement the proposed rule and warrant its revision. The initial estimates by several fleets have found that implementation costs will be substantially greater than the NRC's cost estimates; in many cases this was by a factor of ten.

NEI does not support the belief, as stated in the Regulatory Analysis, that this rulemaking should use the "Adequate Protection Justification" as a basis for not entering the backfit analysis provision per 10 CFR 50.109(a)(4)(ii). In this proposed rulemaking, the NRC requires licensees to provide "'extra-adequate' protection" by ordering plants already satisfying the adequate protection standard to take additional safety measures. As noted in the NRC Regulatory Analysis Guidelines[5], "if there is more than one way to achieve compliance or reach a level of adequate protection, and the Commission finds it necessary or appropriate to specify the way, costs may be a factor in that decision." In our view, alternative means to achieve compliance and/or reach an appropriate level of adequate protection exist; therefore, consideration of the cost to the industry to comply with this rule can and should be considered.

We are also concerned that required long-term cooling research has not been completed (and related regulatory guidance has not yet been developed) to support the agency's proposed changes concerning the analytical limit that must be determined using an NRC approved experimental technique. We believe that establishment of this analytical limit prior to conducting necessary research and establishing an acceptable methodology is premature. Until the necessary research and method development is complete, NEI recommends that the proposed rule language associated with long-term cooling, debris, boric acid precipitation, and fuel fragmentation be removed from this rulemaking.

Since there does not appear to be a significant safety issue being addressed by this rulemaking and there is a large number of comments suggesting alternatives to the proposed rule, NEI recommends re-noticing the rule package following incorporation of stakeholder comments. The industry encourages further interactions with the NRC in workshops, teleconferences, and meetings to further refine the rule language.

[5] NUREG/BR-0058, Rev. 4 (2004).

If you have any questions or require additional information, please contact me.

Sincerely,

Gordon A. Clefton

Attachment

c: Mr. Daniel H. Dorman, NRR, NRC
Dr. Jennifer L. Uhle, NRR, NRC
Mr. Patrick L. Hiland, NRR/DE, NRC
Mr. Timothy J. McGinty, NRR/DSS, NRC
Mr. Victor Cusumano, NRR/DSS/SIR, NRC
Ms. Tara Inverso, NRR/DPR/PRMB
Ms. Michelle Flanagan, RES/DSA/FSCB, NRC

Industry Response to 10CFR50.46c Draft Rule Language

Revision 0

August 2014

Executive Summary

The Nuclear Energy Institute, Inc. (NEI)[1] on behalf of the industry is pleased to offer these consolidated comments on the proposed rule published by the Nuclear Regulatory Commission (NRC) on March 24, 2014. NEI acknowledges the important work done by the subject matter experts from the Electric Power Research Institute (EPRI) Fuel Reliability Program RegTAC, the PWR Owners Group, and the BWR Owners Group in assembling these comments.

This proposed rule would revise the fuel cladding acceptance criteria for the emergency core cooling system (ECCS) for light-water nuclear power reactors. Other minor revisions are proposed to Part 52 and to Appendices A and K of Part 50. The proposed rule addresses recent research findings related to cladding embrittlement mechanisms, expands the applicability to a broader range of fuel and zirconium-alloy materials, and requires evaluation of the thermal effects of crud and corrosion on the cladding surface during a LOCA. The proposed rule also includes revised change and error reporting requirements, as well as an implementation plan. Three accompanying draft regulatory guides provide guidance on cladding breakaway oxidation testing, cladding post-quench ductility testing, and analytical limits for cladding embrittlement. Finally, the proposed rule includes an alternate risk-informed approach for addressing the effects of debris on long-term cooling, which is an option for resolving GSI-191 and sump suction issues.

The comments focus on the issues of the operating fleet but also are generally applicable to the advanced passive reactor designs and small modular reactors. Detailed industry comments on testing will be provided separately by EPRI and the three fuel vendors. The objective of the industry comments is to facilitate a final rule and regulatory guides that will serve both the industry and the NRC in the resolution of the effects of higher burnup on the performance of fuel during a LOCA and also the resolution of GSI-191 issues identified in the proposed newly added 10cfr50.46c requirements. Furthermore, the industry comments will assist in creating a rule that will encourage development and deployment of advanced cladding materials.

Our overarching concern with the proposed rulemaking package is that it does not provide a significant safety benefit for the amount of resources that will be used in its implementation. NEI

[1] NEI is the organization responsible for establishing unified nuclear industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all utilities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

agrees with the NRC safety assessment[2] that documented reasonable assurance that plant operations and public health are not challenged. This NRC safety assessment was also supported by reports submitted by the BWROG[3] and the PWROG[4] that documented no safety issue existed and that the plants have sufficient margin of safety to the proposed oxidation criterion. Thus, there is no need to accelerate implementation and consideration must be given to leaning this rule's content to just what is required and not already covered by existing processes.

Required research and regulatory guidance has not been completed to support the proposed changes to long-term cooling, and in particular the need for an analytical limit. Resolution involves many long-term cooling scenarios and issues and includes significant design-specific considerations. The current 10CFR50.46 rule language remains adequate; no rulemaking on these topics is necessary, until the technical issues are fully characterized and a regulatory guide is issued to reduce regulatory uncertainty. Proceeding with rulemaking on long-term cooling at this time, absent further development of technical bases for such rulemaking, may lead to regulatory requirements that are arbitrary and capricious. It is premature and this specific portion of the proposed rulemaking lacks sufficient technical bases; therefore, including it now does not necessarily serve the purpose of providing reasonable assurance of adequate protection of public health and safety. The industry suggests that the NRC pursue rulemaking on long-term cooling as a separate action in the future, once sufficient technical bases are developed.

The proposed rule's addition of a new analytical limit and associated measurement technique, associated with post-LOCA long-term cooling, is devoid of reasoned decision-making because the Agency has not fully examined relevant technical data, and because the agency has not articulated a satisfactory explanation for its decision to promulgate these new requirements

Changes to some sections of the proposed rule are needed to avoid short-term and long-term compliance issues. If left unaddressed, these compliance difficulties will cause both technical and economic burdens to the industry with no commensurate increase in safety or protection of public health and safety. Significant areas of industry concern are listed below. Where appropriate, the comments include suggested language that will result in necessary improvements.

- Facility names should be deleted from any part of the rule to avoid the need for future exemption requests due to any plant specific changes or requests for plant schedule relief.

- Appendix K content should be moved to a regulatory guide
    - As a regulatory guide, the previous contents of Appendix K would join other lower level documents in providing methods of how to create conservative ECCS Evaluation Models

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[2] NRC safety assessment that considered the information provided in Research Information Letter (RIL) 0801, "Technical Basis for Revision of Embrittlement Criteria in 10CFR50.46", February 23, 2009

[3] BWROG-TP-11-010 (Rev.1), Evaluation of BWR LOCA Analyses and Margins Against High Burnup Fuel Research Findings, June 2011; ML111950139

[4] PWROG Letter Report OG-11-143, 10CFR50 46(b) Margin Assessment Report, April 29, 2011; ML11139A309

   - This would eliminate conflicts between the use of the Baker Just and Cathcart-Pawel models, thereby allowing compliance without exemption requests.

- Overlap exists between proposed Section 50.46c, sump suction issues, and GSI-191 related efforts. Minimal gain is seen by merging the three separate activities.
   - The NRC proposal to limit the alternate risk-informed approach to debris to the long-term cooling period is not consistent with the BWR sump suction project that needs to address the first three minutes.
   - The GSI-191 scope and schedule conflict with the Section 50.46c implementation schedule.

- Long term cooling required research has not been completed (and related regulatory guidance has not yet been developed) to support the agency's proposed changes.
   - Resolution of how to determine an analytical limit involves applying many long-term cooling scenarios and issues to meet significant design-specific considerations.
   - The current rule language on this topic remains adequate until the technical issues are fully characterized and a regulatory guide is issued to reduce regulatory uncertainty.
      - We recommend that the NRC eliminate this long term cooling section of this proposed rule.
      - This part of the proposed rule can be eliminated without adversely affecting other aspects of the rulemaking.
      - Premature promulgation of this aspect of the rule is not necessary for protection of public health and safety. It could result in arbitrary, uninformed requirements that go against the developing science.

- Alternate risk-informed approach for addressing the effects of debris on long-term core cooling should be simplified.
   - NRC could use the language for the risk-informed NFPA-805 fire protection alternative 10CFR50.48(c), Regulatory Guide 1.205, and NEI 04-02.
   - A performance-based approach:
      - Satisfies the performance goals, performance objectives, and performance criteria related to nuclear safety and radiological release
      - Maintains safety margins; and
      - Maintains defense-in-depth.

- Implementation language should be revised to only require each licensee to submit its plan and its "living schedule" within 180 days of the effective date of the rule.
   - Since each plant will have unique issues affecting its plan, a phased-implementation approach will ensue to optimize the use of NRC and industry resources.
   - Since there is no safety issue and each plant will commit to its own schedule, implementation of the proposed rule should be as successful as other phased-implementation of regulatory issues (e.g., emergency preparedness and cyber security).

- Proposed reporting requirements for loss of coolant accident (LOCA) evaluation model and analysis changes and errors should be deleted.
    - Existing NRC reporting requirements, including provisions in 10CFRPart 21, 10CFR50.72, and 10CFR50.73 are sufficient and will continue to ensure adequate reporting.
    - As discussed with NRC staff, the industry proposes development of an NEI document on error/change reporting to be endorsed by NRC that would facilitate standardized reporting provisions throughout the industry, similar to the 10CFR50.59 industry guidance being enhanced by the NEI 01-01 working group.
    - Since the proposed, new reporting requirements would be duplicative of existing ones, they would cause unnecessary work for licensees and the NRC, distract resources from more important tasks, dilute the significance of important reporting, etc. – all without creating any commensurate increase in the protection of public health and safety.

- Annual licensee reporting of breakaway oxidation testing results is unnecessary.
    - Any cladding material that fails the testing criterion (zero failures are expected) would not be delivered for use in a reactor; thus, it would not be accepted by the licensee.
    - Discovery of a failure to conform or a defect must already be reported in accordance with the requirements of 10CFR21.

- Testing requirements in the draft regulatory guides DG-1261 and DG-1262 are too prescriptive and are not practical for use by the industry.
    - Performance based rulemaking requires the rule to state what is required and lower level documents to provide methods of how to comply.
    - Specific details relating to this concern will be provided in the fuel vendor comments submitted separately.

- Existing inventories of fuel assemblies/bundles and cladding that have been designed, fabricated, and procured to current regulations need to be grandfathered.

- Additional regulatory guidance is needed to standardize and bring efficiency to industry development and NRC review.
    - Similar NRC guidance provided in connection with power uprate licensing (e.g. RS-001 and RIS 2002-03) would assist implementation.
    - This guidance should focus on the requirements of the new 10cfr50.46c regulation and not expand into technical issues that are still the subject of ongoing research, e.g., long-term cooling, fuel fragmentation, relocation, and dispersal.

Regarding the NRC's draft Regulatory Analysis relating to the proposed rule (ADAMS Accession No. ML12283A188), NEI has concluded that the NRC should perform a realistic review of proposed rule costs to correct the inaccuracies in the Regulatory Analysis. In industry's view, the cost estimates provided for industry activities associated with this rule are substantially below current experience. Additionally, the Regulatory Analysis revealed the following issues:

- The Decision Rationale that this rulemaking falls under the 'adequate protection' justification appears inconsistent with other included statements.
    - Page 5 of the Regulatory Analysis states that the NRC's preliminary safety assessment in response to the research findings in Research Information Letter 0801 revealed that "immediate regulatory action was not required".
    - The Agency's more detailed safety assessment "confirmed current plant safety for every operating reactor."
    - The proposed rule allows more than one way to achieve compliance and/or reach an appropriate level of adequate protection; therefore, consideration of the cost to the industry to comply with this proposed rule should be considered.
- The proposed rule has expanded significantly from the original request by adding additional requirements and topics that have not been adequately assessed.
- The proposed rule and regulatory analysis fail to demonstrate that the broader reviews contemplated are necessary or that they would produce a commensurate safety benefit.
- Reviews of the NRC calculations shows that most of the estimates are low by at least one order of magnitude.
- The costs associated with the NRC conducting the verification, on an annual basis, of the continued safe operation until each licensee has implemented the new ECCS requirements are significantly less than the resources expenditure of the Industry and NRC in the proposed rule.
- Consistent assumptions must be used for cost estimations and all assumptions must be explicitly stated.

NEI has also reviewed the proposed rule from the perspective of its contribution to the cumulative effects of regulation (CER). In general, we conclude that implementation of the rule as proposed would categorize it in a low priority since there is no safety issue, most of the proposed reporting is already accomplished by existing processes, and significant resources will be consumed to switch to 10cfr50.46c.

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Revision Log

Number	Page	Date	Description
Rev 0	All	August 21, 2014	This is a new document

List of Acronyms

ACRS	Advisory Committee on Reactor Safeguards
ADAMS	Agency-wide Document Access and Management System
ANL	Argonne National Laboratory
ANPR	Advanced Notice of Proposed Rulemaking
ANS	American Nuclear Society
AOR	Analysis of Record
BAP	Boric Acid Precipitation
BWR	Boiling Water Reactor
CDF	Core Damage Frequency
CER	Cumulative Effects of Regulation
CFR	Code of Federal Regulations
COL	Combined License
COLR	Core Operating Limits Report
CP	Cathcart-Pawel
CRUD	Chalk-River Unidentified Deposit
DBA	Design Basis Accident
DG	Draft Guide
ECCS	Emergency Core Cooling System
ECR	Equivalent Cladding Reacted
EPRI	Electric Power Research Institute
FRN	Federal Register Notice
FTE	Full-Time Equivalent
GDC	General Design Criteria
GSI	Generic Safety Issue
IN	Information Notice
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
LAR	License Amendment Request
LER	Licensee Event Report
LERF	Large Early Release Frequency
LOCA	Loss-of-Coolant Accident
LTC	Long Term Cooling
LTR	Licensing Topical Report
LWR	Light Water Reactor
NEI	Nuclear Energy Institute
NFPA	National Fire Protection Association
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
PCT	Peak Clad Temperature
PIRT	Phenomena Identification and Ranking Table
PQD	Post-Quench Ductility
PRA	Probabilistic Risk Assessment
PRM	Petition for Rulemaking
PWR	Pressurized Water Reactor

QA	Quality Assurance
RAI	Request for Additional Information
RG	Regulatory Guide
RIL	Research Information Letter
RIS	Regulatory Issue Summary

List of Acronyms

RS	Review Standard
SAFAL	Specified Acceptable Fuel Analytical Limit
SAFDL	Specified Acceptable Fuel Design Limit
SBLOCA	Small Break LOCA
SER	Safety Evaluation Report
SRM	Staff Requirements Memorandum
SSC	Structures, Systems, and Components
STPNOC	South Texas Project Nuclear Operating Company
USNRC	United States Nuclear Regulatory Commission
ZDT	Zero Ductility Temperature

References

1. FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*

2. DG-1261, Conducting Periodic Testing for Breakaway Oxidation Behavior, USNRC Draft Regulatory Guide. *(ADAMS Accession No. ML12284A324)*

3. DG-1262, Testing for Post Quench Ductility, USNRC Draft Regulatory Guide, *(ADAMS Accession No. ML12284A325)*

4. DG-1263, Establishing Analytical Limits for Zirconium-Based Alloy Cladding, USNRC Draft Regulatory Guide, *(ADAMS Accession No. ML12284A323)*

5. Draft Regulatory Analysis, Nuclear Regulatory Commission, March 24, 2014, *(ADAMS Accession No. ML12283A188)*

1 Introduction

1.1 Background

The U. S. Nuclear Regulatory Commission (NRC) has published Reference 1 for public comment amending current requirements governing emergency core cooling systems set forth in Title 10 CFR 50.46. Other minor revisions to Appendices A and K to Part 50, and to Part 52, are also required to reflect the proposed §50.46c. The proposed rule addresses recent research findings related to cladding embrittlement mechanisms, expands the applicability to a broader range of fuel and cladding design materials, and requires evaluation of the thermal effects of crud and oxide that may have developed on the cladding surface during operation. Additionally, the proposed rule includes revised change and error reporting requirements, and an implementation plan and schedule. The proposed rule also includes an alternate risk-informed approach to address the effects of debris on long-term cooling. Three accompanying regulatory guides provide guidance on cladding breakaway oxidation testing, cladding post-quench ductility testing, and analytical limits for cladding embrittlement, per References 2, 3, & 4. The NRC staff also prepared a regulatory analysis, per Reference 5.

The proposed regulation is the culmination of NRC activities beginning with NRC staff recommendation in SECY-02-0057 to revise 10 CFR 50.46 to a performance-based approach. The NRC commissioners issued a SRM on March 3, 2003 directing NRC staff to risk-inform the ECCS rule. In 2008 the NRC issued RIL-0801 to summarize the results of research findings on the behavior of high-burnup fuel rods during a LOCA, and proposed the need for a revision to the cladding embrittlement criteria in 10 CFR 50.46. Public comments were requested, several industry workshops and public meetings were held, and the ACRS review process started. The industry has been actively participating in this very important regulatory activity by providing input on NRC research activities, by participation in workshops, by funding and performing research, by conducting tests, by replying to USNRC staff requests for information, and by commenting on draft regulations and regulatory guides as various versions have been released.

1.2 Purpose

The purpose of this document is to provide industry comments on the proposed rule package (References 1-5). The comments focus on the operating fleet but are generally applicable to the advanced passive reactor designs and small modular reactors. The objective of the industry comments is to obtain final rule language and regulatory guides that will better serve both the industry and the NRC in the resolution of the effects of higher burnup on the performance of fuel during a LOCA, and also the resolution of GSI-191. Furthermore, industry comments are intended to avoid the situation where initiatives to develop and deploy advanced cladding materials are discouraged due to the burden of excessive regulation.

1.3 Scope and Overview

Comments focus on the proposed rule language, the specific NRC requests for industry comments, and bigger picture issues. This document does not necessarily consider References 2, 3, and 4 as such comments must be submitted to a different post stop per the FRN. Comments on the draft regulatory guides will be provided by EPRI and the fuel vendors.

Comments may consider information in the statement of considerations accompanying the proposed rule, but specific comments on the statement of considerations are not provided. Consistency in the final rule language, and the statement of considerations, is essential to avoid future misinterpretations between regulators and industry, as well as uncertainty regarding what constitutes compliance.

1.3.1 Chapter 2

Provide a summary of the comments on the proposed §50.46c rule language, along with related revisions to Part 50 Appendices A & K, and Part 52. References to specific comments in Appendix A are included.

1.3.2 Chapter 3

Provide comments on bigger picture issues stemming from the FRN proposed rule language.

1.3.3 Chapter 4

Provide comments on the NRC's specific request for comments on twelve topics. Cross-references to the appendices for additional comment details are included.

1.3.4 Chapter 5

Provide comments regarding the regulatory analysis.

1.3.5 Chapter 6

Provide a summary of the high-priority industry comments on rule concept and structure, change management and reporting, implementation, and the alternate risk-informed approach for debris evaluation. The overall industry position on the rule-making is also provided.

1.3.6 Appendix A

Provide specific comments regarding proposed rule language. Comments are in the form of tables with the following format and content:

- Statement: Echo the FRN proposed language
- Comment: Specific comment on the "statement".
- Rationale: A bases for the "comment"
- Proposal: A proposed alternative to the "statement"
- Justification: A reason for the "proposal"

1.3.7 Appendix B

Provide a description of open issues regarding long-term cooling. The information is intended to be useful to the NRC in developing the scope of a regulatory guide.

1.3.8 Appendix C

Discuss a proposal for an industry document to standardize §50.46c change management and reporting/submittal(s). The proposed document, once endorsed by NRC, would replace the proposed rule language.

1.3.9 Appendix D

Provide a revised §50.46c incorporating the revisions proposed by this document.

1.3.10 Appendix E

Provide alternate language related to moving 10 CFR 50 Appendix K to a regulatory guide.

2 NRC Proposed Rule Language

The NRC has proposed specific changes to the existing rule language in Reference 1. This chapter identifies general comments relating to each part of the Reference 1 proposed rule, and includes a cross reference to detailed comments in Appendix A.

Comments are in the form of tables with the following format and content:

- FRN Proposed Language Part: Echo the FRN proposed language
- General Comment: High level comment on FRN proposed language part.
- Cross Reference to Specific Comments: Pointers to comment details in Appendix A.

2.1 Part 50.34

The proposal, shown in Table 2.1, makes a change to the existing 10 CFR 50.34 language that is a matter of cross referencing. No further comments.

Table 2.1: Content of Applications; Technical Information

FRN Proposed Language Part
(a) * * *   (4) A preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. Analysis and evaluation of ECCS cooling performance and the need for high point vents following postulated loss-of-coolant accidents must be performed in accordance with the requirements of §§ 50.46, 50.46b, and 50.46c, as applicable, for facilities for which construction permits may be issued after December 28, 1974.   * * * * *   (b) * * *   (4) A final analysis and evaluation of the design and performance of structures, systems, and components with the objective stated in paragraph (a)(4) of this section and taking into account any pertinent information developed since the submittal of the preliminary safety analysis report. Analysis and evaluation of ECCS cooling performance following postulated loss-of-coolant accidents shall be performed in accordance with the requirements of §§ 50.46 and 50.46c, as applicable, for facilities for which a license to operate may be issued after December 28, 1974.   * * * * *
General Comment
None
Cross Reference to Specific Comments
None

2.2 Part 50.46a

The proposal, shown in Table 2.2, redesignates §50.46a and §50.46b, and adds §50.46c. No further comments.

Table 2.2: Added and Reserved Material

FRN Proposed Language Part
4. Section 50.46a is redesignated as § 50.46b, and a new § 50.46a is added and reserved. 5. A new § 50.46c is added to read as follows:
General Comment
None
Cross Reference to Specific Comments
None

2.3 Part 50.46c

The comments in this section focus on the specific rule language.

2.3.1 Paragraph (a)

In the proposal, shown in Table 2.3, NRC states the applicability of the new §50.46c. This change is administrative in nature. A general comment is added to clarify the applicability.

Table 2.3: Applicability

FRN Proposed Language Part
(a) Applicability. The requirements of this section apply to the design of a light water nuclear power reactor (LWR) and to the following entities who design, construct or operate an LWR: each applicant for or holder of a construction permit under this part, each applicant for or holder of an operating license under this part (until the licensee has submitted the certification required under § 50.82(a)(1) to the NRC), each applicant for or holder of a combined license under part 52 of this chapter, each applicant for a standard design certification (including the applicant for that design certification after the NRC has adopted a final design certification rule), each applicant for a standard design approval under part 52 of this chapter, and each applicant for or holder of a manufacturing license under part 52 of this chapter.
General Comment
Modify draft rule language to state that if a certification of permanent cessation of operations has been submitted that the rule is not applicable.
Cross Reference to Specific Comments
Table A.1

2.3.2 Paragraph (b)

In the proposal, shown in Table 2.4, a new section is proposed for definitions. Comments focus on a revision to the definition of debris evaluation model, and new definitions for cladding, crud, and reload batch.

Table 2.4: Definitions

FRN Proposed Language Part
(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
General Comment
The debris evaluation model definitions require revision, and additional definitions for cladding, crud, and reload batch, should be added for rule clarity.
Cross Reference to Specific Comments
Table A.2, Table A.3, Table A.4, Table A.5, Table A.6, and Table A.7.

2.3.3 Paragraph (c)

In the proposal, shown in Table 2.5, NRC adds administrative language to the newly proposed §50.46c. Should there be cross references to the proposed changes to GDCs 38 and 41?

Table 2.5: Relationship to Other NRC Regulations

FRN Proposed Language Part
(c) *Relationship to other NRC regulations.* The requirements of this section are in addition to any other requirements applicable to an emergency core cooling system (ECCS) set forth in this part, except as noted in this paragraph. The analytical limits established in accordance with this section, with cooling performance calculated in accordance with an NRC approved ECCS evaluation model, are in implementation of the general requirements with respect to ECCS cooling performance design set forth in this part, including in particular Criterion 35 of appendix A to this part. If the effects of debris on long-term cooling are evaluated using a risk-informed method as described in paragraph (e) of this section, then this method and results can be relied upon to demonstrate compliance with other requirements of this part as allowed by this section and requested in the application.
General Comment
Should there be cross references to the proposed revisions to Criteria 38 and 41; how should the design basis vs. risk-informed portions be addressed?
Cross Reference to Specific Comments
Table A.8

2.3.4 Paragraph (d)

Paragraph (d), "Emergency core cooling system design," includes requirements on (1) ECCS performance criteria, (2) ECCS performance demonstration, and (3) required documentation.

2.3.4.1 Sub-Paragraph (1)

The proposed language, shown in Table 2.6, is confusing with regard to "design" vs. "performance." Paragraph (d)(1) should be linked to (g)(1)(v).

Table 2.6: ECCS Design, Sub-Section 1

FRN Proposed Language Part
(d) *Emergency core cooling system design.* (1) *ECCS performance criteria.* Each LWR must be provided with an ECCS designed to satisfy the following performance requirements in the event of, and following, a postulated loss-of- coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section: (i) Core temperature during and following the LOCA event does not exceed the analytical limits for the fuel design used for ensuring acceptable performance as defined in this section. (ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core.
General Comment
This section confuses ECCS design in accordance with GDC 35, with ECCS performance as demonstrated by meeting fuel analytical limits specified in (g). Paragraph (d)(1) should be linked to (g)(1)(v).
Cross Reference to Specific Comments
Table A.9, Table A.10, and Table A.11

2.3.4.2 Sub-Paragraph (2)

The proposed language, shown in Table 2.7, does not allow for a deterministic evaluation of debris outside of the ECCS evaluation model. The industry agrees with the proposed "zirconium-alloy cladding" language as beneficial to avoiding future exemption requests for advanced fuel designs.

Table 2.7: ECCS Design, Sub-Section 2

FRN Proposed Language Part
(d) *Emergency core cooling system design.* (2) *ECCS performance demonstration*. ECCS performance must be demonstrated using an ECCS evaluation model meeting the requirements of either paragraph (d)(2)(i) or (d)(2)(ii), of this section, and satisfy the analytical requirements of paragraph (d)(2)(iii), (d)(2)(iv), and (d)(2)(v) of this section. Paragraph (e) of this section may be used for consideration of debris described in paragraph (d)(2)(iii) of this section. The ECCS evaluation model must be reviewed and approved by the NRC. (i) *Realistic ECCS model.* A realistic model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and NRC-approved analytical limits, there is a high level of probability that the limits would not be exceeded. (ii) *Appendix K model*. Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K to this part, ECCS Evaluation Models. (iii) *Core geometry and coolant flow*. The ECCS evaluation model must address calculated changes in core geometry and must consider those factors, including debris, that may alter localized coolant flow in the core or inhibit delivery of coolant to the core. A licensee may evaluate effects of debris using a risk-informed approach to demonstrate long-term ECCS performance, as specified in paragraph (e) of this section. (iv) *LOCA analytical requirements*. ECCS performance must be demonstrated for a range of postulated loss-of-coolant accidents of different sizes, locations, and other properties, sufficient to provide assurance that the most severe postulated loss-of-coolant accidents have been identified. ECCS performance must be demonstrated for the accident, and the post-accident recovery and recirculation period. (v) *Modeling requirements for fuel designs: uranium oxide or mixed uranium-plutonium oxide pellets within zirconium-alloy cladding*. If the reactor is fueled with uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding, then the ECCS evaluation model must address the fuel system modeling requirements in paragraph (g)(2) of this section.
General Comment
Paragraph (2)(iii) does not allow for the effects of debris to be evaluated deterministically outside of an ECCS evaluation model. The industry agrees with (2)(v) as beneficial in eliminating exemption requests for any zirconium alloy cladding.
Cross Reference to Specific Comments

Table A.12, Table A.13, and Table A.14.

2.3.4.3 Sub-Paragraph (3)

The proposed language, shown in Table 2.8, has extraneous words in paragraph (3)(vi) that need to be deleted.

Table 2.8: ECCS Design, Sub-Section 3

FRN Proposed Language Part
(d) *Emergency core cooling system design.* (3) *Required documentation.* Upon implementation of this section in accordance with paragraph (o) of this section, the documentation requirements of this paragraph apply and supersede the requirements in appendix K to this part, section II, "Required Documentation." (i)(A) A description of each ECCS evaluation model must be furnished. The description must be sufficiently complete to permit technical review of the analytical approach, including the equations used, their approximations in difference form, the assumptions made, and the values of all parameters or the procedure for their selection, as for example, in accordance with a specified physical law or empirical correlation. (B) A complete listing of each computer program, in the same form as used in the evaluation model, must be furnished to the NRC upon request. (ii) For each computer program, solution convergence must be demonstrated by studies of system modeling or noding and calculational time steps. (iii) Appropriate sensitivity studies must be performed for each ECCS evaluation model, to evaluate the effect on the calculated results of variations in noding, phenomena assumed in the calculation to predominate, including pump operation or locking, and values of parameters over their applicable ranges. For items to which results are shown to be sensitive, the choices made must be justified. (iv) To the extent practicable, predictions of the ECCS evaluation model, or portions thereof, must be compared with applicable experimental information. (v) Elements of ECCS evaluation models reviewed will include technical adequacy of the calculational methods, including: for models covered by paragraph (d)(2)(ii) of this section, compliance with required features of section I of appendix K to this part; and, for models covered by paragraph (d)(2)(i) of this section, assurance of a high level of probability that the performance criteria of paragraph (d)(1) of this section would not be exceeded. (vi) For operating licenses issued under this part as of [EFFECTIVE DATE OF RULE], required documentation of Table 1 in paragraph (o) of this section must be submitted to demonstrate compliance by the date specified in Table 1 in paragraph (o) of this section.
General Comment
Item (3)(vi) includes extraneous words that need to be deleted.
Cross Reference to Specific Comments
Table A.15.

2.3.5 Paragraph (e)

Paragraph (e) is "Alternate risk-informed approach for addressing the effects of debris on long-term core cooling." It includes information on (1) risk-informed approach acceptance criteria, (2) contents of application, and (3) NRC approval. A general comment is that the unavailability of the associated regulatory guide until late 2015 significantly complicates the commenting process. The industry requests an opportunity to provide input to the development of the regulatory guide. Another general comment is the risk-informed rule language for fire protection §50.48(c)(4) should be used as a model. Also, industry proposes risk-informed approaches, addressing the effects of debris, cover all applicable time frames. Finally, it is unclear which other paragraphs in §50.46c are applicable (or are not applicable) to paragraph (e).

2.3.5.1 Sub-Paragraph (1)

Sub-Paragraph (1) is titled "Risk-informed approach acceptance criteria," but actually describes at a high-level the required elements of the risk-informed approach with little content on acceptance criteria. The industry comment is to revise the paragraph title.

Table 2.9: Alternate Risk Informed Approach, Sub-Section 1

FRN Proposed Language Part
(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (1) *Risk-informed approach acceptance criteria.* An entity may request the NRC to approve a risk-informed approach for addressing the effects of debris on long-term core cooling to demonstrate compliance with the requirements in paragraph (d)(1)(ii) of this section. 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; (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 applicable plant and industry operational experience, is of sufficient scope, level of detail, and technical adequacy to support the alternative process, and is subjected to a peer review process that assesses the PRA against a standard or set of acceptance criteria that is endorsed by the NRC. .
General Comment
The risk-informed rule language for fire protection (50.48(c)(4)) can be used as a model. The risk-informed approach should address the effects of debris for all applicable time frames. It is unclear which other paragraphs of 50.46c are applicable to (e).
Cross Reference to Specific Comments
Table A.16, Table A.17, Table A.18, and Table A.19.

2.3.5.2 Sub-Paragraph (2)

The proposed language, shown in Table 2.10, is generally consistent with the Regulatory Guide 1.174 approach. An additional requirements to include information on the monitoring program and the notification of NRC of errors and changes, using existing regulations and requirements, should be included.

Table 2.10: Alternate Risk Informed Approach, Sub-Section 2

FRN Proposed Language Part
(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (2) *Content of application.* An entity seeking to use the risk-informed approach under paragraph (e)(1) of this section, must submit an application with the following information: (i) A description of the alternative risk-informed approach; (ii) A description of the measures taken to assure that the scope, level of detail and technical adequacy of the systematic processes that evaluate the plant for internal and external events initiated during full power, low power, and shutdown operation (including the PRA, margins-type approaches, or other systematic evaluation techniques used to evaluate severe accidents) are commensurate with the reliance on risk information; (iii) Results of the PRA review process conducted to satisfy the requirements of paragraphs (e)(1)(iii) and (iv) of this section; (iv) A description of, and basis for acceptability of, the evaluations conducted to demonstrate compliance with paragraphs (e)(1)(i) and (ii) of this section; and (v) The analytical limit on long-term peak cooling temperature as established in paragraph (g)(1)(v) of this section.
General Comment
The application should include information on the monitoring program and notification to NRC of errors and changes using existing regulations and guidance. Remove reference to “long-term” time period terminology as it is not consistent with BWR ECCS design.
Cross Reference to Specific Comments
Table A.20, Table A.21, and Table A.22.

2.3.5.3 Sub-Paragraph (3)

The proposed language, shown in Table 2.11, requires revisions related to the use of "long-term" in relation to the analytical limit and the effects of debris. There should be no need for NRC approval of the process for notification of changes or errors, as existing processes will be used under the industry proposal.

Table 2.11: Alternate Risk Informed Approach, Sub-Section 3

FRN Proposed Language Part
(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (3) *NRC approval.* If the NRC determines that the application demonstrates that the requirements of paragraph (e)(1) of this section are met, and the application establishes an acceptable long-term peak cladding temperature limit, then it may approve the use of the risk-informed approach for addressing debris effects on long-term cooling when issuing the license, regulatory approval or amendments thereto. The NRC's approval must specify the circumstances under which the licensee or design certification applicant, as applicable, shall notify the NRC of changes or errors in the risk evaluation approach utilized to address the effects of debris on long-term cooling.
General Comment
Replace "long-term" language associated with the proposed analytical limit and the debris effects. There should be no need for NRC approval of the process for notification of changes or errors, as existing processes will be used under the industry proposal. In addition, the rule language should not be specifying that a second peak cladding temperature is the only appropriate metric for post-quench core cooling.
Cross Reference to Specific Comments
Table A.23 and Table A.24

2.3.6 Paragraph (g)

Paragraph (g), “Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding,” includes information on (1) fuel performance criteria, and (2) fuel system modeling requirements.

2.3.6.1 Sub-Paragraph (1)

The proposed language, shown in Table 2.12, is only partially performance-based and can be improved. Without additional research and a regulatory guideline the proposed analytical limit on long-term cooling does not have a sufficient technical bases or a reasonable implementation process. Also, the specification of “shall not exceed 2200ºF” is incompatible with realistic ECCS evaluation models.

Table 2.12: Fuel System Design, Sub-Section 1

FRN Proposed Language Part
(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements: (i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200 °F. (ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established that correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200 ºF limit specified in paragraph (g)(1)(i) of this section, then the lower temperature shall be used in place of the 2200 °F limit. (iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC. (iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react. (v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established that corresponds to the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC.
General Comment
Paragraph (g) should be fully performance-based, and therefore numerical values should be removed from the rule. Also, additional research and a regulatory guide are needed prior to any rule language revisions related to core cooling.
Cross Reference to Specific Comments

Table A.25, Table A.26, Table A.27, Table A.28, and Table A.29.

2.3.6.2 Sub-Paragraph (2)

The proposed language, shown in Table 2.13, has new requirements on fuel system modeling. The general comment is the need to confirm that no new inspections for crud are implied by paragraph (2)(i).

Table 2.13: Fuel System Design, Sub-Section 2

FRN Proposed Language Part
(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (2) *Fuel system modeling requirements*. The evaluation model required by paragraph (d)(2) of this section must model the fuel system in accordance with the following requirement: (i) If an oxygen source is present on the inside surfaces of the cladding at the onset of the LOCA, then the effects of oxygen diffusion from the cladding inside surfaces must be considered in the ECCS evaluation model. (ii) The thermal effects of crud and oxide layers that accumulate on the fuel cladding during plant operation must be evaluated. For the purposes of this paragraph, crud means any foreign substance deposited on the surface of fuel cladding prior to initiation of a LOCA..
General Comment
The industry needs confirmation that no new inspections for crud are implied by paragraph (2)(ii). The NRC staff has previously stated that specific fuel inspection requirements should not be imposed by rulemaking (see page 27 of ML12283A213), although it is anticipated that crud models will be supported by operating data.
Cross Reference to Specific Comments
Table A.30 and Table A.31.

2.3.7 *Paragraph (k)*

In the proposal, shown in Table 2.14, NRC states that fuel may not be loaded into a reactor until the new requirements have been met and the fuel is "NRC-approved." Existing inventories of fuel assemblies and bundles that were designed, fabricated, and procured in compliance with existing NRC requirements must be grandfathered.

Table 2.14: Use of NRC Approved Fuel

FRN Proposed Language Part
(k) *Use of NRC-approved fuel in reactor*. A licensee may not load fuel into a reactor, or operate the reactor, unless the licensee either determines that the fuel meets the requirements of paragraph (d) of this section, or complies with technical specifications governing lead test assemblies in its license.
General Comment
Fuel assemblies that have been designed, fabricated, and procured in compliance with existing NRC requirements must be grandfathered to avoid a significant economic penalty. The wording of the section is confusing because the title suggests that "fuel" must be NRC-approved, yet the detail of the language puts the burden on the licensee, not a NRC review process. Most new fuel designs are developed via a process documented in NRC-approved topical reports. As such, the NRC doesn't necessarily "approve" each "new" fuel design developed per an approved process. The NRC can, and does, audit new fuel designs to ensure topical report provisions are followed. Industry believes the FRN language could jeopardize safety evaluations related to approved fuel design processes.
Cross Reference to Specific Comments
Table A.32, Table A.33, and Table A.34.

2.3.8 *Paragraph (l)*

In the proposal, shown in Table 2.15, NRC states its authority to impose restrictions on operation. This language is acceptable. No industry comments.

Table 2.15: Authority to Impose Restrictions on Operation

FRN Proposed Language Part
(l) *Authority to impose restrictions on operation*. The Director of the Office of Nuclear Reactor Regulation or the Director of the Office of New Reactors may impose restrictions on reactor operation if it is found that the evaluations of ECCS cooling performance submitted are not consistent with the requirements of this section.
General Comment
None
Cross Reference to Specific Comments
None

2.3.9 Paragraph (m)

Paragraph (m), "Corrective actions and reporting," includes information on (1) categories of changes, errors, or operation inconsistent with the ECCS evaluation, (2) significant change or error in the ECCS evaluation model, (3) breakaway oxidation, and (4) updates to risk-informed consideration of debris in long-term cooling.

2.3.9.1 Sub-Paragraph (1)

The proposed language, shown in Table 2.16, prompts numerous industry comments as the new requirements are significantly more onerous than the existing requirements and will be a burden to the industry. Refer to Appendix C for a discussion of a proposed NEI document on reporting/submittal(s) and change management. Specific revisions to the proposed rule are also provided.

Table 2.16: Reporting, Sub-Section 1

FRN Proposed Language Part
(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design

certification application, as applicable, reflecting the reanalysis.
General Comment
The reporting of errors and changes is a burden, and the new requirements are a greater burden with no apparent benefit. The rule should be significantly simplified with only general requirements, and the details moved to an NEI document to achieve standardization across the industry. Specific changes are proposed as an alternative approach. Editorial corrections to the proposed rule are needed.
Cross Reference to Specific Comments
Table A.35, Table A.36, Table A.37, Table A.38, Table A.39, Table A.40, and Table A.41.

2.3.9.2 Sub-Paragraph (2)

The proposed language, shown in Table 2.17, needs to be more performance-based, and also needs to allow an alternative to estimate the effects of changes and errors.

Table 2.17: Reporting, Sub-Section 2

FRN Proposed Language Part
(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (2) *Significant change or error in the ECCS evaluation model.* For the purposes of paragraph (m)(1) of this section, a significant change or error in an ECCS evaluation model is one that results in a calculated - (i) Peak fuel cladding temperature different by more than 50 °F from the temperature calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 °F; or. (ii) Integral time at temperature different by more than 0.4 percent ECR from the oxidation calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective oxidation changes is greater than 0.4 percent ECR.
General Comment
The industry proposes a more performance-based approach for reporting, and an alternative to estimate the effect of changes and errors is needed to avoid unwarranted reanalysis cost to the industry.
Cross Reference to Specific Comments
Table A.42 and Table A.43.

2.3.9.3 Sub-Paragraph (3)

The proposed language, shown in Table 2.18, requires measurement of breakaway oxidation for each reload batch and annual reporting of the test results by the licensees. The industry proposes that the fuel vendors develop a performance-based testing program under their QA programs and report issues through normal requirements.

Table 2.18: Reporting, Sub-Section 3

FRN Proposed Language Part
(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (3) *Breakaway oxidation*. Each holder of an operating license or combined license shall measure breakaway oxidation for each reload batch. The holder must report the results to the NRC annually (i.e., anytime within each calendar year), in accordance with § 50.4 or § 52.3 of this chapter, and evaluate the results to determine if there is a failure to conform or a defect that must be reported in accordance with the requirements of 10 CFR part 21.
General Comment
The industry proposes that the fuel vendors will develop a performance-based testing program under their QA programs and report issues through existing requirements.
Cross Reference to Specific Comments
Table A.44

2.3.9.4 Sub-Paragraph (4)

The proposed language, shown in Table 2.19, has extensive requirements for updating the risk-informed evaluation of the effects of debris. The industry considers the rule language to be excessive and unnecessary. The intent of the rule language can be achieved by requiring the applicant to include in the LAR submittal the information that the NRC requires, such as a commitment for a monitoring program and the process for notifying NRC of errors and changes using existing processes. The NRC can describe an acceptable approach in the future regulatory guide. The proposed language does not provide for restoring the plant to within the licensing basis rather than submittal of an LAR.

Table 2.19: Reporting, Sub-Section 4

FRN Proposed Language Part
(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (4) *Updates to risk-informed consideration of debris in long-term cooling.* (i) *Design certification before issuance of final design certification rule*. If a design certification applicant, after performing the evaluation under paragraph (e) of this section and including the information in its application, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the applicant shall submit a report describing its determination. Thereafter, the applicant shall submit, in a timely manner, an amendment to its pending design certification application. The amendment application must describe any changes to the certified design and/or changes in the analyses, evaluations, and modeling (including the debris evaluation model and the PRA and its supporting analyses) needed to demonstrate that the certified design meets the acceptance criteria in paragraph (e)(1) of this section. (ii) *Design certification during the period of validity under § 52.55(a) and (b) of this chapter - not currently referenced in any COL application or COL*. The design certification applicant need not report any information concerning compliance with the acceptance criterion of paragraph (e)(1) of this section in accordance with the requirements of part 21 of this chapter until 30 days after the design certification is referenced by a COL applicant. (iii) *Design certification during the period of validity under § 52.55(a) and (b) of this chapter - once referenced in a COL application or COL*. The design certification applicant shall evaluate and report any information concerning compliance with the acceptance criterion of paragraph (e)(1) of this section in accordance with the requirements of part 21 of this chapter. (iv) *Design certification - renewal*. The applicant for renewal of a design certification shall update the debris evaluation model and the PRA and its supporting analyses, taking into account all known applicable industry operational experience. The applicant shall re-perform the evaluations of risk, defense-in-depth, and safety margins using the updated model. If any of the acceptance criteria in paragraph (e)(1) of this section are not met, then applicant shall include necessary changes to the certified design, debris evaluation model, PRA or supporting analyses to demonstrate that the renewed certified design meets the acceptance criteria in paragraph (e)(1) of this section. (v) *Combined license application*. If a combined license applicant, after performing the evaluation required by paragraph (e) of this section and including the information in its application, determines that any acceptance

criterion of paragraph (e)(1) of this section is not met, then the applicant shall submit a report describing its determination within 30 days of completion of the determination. Thereafter, the applicant shall submit, in a timely manner, an amendment to its pending combined license application. The amendment application must describe any changes to the design of the facility and/or changes in the analyses, evaluations, and modeling (including the debris evaluation model and the PRA and its supporting analyses) needed to demonstrate that the design of the facility meets the acceptance criteria in paragraph (e)(1) of this section, any necessary changes to previously-submitted inspections, tests, analyses and acceptance criteria, and either the bases for any change to the inspections, tests, analyses, and acceptance criteria (ITAAC) or why no changes to the ITAAC are needed

(vi) *Combined licenses before finding under § 52.103(g)of this chapter*. Each holder of a combined license must, no later than the scheduled date for initial loading of fuel under § 52.103(a) of this chapter, update the analyses, evaluations, and modeling performed under paragraph (e) of this section. The updating must correct identified errors, and incorporate licensee-adopted changes to the plant design, the licensee's proposed operational practices, and any applicable industry operational experience known to the licensee. As appropriate, the licensee shall update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in-depth, and safety margins to confirm that the acceptance criteria identified in paragraph (e)(1) of this section continue to be met. After submitting the update under this paragraph and until the Commission has made the finding under § 52.103(g) of this chapter, the licensee shall re-perform this evaluation in a timely manner if the licensee identifies a change or error in the analyses, evaluations, and modeling, makes a change in the plant design or the plant's proposed operational practices, or identifies applicable industry operational experience. The licensee shall re-perform the evaluation, even if no changes or errors are identified, by no later than 48 months after the last review. If the licensee determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the licensee shall submit, in a timely fashion, an application for amendment of its combined license (and departure from a referenced design certification rule, if applicable), including necessary changes to its updated final safety analysis report and any necessary changes to the ITAAC. The amendment application must demonstrate that the acceptance criteria of paragraph (e)(1) of this section are met, and must describe any changes to the analyses, evaluations and modeling needed to support that conclusion. The application must explain either the bases for any change to ITAAC or why no changes to ITAAC are needed. The application must, if applicable, include a request for exemption from a referenced design certification rule, but need not address the criteria for obtaining an exemption. The licensee shall also submit any report required by § 52.99 of this chapter. The NRC need not address the issue finality criteria in §§ 52.63, 52.83, and 52.98 of this chapter when acting on this amendment, and shall – as part of any approved amendment issue any necessary exemption upon a finding that the exemption is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

(vii) *Operating licenses and combined licenses after finding under § 52.103(g) of this chapter – updating and corrections.* The licensee shall review the analyses, evaluations, and modeling performed under paragraph (e) of this section for changes and errors and incorporate changes to the design, plant, operational practices, and applicable plant and industry operational experience. As appropriate, the licensee shall update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in depth, and safety margins to confirm that the acceptance criteria identified in paragraph (e)(1) of this section continue to be met. The licensee shall perform this review in a timely manner after a change or error is identified in the analyses, evaluations, and modeling or a change is identified in the design, plant, operational practices, or applicable plant and industry operational experience. The licensee shall perform this review even if no changes or errors are identified, by no later than 48 months after the last review. If the licensee, at any time, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the licensee shall take action in a timely manner to bring the facility into compliance with the acceptance criteria of paragraph (e)(1) of this section. The licensee shall also report the failure to meet the long-term cooling acceptance criterion in paragraph (e)(1) of this section. The report must be prepared and submitted in accordance with, §§ 50.72, and 50.73, as applicable. Thereafter, the licensee shall submit, in a timely fashion, an application for amendment of its license, including necessary changes to its updated final safety analysis report. The amendment application must demonstrate that the acceptance criteria of paragraph (e)(1) of this section are met, and must describe any changes to the analyses, evaluations and modeling needed to support that conclusion. The amendment application for a combined license must, if applicable, include a request for exemption from a referenced design certification rule, but need not address the criteria for obtaining an exemption. The NRC need not address either the backfitting criteria in § 50.109 or the issue finality criteria in §§ 52.63, 52.83, and 52.98 of this chapter when acting on this amendment and shall, as part of any approved amendment, issue any necessary exemption upon a finding that the exemption is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest

General Comment
The industry considers the rule language be excessive and unnecessary. The intent of the rule language can be achieved by requiring the applicant to include in the LAR submittal the information that the NRC requires, such as a commitment for a monitoring program and the process for notifying NRC of errors and changes using existing processes. The NRC can describe an acceptable approach in the future regulatory guide. The proposed language does not provide for restoring the plant to within the licensing basis rather than submittal of an LAR
Cross Reference to Specific Comments
Table A.45 and Table A.46

2.3.10 <u>Paragraph (o)</u>

Paragraph (o) is the implementation process. Refer to Section 2.3.10.3 for the general industry comments.

Sub-Paragraph (1)

The proposal, shown in Table 2.20, is acceptable, but all of paragraph (o) is not applicable to the paragraph (e) alternate risk-informed debris approach, and a clarification is needed.

Table 2.20: Implementation, Sub-Section 1

FRN Proposed Language Part
(o) *Implementation* (1) Construction permits issued under this part after [**EFFECTIVE DATE OF RULE**] must comply with the requirements of this section at their issuance.
General Comment
Paragraph (o) is not applicable to the alternate risk-informed debris approach, as it is an optional feature; clarification is needed.
Cross Reference to Specific Comments
Table A.47

2.3.10.1 Sub-Paragraph (2)

The proposed language, shown in Table 2.21, requires removal of the reference to Table 1 for consistency with the industry implementation proposal described in another comment.

Table 2.21: Implementation, Sub-Section 2

FRN Proposed Language Part
(o) *Implementation* (2) Operating licenses issued under this part that are based upon construction permits in effect as of [**EFFECTIVE DATE OF RULE**] (including deferred and reinstated construction permits) must comply with the requirements of this section by no later than the applicable date set forth in Table 1 in paragraph (o) of this section. Until such compliance is achieved, the requirements of § 50.46 continue to apply.
General Comment
Remove reference to Table 1 for consistency with industry implementation proposal described in another comment.
Cross Reference to Specific Comments
Table A.50.

2.3.10.2 Sub-Paragraph (3)

The proposed language, shown in Table 2.22, is acceptable. No industry comments.

Table 2.22: Implementation, Sub-Section 3

FRN Proposed Language Part
(o) *Implementation* (3) Operating licenses issued under this part after [**EFFECTIVE DATE OF RULE**] must comply with the requirements of this section.
General Comment
None
Cross Reference to Specific Comments
None

2.3.10.3 Sub-Paragraph (4)

The proposed language, shown in Table 2.23, is applicable to the operating fleet. The industry proposes that the implementation plan be revised to only require each licensee to submit a plan for compliance within 180 days of the effective date of the rule. The proposed plan, a phased approach, would consist of a living schedule based on milestones. NRC would review and approve the plans, and manage the implementation outside of the rule. There is no need for the rule to specify plant names. The NRC and industry need flexibility to make schedule revisions that are necessary and appropriate without processing an exemption request.

Table 2.23: Implementation, Sub-Section 4

FRN Proposed Language Part
(o) *Implementation* (4) Operating licenses issued under this part as of [**EFFECTIVE DATE OF RULE**] must comply with the requirements of this section by no later than the applicable date set forth in Table 1 in paragraph (o) of this section. Until such compliance is achieved, the requirements of § 50.46 continue to apply.
General Comment
The industry proposes that the implementation plan be revised to only require each licensee to submit a plan for compliance within 180 days of the effective date of the rule. The proposed plan, a phased approach, would consist of a living schedule based on milestones. NRC could review the plans, with implementation details managed outside of the rule language, (e.g., via licensee regulatory commitments, orders, inspections, etc.). As an alternative the industry proposes deletion of Table 1. This would allow NRC to revise schedules based on a necessary and appropriate plant-specific basis without processing an exemption request.
Cross Reference to Specific Comments
Table A.48, Table A.49, Table A.50, and Table A.51.

2.3.10.4 Sub-Paragraph (5)

The proposed language, shown in Table 2.24, is acceptable. No industry comments.

Table 2.24: Implementation, Sub-Section 5

FRN Proposed Language Part
(o) *Implementation* (5) Standard design certifications, standard design approvals, and manufacturing licenses under part 52 of this chapter, whose applications (including applications for amendment) are docketed after [**EFFECTIVE DATE OF RULE**], and new branches of these certifications whose applications are docketed after [**EFFECTIVE DATE OF RULE**] must comply with this section at their issuance.
General Comment
None
Cross Reference to Specific Comments
None

2.3.10.5 Sub-Paragraph (6)

The proposed language, shown in Table 2.25, is acceptable. No industry comments.

Table 2.25: Implementation, Sub-Section 6

FRN Proposed Language Part
(o) *Implementation* (6) Standard design certifications under part 52 of this chapter issued before [**EFFECTIVE DATE OF RULE**] must comply with this section by the time of renewal.
General Comment
None
Cross Reference to Specific Comments
None

2.3.10.6 Sub-Paragraph (7)

The proposed language, shown in Table 2.26, is acceptable. No industry comments.

Table 2.26: Implementation, Sub-Section 7

FRN Proposed Language Part
(o) *Implementation* (7) Standard design certifications, standard design approvals, and manufacturing licenses under part 52 of this chapter issued after [**EFFECTIVE DATE OF RULE**] whose applications were pending as of [**EFFECTIVE DATE OF RULE**] and new branches of certifications issued after [**EFFECTIVE DATE OF RULE**] whose applications were pending as of [**EFFECTIVE DATE OF RULE**] must comply with this section by the time of renewal.
General Comment
None
Cross Reference to Specific Comments
None

2.3.10.7 Sub-Paragraph (8)

The proposed language, shown in Table 2.27, is acceptable. No industry comments.

Table 2.27: Implementation, Sub-Section 8

FRN Proposed Language Part
(o) *Implementation* (8) Combined license applications under part 52 of this chapter whose applications are docketed after [**EFFECTIVE DATE OF RULE**] must comply with this section.
General Comment
None
Cross Reference to Specific Comments
None

2.3.10.8 Sub-Paragraph (9)

The proposed language, shown in Table 2.28, needs clarification to address a compliance schedule issue.

Table 2.28: Implementation, Sub-Section 9

FRN Proposed Language Part
(o) *Implementation* (9) Combined licenses issued under part 52 of this chapter, before [**EFFECTIVE DATE OF RULE**] and combined licenses issued after the [**EFFECTIVE DATE OF RULE**] whose applications were docketed before [**EFFECTIVE DATE OF RULE**] must comply with this section no later than completion of the first refueling outage after initial fuel load. Until such compliance is achieved, the requirements in § 50.46 continue to apply.
General Comment
The compliance schedule for new plants is unclear during the first fuel cycle.
Cross Reference to Specific Comments
Table A.52

2.3.10.9 Table 1

The proposed language, shown in Table 2.29, needs to be revised to delete the plant names. This will allow NRC to revise implementation schedules on a plant-specific basis with necessary and appropriate justification without an exemption request.

Table 2.29: Implementation, Table 1

FRN Proposed Language Part
(o) *Implementation* Table 1: Implementation Dates for Nuclear Power Plants with Operating Licenses as of [**EFFECTIVE DATE OF RULE**]. Track 1 ..... Track 2 ..... Track 3 .....
General Comment
The industry comment is that Table 1 should be removed.
Cross Reference to Specific Comments
Table A.49, Table A.50, and Table A.51

2.4 Part 50: Appendix A

2.4.1 Nuclear Power Plant General Design Criteria Revisions

The proposed language, shown in Table 2.30, Table 2.31, and Table 2.32, enables the risk-informed debris evaluation alternative without requiring an exemption request. The industry general comments on the language are provided in Table 2.30.

Table 2.30: GDC 35 Revision

FRN Proposed Language Part
Emergency Core Cooling. A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that 1) fuel and clad damage that could interfere with continued effective core cooling is prevented and 2) clad metal-water reaction is limited to negligible amounts. Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure. 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 § 50.46c.
General Comment
The industry has several comments on the existing GDC 35 language.
Cross Reference to Specific Comments
Table A.53 and Table A.54

Table 2.31: GDC 38 Revision

FRN Proposed Language Part
Containment Heat Removal System. A system to remove heat from the reactor containment shall be provided. The system safety function shall be to reduce rapidly, consistent with the functioning of other associated systems, the containment pressure and temperature following any loss-of-coolant accident and maintain them at acceptably low levels. Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure. 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 § 50.46c.
General Comment
The proposed GDC language should not refer to lower level regulations.
Cross Reference to Specific Comments
Table A.55

Table 2.32: GDC 41 Revision

FRN Proposed Language Part
Containment Atmosphere Cleanup. Systems to control fission products, hydrogen, oxygen, and other substances which may be released into the reactor containment shall be provided as necessary to reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment following postulated accidents, and to control the concentration of hydrogen or oxygen and other substances in the containment atmosphere following postulated accidents to assure that containment integrity is maintained. Each system shall have suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) its safety function can be accomplished, assuming a single failure. The effects of debris on system safety function following occurrence of the postulated accidents may be evaluated in accordance with all requirements applicable to the risk-informed approach in § 50.46c.
General Comment
The proposed GDC language should not refer to lower level regulations.
Cross Reference to Specific Comments
Table A.56

2.5 Part 50: Appendix K

The proposed language, shown in Table 2.33, is administrative in nature and is acceptable. A general comment is provided on moving the details of Appendix K to a regulatory guide. Two specific changes to Appendix K are proposed.

Table 2.33: ECCS Evaluation Models

FRN Proposed Language Part
II. * * *   6. Upon implementation of 10 CFR 50.46c in accordance with § 50.46c(o), the documentation requirements in § 50.46c(d)(3) apply and supersede the requirements of section II of this appendix.
General Comment
Move the technical details of Appendix K to a regulatory guide. Allow use of the Cathcart-Pawel correlation in Appendix K ECCS evaluation models. Allow use of a more appropriate, yet still conservative decay heat model for the non-blowdown core cooling evaluations.
Cross Reference to Specific Comments
Table A.57, Table A.58, and Table A.59.

2.6 Part 52: Content of Applications

2.6.1 52.47: Technical Information

The proposal, shown in Table 2.34, links Part 52.47 requirements to the proposed 50.46c rule, and is acceptable. No industry comments.

Table 2.34: Technical Information (52.47)

FRN Proposed Language Part
* * * * *   (a) * * *   (4) An analysis and evaluation of the design and performance of structures, systems, and components with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. Analysis and evaluation of emergency core cooling system (ECCS) cooling performance and the need for high-point vents following postulated loss-of-coolant accidents shall be performed in accordance with the requirements of §§ 50.46, 50.46b and 50.46c of this chapter, as applicable;   * * * * *
General Comment
None
Cross Reference to Specific Comments
None

2.6.2 52.79: Technical Information in Final Safety Analysis Report

The proposal, shown in Table 2.35, links Part 52.79 requirements to the proposed §50.46c rule, and is acceptable. No industry comments.

Table 2.35: Technical Information (52.79)

FRN Proposed Language Part
* * * * * (a) * * * (5) An analysis and evaluation of the design and performance of structures, systems, and components with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. Analysis and evaluation of ECCS cooling performance and the need for high-point vents following postulated loss-of-coolant accidents shall be performed in accordance with the requirements of §§ 50.46, 50.46b and 50.46c of this chapter, as applicable; * * * * *
General Comment
None
Cross Reference to Specific Comments
None

2.6.3 52.137 Technical Information

The proposal, shown in Table 2.36, links Part 52.137 requirements to the proposed §50.46c rule, and is acceptable. No industry comments.

Table 2.36: Technical Information (52.137)

FRN Proposed Language Part
* * * * * (a) * * * (4) An analysis and evaluation of the design and performance of SSCs with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of SSCs provided for the prevention of accidents and the mitigation of the consequences of accidents. Analysis and evaluation of ECCS cooling performance and the need for high-point vents following postulated loss-of-coolant accidents shall be performed in accordance with the requirements of §§ 50.46, 50.46b, and 50.46c of this chapter, as applicable * * * * *
General Comment
None
Cross Reference to Specific Comments
None

2.6.4 <u>52.157: Technical Information in the Final Safety Analysis Report</u>

The proposal, shown in Table 2.37, links Part 52.157 requirements to the proposed §50.46c rule, and is acceptable. No industry comments.

Table 2.37: Technical Information (52.157)

FRN Proposed Language Part
* * * * *   (f) * * *   (1) An analysis and evaluation of the design and performance of structures, systems, and components with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. Analysis and evaluation of ECCS cooling performance and the need for high-point vents following postulated loss-of-coolant accidents shall be performed in accordance with the requirements of §§ 50.46, 50.46b, and 50.46c of this chapter, as applicable;   * * * * *
General Comment
None
Cross Reference to Specific Comments
None

3 Bigger Picture Issues

3.1 Conflicting Standards

Historically, the standard for LOCA acceptance criteria was to prevent brittle failure during quench. This standard was assumed achievable by a conservative interpretation of maintaining post-quench ductility, thereby minimizing the likelihood of cladding being in a brittle condition.

In reading through the proposed rule, it is evident a variety of standards are being quoted which are inconsistent. The following list of standards was noted:

- Adequate Protection
- Maintain ductility during quench
- Prevent
- Maintain a measure of
- Ensure
- Reasonable assurance
- Adequate margin

In one instance, the FRN quotes 3 different standards in a single sentence:

(Reference 1, page 16136, starting at the bottom of middle column)

*…In sum, the NRC believes that imposing the requirements of the proposed rule is necessary to prevent embrittlement of fuel cladding and to ensure that the rule maintains reasonable assurance of **adequate protection** to public health and safety…*

Industry believes there should only be one standard by which acceptance criteria are weighed: reasonable assurance. Embedding gross conservatism in the rule to achieve excessive retained margin is not consistent with performance based or risk-informed rulemaking; it should be avoided.

3.2 Risk-Informed Regulation vs Risk-Informed Rule

As part of the proposed risk informed portions of the proposed rule, NRC seeks comment on and proposes application specific requirements for PRA, as well as error reporting and change controls. While these potentially make sense from a specific rule perspective, industry is concerned about the larger trend.

Risk-Informed regulation is not necessarily the same thing as a risk-informed rule. Risk-informed regulation has an expectation that all rules would adhere to a common way of treating issues surrounding the PRA. The direction of the proposed rulemaking adds to the perception that the agency is going down a path of application specific control. In order for a PRA to provide consistently useful information, we need to avoid application specific control of PRA inputs.

Likewise, an individual rule should not create reporting requirements which could be triggered by unrelated activity, with little or no impact to the application specific risk insight.

Industry recommends looking at a way to develop standard PRA configuration control and reporting mechanisms which are not rule specific. We want to avoid the need for multiple PRA's with multiple configuration controls.

3.3 Scope Complexity

The scope of References 1 & 5, along with associated documents, make this rulemaking package extremely complex. Through the process of reviewing the material, it becomes increasingly clear there are significant open issues which do not have obvious paths to closure. It is difficult at this time to have a clear understanding of what the final rule package would look like. Consequently, industry recommends working with the staff to better identify and understand the issues at stake and then to re-issue a second draft rule package for public comment. This additional process step could prove vital to an effective, smooth implementation of the final rule.

3.3.1 Adequate Protection

As a result of Reference 1, along with statements of clarification at public meetings during the public comment period, it is obvious not all aspects of the proposed new rule language are necessary to achieve adequate protection of the public health and safety.

Industry believes the following items are necessary:

- PQD as a function of cladding Hydrogen content
- Short term breakaway oxidation phenomenon
- Interior cladding oxidation
- Crud effects

Industry believes NRC should give serious consideration to breaking this rulemaking scope into a minimum of 2 different rulemakings. New rulemaking should look at the possibility of a simple retrofit of the existing §50.46b. The current §50.46c rulemaking could also drop issues related to a future §50.46a, as well as risk-informed aspects. Industry does not yet know if such a path would be more cost effective in the long run, or not, but the concept should be explored and not dismissed.

3.3.2 Substantial Open Issue

The current rule language of §50.46 addresses the issue of core coolability; or does the core geometry remain in a coolable configuration post event.

Reference 1 proposals associated with "long-term" cooling are seen by the industry as an entirely new development (paragraph(g)(1)(v), and NRC question 3). NRC staff stated in a public meeting at NRC headquarters, during the public comment period, that NRC intends that the new analytical limit would be supported by appropriate test data.

A review of publicly available information cannot find a technical basis for (a) an analytical limit for peak clad temperature corresponding to a measured ductile-to-brittle transition during the long-term cooling phase and (b) an associated NRC-approved experimental technique for measuring the identified transition.

SECY-12-0034 suggests it was NRC's intent to include these requirements for the following purposes only: (1) to "add clarity and define a performance-based metric"; and (2) to "preserve a measure of cladding ductility throughout the period of long-term demonstration." It should be noted the "Background" section of SECY-12-0034, including its reference to technical bases for regulatory action published in July 2008, is silent regarding the technical bases for these new long-term cooling requirements.

The NRC's addition of a new long-term cooling analytical limit, and associated measurement technique, is devoid of reasoned decision-making because the agency has not fully examined relevant technical data. Also, the agency has not articulated a satisfactory explanation for its decision to promulgate these specific new requirements. Industry believes new rulemaking on long-term cooling, apart from GSI-191 aspects, is premature and views this situation as bordering on "arbitrary and capricious." Industry recommends it is best to drop this aspect of the rulemaking until such time as a firm technical basis is ready.

4 Specific Request for Comments

This chapter has the industry response to NRC's "specific request for comments on the proposed rule", Section VII of Reference 1. The NRC has twelve specific requests for industry comments.

4.1 Performance-Based Peak Cladding Temperature Limit

The NRC is proposing, in § 50.46c(g)(1)(i), to maintain the existing prescriptive criterion on PCT for zirconium alloy cladding. Limits on cladding temperature are necessary to protect against a loss of coolable geometry resulting from brittle failure upon quench, to protect against high temperature ductile failure, and to prevent reaching the point at which the zirconium-water reaction would become autocatalytic. In the original § 50.46 rulemaking, the 2200 °F limit on PCT was based on cladding embrittlement (i.e., protection against brittle failure upon quench), which was determined to be more limiting than either high temperature ductile failure or autocatalytic oxidation. The NRC's LOCA research program did not investigate cladding degradation mechanisms or develop the technical basis for performance-based requirements beyond the existing 2200 °F PCT criterion. Since the cladding embrittlement mechanism, oxygen diffusion, is strongly dependent on temperature, there exists an upper temperature at which the allowable time duration to nil ductility approaches zero (i.e., PCT °limit). As described in Section V.B.1 of this document, recent research has confirmed that 2200 °F remains an appropriate upper limit to protect against cladding embrittlement since nil ductility is achieved rapidly at higher temperature. As such, the proposed § 50.46c maintains the 2200 °F prescriptive PCT criterion.

The NRC requests comment on the proposed rule's retention of the prescriptive PCT criterion, specifically:

a. In place of the prescriptive PCT criterion, should the NRC adopt performance-based requirements for zirconium alloy cladding to protect against high temperature ductile failure and autocatalytic oxidation?

b. Do established testing procedures already exist for demonstrating acceptable high temperature cladding performance and defining acceptance criteria to meet these new performance-based requirements?

4.1.1 Industry Comment

The industry supports a performance based approach for the peak cladding temperature limit. Refer to Table A.25 and Table A.28 for specific comments.

a. In place of the prescriptive PCT criterion, should the NRC adopt performance-based requirements for zirconium alloy cladding to protect against high temperature ductile failure and autocatalytic oxidation?

At present there are no industry plans to immediately seek a peak cladding temperature limit greater than 2200°F. Consequently, future regulatory guidance on this issue is not something the industry would consider to be a high priority, (i.e., a regulatory guide concurrent with the final rule making would not be necessary). If the industry desires to extend beyond 2200°F, each fuel vendor ECCS evaluation model will propose a new upper limit for peak cladding temperature. The NRC will then have an opportunity to review the proposed criterion and testing basis.

b. Do established testing procedures already exist for demonstrating acceptable high temperature cladding performance and defining acceptance criteria to meet these new performance-based requirements?

As regards testing procedures, the real issues are material properties at higher temperatures; specifically temperature dependent creep and oxidation rates. Uncontrolled heatup source terms due to oxidation rates (commonly called "autocatalytic" oxidation) are really just a competition between oxidation energy release versus convective and thermal radiative cooling mechanisms (there is no "catalytic" component). Testing protocols to expand the material database can be developed from existing industry standards.

4.2 Periodic Breakaway Testing

To address the breakaway oxidation phenomenon, the NRC proposes to add a performance-based requirement in § 50.46c(m)(3) that the licensee measure the onset of breakaway oxidation periodically on manufactured cladding material and report any changes in the onset of breakaway oxidation at least annually. This requirement, along with a periodic test requirement (defined as each reload batch in the proposed rule language), would confirm that slight composition changes or manufacturing changes have not inadvertently altered the cladding's susceptibility to breakaway oxidation. The NRC is considering adopting, as a final rule, a requirement that each licensee measure breakaway oxidation behavior for each re-load batch. The NRC requests specific comment on the type of data reported and the proposed frequency of required testing. The objective of periodic testing is to prevent affected fuel from being loaded into a reactor. At the same time, the objective is to do so without adding ineffective requirements and unnecessary burden. Other sampling approaches may be more effective. For example, 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 (e.g., test every 10,000 rods, tubing lot, or ingot) of the same zirconium-based alloy cladding compiled during the period from the last report?.

4.2.1 Industry Comment

Each fuel fabrication vendor will develop and propose a program for performing breakaway oxidation testing and reporting with the intent of meeting the proposed rule. The industry comment is that the objective of the rule can be achieved with rule language that simply requires a fuel vendor to submit a breakaway oxidation testing program for NRC review and approval. Each licensee would then reference an NRC-approved vendor program. Any reporting regarding test results would be described in the NRC-approved vendor program and the responsibility of the vendor. DG-1261 describes a breakaway oxidation testing program that is acceptable to the NRC staff, and that information will be useful in the development of breakaway oxidation testing programs. Refer to Table A.44, for specific comments.

4.3 Analytical Long-Term Peak Cladding Temperature Limit

Section 50.46c(g)(1)(v) of the proposed rule would require that a specified and NRC-approved limit on long-term peak cladding temperature be established which preserves a measure of cladding ductility throughout the period of long-term demonstration (e.g., 30 days). The current regulation at § 50.46(b)(5) stipulates that long-term temperature be maintained "at an acceptably low value." The proposed rule would define the performance-based metric to judge an acceptably low temperature. The overall goal of preserving ductility would provide reasonable assurance that the fuel rods will maintain their coolable bundle array. The NRC is requesting input regarding this performance objective to determine if this is the most suitable performance-based metric to demonstrate long-term cladding performance.

Alternatively, the proposed rule could establish an analytical limit of long-term fuel rod cladding temperature related to observed corrosion behavior. For example, the Pressurized Water Reactor Owners Group (PWROG) has applied as a long-term core cooling acceptance criterion that the cladding temperature be maintained below 800 °F (see Topical Report (TR) Westinghouse Commercial Atomic Power (WCAP)-16793-NP, Revision 2, "Evaluation of Long-Term Cooling Considering Particulate, *Fibrous and Chemical Debris in the Recirculating Fluid," Appendix A (ADAMS Accession No. ML11292A021)). Doing so will ensure that additional corrosion and hydrogen pickup over a 30-day period will not significantly affect cladding properties. The NRC seeks comment on the acceptance criterion for long-term cooling and whether there is justification for a different temperature limit (other than the 800 °F provided in the WCAP).*

4.3.1 Industry Comment

1) The industry does not support a rule change to *specify* an analytical limit on long-term peak cladding temperature, and this limit should be removed from the proposed rule. Numerical limits are not appropriate in a performance-based rule. General language for a core coolability requirement such as the existing rule language remains sufficient. The core cooling demonstration is envisioned to be substantially more detailed than current practice. Core cooling issues need to be addressed in a future regulatory guide published concurrent with proposed rulemaking.

2) It is not clear at this time that a single PCT criterion is appropriate for both BWR's and PWR's. It is also not clear that a single criterion is appropriate to the entire time frame of "long term." As an example, a brief temperature excursion followed by a return to a lower stable temperature needs to be considered in the development of an analytical limit. Figures of merit other than peak cladding temperature may be more appropriate.

3) The industry proposes that the NRC should continue to use the current language in 10CFR50.46 that refers to the use of an acceptable analysis or ECCS evaluation model vice the proposed language of an approved ECCS evaluation model.

The NRC staff has not provided a sufficient regulatory basis to support extension of their review and approval to ALL analyses supporting ECCS evaluations. 10CFR50.46 requires the use of an acceptable ECCS evaluation model. The industry provides ECCS evaluation models for NRC review and approval for the determination of acceptable results with respect to (b)(1) Peak cladding temperature, (2) Maximum cladding oxidation, (3) Maximum hydrogen generation, and (4) Coolable geometry.

In the Public Meeting on June 24-26, 2014, the industry provided information to the NRC staff on long-term cooling analyses. Analyses supporting demonstration of acceptable results for PCT, local oxidation, core-wide oxidation and coolable geometry have in general been reviewed and approved under the current 10CFR50.46 rule. Analyses for long-term cooling sometimes have been reviewed to this level. Other analyses for long term cooling have been found to be acceptable under the current 10CFR50.46 statute without affecting the reasonable assurance of the Health and Safety of the Public. The NRC has not identified a clear benefit to the Health and Safety of the Public by the imposition in the proposed rule to require that ALL supporting methods and application of these methods be submitted to the NRC for review and approval.

To date, there is no listing of ALL analyses requiring prior NRC review and approval. NRC reviewers have often extended the review of licensee submittals outside of the scope of the amendment request. The proposed language could result in additional calculations being brought within the scope of the proposed rule without appropriate rulemaking. Without an all-inclusive list, the industry and public at large cannot provide sufficient and accurate comments on the proposed 10CFR50.46 rule with regards to acceptance criteria, ECCS evaluation models, future compliance, and regulatory analysis.

In addition, the NRC regulatory analysis does not consider the impact of the extension of the requirement for NRC review and approval to the here before-acceptable analyses that may support long-term cooling. The NRC has not specifically identified those methods and models that may be affected by this change in regulatory approach. The NRC staff has therefore not identified the industry and NRC costs in the imposition of this change in regulatory approach. This cost would be significant.

4) The industry proposes the NRC should include an option for a comprehensive risk-informed approach for core cooling. The proposed rule language restricts the use of a risk-informed approach to the consideration of debris. This approach was meant for resolution of Generic Safety Issue (GSI) -191; although perhaps adequate for its intended purpose, the proposal is not flexible enough to support risk-informed approaches for debris and boric acid precipitation, either together or separate, with one being evaluated deterministically and one with a risk-informed approach.

A more general risk-informed approach would provide the industry with a tool for evaluation of BAP. This approach would likely build on the previously documented break-size probabilities as documented in NUREG-1829. As an example of earlier rulemaking using a risk-informed approach, the NRC staff considered the information in NUREG-1829 during the selection of the BWR and PWR transition break sizes for the proposed 10 CFR50.46a rulemaking. The use of a risk-informed approach for BAP is not expected to affect the reasonable assurance of the Health and Safety of the Public. Therefore, the NRC staff is requested to consider inclusion of a comprehensive risk informed approach for long-term cooling.

Industry specific comments are identified in Table A.29. The industry input to the proposed regulatory guide related to the “long-term” cooling issue is provided in Appendix (C).

4.4 Acceptance Criteria for Risk-Informed Alternative

Section 50.46c(e) of the proposed rule contains the high-level acceptance criteria for an alternative that would allow entities to use, on a case-by-case basis, a risk-informed approach to address the effects of debris on long-term core cooling. In addition, the NRC will develop draft regulatory guidance for this provision concurrent with the staff’s review of the STPNOC’s pilot application for a risk-informed approach to address the closely related topic of GSI-191. The NRC seeks comment on whether the detailed acceptance criteria should be set forth in § 50.46c, or in the associated regulatory guidance.

4.4.1 <u>Industry Comment</u>

Industry supports the risk-informed alternative to address debris effects on core cooling (risk-informed being available for all time frames), with the detailed acceptance criteria specified in a regulatory guide rather than in the rule. Future regulatory guidance should maintain consistency with existing regulatory guidance and acceptance criteria (e.g., Reg. Guide 1.174) to the extent possible. The §50.48(c)(4) risk-informed alternative to comply with the NFPA-805 fire protection requirements can be used as a model for the level of detail that the acceptance criteria are needed in the §50.46c rule.

Refer to Table A.17 and Table **A.23**, for specific comments.

4.5 Regulatory Approach for Risk-Informed Regulation

The NRC seeks comment on whether the risk-informed alternative offered by this regulation should require meeting numeric-risk acceptance criteria as a matter of compliance (similar to § 50.48c) or whether other risk-informed approaches that use risk-importance insights to establish measurable criteria or performance objectives, such as those in use by §§ 50.62, 50.63, and 50.65, or approaches using both risk importance and numeric-risk acceptance criteria, such as those in use by § 50.69, would be preferable.

4.5.1 Industry Comment

The approach should not be a single selection approach. Some plants may choose to utilize numeric-risk acceptance criteria (e.g., STP approach) whereas others may use risk-importance insights (e.g., break size risk-importance along with deterministic criteria), or a combination of both. As long as the appropriate risk threshold can be identified, and in some cases, quantified, then all approaches should be acceptable.

Performance objectives could provide some flexibility over that of numeric risk acceptance criteria. The referenced Maintenance Rule 50.65 provides an example of how this could be implemented

The 50.48(c)(4) risk-informed alternative to comply with the NFPA-805 fire protection requirements could be used as a model for the risk acceptance criteria in the §50.46c rule. The risk-informed alternative should be expanded for all core cooling periods, not just long-term.

Refer to Table **A.18**, Table 2.20, Table 2.21, and Table 2.22 for specific comments.

4.6 Operational Modes Considered in Risk-Informed Alternative

Deterministic evaluations of GSI-191 are currently required only for those modes of operation where both recirculation from the sump is relied upon and the plant accident can cause high pressure jets that can result in generation and transport of debris to the sump. By contrast, probabilistic evaluations generally consider all modes of operation. The NRC seeks comment on whether the risk-informed approach provided in § 50.46(e) could generically exclude any plant operational modes (e.g., low power or shutdown) from consideration. If so, what are the bases for excluding these operational modes from consideration?

4.6.1 Industry Comment

Paragraph (e)(1)(iv) states the risk-informed approach should "Utilize a PRA that, at a minimum, models severe accident scenarios resulting from internal events occurring at full power." Paragraph (e)(2)(ii) expands the scope of the risk evaluation to "...internal and external events initiated during full power, low power, and shutdown operation..." This rule language requires the applicant to evaluate all initial conditions without requiring those initial conditions to be an integral part of the PRA.

This rule language may impose requirements above and beyond those necessary to demonstrate acceptable risk for those events leading to recirculation, and should not require consideration of those operating modes where the equipment supporting the recirculation function is not required by technical specifications. Additionally, modeling of severe accidents does not appear to be necessary since successful operation of those systems required to demonstrate acceptable performance for postulated design basis events is all that should be required.

The risk-informed approach should not have to consider modes of operation for which the recirculation function is not currently required by Technical Specifications. During the non-required modes of operation, there are multiple factors negating the need to consider debris impacts in the coolant. First, the quantity of debris that could be generated is significantly reduced since there is no potential for a significant break jet to form. Second, in the lower operation modes, the safety injection signal is blocked from actuation which results in significantly less flow and significantly reduced debris transport. Third, the core decay heat load is significantly reduced which, if recirculation was required, would result in significantly less transport of debris to the core resulting in a condition where the core cooling geometry is maintained.

Additionally, non-DBA events should not be considered as part of this rule, and associated implementation guidance, as this rulemaking is only about one specific DBA.

4.7 Reporting Criteria for the Risk-Informed Alternative

Reporting Criteria for the Risk-Informed Alternative. The NRC is proposing in § 50.46c(m) corrective actions and reporting criteria specific to the risk-informed approach for addressing the effects of debris on long-term cooling. These criteria are performance-based and similar in concept to the reporting criteria in § 50.69. Per proposed § 50.46c(m), the NRC's approval of the entity's risk-informed application would specify the circumstances under which the licensee or design certification applicant shall notify the NRC of changes or errors in the risk evaluation approach. In addition, the proposed rule would require entities to review the analyses, evaluations, and modeling for changes and errors and incorporate changes to the design, plant, operational practices, and operation experience. The entity would then be required to update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in-depth, and safety margins to confirm the acceptance criteria for the risk-informed approach continue to be met. The NRC seeks specific comment on the reporting criteria for the risk-informed approach.

Alternatively, the NRC seeks comment on whether the reporting criteria for the risk-informed approach should be more prescriptive and establish requirements similar to those for the ECCS model (i.e., § 50.46c(m)(1) through (m)(3)). For instance, should the rule establish values for changes in Δ CDF, Δ LERF, defense-in-depth, and safety margins that would trigger specific reporting actions? If so, what values should reporting criteria establish as reporting triggers and what are the bases for selecting those values?

4.7.1 *Industry Comment*

Industry acknowledges that a monitoring program for risk-informed licensing basis changes is fundamental element of RG 1.174. Future regulatory guidance is expected to include a description of an acceptable monitoring program, and the industry requests an opportunity to provide input on that content. The industry strongly prefers including only general requirements in the rule. The industry proposes simple rule language requiring the licensee to submit a description of the monitoring program and a process for NRC notification of changes and errors in the LAR. The NRC would then review and approve the plan in the LAR. Refer to Table A.45, for specific comments.

The current language in the proposed rule appears to require reporting for the effects of debris on long-term cooling the same as for a traditional ECCS evaluation model. There should be discrete criteria developed for each applicant based on their risk values. For example, if a licensee's application identifies that their risk places them in the mid-range of Region II of RG 1.174, then the most significant change or error would be one resulting in the risk meeting or exceeding the Region I criteria. The next lower threshold would be one that results in an increase in risk that is greater than or equal to 50% of the margin available between their initial risk and the Region II / Region I threshold. The lowest threshold (requiring an annual report) would be one that results in an increase in risk that is greater than or equal to 25% of the margin between their initial risk and the Region II / Region I threshold. Additionally, there should also be a requirement that monitoring of cumulative changes should also be undertaken (as a matter of performance for each change or error) and if the cumulative impact meets the criteria specified above, the respective reporting and actions shall be taken.

For licensed defense-in-depth and safety margins, if not currently part of the licensed risk analysis, and not falling under Technical Specification requirements, then any reduction in these margins should be reported in annual report if evaluated and determined to not remove a necessary function (e.g., alternate core cooling capability) that was credited in the approval. If determined to result in a complete loss of a credited function, then the highest level of reporting should be required.

Refer to Table **A.24** for specific comments.

4.8 Exemptions Needed to Implement the Risk-Informed Alternative

One objective of the proposed rule is to allow entities to submit a risk-informed alternative to address the effects of debris on long-term core cooling without the need to submit an exemption request. The NRC identified that, in order to eliminate the need for an exemption, changes may be necessary in GDCs 35, 38, and 41, as provided in the proposed rule. The NRC seeks input on whether conforming changes to other regulations would be necessary or desirable. Such conforming changes may avoid the need for entities wishing to use the risk-informed alternative to request exemptions from those regulations in order to effectively implement the risk-informed alternative. If you believe it is necessary or desirable to provide a conforming change to a regulation in order to avoid an exemption from that regulation, then please identify the specific regulation (and specific regulatory provisions, if applicable) for which a conforming change would be made, either the language of the change or a description of the conforming change's objective, and the reason(s) why an exemption would otherwise be needed if the NRC did not make a conforming change to that regulation.

4.8.1 Industry Comment

The industry has not identified any additional regulations for which exemption requests are expected to be necessary to support the implementation of the alternate risk-informed approach for addressing the effects of debris on core cooling. Industry does believe the risk-informed alternative to address debris effects should be available for all time frames, not just long-term. Continued use of the "long-term" terminology could lead to further exemption requests.

4.9 Staged Implementation

The NRC is proposing, in § 50.46c(o), a staged implementation plan for the proposed rule. As part of this plan, licensees have been divided among three implementation tracks based upon existing margin to the revised requirements and anticipated level of effort to demonstrate compliance. The NRC requests specific comment on the staged implementation plan, track assignments, or alternative means to implement the requirements of the proposed rule.

4.9.1 Industry Comment

The industry has significant comments regarding the proposed staged implementation plan. Refer to Section 2.3.10 for the rule language general comments and the cross reference to the specific comments in Appendix A.

1) The industry proposal is to revise the implementation language to require each licensee to submit within 180 days a milestone based plan to comply with the rule. Also, a phased-implementation approach has been successful for other regulatory issues (e.g. emergency preparedness and cyber security) and is appropriate for 50.46c. A separate compliance schedule for debris effects on core cooling requirements is definitely needed by industry due to the regulatory uncertainty on this subject. An alternative implementation proposal is to delete the plant names from Table 1 to avoid future exemption requests due to necessary changes in track assignments and requests for schedule relief. The NRC can manage implementation through normal processes without including plant names in the rule.

2) The NRC assumes plants assigned to Track 1 can demonstrate compliance via submittal of a letter report not involving a LAR as technical specification changes or licensing basis changes would not be required. The industry perspective is the fuel vendors will be developing LTR's, for NRC review and approval, of new hydrogen pickup models, and new debris effects on core cooling evaluation methodology. Both of these would require a licensee to revise the list of methodology reports, which would necessitate submitting a LAR. There are several such issues which would require plant specific LAR. The industry would appreciate working with NRC to explore and identify a compliance approach for the Track 1 plants that does not require submittal of an LAR. An example would be a plant-specific safety evaluation allowing use of Cathcart-Pawel in place of Baker-Just.

3) The industry would appreciate working with NRC to explore a compliance approach for the Track 2 and 3 plants that does not require revising the ECCS evaluation model topical report. The technical content would be submitted with an LAR on a plant-specific basis. (It is not clear at this time that such an outcome is possible).

4) The industry notes compliance with the proposed §50.46c rule language only involves the licensees meeting the submittal dates currently in Reference 1, Table 1. The rule does not state the specific content of the submittals, or which paragraphs of the rule are related to the submittals. The rule does not speak to the schedule for completion of the NRC review activities or the schedule for formal LOCA analyses using the revised or new ECCS evaluation models following NRC approval. Completion of all of these activities given the resource limitations at both the NRC and in the industry will require many years.

5) The industry maintains that grandfathering of fuel assemblies/bundles and cladding manufactured under the existing regulations is necessary. The industry proposes that all irradiated and unirradiated fuel assemblies/bundles and cladding inventories that exist up to 60 months after the effective date of the rule be permanently exempted from the new rule requirements. These items would remain available for use in future reactor cores until they are permanently discharged into long-term storage.

6) The industry is concerned the NRC review of submittals related to the proposed §50.46c rule will expand into a broad review of aspects of the ECCS evaluation models, applications, and plant design that are unrelated to the rule revision. A focused review, limited to the new elements of §50.46c, is needed for the completion of the very substantial review effort within a reasonable period of time. The NRC should develop a Review Standard (RS) for §50.46c submittals. RS-001 was developed for the extended power up-rates and was beneficial to all parties.

7) The implementation requirements and schedule should not discourage licensees from pursuing the hardware fix of implementing advanced cladding. For example, if a plant wants to implement an improved cladding material right now, via a LAR, would the docketed LAR be placed in an effectively untenable situation where LOCA related RAI couldn't be answered in a timely manner? Such an outcome could lead to a situation where the new rule making actually hinders a material improvement to physical safety margins.

8) The industry requests that a Regulatory Information Summary (RIS) be developed to support rule implementation. The RIS will be beneficial in standardizing the contents of industry submittals. RIS 2002-03 was developed for the measurement uncertainty recapture uprate submittals and was very beneficial to the industry.

9) The proposed § 50.46c(g)(1)(v) has ramifications to the ongoing GSI-191 efforts of the owners groups. Specifically with respect to the timing of test scope definition, completion, and ultimately, supporting ECCS rulemaking implementation. This needs to be considered as part of a multiple path compliance effort.

Refer to Table A.47, Table A.48, Table A.49, Table **A.50**, and Table A.51 for specific comments.

4.10 New Reactor Implementation

The NRC is proposing, in § 50.46c(o)(5) through (9), 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. The proposed implementation plan for new reactors would allow applicants for a design certification, standard design approval, and manufacturing license under review at the time of the effective date of the rule to come into compliance with the rule at time of renewal. The holder of a combined license issued prior to the effective date of the rule would be permitted to operate the plant for one fuel cycle before coming into compliance with the rule. Therefore, the NRC is proposing to recognize that new reactors may operate for the initial fuel cycle with fuel for which the burnup effects being accounted for in the rule would not be a consideration. Applications for design certifications, standard design approvals, manufacturing licenses and combined licenses submitted after the effective date of the rule would be expected to be in compliance with the rule at the time of approval.

The NRC is requesting input regarding this implementation proposal, including suggestions for alternate approaches.

4.10.1 Industry Comment

There can be a conflict between the compliance date for new plants and the completion of the first fuel cycle. The license approval date, the rule effective date, and the track compliance date can combine to create an unanticipated complication for new plants. Refer to Table A.52 for comment details.

4.11 Restructuring 10 CFR Chapter 1 with Respect to ECCS Regulations

The NRC is considering restructuring its ECCS regulations as part of the finalization of this rulemaking due to: 1) Commission direction to include in the proposed rule a provision allowing licensees to use a risk-informed submittal to address the effects of debris during the long-term recovery period; and 2) the potential benefit and efficiency of collocating all ECCS-related requirements within the CFR. As such, the NRC seeks comment on the following potential administrative changes:

- *Codify the performance-based ECCS and cladding requirements (as proposed in this document) as a new section, § 50.181.*
- *Reserve § 50.183 for the potential future risk-informed ECCS requirements rule (currently referred to as the draft final § 50.46a rule).*
- *Codify the requirements for the risk-informed submittals (proposed as § 50.46c(e) in this proposed rule) to address the effects of debris in the long-term recovery period as a new section, § 50.185.*
- *Duplicate the content of appendix K to 10 CFR part 50, ECCS evaluation models, and add the content as a new section, § 50.187. (The NRC notes that appendix K to 10 CFR part 50 will remain in place until all licensees have implemented the proposed requirements (i.e., until completion of the proposed staged implementation period).)*
- *If this restructure is pursued, following the completion of the proposed staged implementation period, the NRC would make the following administrative changes:*
    - *Remove the current § 50.46, ECCS acceptance criteria, in its entirety.*
    - *Remove the current appendix K to 10 CFR part 50, in its entirety. (The content will exist as § 50.187.)*

- *Redesignate the current § 50.46a, "Acceptance criteria for reactor coolant system venting systems," as § 50.46.*

The tables that follow depict the described potential changes:

Existing NRC Requirements and Proposed New Regulations (Bolded rules are currently in effect)	**Rulemaking and Implementation Activities**		
	Initial Codification of Final Performance-Based Fuel Cladding Requirements	**End of Phased Implementation Period for Performance-Based Fuel Cladding Requirements**	**Finalization of Risk-Informed ECCS Requirements (currently referred to as draft final § 50.46a)**
§ 50.46 ECCS Acceptance Criteria	§ 50.46 ECCS acceptance criteria (no change)	Removed from 10 CFR Chapter I in its entirety	Removed from 10 CFR Chapter I in its entirety
§ 50.46a Reactor Coolant Venting Systems	NO CHANGE	§ 50.46	§ 50.46
Draft final rule: § 50.46a Risk-Informed ECCS Requirements	See Note 1.	See Note 1.	§ 50.183 Risk-informed emergency core cooling system requirements
Performance-based ECCS and cladding requirements (currently designated in draft proposed rulemaking package as § 50.46c)	§ 50.181 Emergency core cooling system performance during loss-of-coolant accidents	§ 50.181	§ 50.181
Requirements for risk-informed submittals to address effects of debris in the long-term post-quench cooling period (currently designated in draft proposed rulemaking package as § 50.184)	§ 50.185 Requirements for risk-informed submittals to address effects of debris in the long-term post-quench cooling period	§ 50.185 Requirements for risk-informed submittals to address effects of debris in the long-term post-quench cooling period	§ 50.185
Appendix K to 10 CFR part 50: ECCS Evaluation Models	Appendix K to 10 CFR part 50: ECCS Evaluation Models And § 50.187 ECCS evaluation models See Note 2.	§ 50.187 ECCS evaluation models	§ 50.187

Note 1: The staff plans to submit the draft final § 50.46a rulemaking package to the Commission following completion of NTTF Recommendation 1 activities. At this time, it is uncertain whether finalization of the draft final § 50.46a rule would occur before the finalization of the proposed § 50.46c rule.
Note 2: Until all licensees have implemented the proposed requirements (i.e., the proposed staged implementation is complete), appendix K to 10 CFR part 50, "ECCS Evaluation Models," and § 50.187, "ECCS Evaluation Models," would coexist.

Should this restructure be pursued, the following table depicts the structure of 10 CFR part 50 after finalization of the § 50.46a Risk-Informed ECCS Requirements and after the proposed staged implementation of the § 50.46c Performance-based ECCS and Cladding Requirements rulemaking is complete:

Section	Title
§ 50.46	Reactor coolant venting systems
§ 50.181	Emergency core cooling system performance during loss-of-coolant accidents (§ 50.46c)
§ 50.183	Risk-informed emergency core cooling system requirements (§ 50.46a)
§ 50.185	Requirements for risk-informed submittals to address effects of debris in the long-term post-quench cooling period
§ 50.187	ECCS evaluation models (appendix K to 10 CFR part 50)

The NRC acknowledges that such changes could have a large impact on licensees and vendors with regard to procedures, plans, programs, topical reports, and engineering calculations that reference appendix K to 10 CFR part 50 and the current ECCS regulations. In your comments, please include the estimated cost for conforming changes to topical reports, licensing amendments, and other technical documents. Please also comment on whether the anticipated benefits and efficiencies would outweigh the administrative burden, costs, and complexities.

4.11.1 Industry Comment

The industry has given consideration to the proposed restructuring of 10 CFR 50.46 and Appendix K. As acknowledged by the NRC there would be a large cost to revise industry documentation to reflect the changes. The industry perceives the benefits to be small in comparison, and therefore has not developed a cost estimate.

The industry does see a significant benefit in removing the technical details in Appendix K from Part 50 and placing them in a new regulatory guide ("Conservative ECCS Evaluation Models"). There are desired changes to existing Appendix K ECCS evaluation models, including some prompted by the new proposed 50.46c language that would benefit from not requiring processing of exemption requests. Moving the technical details in Appendix K to a regulatory guide would also provide an opportunity for the NRC staff to address known legacy issues and modernize the content. The industry welcomes an opportunity to support the development of the proposed regulatory guide. Refer to Table **A.14**, Table A.57, Table A.58, and Table A.59 for specific comments

4.12 Cumulative Effects of Regulation

The cumulative effects of regulation (CER) consist of the challenges licensees face in addressing the implementation of new regulatory positions, programs, and requirements (e.g., rulemaking, guidance, generic letters, backfits, inspections). The CER is manifested in several ways, including the total burden imposed on licensees by the NRC from simultaneous or consecutive regulatory actions that can *adversely affect the licensee's capability to implement those requirements while continuing to operate or construct its facility in a safe and secure manner. Consistent with SECY-11-0032, "Consideration of the Cumulative Effects of Regulation in the Rulemaking Process," dated March 2, 2011 (ADAMS Accession No. ML110190027), the NRC is requesting comments on CER with respect to this proposed rulemaking. The NRC's consideration of CER will be based, in part, on the NRC's confirmation of the safe operation for each operating reactor, as described in Section III, "Operating Plant Safety," of this document. During the development of this proposed rulemaking, the NRC engaged external stakeholders through multiple public meetings, an ANPR, and solicitation of public comments. Additionally, the proposed rule would establish a staged implementation plan, which would reduce the overall implementation burden on licensees.*

With regard to CER, the NRC requests specific comment on the proposed rule's implementation schedule in light of any existing CER challenges, specifically:

a. *Do the proposed rule's effective date, compliance date, and submittal dates provide sufficient time to implement the new proposed requirements, including changes to programs, procedures, and the facility, in light of any ongoing CER challenges?*
b. *If there are ongoing CER challenges, what do you suggest as a means to address this situation (e.g., if more time is required for implementation of the new requirements, what time period is sufficient)?*
c. *Are there unintended consequences (e.g., does the proposed rule create conditions that would be contrary to the proposed rule's purpose and objectives)? If so, what are the unintended consequences?*
d. *Please comment on the NRC's cost and benefit estimates in the proposed rule regulatory analysis (ADAMS Accession No. ML12283A188). Specifically, please comment on the vendor hydrogen uptake and LOCA model costs, costs of PQD and breakaway testing, and licensee analysis costs.*

4.12.1 Industry Comment

a. *Do the proposed rule's effective date, compliance date, and submittal dates provide sufficient time to implement the new proposed requirements, including changes to programs, procedures, and the facility, in light of any ongoing CER challenges?*

The proposed rule only includes compliance dates for licensee submittals. There are no schedules for the NRC review activities, and consequently licensees will not be able to plan the downstream work activities. The industry will need NRC agreement to grandfather the existing fuel assembly/bundle designs and cladding materials well into the future to allow the post-submittal activities to be completed. It will not be possible for licensees to make any decisions or plans in this uncertain situation. There are major concerns with both industry and NRC technical resources to support the implementation of the rule.

Another major issue is the NRC's intent to adopt a limit on cladding temperatures related to long-term cooling prior to preparing a regulatory guide that captures the research and proposes a methodology that is acceptable to the NRC. This is contrary to the NRC approach on cladding embrittlement and breakaway oxidation that was accompanied by regulatory guides.

The same situation exists with the alternate risk-informed approach for addressing the effects of debris on long-term cooling - the rule precedes the regulatory guide.

b. *If there are ongoing CER challenges, what do you suggest as a means to address this situation (e.g., if more time is required for implementation of the new requirements, what time period is sufficient)?*

The industry is very concerned about the adequacy of industry resources (i.e. LOCA analysts) and NRC resources (i.e. technical reviewers) that will be required to perform the work activities resulting from the proposed rule. The rule does not require the NRC review to be completed on any particular schedule. Without that schedule information the licensees will not be able to plan their work activities that are downstream of the NRC review. The resulting uncertainty may cause stagnation in development of advanced fuel assembly and cladding designs. Conservative decision-making will be the norm.

c. *Are there unintended consequences (e.g., does the proposed rule create conditions that would be contrary to the proposed rule's purpose and objectives)? If so, what are the unintended consequences?*

One possible unintended consequence of the proposed rule is that vendors and licensees may choose not to pursue advanced cladding and fuel assembly designs due to the associated increased cost of performing LOCA analyses for a range of fuel exposures, due to the cladding embrittlement analytical limits being exposure-dependent. Also, the cost of testing of new cladding materials will increase with the proposed testing requirements, in particular if testing of irradiated materials is required rather than allowing testing of hydrogen-charged materials as a surrogate.

Another possible unintended consequence is that the NRC review of the industry submittals will expand into technical areas unrelated to the rule (e.g. the fuel fragmentation, relocation, and dispersal issue currently in the discovery phase). Should this occur the progress with reviewing the large volume of submittals will be slow, which will eventually challenge plant operation decisions.

Another possible unintended consequence relates to the proposal regarding long-term cooling. If an ECCS demonstration is required for some explicitly definable time period, it has the potential to increase the number of systems which fall under the new rule because they may be relied upon, even though they are not formally identified as being safety related ECCS systems. We don't want to create a situation where equipment which is not seismically qualified might need to be credited on a long term basis, and thus fall into a trap that did not previously exist (potential GDC2 issue).

Another problem with the long-term cooling proposal is from the perspective of what is a design basis accident. Explicitly defining a cooling period which must be demonstrated using reviewed and approved methods and acceptance criteria would invariably lead to an expansion of what constitutes a design basis LOCA. A related issue then presents itself. When defining a long-term cooling accident, when exactly does the postulated accident/DBA end?

d. *Please comment on the NRC's cost and benefit estimates in the proposed rule regulatory analysis (ADAMS Accession No. ML12283A188). Specifically, please comment on the vendor hydrogen uptake and LOCA model costs, costs of PQD and breakaway testing, and licensee analysis costs.*

Based on the statement in the regulatory analysis, using the "adequate protection justification" as a basis for not entering the backfit analysis provision per 10 CFR 50.109(a)(4)(ii), industry does not agree that the entire content of the proposed rulemaking meets the backfit requirements. Industry believes NRC should perform a realistic review of the cost of the proposed rule and consider the inaccuracies identified in the regulatory analysis. The overall perception by the industry is that the NRC's cost estimates for industry activities is substantially below current estimates. This perception has been confirmed by both the industry review and in a recent NEI study comparing actual vs. estimated cost for previous regulatory issues (see Figure 4.1), showing a consistent, significant, under estimation of actual costs. Refer to Chapter 5 of this report for the detailed industry comments.

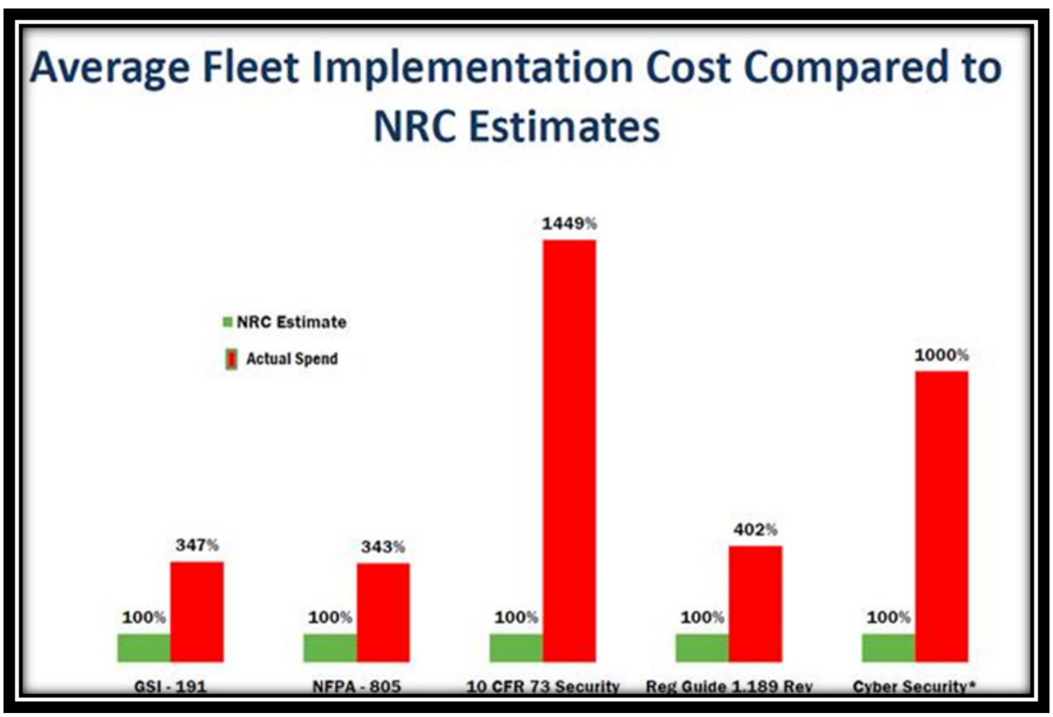


Figure 4.1: Regulatory Issues Implementation Cost Comparisons

5 Regulatory Analysis

This chapter provides the industry's general and specific comments on the regulatory analysis (Reference 5). Industry believes the NRC should perform a realistic review of proposed rule cost and consider the inaccuracies identified in the regulatory analysis. The overall perception by the industry is that cost estimates for industry activities are substantially below current experience. The following comments provide some examples.

5.1 General Comments

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: 39, Date: March 24, 2014
Statement	The regulatory analysis states in part on page 39, "This rulemaking is predicated upon the belief that this proposed action falls under the adequate protection justification. The Regulatory Analysis Guidelines state that, "The level of protection constituting 'adequate protection' is that level which must be assured without regard to cost" (emphasis added). The Guidelines also state that, ". . . a proposed backfit to one or more of the facilities regulated under 10 CFR Part 50 does not require a regulatory analysis if the resulting safety benefit is required for purposes of compliance or adequate protection under 10 CFR 50.109(a)(4)."
Comment	The U.S. court of appeals for the D.C. Circuit ruled in 1987 that in setting or enforcing the standard of "adequate protection" to the public health and safety set forth in Atomic Energy Act Section 182.a., the NRC "may not consider the economic costs of safety measures." Here the NRC requires licensees to provide "'extra-adequate' protection" such as by ordering plants already satisfying the adequate protection standard to take additional safety measures, under the authority of AEA Section 161, "the Commission may take into account economic costs." Union of Concerned Scientists v. NRC, 824 F.2d 108, 114, 118. Further, the NRC Regulatory Analysis Guidelines, NUREG/BR-0058, Rev. 4 (2004), states (p.7) that "if there is more than one way to achieve compliance or reach a level of adequate protection, and the Commission finds it necessary or appropriate to specify the way, costs may be a factor in that decision." In our view, the proposed rule allows more than one way to achieve compliance and/or reach an appropriate level of adequate protection; therefore, consideration of the cost to the industry to comply with this rule can and should be considered.
Bases	*Since it has been determined by the NRC that the plants are operating safely and the costs associated with this proposed rule change have been grossly underestimated (by at least an order of magnitude), the benefit of the rule change has not been adequately demonstrated.*
Proposal	NEI, with support of the EPRI Regulatory Technical Advisory Committee (Reg TAC), the BWR Owners Group, PWR Owners Group, and industry technical experts, will provide written comments that will: • Identify alternatives to achieve compliance or reach a level of adequate protection • Identify alternatives to allow NRC to consider economic costs • Help issue a NEI document on reporting requirements, corrective action requirements, and change management processes prior to publication of final rule These comments will propose an approach analogous to that taken during 10 CFR 50.59 rulemaking that received NRC endorsement of an NEI document via a Regulatory Guide
Bases	*The rule change, as it was first conceived, had a valid basis and could be implemented in a timely manner. Adding the additional reporting requirements, with no documented benefit or safety increase slows down the process and incurs additional costs. The NRC has indicated, on page 5 of this analysis, "That the NRC, after conducting audits of the Owners Group reports and supporting NSSS supplier engineering calculations has confirmed, for every operating reactor is currently safe to operate", which does not support the NRC belief stated on page 39.*

5.2 Industry Comments on Background

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: 5, Date: March 24, 2014
Statement	Recognizing that finalization and implementation of the new ECCS requirements would take several years, the NRC completed a more detailed safety assessment which confirmed current plant safety for every operating plant. See Section III.A of the proposed rule SOC for further information.
Comment	As indicated in the reference to the proposed rule, The NRC conducted an audit of the Owners Group reports and supporting General Electric-Hitachi (GEH), AREVA, and Westinghouse engineering calculations. Based on the OG reports and supplemental information collected during the audits, the NRC was able to confirm, for every operating reactor, current safe operation of the units
Bases	*The NRC has already concluded that the operating plants are safe and continue to have margin.*
Proposal	Continue to monitor, on an annual basis, the continued safe operation of each plant. There is no pressing need to change the process.
Bases	*As indicated in the reference to the proposed rule, the existing audit report documents and safety assessment ("ECCS Performance Safety Assessment and Audit Report," dated February 10, 2012 (ADAMS Accession No. ML12041A078)), the NRC intends to verify, on an annual basis, continued safe operation until each licensee has implemented the new ECCS requirements. The costs associated with doing this annual review is significantly less than the amount of Industry and NRC reviews proposed in the new rule.*

5.3 Industry Comments on No-Action Alternative

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: 12, Date: March 24, 2014
Statement	Paragraph 3.1 states in part, "The no-action alternative requires that the embrittlement issue and the risk-informed approach to evaluating the effects of debris on long-term cooling be resolved on a case-by-case basis (e.g., license amendments, orders). This would require exemption requests and other administrative costs that are shown in the attributes as negative costs.
Comment	This statement does not take into consideration the increased costs placed on the license holders to perform the required analysis. As it is the NRC's intent to proceed with the rule without a backfitting analysis per 10 CFR 50.109(a)(4)(ii), industry feels it is important, moving forward, that the NRC have a better concept of the inaccuracies contained within the regulatory analysis. The overall perception by the industry is that the NRC's cost estimates for industry activities was substantially below what we expect. Comments received from one fleet (22 plants) have estimated costs in excess of $1 million/unit.
Bases	*The industry perception is in part based on an NEI study showing actual vs. estimated costs for previous regulatory issues that shows gross under-estimation of actual costs (Table 4.1). Recent fleet implementation costs when compared to NRC estimates indicate a very poor understanding of what it takes to implement a new requirement. Examples include GSI-191 (actual cost 347% higher than NRC estimates), NFPA-805 (343% higher, 10CFR73 (1449% higher, Reg. Guide 1.189 (402% higher), and Cyber (1000% higher)*
Proposal	Work with the industry to understand the true cost of implementing new regulations and re-perform the regulatory analysis using improved cost estimating.
Bases	*Need to reflect the true cost of implementing this change in regulations.*

5.4 Industry Comments on Industry Implementation

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: 19, Date: March 24, 2014
Statement	The plants in Track 1 meet the new requirements without new analysis or model revisions (beyond use of Cathcart-Pawel-Equivalent Cladding Reacted (CP-ECR)) to integrate time-at-temperature and hydrogen uptake models to establish PQD analytical limits), and thus would meet the new requirements with a low level of effort.
Comment	While plants in Track 1 do meet some of the new requirements in the proposed rule, new codes and methods and analyses will be required for compliance. Since the required new vendor methods have not been developed or submitted for approval by the NRC, indicating that the efforts required to meet the new requirements will only require a low level of effort is premature. The cost/benefit of the proposed rule has not been adequately established. For a plant to be in compliance, its Technical Specifications will need to be revised to include the new vendor methods.
Bases	*The number of additions to the proposed rule have made Track 1 compliance rise to a level requiring a medium to high level of effort.*
Proposal	Remove the new additions and bring the proposed rule back to its original response to the two petitions. Allow orders, ongoing reviews, and other methods to ensure compliance with the other requirements proposed in this rule.
Bases	*The proposed rule has departed from the original request for a rule change by adding additional requirements that have not been adequately assessed.*

5.5 Industry Comments on Assumptions

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: 26, B-10, Date: March 24, 2014
Statement	The NRC assumes that there would be 49, 12, and 13 revised AORs in the three tracks, respectively. Due to multiple unit sites that share common analyses, the number of AORs is less than the 100 plants. Track 1 actions would require 0.5 FTE over a 2-year period (0.25 FTE/year); Track 2 actions would require 1.5 FTE over a 3-year period (0.5 FTE/year); Track 3 actions would require 2.25 FTE over a 3-year period (0.75 FTE/year).
Comment	The regulatory analysis assumes the indirect industry cost of revised ECCS analysis of record (AOR) is $300,000. This is based on a three year period, 1.5 FTE/year, and a labor rate of $200,000/year. The NRC assumes that 12 AORs will be required for Track 2 plants, which results in a total cost of $3.6 million, as reflected in Table 8, page B-10. It is not clear if the NRC's estimated cost for new AORs includes both, (1) new AOR for short-term cooling for peak cladding temperature and cladding embrittlement, and (2) new AOR for long-term cooling. One of the PWR fuel vendors has informed the industry that all of their currently licensed ECCS evaluation models will be replaced by one new ECCS evaluation model, currently being reviewed by the NRC. This new ECCS evaluation model wasn't developed to address the new criteria per 10 CFR 50.46c; for example it does not explicitly address long-term core cooling. None of the currently licensed ECCS evaluation models used by this vendor will be revised to address the criteria proposed in 10 CFR 50.46c. This vendor has cited an NRC desire to reduce the number of licensed ECCS models as partial justification for retirement of the currently licensed ECCS evaluation models once 10 CFR 50.46c becomes effective.

	For a plant in Track 2, recent cost estimates to obtain a new ECCS analysis of record using this new ECCS evaluation model when approved (short-term cooling only) could be an order of magnitude higher than that assumed by the NRC. One large fleet estimates a cost of $1 million / unit. This discrepancy greatly undermines any usefulness of the total cost estimate for the industry as provided in the Regulatory Analysis.
Bases	*Non-realistic cost estimates for new ECCS AORs and COLRs.*
Proposal	Work with the fuel vendors and licensees to obtain actual cost data when estimating industry costs to perform new ECCS analyses of record.
Bases	*Cost estimates are not meaningful, or truly reflective of costs to industry.*

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: 25, B-9, Date: March 24, 2014
Statement	(For this analysis, the NRC assumes an industry labor rate of $200,000/year.) The 12 LOCA models (PQD and breakaway) are assumed to require 0.75 FTE/year/alloy.
Comment	The regulatory analysis assumes the indirect industry cost of revised ECCS evaluation models for PQD and oxidation is $300,000/alloy. This is based on a two year period, 0.75 FTE/year/alloy, and a labor rate of $200,000/year. The number of alloys considered for the cost estimation to develop new ECCS models is unclear. The data shown in Table 8 implies 6 alloys, since a yearly cost of $900,000 is presented for new LOCA models (PDQ and breakaway). However, the text related to breakaway oxidation testing states that 9 cladding alloys are considered. Also, it is not clear how many of the estimated 12 new ECCS models (PDQ and breakaway) are anticipated to share a common alloy.
Bases	*Assumptions are not stated or are not consistent.*
Proposal	Revise the regulatory analysis so that consistent assumptions are used for cost estimations, and that all assumptions are explicitly stated.
Bases	*Consistent statement and use of assumptions is needed for the regulatory analysis to be useful.*

5.6 Industry Comments on Analysis

Reference	Regulatory Analysis for Proposed Rulemaking 10 CFR 50.46c:, Pages: B-1 through B-22, Date: March 24, 2014
Statement	Appendix B Tables Industry and NRC Cost Estimates
Comment	Since development of these tables used inaccurate information associated with required activities and costs, these tables are incorrect.
Bases	*Initial reviews of the NRC calculations shows that most of the estimates are low by at least one order of magnitude.*

Proposal	The Table B tables need to be developed using correct data.
Bases	*Initial reviews of the NRC calculations shows that most of the estimates are low by at least one order of magnitude.*

6 Summary

Industry acknowledges the need to revise the ECCS acceptance criteria related to cladding embrittlement to reflect research insights since the current 10 CFR 50.46 rule was issued in 1974. The industry agrees with the intent of the proposed revision to be performance-based, and to allow implementation of oxide fuel and zirconium alloy cladding design improvements without further rulemaking or exemption requests. The 1988 revision to 10CFR50.46 allowing use of realistic ECCS evaluation models, accounting for uncertainty, incorporated research insights and advanced LOCA simulation codes into the regulations. Industry also acknowledges the benefits of including the alternate risk-informed approach for addressing the effects of debris on core cooling in the proposed rule.

These NEI-industry comments take into account the insights of the operating U.S. fleet and the perspective of PWR and BWR fuel design and performance during LOCAs. Most comments are also applicable to the advanced passive reactor designs and to small modular reactors. In some cases, this has necessitated multiple comments on certain provisions. In these cases, we ask NRC to consider the primary comment as an indicator of the preferred industry approach. Where there is a secondary comment, we ask that it be considered as an alternative approach if the preferred approach is not acceptable to the Agency. In some situations a minimum alternative approach is also included.

Industry has been engaged with the NRC and the worldwide nuclear community regarding LOCA-related tests of cladding embrittlement and breakaway oxidation phenomena and interpretation of test results. This has led to the proposed rule and associated draft regulatory guides. With regard to the NRC proposed scope of testing, we understand that separate comments will be provided by nuclear fuel vendors as they are responsible for testing.

One rule requirement related to testing reporting has a direct impact on the licensees and warrants a comment. The NRC is proposing annual reporting by licensees of cladding breakaway oxidation testing results. Each holder of an operating license or combined license can retain documentation demonstrating that cladding used for each reload batch has satisfied the fuel supplier's NRC-approved acceptance criteria that assures the cladding is not susceptible to breakaway oxidation within the approved timeframe. Discovery of a failure to conform or a defect would be reported in accordance with the requirements of 10 CFR part 21.

As set forth in the Table of Contents, these comments are organized as follows:

- Comments on the proposed §50.46c rule (Chapter 2 and Appendix A)
- Big picture issues related to FRN (Chapter 3)
- Responses to the twelve NRC specific requests for comments (Chapter 4)
- Comments on the NRC Regulatory Analysis (Chapter 5)
- Input to a proposed regulatory guide on long-term cooling (Appendix B)

- A high level discussion regarding an industry document to standardize LOCA change management, errors, and reporting/submittal(s) (Appendix C)
- The proposed 50.46c with the changes based on this document included (Appendix D)
- The proposed content for a new regulatory guide with the technical content of the current Appendix K with specific industry proposed changes (Appendix E)

The highest-priority industry comments are summarized in the following sections.

6.1 Rule Concept /Structure

Required research and regulatory guidance has not been completed to support the proposed changes to long-term cooling requirements. In particular, this is the requirement for an analytical limit on long-term peak cladding temperature. Long-term cooling involves many LOCA scenarios and phenomena with significant design-specific considerations. The current rule language remains adequate until the technical issues are fully characterized in a regulatory guide to reduce regulatory uncertainty. The industry is providing input on the content of a long-term cooling regulatory guide in Appendix B.

In addition regulatory guidance is needed to standardize the 50.46c industry submittals and the regulatory review. This would be similar to the power uprate licensing (e.g., RS-001 and RIS 2002-03) and bring efficiency to the development by industry and review by NRC of a large volume of submittals.

10 CFR 50 Appendix K has legacy issues and changes desired by the industry that would be more efficiently addressed by moving the technical content to a new regulatory guide (Appendix E). The industry is proposing that a more realistic and time-dependent, yet still conservative, decay heat model be allowed for the long-term cooling evaluations. Moving the technical content of Appendix K to a new regulatory guide ("Conservative ECCS Evaluation Models") would also be consistent with the technical guidance for the best-estimate ECCS evaluation models located in Regulatory Guide 1.157.

6.2 Change Management and Reporting

The current rule has special reporting requirements to evaluate changes and errors in a vendor ECCS evaluation model or in the application of a model. A determination of significance is based on a ∆PCT, or a cumulative sum of absolute values of all ∆PCTs for each change or error, greater than 50ºF. NRC notification of significant errors within 30 days is required along with a schedule for reanalysis. Annual reports summarizing changes in LOCA methods and codes are also required. All licensees submit these annual reports using information provided by their fuel vendors. The proposed §50.46c expands these reporting requirements including the addition of ∆ECR reporting, and additional requirements to analyze, rather than estimate, the impact of changes and errors.

The industry proposal is that rule language on reporting requirements for ECCS and Debris evaluation models and analysis changes and errors should be deleted. Existing reporting processes including Part 21, 50.72, and 50.73 are sufficient. As an alternative, the industry proposes development of a document on change management and error reporting/submittal(s), which could be endorsed by NRC via a regulatory guide, leading to industry standardization. This proposal is similar to the 10 CFR 50.59 industry standardization initiative producing NEI-96-07, NEI 01-01, and other guidance. The proposed document is discussed in Appendix C.

If the NRC does not agree with this proposed approach, an alternative proposal is to address the numerous industry comments that identify problems with the rule language. As a minimum, industry needs to be able to continue to estimate (rather than analyze per the proposed rule language) the effects (ΔPCTs and new ΔECRs) of ECCS evaluation model and analysis changes and errors. The new proposed rule language requiring LOCA reanalysis to evaluate changes and errors is an unnecessary burden with significant cost to the industry on an ongoing basis.

6.3 Implementation

The proposed NRC implementation rule language assigns each reactor to one of three tracks, and the three tracks have compliance schedules of 24, 48, or 60 months after the effective date of the rule, respectively. The assignment of the reactor to each track was based on the existing rulemaking scope, the NRC staff audits of the three vendors in July 2011, and a review of reports provided by the PWR and BWR Owners Groups as to the current PCT and ECR margins, along with the estimated LOCA development effort necessary to bring each reactor into compliance with the proposed rule.

The industry proposal is to revise the implementation language to require each licensee to submit within 180 days a milestone-based plan to achieve compliance with the proposed rule. A phased-implementation approach has been successful for other regulatory issues (e.g. emergency preparedness and cyber security) and is appropriate for 50.46c. A separate compliance schedule for the long-term cooling requirements is needed due to the regulatory uncertainty on this subject. As a minimum delete Table 1 to avoid future exemption requests due to avoidable changes in track assignments and requests for schedule relief. The existing licensing commitment tracking processes will be sufficient to implement the rule and will provide the needed flexibility.

Existing inventories of irradiated and unirradiated fuel assemblies/bundles and cladding that have been designed, fabricated, and procured to current regulations need to be grandfathered. The industry proposes a 60 month (after the effective rule date) schedule for grandfathering existing inventories. Grandfathered items would remain available for use in future reactor cores until they are permanently discharged into long-term storage.

The implementation language for new plants that fall under paragraph (o)(9) needs revision due to a compliance timing issue during the first cycle of operation.

The industry requests NRC review of §50.46c-related submittals remain focused on the requirements of the proposed regulation and not expand into technical issues that are still in discovery such as fuel fragmentation, relocation, and dispersal.

6.4 Alternate Risk-Informed Approach for Debris Evaluation

The industry proposal is that the rule language for the alternate risk-informed approach for addressing the effects of debris on core cooling for all time periods should be simplified using the rule language for the risk-informed NFPA-805 fire protection alternative 50.48(c)(4) as a model. Proposed rule language based on 50.48(c)(4) is included in Appendix E. Industry acknowledges the need for a monitoring program and a process for notifying NRC of errors/changes, but believes that existing industry programs provide substantially all that is necessary to assure that conditions are identified and assessed commensurate with their safety significance (e.g., corrective action program, Maintenance Rule programs, existing reporting requirements, etc.). The details of the alternate approach can be included in the future regulatory guide, with references to Regulatory Guides 1.174 and 1.200. The exhaustive proposed rule language in paragraph (m)(4) can be deleted. An LAR submitted to apply for the alternate risk-informed approach will provide the NRC with the opportunity to determine the acceptability of the proposed approach.

6.5 Other Industry Recommendations

Comments are intended to improve and clarify the proposed 50.46c rule and associated documents, make the rule more performance-based, make reporting requirements more consistent with other regulations, and to reduce the burden and cost to the industry for compliance with the new rule, particularly from an ongoing basis perspective.

One common theme is to move rule details (how to comply) to regulatory guides. The NRC took this approach for the breakaway oxidation and cladding embrittlement parts of the rule. The same approach is needed for both risk-informed and deterministic approaches to debris effects on core cooling. NRC review and approval of industry submittals provides the opportunity for regulatory review with consistency established by defining the specific criteria in an associated regulatory guide. Excessively detailed rule language does not allow for regulatory flexibility and will lead to exemption requests, which are not a good use of NRC or industry resources.

Consistency in the final rule language, and the statement of considerations, is essential to avoid future misinterpretations by both the regulator and the industry, and uncertainty in what constitutes compliance. The industry requests NRC ensure final rule content is highly consistent.

The industry is concerned that overly prescriptive requirements in the 50.46c rule and the associated regulatory guides will cause the industry to move away from development and implementation of advanced cladding materials. This is not in the interest of public health and safety.

The resource burden compliance with the proposed rule will be significant for both NRC and licensees. There is both an initial cost of compliance due to revision of ECCS evaluation models and plant-specific analyses and a recurring cost due to reload core design and analysis impact. Many of the industry comments provide alternative means to achieve adequate protection with no reduction in safety.

Finally, the risk-significance of LOCA, due to its low probability of occurrence, must be a consideration in the design and implementation of the proposed rule. The cumulative effect of regulations continues to be a major concern to the industry. Report comments are consistent with current industry concerns.

Appendix A: *Specific Comments Regarding Rule Language*

Table A.1: Specific Rule Language Comment 1

Statement	*(a) Applicability.* The requirements of this section apply to the design of a light water nuclear power reactor (LWR) and to the following entities who design, construct or operate an LWR: each applicant for or holder of a construction permit under this part, each applicant for or holder of an operating license under this part (until the licensee has submitted the certification required under § 50.82(a)(1) to the NRC), each applicant for or holder of a combined license under part 52 of this chapter, each applicant for a standard design certification (including the applicant for that design certification after the NRC has adopted a final design certification rule), each applicant for a standard design approval under part 52 of this chapter, and each applicant for or holder of a manufacturing license under part 52 of this chapter.
Comment	Modify draft rule language to state that if a certification of permanent cessation of operations has been submitted that the rule is not applicable.
Rationale	*This will add clarification to the entities to which the rule is applicable.*
Proposal	Continue the last sentence in (a) with the following: ", provided that the licensee has not submitted to the NRC a certification of permanent cessation of operations required under §§ 50.82(a)(1) or 52.110(a)(1) of this chapter."
Justification	*The proposed language provides the needed clarification.*

Table A.2: Specific Rule Language Comment 2

Statement	(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
Comment	The definition of the ECCS evaluation model should not include plant-specific inputs, which could be interpreted as “values of parameters, and all other information.”
Rationale	*There is a clear distinction between the scope of an ECCS evaluation model, and the plant-specific inputs to that model. Plant-specific inputs, which include parameter values such as dimensions, pressures, flow rates, core peaking factors, response times, etc., are not elements of a vendor ECCS evaluation model. The values of those parameters are used in the application of a vendor ECCS evaluation model to obtain a plant-specific analysis result. Therefore, plant-specific inputs should not be included in the definition of ECCS evaluation model.*
Proposal	Insert the following words in parentheses: “ . . and all other information (but excluding plant-specific inputs) necessary”
Justification	*The proposed language provides the necessary clarification to the scope of the ECCS evaluation model.*

Table A.3: Specific Rule Language Comment 3

Statement	(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
Comment	The definition of "Debris evaluation model" is replaced with a new definition for "Risk-informed debris evaluation model." The new definition is modified to eliminate the specific details associated with the deterministic GSI-191 analysis approach since the methodology for achieving a successful outcome can take many forms. Also, the potential effects of debris on core cooling are also applicable for BWRs during the short-term post-LOCA period. These considerations should also be in the scope of the alternative risk-informed approach.
Rationale	*Simplification of the definition is sufficient for rule language and will avoid future exemption requests due to excessive specific language. The proposed definition of debris evaluation model did not consider that debris effect can potentially occur in BWRs during the short-term post-LOCA period. The alternate risk-informed approach needs to include the short-term period for BWRs.*
Proposal	Replace the definition of "debris evaluation model" with the following definition of "risk-informed debris evaluation model." Risk-Informed Debris evaluation model means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, and other phenomena important to core cooling. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris.
Justification	*The proposed language will extend the alternate risk-informed evaluation of debris to the entire post-LOCA core cooling period that is needed for BWRs and provide for a more consistent understanding of the intent of the model at a higher level.*

Table A.4: Specific Rule Language Comment 4

Statement	(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
Comment	Add a definition for cladding
Rationale	*A definition for cladding would clarify the intent of the rule*
Proposal	Industry proposes addition of the following definition: *Cladding* means the material structure separating fuel from coolant that provides a barrier inhibiting fission product transport to the coolant.
Justification	*While cladding has not been previously defined, it would be useful to in light of the many structures and components comprising fuel assemblies.*

Table A.5: Specific Rule Language Comment 5

Statement	(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
Comment	Remove redundant definition
Rationale	*10 CFR 50 Appendix A already contains definition*
Proposal	Remove definition from §50.46c
Justification	*Redundancy. 10 CFR 50 Appendix A definition would be changed with future §50.46a efforts.*

Table A.6: Specific Rule Language Comment 6

Statement	(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
Comment	Add a definition for crud
Rationale	*A definition for crud would clarify the intent of the rule*
Proposal	Industry proposes addition of the following definition, which is taken from the proposed (g)(2)(ii). *Crud* means any foreign substance deposited on the surface of the fuel cladding prior to the LOCA.
Justification	*Addition of this definition adds clarity to the proposed rule*

Table A.7: Specific Rule Language Comment 7

Statement	(b) *Definitions*. As used in this section: *Breakaway oxidation,* for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility. *Evaluation model* means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. *Debris evaluation model* means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, chemical precipitation, and other phenomena important to long-term cooling. It includes one or more computer programs and other information necessary for application of the calculational framework to a set of initiating events, the mitigation of which requires long term cooling via recirculation. It also includes mathematical models used, assumptions used by the programs, procedures for treating the program input and output information, specifications of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure. The debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris *Loss-of-coolant accident (LOCA)* means a hypothetical accident that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.
Comment	Add a definition for reload batch to support interpretation of breakaway oxidation testing requirements.
Rationale	*A definition for reload batch would clarify the intent of the rule*
Proposal	Industry proposes addition of the following definition: *Reload batch* means the entirety of unirradiated fuel assemblies or bundles that are loaded into a reactor during refueling. A full reload batch could include multiple fuel types from multiple vendors, as well as lead fuel/test assemblies.
Justification	*Addition of this definition adds clarity to the proposed rule*

Table A.8: Specific Rule Language Comment 8

Statement	(c) *Relationship to other NRC regulations.* The requirements of this section are in addition to any other requirements applicable to an emergency core cooling system (ECCS) set forth in this part, except as noted in this paragraph. The analytical limits established in accordance with this section, with cooling performance calculated in accordance with an NRC approved ECCS evaluation model, are in implementation of the general requirements with respect to ECCS cooling performance design set forth in this part, including in particular Criterion 35 of appendix A to this part. If the effects of debris on long-term cooling are evaluated using a risk-informed method as described in paragraph (e) of this section, then this method and results can be relied upon to demonstrate compliance with other requirements of this part as allowed by this section and requested in the application.
Comment	The proposed rule language ties to the proposed revision to GDC 35, but not to similar proposed revisions to GDCs 38 and 41.
Rationale	*There appears to be an oversight in the proposed rule language due to no ties to the proposed revisions to GDCs 38 and 41, similar to the tie to GDC 35.*
Proposal	Add the following to the end of the last sentence in (c): “. . , including Appendix A Criteria 38 and 41.”
Justification	*The proposed additional language provides a tie to the GDC 38 and 41 revisions. There may be aspects of the GDC’s which are deterministic vs risk-informed.*

Table A.9: Specific Rule Language Comment 9

Statement	(d) *Emergency core cooling system design.* (1) *ECCS performance criteria.* Each LWR must be provided with an ECCS designed to satisfy the following performance requirements in the event of, and following, a postulated loss-of-coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section: (i) Core temperature during and following the LOCA event does not exceed the analytical limits for the fuel design used for ensuring acceptable performance as defined in this section. (ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core.
Comment	This section confuses ECCS design in accordance with GDC 35, with ECCS performance as demonstrated by meeting fuel analytical limits specified in (g).
Rationale	*"ECCS design" typically refers to system performance parameters rather than fuel performance metrics. It would be better to change the paragraph title and to refer to GDC 35 for the design criteria.*
Proposal	Change Paragraph 1 to: (d) *Emergency core cooling* system performance. (1) *ECCS performance criteria.* Each LWR must be provided with an ECCS designed in accordance with GDC 35 to satisfy the following performance requirements in the event of, and following, a postulated loss-of- coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section: (i) System performance during and following the LOCA event does not exceed the specified acceptable fuel analytical limits for the fuel design used for ensuring acceptable performance as defined in paragraph (g).
Justification	*The proposed changes clarify the intent of the paragraph and provide references to GDC 35 and to paragraph (g).*

Table A.10: Specific Rule Language Comment 10

Statement	(d) *Emergency core cooling system design.* (1) *ECCS performance criteria.* Each LWR must be provided with an ECCS designed to satisfy the following performance requirements in the event of, and following, a postulated loss-of-coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section: (i) Core temperature during and following the LOCA event does not exceed the analytical limits for the fuel design used for ensuring acceptable performance as defined in this section. (ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core.
Comment	Entire item is about Fuel Performance (SAFAL), not ECCS performance.
Rationale	*Requirement is fuel based, not ECCS.*
Proposal	Change sub-paragraph (i) to: (i) System performance during and following the LOCA event does not exceed the specified acceptable fuel analytical limits for the fuel design used for ensuring acceptable performance as defined in paragraph (g).
Justification	*Don't confuse ECCS performance with fuel performance. Sets the standard as performance based.*

Table A.11: Specific Rule Language Comment 11

Statement	(d) *Emergency core cooling system design.* (1) *ECCS performance criteria.* Each LWR must be provided with an ECCS designed to satisfy the following performance requirements in the event of, and following, a postulated loss-of-coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section: (i) Core temperature during and following the LOCA event does not exceed the analytical limits for the fuel design used for ensuring acceptable performance as defined in this section. (ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core.
Comment	Paragraph (1)(ii) should refer to the core cooling acceptance criterion.
Rationale	*The core cooling criterion of paragraph (g)(1)(v) should be specifically referred to for clarification purposes.*
Proposal	Change (ii) to: (ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core to comply with the criterion of paragraph (g)(1)(v).
Justification	*The proposed language provides the reference to paragraph (g(1)(v).*

Table A.12: Specific Rule Language Comment 12

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(d) *Emergency core cooling system design.* (2) *ECCS performance demonstration*. ECCS performance must be demonstrated using an ECCS evaluation model meeting the requirements of either paragraph (d)(2)(i) or (d)(2)(ii), of this section, and satisfy the analytical requirements of paragraph (d)(2)(iii), (d)(2)(iv), and (d)(2)(v) of this section. Paragraph (e) of this section may be used for consideration of debris described in paragraph (d)(2)(iii) of this section. The ECCS evaluation model must be reviewed and approved by the NRC. (i) *Realistic ECCS model*. A realistic model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and NRC-approved analytical limits, there is a high level of probability that the limits would not be exceeded. (ii) *Appendix K model*. Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K to this part, ECCS Evaluation Models. (iii) *Core geometry and coolant flow*. The ECCS evaluation model must address calculated changes in core geometry and must consider those factors, including debris, that may alter localized coolant flow in the core or inhibit delivery of coolant to the core. A licensee may evaluate effects of debris using a risk-informed approach to demonstrate long-term ECCS performance, as specified in paragraph (e) of this section. (iv) *LOCA analytical requirements*. ECCS performance must be demonstrated for a range of postulated loss-of-coolant accidents of different sizes, locations, and other properties, sufficient to provide assurance that the most severe postulated loss-of-coolant accidents have been identified. ECCS performance must be demonstrated for the accident, and the post-accident recovery and recirculation period. (v) *Modeling requirements for fuel designs: uranium oxide or mixed uranium-plutonium oxide pellets within zirconium-alloy cladding*. If the reactor is fueled with uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding, then the ECCS evaluation model must address the fuel system modeling requirements in paragraph (g)(2) of this section.
Comment	The industry agrees with the inclusion of all zirconium-alloy claddings and mixed uranium-plutonium oxide fuel within the proposed rule. This change will facilitate the deployment of advanced materials without the burden of submitting exemption requests or additional future rulemaking. The proposed rule meets the intent of the March 14, 2000, as amended on April 12, 2000, Nuclear Energy Institute (NEI) petition for rulemaking requesting that the NRC amend its regulations in §§ 50.44 and 50.46 (PRM-50-71).
Rationale	N/A

Proposal	N/A
Justification	N/a

Table A.13: Specific Rule Language Comment 13

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(d) *Emergency core cooling system design.* (2) *ECCS performance demonstration*. ECCS performance must be demonstrated using an ECCS evaluation model meeting the requirements of either paragraph (d)(2)(i) or (d)(2)(ii), of this section, and satisfy the analytical requirements of paragraph (d)(2)(iii), (d)(2)(iv), and (d)(2)(v) of this section. Paragraph (e) of this section may be used for consideration of debris described in paragraph (d)(2)(iii) of this section. The ECCS evaluation model must be reviewed and approved by the NRC. (i) *Realistic ECCS model*. A realistic model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and NRC-approved analytical limits, there is a high level of probability that the limits would not be exceeded. (ii) *Appendix K model*. Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K to this part, ECCS Evaluation Models. (iii) *Core geometry and coolant flow*. The ECCS evaluation model must address calculated changes in core geometry and must consider those factors, including debris, that may alter localized coolant flow in the core or inhibit delivery of coolant to the core. A licensee may evaluate effects of debris using a risk-informed approach to demonstrate long-term ECCS performance, as specified in paragraph (e) of this section. (iv) *LOCA analytical requirements*. ECCS performance must be demonstrated for a range of postulated loss-of-coolant accidents of different sizes, locations, and other properties, sufficient to provide assurance that the most severe postulated loss-of-coolant accidents have been identified. ECCS performance must be demonstrated for the accident, and the post-accident recovery and recirculation period. (v) *Modeling requirements for fuel designs: uranium oxide or mixed uranium-plutonium oxide pellets within zirconium-alloy cladding*. If the reactor is fueled with uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding, then the ECCS evaluation model must address the fuel system modeling requirements in paragraph (g)(2) of this section.
Comment	Section (d)(2)(iii) requires the ECCS evaluation model to consider debris, or the licensee may evaluate effects of debris using the risk-informed approach in section (e). The language should be clarified better distinguish deterministic vs. risk-informed. Also, drop the long-term aspect of risk informed debris assessments.
Rationale	*Some licensees have obtained NRC approval and resolved GSI-191 using a deterministic methodology. Other licensees may also prefer a deterministic approach to resolve GSI-191 going forward. The rule language needs to include this third option. Limiting risk-informed debris assessment is not compatible with BWR designs.*

Proposal	The following proposed language adds a third option to demonstrate the effects of debris on post-LOCA long-term cooling. (iii) *Core geometry and coolant flow*. The ECCS evaluation model must address calculated changes in core geometry and must consider those factors that may alter localized coolant flow in the core or inhibit delivery of coolant to the core. The effects of debris must be included in the ECCS evaluation model, or in a separate model, on a deterministic basis. Alternatively, a licensee may evaluate effects of debris using a risk-informed approach to demonstrate ECCS performance, as specified in paragraph (e) of this section.
Justification	*The proposed language allows for the third option, a deterministic evaluation that is not in the ECCS evaluation model. This option is needed to enable a deterministic debris evaluation approach that has been approved by the NRC for some licensees.*

Table A.14: Specific Rule Language Comment 14

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*(d) Emergency core cooling system design.* *(2) ECCS performance demonstration*. ECCS performance must be demonstrated using an ECCS evaluation model meeting the requirements of either paragraph (d)(2)(i) or (d)(2)(ii), of this section, and satisfy the analytical requirements of paragraph (d)(2)(iii), (d)(2)(iv), and (d)(2)(v) of this section. Paragraph (e) of this section may be used for consideration of debris described in paragraph (d)(2)(iii) of this section. The ECCS evaluation model must be reviewed and approved by the NRC. *(i) Realistic ECCS model*. A realistic model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and NRC-approved analytical limits, there is a high level of probability that the limits would not be exceeded. *(ii) Appendix K model*. Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K to this part, ECCS Evaluation Models.
Comment	Item (d)(2)(ii) should be revised to be consistent with (d)(2)(i) Note: There are numerous other rule paragraphs that include a reference to "Appendix K" that will require a similar revision. Those are not individually identified.
Rationale	*In the context of the proposal to move Appendix K content to a new regulatory guide (per Table A.57), we should no longer refer to an acceptable conservative model as "Appendix K". Rather call it the analog of realistic as follows:*
Proposal	*(ii) Conservative ECCS evaluation model.* Alternatively, a conservative ECCS evaluation model may be developed using the acceptable features of Appendix K to this part, and associated regulatory guidance.
Justification	*The proposed change would allow continuity with the Table A.57 proposal.*

Table A.15: Specific Rule Language Comment 15

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(d) *Emergency core cooling system design.* (3) *Required documentation.* Upon implementation of this section in accordance with paragraph (o) of this section, the documentation requirements of this paragraph apply and supersede the requirements in appendix K to this part, section II, "Required Documentation." (i)(A) A description of each ECCS evaluation model must be furnished. The description must be sufficiently complete to permit technical review of the analytical approach, including the equations used, their approximations in difference form, the assumptions made, and the values of all parameters or the procedure for their selection, as for example, in accordance with a specified physical law or empirical correlation. (B) A complete listing of each computer program, in the same form as used in the evaluation model, must be furnished to the NRC upon request. (ii) For each computer program, solution convergence must be demonstrated by studies of system modeling or noding and calculational time steps. (iii) Appropriate sensitivity studies must be performed for each ECCS evaluation model, to evaluate the effect on the calculated results of variations in noding, phenomena assumed in the calculation to predominate, including pump operation or locking, and values of parameters over their applicable ranges. For items to which results are shown to be sensitive, the choices made must be justified. (iv) To the extent practicable, predictions of the ECCS evaluation model, or portions thereof, must be compared with applicable experimental information. (v) Elements of ECCS evaluation models reviewed will include technical adequacy of the calculational methods, including: for models covered by paragraph (d)(2)(ii) of this section, compliance with required features of section I of appendix K to this part; and, for models covered by paragraph (d)(2)(i) of this section, assurance of a high level of probability that the performance criteria of paragraph (d)(1) of this section would not be exceeded. (vi) For operating licenses issued under this part as of [EFFECTIVE DATE OF RULE], required documentation of Table 1 in paragraph (o) of this section must be submitted to demonstrate compliance by the date specified in Table 1 in paragraph (o) of this section.
Comment	The highlighted words in (B)(vi) are extraneous and should be deleted.
Rationale	*Table 1 does not state what documentation is required to be submitted, so the proposed language must be changed to state that Table 1 only includes the compliance date.*
Proposal	(vi) For operating licenses issued under this part as of [EFFECTIVE DATE OF RULE], documentation must be submitted to demonstrate compliance per the implementation process identified in paragraph (o) of this section.

Justification	*Rewording would be consistent with proposals regarding paragraph (o).*

Table A.16: Specific Rule Language Comment 16

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.*
Comment	Need to extend the alternate risk-informed approach for addressing the effects of debris to short-term core cooling. This can be accomplished by deleting the language “long-term” in the title and throughout paragraph (e).
Rationale	*For BWRs there is a possible challenge to core cooling in the short-term due to post-LOCA debris effects. Also, depending on the definition of “long-term” there may also be a short-term issue for PWRs. Therefore, the same rationale exists for the rule to apply to the short-term core cooling period.*
Proposal	Change title of (e) to the following: (e) *Alternate risk-informed approach for addressing the effects of debris on core cooling* Delete “long-term” in (e)(1) and in (e)(3) This proposal involves similar revisions to the definition of “Risk-Informed Debris evaluation model” in paragraph (b), and in (m)(4), to delete the reference to “long-term”.
Justification	*The proposed changes would extend the risk-informed alternate approach to all core cooling periods.*

Table A.17: Specific Rule Language Comment 17

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.*
Comment	Paragraph (e) should use the precedent of 50.48(c)(4) as a model for rule language for an alternate risk-informed licensing approach.
Rationale	*The intent of 50.46c(e) is similar to the existing 50.48(c)(4) rule language used to allow a risk-informed approach to fire protection. The existing rule language for50.48(c)(4) is a good model.*
Proposal	Starting from the existing rule language for 50.48(c)(4), replace the fire protection related language with core cooling effects of debris language as follows: (4e) ~~Risk-informed or performance-based alternatives to compliance with NFPA 805~~. Alternate risk-informed approach for addressing the effects of debris on core cooling. A licensee may submit a request to use risk-informed ~~or performance-based~~ alternatives to address ~~compliance with NFPA 805~~ the effects of debris on core cooling. The request must be in the form of an application for license amendment under § 50.90 of this chapter. The Director of the Office of Nuclear Reactor Regulation, or designee of the Director, may approve the application if the Director or designee determines that the proposed alternatives: (i) Satisfy the performance goals, performance objectives, and performance criteria ~~specified in NFPA 805~~ related to nuclear safety and radiological release; (ii) Maintain safety margins; ~~and~~ (iii) Maintain ~~fire protection~~ defense-in-depth ~~(fire prevention, fire detection, fire suppression, mitigation, and post-fire safe shutdown capability~~).; and (iv) Include an acceptable program for monitoring the risk-informed approach and notifying NRC of the impact of changes and errors.
Justification	*The proposed re-write of 50.48(c)(4) achieves rule language that meets the intent of 50.46c to allow a risk-informed alternate approach. The additional requirement to submit for NRC review and approval a plan for monitoring the risk-informed approach, and for notifying NRC of changes and errors, is sufficient to address the stated NRC concerns. Also fixes the long-term vs. all term time period issue.*

Table A.18: Specific Rule Language Comment 18

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.*
Comment	It is unclear which other paragraphs of 50.46c are applicable (or not applicable) to (e). Clarification needs to be added. An alternative would be to use "ECCS evaluation model" and "risk-informed debris evaluation model" consistently throughout the rule language. Also, drop the long-term time period issue so all time periods are appropriate.
Rationale	*Questions have been raised regarding the applicability of other paragraphs in 50.46c to the alternate risk-informed debris approach of paragraph (e). As an example, are the fuel performance criteria in (g)(1) applicable to (e)? A clarification to the rule language is needed.*
Proposal	Add to paragraph (e) a list of the other elements of 50.46c that are applicable (or not applicable) to (e). As an alternative, use "ECCS evaluation model" and "risk-informed evaluation model throughout the rule.
Justification	*The proposed revision will provide the needed clarifications.*

Table A.19: Specific Rule Language Comment 19

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (1) *Risk-informed approach acceptance criteria.* An entity may request the NRC to approve a risk-informed approach for addressing the effects of debris on long-term core cooling to demonstrate compliance with the requirements in paragraph (d)(1)(ii) of this section. 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; (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 applicable plant and industry operational experience, is of sufficient scope, level of detail, and technical adequacy to support the alternative process, and is subjected to a peer review process that assesses the PRA against a standard or set of acceptance criteria that is endorsed by the NRC. .
Comment	The title of Sub-Paragraph (1) is not consistent with the content as items (iii) and (iv) are not acceptance criteria
Rationale	*Editorial correction to title only*
Proposal	New title is proposed "(1) Risk-informed approach required elements"
Justification	*Proposed title is consistent with content that includes requirements other than acceptance criteria. Also addresses the long-term vs. all time frame issue.*

Table A.20: Specific Rule Language Comment 20

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (2) *Content of application.* An entity seeking to use the risk-informed approach under paragraph (e)(1) of this section, must submit an application with the following information: (i) A description of the alternative risk-informed approach; (ii) A description of the measures taken to assure that the scope, level of detail and technical adequacy of the systematic processes that evaluate the plant for internal and external events initiated during full power, low power, and shutdown operation (including the PRA, margins-type approaches, or other systematic evaluation techniques used to evaluate severe accidents) are commensurate with the reliance on risk information; (iii) Results of the PRA review process conducted to satisfy the requirements of paragraphs (e)(1)(iii) and (iv) of this section; (iv) A description of, and basis for acceptability of, the evaluations conducted to demonstrate compliance with paragraphs (e)(1)(i) and (ii) of this section; and (v) The analytical limit on long-term peak cooling temperature as established in paragraph (g)(1)(v) of this section.
Comment	In (e)(2)(v) the word “cooling” should be “cladding”. Also drop the “long-term” phrase in the title.
Rationale	*Editorial correction. Provide for BWR nature of debris with respect to ECCS design.*
Proposal	(e) *Alternate risk-informed approach for addressing the effects of debris on core cooling.* Change (v) as follows. [Note that a subsequent comment proposes deleting the analytical limit on long-term peak cladding temperature, so this comment would be moot.] (v) The analytical limit on long-term peak cladding temperature as established in paragraph (g)(1)(v) of this section.
Justification	*Editorial correction. Provides for BWR nature of debris with respect to ECCS design.*

Table A.21: Specific Rule Language Comment 21

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (2) *Content of application.* An entity seeking to use the risk-informed approach under paragraph (e)(1) of this section, must submit an application with the following information: (i) A description of the alternative risk-informed approach; (ii) A description of the measures taken to assure that the scope, level of detail and technical adequacy of the systematic processes that evaluate the plant for internal and external events initiated during full power, low power, and shutdown operation (including the PRA, margins-type approaches, or other systematic evaluation techniques used to evaluate severe accidents) are commensurate with the reliance on risk information; (iii) Results of the PRA review process conducted to satisfy the requirements of paragraphs (e)(1)(iii) and (iv) of this section; (iv) A description of, and basis for acceptability of, the evaluations conducted to demonstrate compliance with paragraphs (e)(1)(i) and (ii) of this section; and (v) The analytical limit on long-term peak cooling temperature as established in paragraph (g)(1)(v) of this section.
Comment	In (e)(2)(v) there is a reference to the proposed analytical limit on long-term peak cladding temperature in (g)(2)(v). Peak cladding temperature may not be the best analytical limit. Drop long-term phrase to allow for the nature of BWR ECCS design.
Rationale	*Inadvertently creates an unnecessary link to aspects of GSI-191. This is an unnecessary linkage of the two regulatory issues. The industry expects that the analytical limit may not be established in the near term due to regulatory reviews and testing uncertainty. Also, at this time there is not a consensus that peak cladding temperature is the appropriate parameter.*
Proposal	Delete (e)(2)(v)
Justification	*The deletion of (e)(2)(v) will separate full closure of GSI-191 and generalize risk-informed options consistent with BWR ECCS design.*

Table A.22: Specific Rule Language Comment 22

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (2) *Content of application.* An entity seeking to use the risk-informed approach under paragraph (e)(1) of this section, must submit an application with the following information: (i) A description of the alternative risk-informed approach; (ii) A description of the measures taken to assure that the scope, level of detail and technical adequacy of the systematic processes that evaluate the plant for internal and external events initiated during full power, low power, and shutdown operation (including the PRA, margins-type approaches, or other systematic evaluation techniques used to evaluate severe accidents) are commensurate with the reliance on risk information; (iii) Results of the PRA review process conducted to satisfy the requirements of paragraphs (e)(1)(iii) and (iv) of this section; (iv) A description of, and basis for acceptability of, the evaluations conducted to demonstrate compliance with paragraphs (e)(1)(i) and (ii) of this section; and (v) The analytical limit on long-term peak cooling temperature as established in paragraph (g)(1)(v) of this section.
Comment	Add a new sub-paragraph (2)(vi) to require that an application include information on the monitoring program and the process for notifying NRC of changes and errors.
Rationale	*This proposed change will require the application to include information on the monitoring program and the process for notifying NRC of changes and errors. The NRC review of the application will include a review of these elements of the risk-informed approach, and the NRC safety evaluation will state the conditions of approval of these elements.*
Proposal	New (2)(vi) as follows: [Note that this proposed change must be coordinated with an associated proposed change to delete (m)(4)] (vi) A description of the monitoring program and the process for notifying NRC of changes and errors."
Justification	*The proposed change and the associated proposed deletion of (m)(4) will remove the details of the monitoring program and the reporting of errors and changes from the rule. The requirement for these elements will remain in the rule. The applicant will propose a process for these elements in the submittal and the NRC will review and approve them along with any conditions of the approval in the safety evaluation. The NRC can propose an acceptable approach in the future regulatory guide. This approach is consistent with prior risk-informed licensing precedents that did not include these elements in rule language. Existing monitoring programs along with change and error reporting mechanisms should be sufficient.*

Table A.23: Specific Rule Language Comment 23

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (3) *NRC approval.* If the NRC determines that the application demonstrates that the requirements of paragraph (e)(1) of this section are met, and the application establishes an acceptable long-term peak cladding temperature limit, then it may approve the use of the risk-informed approach for addressing debris effects on long-term cooling when issuing the license, regulatory approval or amendments thereto. The NRC's approval must specify the circumstances under which the licensee or design certification applicant, as applicable, shall notify the NRC of changes or errors in the risk evaluation approach utilized to address the effects of debris on long-term cooling.
Comment	Revise for long-term terminology and peak cladding temperature issues.
Rationale	*Use of long-term not consistent with BWR ECCS design. Peak cladding temperature may not be the appropriate metric.*
Proposal	(e) *Alternate risk-informed approach for addressing the effects of debris on core cooling.* (3) *NRC approval.* If the NRC determines the application demonstrates the requirements of paragraph (e)(1) of this section are met, and the application establishes an acceptable analytical limit, then it may approve the use of the risk-informed approach for addressing debris effects on core cooling when issuing the license, regulatory approval or amendments thereto. The NRC's approval must specify the circumstances under which the licensee or design certification applicant, as applicable, shall notify the NRC of changes or errors in the risk evaluation approach utilized to address the effects of debris on core cooling.
Justification	*The proposed change addresses identified issues.*

Table A.24: Specific Rule Language Comment 24

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling.* (3) *NRC approval.* If the NRC determines that the application demonstrates that the requirements of paragraph (e)(1) of this section are met, and the application establishes an acceptable long-term peak cladding temperature limit, then it may approve the use of the risk-informed approach for addressing debris effects on long-term cooling when issuing the license, regulatory approval or amendments thereto. The NRC's approval must specify the circumstances under which the licensee or design certification applicant, as applicable, shall notify the NRC of changes or errors in the risk evaluation approach utilized to address the effects of debris on long-term cooling.
Comment	Approval of new change and error reporting mechanisms are an unnecessary burden. There should be no need for NRC approval of the process for notification of changes or errors, as existing processes can be used, such as 50.73 or part 21.
Rationale	*Existing reporting mechanisms are adequate.*
Proposal	(e) *Alternate risk-informed approach for addressing the effects of debris on core cooling.* (3) *NRC approval.* If the NRC determines the application demonstrates the requirements of paragraph (e)(1) of this section are met, and the application establishes an acceptable analytical limit, then it may approve the use of the risk-informed approach for addressing debris effects on core cooling when issuing the license, regulatory approval or amendments thereto.
Justification	*The proposed change addresses identified issues.*

Table A.25: Specific Rule Language Comment 25

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements: (i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200 °F. (ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established that correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200 ºF limit specified in paragraph (g)(1)(i) of this section, then the lower temperature shall be used in place of the 2200 °F limit. (iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC. (iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react. (v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established that corresponds to the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC.
Comment	Utilization of specific numerical values is not consistent with respect to a performance based rule. Guidance regarding how to compute a numerical value for comparison to a limit is not appropriate to rule language. Guidance belongs within the scope of Regulatory Guides. Comments by Commissioner Magwood in his voting record comments dated 11/29/2012 are consistent with this industry comment: "In keeping with the philosophy at the core of the proposed rule, I recommend that the prescriptive 2200°F peak cladding temperature limit for zirconium-based fuels be removed and replaced with a performance-based requirement."

Rationale	*Prescriptive limits are not compatible with a performance based rule. A specified maximum limit will preclude future research/development efforts to improve the safety and performance of zirconium based alloys. If test data using an NRC acceptable method shows that post quench ductility is maintained, then it doesn't matter what the associated temperature is. Placing an arbitrary temperature limit on any zirconium based alloy will discourage any effort to even consider improving material performance, or to investigate actual margins to failure. It may be possible to have a performance based rule which retains a 2200°F value.*
Proposal	Replace (g)(1)(i and ii) with the following: (i) Peak cladding temperature. Maximum cladding temperature shall not exceed the basis of the acceptable embrittlement analytical limit. (ii) Cladding integral time at temperature. Maximum local cladding oxidation shall not exceed an acceptable analytical limit. Cladding oxidation limits shall, as a minimum, be a function of cladding hydrogen uptake and experimental temperature basis.
Justification	*Remains consistent with performance based goal, while maintaining NRC review and approval of an acceptable analytical limit.*

Table A.26: Specific Rule Language Comment 26

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (1) *Fuel performance criteria*. Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements: (i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200 °F. (ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established that correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200 °F limit specified in paragraph (g)(1)(i) of this section, then the lower temperature shall be used in place of the 2200 °F limit. (iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC. (iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react. (v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established that corresponds to the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC.
Comment	The proposed language is not compatible with realistic ECCS evaluation models where there is only a statistical probability that 2200ºF will not be exceeded.
Rationale	*Realistic ECCS evaluation models only assure a high probability of staying below the 2200ºF limit, and so they cannot meet rule language requiring "shall not exceed 2200ºF." A clarification is needed.*
Proposal	Add the following language to the end of (g)(1)(i): ". ". . or a high level of probability of not exceeding 2200ºF for models covered by paragraph (d)(2)(i)."

Justification	The proposal clarifies the intent of (g)(1)(i) in that there is only a high probability of assurance of not exceeding the 2200ºF limit for realistic ECCS evaluation models permitted by (d)(2)(i).

Table A.27: Specific Rule Language Comment 27

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements: (i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200 °F. (ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established that correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200 ºF limit specified in paragraph (g)(1)(i) of this section, then the lower temperature shall be used in place of the 2200 °F limit. (iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC. (iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react. (v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established that corresponds to the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC.
Comment	The proposed language could be interpreted as requiring use of a lower PCT analytical limit for all fuel assemblies, even if different analytical limits are applicable to various groups of fuel assemblies.
Rationale	*The proposed rule allows a licensee to submit for NRC approval a PCT analytical limit lower than 2200°F to preserve cladding ductility. This would allow, for example, higher burnup fuel assemblies that operate at a reduced power level due to burn down and thereby result in lower PCTs, to credit the lower PCT. The current rule language could be misinterpreted as requiring the lower PCT limit to be applicable to all fuel assemblies. The intent should be that different PCT limits can be applicable to specific fuel assemblies and cladding consistent with the evaluation crediting the lower PCTs. The comment identifies this possible misinterpretation.*

Proposal	Add the following language in italics to the end of (g)(1)(ii): ". . . shall be used in place of the 2200°F limit for the cladding that credits the lower temperature."
Justification	*The proposal clarifies the intent of (g)(1)(ii) in that crediting a PCT lower than 2200°F is applicable to the cladding that credits the lower temperature in the cladding embrittlement evaluation. The proposal implicitly allows for use of different PCT limits up to 2200°F for different groups of fuel assemblies and cladding types consistent with the evaluation.*

Table A.28: Specific Rule Language Comment 28

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements: (i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200 °F. (ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established that correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200 ºF limit specified in paragraph (g)(1)(i) of this section, then the lower temperature shall be used in place of the 2200 °F limit. (iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC. (iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react. (v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established that corresponds to the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC.
Comment	Use of a specific numerical value (i.e.0.01) for the hydrogen generation limit is not consistent with the goal of a performance based rule. Analytical limits are properly within the scope of regulatory guides.
Rationale	*Removal of numerical limit values from the rule language is required to achieve a performance-based rule. The NRC can move the analytical limit value to a regulatory guide. The applicant can use the regulatory guide value or propose an alternate value. The NRC will then review the submittal and render a decision.*
Proposal	(iv) Maximum hydrogen generation. The calculated total amount of hydrogen generated from fuel cladding oxidation in a water/steam environment shall not exceed an acceptable

	analytical limit.
Justification	*The proposal remains consistent with the performance-based goal, while maintaining NRC review and approval of an acceptable analytical limit.*

Table A.29: Specific Rule Language Comment 29

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements: (i) *Peak cladding temperature*. Except as provided in paragraph (g)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200 °F. (ii) *Cladding embrittlement*. Analytical limits on peak cladding temperature and integral time at temperature shall be established that correspond to the measured ductile-to-brittle transition for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The calculated maximum fuel element temperature and time at elevated temperature shall not exceed the established analytical limits. The analytical limits must be approved by the NRC. If the peak cladding temperature, in conjunction with the integral time at temperature analytical limit, established to preserve cladding ductility is lower than the 2200 ºF limit specified in paragraph (g)(1)(i) of this section, then the lower temperature shall be used in place of the 2200 °F limit. (iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC. (iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from any chemical reaction of the fuel cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react. (v) *Long-term cooling*. An analytical limit on long-term peak cladding temperature shall be established that corresponds to the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC.
Comment	Sufficient research has not been completed to establish the technical bases for an analytical limit on peak cladding temperature (or any other parameter) for long-term cooling. Until sufficient research has been completed the proposed rule language should not be implemented. No "NRC-approved experimental technique" currently exists. Specifying that the analytical limit shall be based on the ductile-to-brittle transition may not be the best choice and is not appropriate in rule language. Rather, the technical details of the analytical limit should be in a regulatory guide. A regulatory guide is required before the rule language is revised.
Rationale	*The proposed rule changes for cladding embrittlement and breakaway oxidation are based on extensive research programs that have been subjected to industry review. The NRC has*

	published draft regulatory guides including proposed analytical limits based on the research results. In contrast, the proposed rule for long-term cooling does not have the research base or any regulatory guidance. Therefore, the proposed rule changes are premature. Rule changes should be deferred or of a more general nature that does not require supporting research. *The proposed regulatory guide would need to address the scenarios (e.g. core uncovering, boric acid precipitation, and coolant channel blockage) and key phenomena associated with challenges to long-term core cooling and potential cladding failure causes. Some of these scenarios involve limited duration cladding temperature increases that have no adverse effect on cladding integrity. Any analytical limit would need to accommodate this consideration. The industry recommends that a realistic methodology, rather than a conservative methodology, be the standard for evaluating long-term cooling. The §50.46a concept of a transition break size is appropriate in a realistic methodology. An example of a key parameter that should be treated realistically would be decay heat. The most recent ANS decay heat standard may be appropriate. It is noted that NUREG-1230 also endorses a model for long-term decay heat. All of these methodology elements are suitable for inclusion in the proposed regulatory guide. In conjunction with the proposed regulatory guide the rule language can remain general, thus allowing for a performance-based approach and future revisions as new research results become available.*
Proposal	Replace (v) with the following: (v) *Post-quench core cooling*. An analytical limit for core cooling shall be established corresponding with the ductile-to-brittle transition for the zirconium-alloy cladding material determined using an NRC-approved experimental technique. The analytical limit must be approved by the NRC. Alternatively, the industry supports retaining the current language in 50.46(b)(5) Refer to Appendix B for a description of the long-term cooling guidance proposal.
Justification	*The NRC staff's proposal for a specific long-term cooling peak cladding temperature limit is a recent change to the proposed regulation language and has not been adequately studied by the NRC or the industry. The industry recommends, similar to the regulatory approach for other elements of the proposed rule, that additional research by the NRC and by the industry be conducted and a new regulatory guide prepared on this subject. Prior to completion of the research and the regulatory guide the existing rule language remains sufficient, or revisions such as those proposed by industry are suitable at this time.*

Table A.30: Specific Rule Language Comment 30

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (2) *Fuel system modeling requirements*. The evaluation model required by paragraph (d)(2) of this section must model the fuel system in accordance with the following requirement: (i) If an oxygen source is present on the inside surfaces of the cladding at the onset of the LOCA, then the effects of oxygen diffusion from the cladding inside surfaces must be considered in the ECCS evaluation model. (ii) The thermal effects of crud and oxide layers that accumulate on the fuel cladding during plant operation must be evaluated. For the purposes of this paragraph, crud means any foreign substance deposited on the surface of fuel cladding prior to initiation of a LOCA.
Comment	The embedded definition of crud in sub-paragraph (ii) should be moved to paragraph (b).
Rationale	*All definitions should be in paragraph (b).*
Proposal	Add the following definition of crud to paragraph (b): "*Crud* means the presence of any foreign substance on the surface of the fuel cladding prior to the LOCA."
Justification	*The proposed definition of crud located in paragraph (b) resolves the comment.*

Table A.31: Specific Rule Language Comment 31

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.* (2) *Fuel system modeling requirements*. The evaluation model required by paragraph (d)(2) of this section must model the fuel system in accordance with the following requirement: (i) If an oxygen source is present on the inside surfaces of the cladding at the onset of the LOCA, then the effects of oxygen diffusion from the cladding inside surfaces must be considered in the ECCS evaluation model. (ii) The thermal effects of crud and oxide layers that accumulate on the fuel cladding during plant operation must be evaluated. For the purposes of this paragraph, crud means any foreign substance deposited on the surface of fuel cladding prior to initiation of a LOCA.
Comment	The rule language should not imply any additional crud inspections.
Rationale	*The rule language could be interpreted to imply that crud inspections are a part of the evaluation of the thermal effects. The industry's position is that additional crud inspections are not warranted. Crud inspections are time consuming during outages, and in the case of BWRs cannot be performed without fuel bundle disassembly, which risks reinsertion, outage extension, and cost.*
Proposal	The industry proposal is for the statement of considerations to include a clarification that (g)(2)(ii) does not require inspections to be performed for compliance with the rule.
Justification	*The proposed clarification to the statement of considerations will address this industry concern.*

Table A.32: Specific Rule Language Comment 32

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(k) *Use of NRC-approved fuel in reactor*. A licensee may not load fuel into a reactor, or operate the reactor, unless the licensee either determines that the fuel meets the requirements of paragraph (d) of this section, or complies with technical specifications governing lead test assemblies in its license.
Comment	The industry recommends that irradiated an unirradiated fuel assemblies that are procured within 60 months of the effective implementation date be permanently grandfathered. This will allow existing inventories of fuel to be used for power generation.
Rationale	*Fuel assemblies and cladding that are procured and were designed and fabricated per the existing NRC regulations must be allowed to be used without any restrictions related to the proposed regulations. Otherwise there will be a major economic impact on the industry. Permanent grandfathering of items that were procured within 60 months after the effective date of the rule is appropriate and provides time for fuel vendors and licensees to transition their programs to implement the new rule requirements.*
Proposal	Add the following language to (k): "Fuel assemblies and cladding procured prior to 60 months after [EFFECTIVE DATE OF RULE] are not required to comply with the new requirements of paragraph (g)."
Justification	*The proposed language permanently grandfathers fuel assemblies/bundles and cladding that are procured within 60 months after the effective date of the rule. This allows for the inventory of fuel assemblies and cladding previously designed and fabricated under the existing regulations to be used in future reactor cores without imposing new requirements post-manufacturing.*

Table A.33: Specific Rule Language Comment 33

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(k) *Use of NRC-approved fuel in reactor*. A licensee may not load fuel into a reactor, or operate the reactor, unless the licensee either determines that the fuel meets the requirements of paragraph (d) of this section, or complies with technical specifications governing lead test assemblies in its license.
Comment	The terminology "NRC-approved" may be problematic depending on the licensing history of the commercial fuel designs.
Rationale	*For some commercial fuel designs the terminology "NRC-approved" may present a legal or licensing problem depending on the actual licensing history and process. In addition, some vendors have established NRC approved processes for minor design changes without NRC review and approval. Therefore, what constitutes "NRC-approved" may not be clear.*
Proposal	Delete "NRC-approved"
Justification	*The proposed change resolves the potential licensing and legal questions while preserving the intent of the proposed rule language.*

Table A.34: Specific Rule Language Comment 34

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(k) *Use of NRC-approved fuel in reactor*. A licensee may not load fuel into a reactor, or operate the reactor, unless the licensee either determines that the fuel meets the requirements of paragraph (d) of this section, or complies with technical specifications governing lead test assemblies in its license.
Comment	It appears that "paragraph (d)" should be "paragraph (g)", since that is where the fuel requirements are specified.
Rationale	*Editorial error*
Proposal	Replace with ". . paragraph (g) . . "
Justification	*N/A*

Table A.35: Specific Rule Language Comment 35

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section. (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis. (2) *Significant change or error in the ECCS evaluation model.* For the purposes of paragraph (m)(1) of this section, a significant change or error in an ECCS evaluation model is one that results in a calculated - (i) Peak fuel cladding temperature different by more than 50 °F from the temperature calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 °F; or. (ii) Integral time at temperature different by more than 0.4 percent ECR from the oxidation calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a

	cumulation of changes and errors such that the sum of the absolute magnitudes of the respective oxidation changes is greater than 0.4 percent ECR.
Comment	The (m)(1) and (m)(2) reporting and corrective action requirements associated with ECCS evaluation model and analysis changes and errors should be deleted from the rule. The industry proposes to develop an NEI guidance document to standardize reporting in the industry.
Rationale	*Industry experience with the ECCS evaluation model and analysis changes and errors reporting and corrective action processes has led to the conclusion that these requirements should be deleted from the rule. The inclusion of these requirements in the current rule has led to inconsistent reporting by industry. The development of a guidance document will facilitate standardization of both NRC expectations and industry reporting.*
Proposal	Replace paragraph (m)(1 and 2) with the following: (m) *Reporting of errors and changes in ECCS evaluation models and applications*. The licensee must submit for NRC review and approval a program for notifying NRC of the impact of changes and errors in the ECCS evaluation models and use of the models Refer to Appendix C: for discussion points regarding a proposed document on reporting/submittal(s) and change management regulatory guide.
Justification	*An industry guidance document will be developed to standardize the revised reporting requirements. This approach is envisioned to follow the industry approach to standardize the application of the 50.59 regulation in NEI-96-07. The proposed industry guidance document will standardize the reporting of what information the NRC actually requires, developed via wide stakeholder participation.*

Table A.36: Specific Rule Language Comment 36

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section. (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis.
Comment	The highlighted language in (i) needs to be added to (ii) and (iii).
Rationale	*The language "or the application of such a model" appears to be missing from (ii) and (iii) and is assumed to be an editorial problem.*

Proposal	Insert the following language in (ii) and (iii) as follows: "with the ECCS evaluation model, or in the application of such a model, that"
Justification	*The proposed insertion of language addresses this apparent editorial problem.*

Table A.37: Specific Rule Language Comment 37

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section. (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis.
Comment	The highlighted language appears to be an editorial issue and needs to be deleted
Rationale	*The language "or resulting noncompliance with the acceptance criteria in this section" is assumed to be an editorial problem.*
Proposal	Delete the language in (i) as follows: "ECCS evaluation model ~~or resulting noncompliance with the acceptance criteria in this section,~~ that . . "

Justification	*The proposed deletion of language addresses this apparent editorial problem.*

Table A.38: Specific Rule Language Comment 38

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section. (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis.
Comment	The Commission's use of the phrase "predicted response" with regard to reporting of changes or errors is subject to misinterpretation.

Rationale	*10 CFR 50.46(a)(3) currently requires reporting of ". . . the nature of the change or error and its estimated effect on the limiting ECCS analysis. . . ." The proposed § 50.46c(m)(1) removes the phrase "estimated effect" and effectively replaces it with "predicted response". Some entities might interpret "predicted response" to mean a full execution of an approved ECCS evaluation model (with any needed adjustments). Others may simply read "predicted response" as no more than what is currently specified, where estimates of impact are allowed.*
Proposal	Revise the language of the rule to remove the phrase "predicted response". The use of the phrase "estimated effect," as it is used in current regulations, would be more appropriate. Refer to Appendix C for discussion points for proposed reporting/submittal(s) and change management regulatory guidance.
Justification	*The proposal would allow continued use of estimating the effect of errors or changes that is allowed by the current rule in 10 CFR 50.46(a)(3).*

Table A.39: Specific Rule Language Comment 39

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis.
Comment	The proposed language introduces the concept of “operation inconsistent with the ECCS evaluation model” or “operation” which is vague and also unnecessary, as the existing language “changes, errors” remains sufficient. Operation that is inconsistent with the analyses is considered to be an unanalyzed condition, and as such should be considered for reportability under 50.72 not 50.46c.

Rationale	*The proposed language is vague and unnecessary, and the existing language remains sufficient. The applicable reporting criteria are 50.72.*
Proposal	Delete the proposed language and keep the existing language. Refer to Appendix C for discussion points for proposed reporting/submittal(s) and change management regulatory guidance.
Justification	*The existing language is sufficient and the proposed language describes a situation that should be reported under 50.72 not 50.46c.*

Table A.40: Specific Rule Language Comment 40

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis.
Comment	Revise the 30 day reporting period to 60 days for consistency with other similar regulations. Refer to Appendix C for a discussion of a proposed NEI document on reporting/submittal(s) and change management.

Rationale	*Other similar regulations for reporting require 60 day reports. 10 CFR Part 21 and 10 CFR 50.55(e) require that interim reports be submitted to the Commission within 60 days from discovery of a deviation or failure to comply, if an entity cannot complete its evaluation of a potential substantial safety hazard within that time frame. Likewise,10 CFR 50.73 requires that Licensee Event Reports (LERs) be submitted within 60 days after the discovery of a reportable event, including certain events involving a plant being in an unanalyzed condition. For occurrences that potentially affect plant safety, 10 CFR Part 21, 10 CFR 50.55(e), and 10 CFR 50.72 provide certain other reporting requirements. Application of a 30-day reporting requirement for all significant changes and errors, pursuant to 10 CFR 50.46c, may thus require licensees to report certain changes or errors in a more rapid manner than would otherwise be required for a more significant event that would be reportable as a LER pursuant to 10 CFR 50.73.*
Proposal	Replace the 30 day reporting requirement in (ii) and (iii) with "60 day". Note: A 60 day reporting period is also recommended in paragraph (m)(1)(iii). Refer to Appendix C for discussion points for proposed reporting/submittal(s) and change management regulatory guidance.
Justification	*The proposal is intended to better align reporting requirements.*

Table A.41: Specific Rule Language Comment 41

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (1) *Categories of changes, errors, or operation inconsistent with the ECCS evaluation model.* (i) If an entity identifies any change to, or error in, an ECCS evaluation model or the application of such a model, or any operation inconsistent with the ECCS evaluation model or resulting noncompliance with the acceptance criteria in this section, that does not result in any predicted response that exceeds any acceptance criteria specified in this section and is itself not significant, then a report describing each such change, error, or operation and a demonstration that the error, change, or operation is not significant must be submitted to the NRC no later than 12 months after the change or discovery of the error, or operation. (ii) If an entity identifies a change, error, or operation inconsistent with the ECCS evaluation model that does not result in any predicted response that exceeds any of the acceptance criteria but is significant, then a report describing each such change, error, or operation, and a schedule for submitting a reanalysis and implementation of corrective actions must be submitted within 30 days of the change, discovery of the error, or operation. (iii) If a licensee of a facility licensed to operate identifies a change, error, or operation inconsistent with the ECCS evaluation model that results in any of the acceptance criteria specified in this section to be exceeded at the facility, then the licensee shall report the change, error, or operation under §§ 50.55(e), 50.72, and 50.73, as applicable, and submit a report describing each such change, error, or operation and a schedule for submitting a reanalysis and implementation of corrective actions within 30 days of the change, discovery of the error, or operation. In addition, the licensee (in the case of a combined license under part 52 of this chapter, after the Commission has made the finding under § 52.103(g) shall take immediate action to bring the facility into compliance with the acceptance criteria. (iv) If a design certification applicant is required by paragraphs (m)(1)(ii) of this section to submit a reanalysis, or identifies a change, error, or operation that results in any predicted response that exceeds any of the acceptance criteria specified in this section, then the applicant must submit a reanalysis, accompanied by either a revision to its design certification application under review, or an application to amend the design certification application, as applicable, reflecting the reanalysis.
Comment	The proposed rule language does not allow for the existing rule language "or taking other action as may be needed" as an alternative to submitting a reanalysis for errors or changes that are significant. Requiring a reanalysis will impose a significant cost with no obvious impact on public health and safety.
Rationale	*Depending on the nature of the changes and errors, and the margin to the acceptance limits, requiring a reanalysis may not be appropriate. Note that changes and errors that decrease the analysis result can also be designated as significant, and a reanalysis for that situation is clearly not warranted.*

Proposal	Keep the existing rule language. Refer to Appendix C for discussion points for proposed reporting/submittal(s) and change management regulatory guidance.
Justification	*The existing rule language remains sufficient and appropriate.*

Table A.42: Specific Rule Language Comment 42

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (2) *Significant change or error in the ECCS evaluation model.* For the purposes of paragraph (m)(1) of this section, a significant change or error in an ECCS evaluation model is one that results in a calculated - (i) Peak fuel cladding temperature different by more than 50 °F from the temperature calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 °F; or. (ii) Integral time at temperature different by more than 0.4 percent ECR from the oxidation calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective oxidation changes is greater than 0.4 percent ECR.
Comment	The proposed LOCA analysis reporting requirements need to be more performance-based.
Rationale	*A performance-based approach would allow reactors with LOCA analyses with large PCT and ECR margins more favorable reporting requirements. Both the existing rule ΔPCT threshold of 50°F, and the proposed rule ΔECR threshold of 0.4% are too restrictive for determining significance.*
Proposal	The following proposal is performance-based and determines significance based on margin to the analytical limit: Analyses with PCT+ΔPCT < 2000°F: Significant if ΔPCT >100ºF Analyses with PCT+ΔPCT ≥ 2000°F: Significant if ΔPCT > half of the margin to the analytical limit ECR Analyses with ECR+ΔECR ≥ 80% of the analytical limit: Significant if ΔECR > half of the margin to the analytical limit Refer to Appendix C for discussion points for proposed reporting/submittal(s) and change management regulatory guidance.
Justification	*The proposed definitions of significance are prudent in a performance-based approach.*

Table A.43: Specific Rule Language Comment 43

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (2) *Significant change or error in the ECCS evaluation model.* For the purposes of paragraph (m)(1) of this section, a significant change or error in an ECCS evaluation model is one that results in a calculated - (i) Peak fuel cladding temperature different by more than 50 °F from the temperature calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 °F; or. (ii) Integral time at temperature different by more than 0.4 percent ECR from the oxidation calculated for the limiting transient using the last NRC-approved ECCS evaluation model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective oxidation changes is greater than 0.4 percent ECR.
Comment	The proposed rule requires that the magnitude of change or error be “calculated” which may be interpreted as running the ECCS evaluation model. The licensees need to be allowed to estimate PCTs and ECRs to avoid excessive cost to the industry.
Rationale	*The current practice in the industry for quantifying the effect of changes and errors in the ECCS evaluation models or analyses is to use estimates or analytical results. The proposed rule language may be interpreted to require use of calculations, which implies running the ECCS evaluation model and the large associated cost. This requirement is not consistent with the intended performance-based approach. Small changes or errors, or large margins to the analytical limits, justifies continued use of estimates. In addition, if the result of the change or error is a reduction in the result, then the cost of analysis is not warranted.*
Proposal	(m) Reporting. (2) For the purposes of this section, a significant change or error is one which results in a calculated or estimated – ”. Refer to Appendix C for discussion points for proposed reporting/submittal(s) and change management regulatory guidance.
Justification	*The proposal would allow continued use of estimating the effect of errors or changes that is the current industry practice. NRC staff practice recognizes the acceptability of engineering judgment in lieu of a documented analysis, as evidenced by Section 2.1 of Revision 3 to NUREG-1022, “Event Report Guidelines 10 CFR 50.72 and 50.73, Final Report,” dated January 2013..*

Table A.44: Specific Rule Language Comment 44

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (3) *Breakaway oxidation*. Each holder of an operating license or combined license shall measure breakaway oxidation for each reload batch. The holder must report the results to the NRC annually (i.e., anytime within each calendar year), in accordance with § 50.4 or § 52.3 of this chapter, and evaluate the results to determine if there is a failure to conform or a defect that must be reported in accordance with the requirements of 10 CFR part 21.
Comment	The short time-at--temperature for the occurrence of breakaway oxidation behavior observed for an older Russian E-110 cladding and manufacturing process is not expected for cladding alloys and manufacturing processes used domestically. Based on the ANL and industry testing results for cladding used domestically, all of the domestic fleet has LOCA time-at-temperature analysis results show large margin to the occurrence of breakaway oxidation. Therefore, the burdensome testing and reporting requirements in (m)(3) for breakaway oxidation are not justified. Furthermore, the proposed rule language is not performance-based and will not allow a future reduction in testing based on positive testing experience without a subsequent rule change.
Rationale	*While zirconium based alloys are susceptible to breakaway oxidation after prolonged exposure to certain temperature regimes under steam environment, the incubation time it takes to reach the breakaway mode is stable at around 5000 seconds – a time significantly longer than occurs in the LOCA analyses. The proposed requirement for breakaway oxidation testing appears to result from the testing of the Russian E110 alloy, which showed a short breakaway incubation time of around 500 seconds. The cause for the short breakaway time for the E110 alloy is attributed to the electrolytic process utilized in its manufacture. Compared to the stable process used by the rest of the world, the Russian E110 processing heavily utilized fluorine containing processing material, from ore separation to final reduction. Etching of zirconium based alloy cladding with fluoric acid is known to significantly reduce the incubation time required to reach the breakaway oxidation mode. Recent published results showed the Russian electrolytic produced E110 to have significantly higher fluorine content compared to E110 manufactured from sponge zirconium manufactured outside of Russia. The same literature source also conducted extensive side-by-side study of E110 manufactured from electrolytic and Kroll (non-electrolytic) processed source materials. While the basic manufacturing process used, with the exception of the source material, was identical, the Kroll sourced E110 did not exhibit any sign of early breakaway oxidation. This would indicate the observed E110 short breakaway oxidation incubation time is caused by the electrolytic process used in the manufacturing of the source material. The Russians have since abandoned the electrolytic process.* *ANL and industry testing of cladding used domestically show longer (greater than one hour) time-at-temperature at 1000ºC for occurrence of breakaway oxidation. All of the current domestic fleet have LOCA analysis results with large margin to the occurrence of breakaway oxidation. BWR-2 plants have been identified to have small margins, but planned LOCA reanalysis will demonstrate large margins. Consequently, as the entire fleet has large margins to the occurrence of breakaway oxidation, performance is good, and any rule language should be performance-based and not cause undue burden and cost to the industry.* *The annual reporting of test results commits the industry to permanent testing for the short*

	breakaway oxidation phenomenon. Given that short breakaway oxidation has never been detected with Kroll processed material and linking of the phenomenon to the electrolytic process that is no longer in production, the benefits do not outweigh the burden. *The industry is expected to perform pass/fail type of tests. Only materials pass the test will be used in actual fuel construction and thus the NRC would only receive "pass" laboratory reports.* ***Commissioner Magwood's voting record comments dated 11/29/2012**: His comments were consistent with the industry comments:* *"I agree with the ACRS that rather than the current draft rule's requirement that licensees be required to measure the breakaway oxidation properties of each batch of reload fuel and provide an annual evaluation report to NRC, it would be more effective to require licensees to assure that the breakaway oxidation resistance requirements met for the fuel in their reactors (via the fuel quality requirements in their supply agreements) and provide supporting documentation to the NRC."* ***ACRS letter dated 1/30/2012 to G. B. Jaczko (ML#12030A011):** Stated the following which is consistent with the industry comment:* *"The breakaway oxidation testing requirement for each reload batch and annual reporting requirement in the draft rule should be replaced by a requirement that licensees assure that the breakaway oxidation resistance requirements of the proposed rule are met for the fuel in their reactors and provide supporting documentation."*
Proposal	Delete (m)(3)
Justification	*The industry is proposing different testing and reporting processes to address breakaway oxidation commensurate with the phenomena, state of knowledge and large margins that exist. These changes are consistent with the performance-based intent of the proposed rule. The proposal does not require rule language and so (m)(3) can be deleted.* *The vendors will propose and commit to programs that address the NRC's concerns regarding breakaway oxidation. The programs will be submitted for NRC review and approval along with the other methodology changes required for compliance with the 50.46c rule. Details about the frequency and reporting of test results would be contained within that program. With the program, there is a high probability that cladding which violates the established analytical limit is not provided to the utility. Any significant deviation in the cladding product that meets the criteria of 10 CFR 21 will be reported by the vendor.*

Table A.45: Specific Rule Language Comment 45

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (4) *Updates to risk-informed consideration of debris in long-term cooling.* (i) *Design certification before issuance of final design certification rule*. If a design certification applicant, after performing the evaluation under paragraph (e) of this section and including the information in its application, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the applicant shall submit a report describing its determination. Thereafter, the applicant shall submit, in a timely manner, an amendment to its pending design certification application. The amendment application must describe any changes to the certified design and/or changes in the analyses, evaluations, and modeling (including the debris evaluation model and the PRA and its supporting analyses) needed to demonstrate that the certified design meets the acceptance criteria in paragraph (e)(1) of this section. (ii) *Design certification during the period of validity under § 52.55(a) and (b) of this chapter - not currently referenced in any COL application or COL*. The design certification applicant need not report any information concerning compliance with the acceptance criterion of paragraph (e)(1) of this section in accordance with the requirements of part 21 of this chapter until 30 days after the design certification is referenced by a COL applicant. (iii) *Design certification during the period of validity under § 52.55(a) and (b) of this chapter - once referenced in a COL application or COL*. The design certification applicant shall evaluate and report any information concerning compliance with the acceptance criterion of paragraph (e)(1) of this section in accordance with the requirements of part 21 of this chapter. (iv) *Design certification - renewal*. The applicant for renewal of a design certification shall update the debris evaluation model and the PRA and its supporting analyses, taking into account all known applicable industry operational experience. The applicant shall re-perform the evaluations of risk, defense-in-depth, and safety margins using the updated model. If any of the acceptance criteria in paragraph (e)(1) of this section are not met, then applicant shall include necessary changes to the certified design, debris evaluation model, PRA or supporting analyses to demonstrate that the renewed certified design meets the acceptance criteria in paragraph (e)(1) of this section. (v) *Combined license application*. If a combined license applicant, after performing the evaluation required by paragraph (e) of this section and including the information in its application, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the applicant shall submit a report describing its determination within 30 days of completion of the determination. Thereafter, the applicant shall submit, in a timely manner, an amendment to its pending combined license application. The amendment application must describe any changes to the design of the facility and/or changes in the analyses, evaluations, and modeling (including the debris evaluation model and the PRA and its supporting analyses) needed to demonstrate that the design of the facility meets the acceptance criteria in paragraph (e)(1) of this section, any necessary changes to

	previously-submitted inspections, tests, analyses and acceptance criteria, and either the bases for any change to the inspections, tests, analyses, and acceptance criteria (ITAAC) or why no changes to the ITAAC are needed (vi) *Combined licenses before finding under § 52.103(g)of this chapter*. Each holder of a combined license must, no later than the scheduled date for initial loading of fuel under § 52.103(a) of this chapter, update the analyses, evaluations, and modeling performed under paragraph (e) of this section. The updating must correct identified errors, and incorporate licensee-adopted changes to the plant design, the licensee's proposed operational practices, and any applicable industry operational experience known to the licensee. As appropriate, the licensee shall update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in-depth, and safety margins to confirm that the acceptance criteria identified in paragraph (e)(1) of this section continue to be met. After submitting the update under this paragraph and until the Commission has made the finding under § 52.103(g) of this chapter, the licensee shall re-perform this evaluation in a timely manner if the licensee identifies a change or error in the analyses, evaluations, and modeling, makes a change in the plant design or the plant's proposed operational practices, or identifies applicable industry operational experience. The licensee shall re-perform the evaluation, even if no changes or errors are identified, by no later than 48 months after the last review. If the licensee determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the licensee shall submit, in a timely fashion, an application for amendment of its combined license (and departure from a referenced design certification rule, if applicable), including necessary changes to its updated final safety analysis report and any necessary changes to the ITAAC. The amendment application must demonstrate that the acceptance criteria of paragraph (e)(1) of this section are met, and must describe any changes to the analyses, evaluations and modeling needed to support that conclusion. The application must explain either the bases for any change to ITAAC or why no changes to ITAAC are needed. The application must, if applicable, include a request for exemption from a referenced design certification rule, but need not address the criteria for obtaining an exemption. The licensee shall also submit any report required by § 52.99 of this chapter. The NRC need not address the issue finality criteria in §§ 52.63, 52.83, and 52.98 of this chapter when acting on this amendment, and shall – as part of any approved amendment issue any necessary exemption upon a finding that the exemption is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest. (vii) *Operating licenses and combined licenses after finding under § 52.103(g) of this chapter – updating and corrections.* The licensee shall review the analyses, evaluations, and modeling performed under paragraph (e) of this section for changes and errors and incorporate changes to the design, plant, operational practices, and applicable plant and industry operational experience. As appropriate, the licensee shall update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in depth, and safety margins to confirm that the acceptance criteria identified in paragraph (e)(1) of this section continue to be met. The licensee shall perform this review in a timely manner after a change or error is identified in the analyses, evaluations, and modeling or a change is identified in the design, plant, operational practices, or applicable plant and industry operational experience. The licensee shall perform this review even if no changes or errors are identified, by no later than 48 months after the last review. If the licensee, at any time, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the licensee shall take action in a timely manner to bring the facility into compliance with the acceptance criteria of paragraph (e)(1) of this section. The licensee shall also report the failure to meet the long-term cooling acceptance criterion in paragraph (e)(1) of this section. The report must be prepared and submitted in accordance with, §§ 50.72, and 50.73, as applicable. Thereafter, the licensee shall submit, in a timely fashion, an application for amendment of its license, including necessary changes to its updated final safety analysis report. The amendment application must demonstrate that the acceptance criteria of paragraph (e)(1) of this section are met, and must describe any changes to the analyses, evaluations and modeling needed to support that conclusion. The amendment application for a combined license must, if applicable, include a request for exemption from a referenced design

	certification rule, but need not address the criteria for obtaining an exemption. The NRC need not address either the backfitting criteria in § 50.109 or the issue finality criteria in §§ 52.63, 52.83, and 52.98 of this chapter when acting on this amendment and shall, as part of any approved amendment, issue any necessary exemption upon a finding that the exemption is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest
Comment	Paragraph (m)(4) can be deleted in its entirety based on a simpler requirement (proposed (e)(1)(vi)) for the risk-informed LAR to include a monitoring program and a process for notifying NRC of changes and errors. The NRC will review and approve the LAR. The future regulatory guide will specify a monitoring and changes and error reporting program acceptable to the NRC, and the industry requests an opportunity to provide input. The applicant can submit a program that is consistent with the regulatory guide or propose an alternative approach in the LAR. The industry considers that a performance-based reporting program would be appropriate based on the R. G. 1.174 risk metrics and plant-specific margin.
Rationale	*The content of (m)(4) is unnecessary rule language. The intent of (m)(4) can be achieved by the proposed addition of (e)(1)(vi) per the previous comment.*
Proposal	Delete (m)(4) in its entirety and include the proposed (e)(2)(vi) requirement (Refer to Comment 22). If this proposal is not acceptable, then the language "long-term" needs to be deleted throughout (m)(4) (Refer to Comment 20)
Justification	*The deletion of (m)(4) along with the addition of (e)(1(vi) will achieve the same purpose without requiring extensive rule language.*

Table A.46: Specific Rule Language Comment 46

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(m) *Corrective actions and reporting*. Each entity subject to the requirements of this section must comply with paragraphs (m)(1) through (3) of this section. Each entity demonstrating acceptable long-term core cooling under the provisions of paragraph (e) of this section shall also comply with the requirements of paragraph (m)(4) of this section (4) *Updates to risk-informed consideration of debris in long-term cooling.* (i) *Design certification before issuance of final design certification rule*. If a design certification applicant, after performing the evaluation under paragraph (e) of this section and including the information in its application, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the applicant shall submit a report describing its determination. Thereafter, the applicant shall submit, in a timely manner, an amendment to its pending design certification application. The amendment application must describe any changes to the certified design and/or changes in the analyses, evaluations, and modeling (including the debris evaluation model and the PRA and its supporting analyses) needed to demonstrate that the certified design meets the acceptance criteria in paragraph (e)(1) of this section. (ii) *Design certification during the period of validity under § 52.55(a) and (b) of this chapter - not currently referenced in any COL application or COL*. The design certification applicant need not report any information concerning compliance with the acceptance criterion of paragraph (e)(1) of this section in accordance with the requirements of part 21 of this chapter until 30 days after the design certification is referenced by a COL applicant. (iii) *Design certification during the period of validity under § 52.55(a) and (b) of this chapter - once referenced in a COL application or COL*. The design certification applicant shall evaluate and report any information concerning compliance with the acceptance criterion of paragraph (e)(1) of this section in accordance with the requirements of part 21 of this chapter. (iv) *Design certification - renewal*. The applicant for renewal of a design certification shall update the debris evaluation model and the PRA and its supporting analyses, taking into account all known applicable industry operational experience. The applicant shall re-perform the evaluations of risk, defense-in-depth, and safety margins using the updated model. If any of the acceptance criteria in paragraph (e)(1) of this section are not met, then applicant shall include necessary changes to the certified design, debris evaluation model, PRA or supporting analyses to demonstrate that the renewed certified design meets the acceptance criteria in paragraph (e)(1) of this section. (v) *Combined license application*. If a combined license applicant, after performing the evaluation required by paragraph (e) of this section and including the information in its application, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the applicant shall submit a report describing its determination within 30 days of completion of the determination. Thereafter, the applicant shall submit, in a timely manner, an amendment to its pending combined license application. The amendment application must describe any changes to the design of the facility and/or changes in the analyses, evaluations, and modeling (including the debris evaluation model and the PRA and its supporting analyses) needed to demonstrate that the design of the facility meets the acceptance criteria in paragraph (e)(1) of this section, any necessary changes to previously-submitted inspections, tests, analyses and acceptance criteria, and either the bases for any change to the inspections, tests, analyses, and acceptance criteria (ITAAC)

	or why no changes to the ITAAC are needed (vi) *Combined licenses before finding under § 52.103(g)of this chapter*. Each holder of a combined license must, no later than the scheduled date for initial loading of fuel under § 52.103(a) of this chapter, update the analyses, evaluations, and modeling performed under paragraph (e) of this section. The updating must correct identified errors, and incorporate licensee-adopted changes to the plant design, the licensee's proposed operational practices, and any applicable industry operational experience known to the licensee. As appropriate, the licensee shall update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in-depth, and safety margins to confirm that the acceptance criteria identified in paragraph (e)(1) of this section continue to be met. After submitting the update under this paragraph and until the Commission has made the finding under § 52.103(g) of this chapter, the licensee shall re-perform this evaluation in a timely manner if the licensee identifies a change or error in the analyses, evaluations, and modeling, makes a change in the plant design or the plant's proposed operational practices, or identifies applicable industry operational experience. The licensee shall re-perform the evaluation, even if no changes or errors are identified, by no later than 48 months after the last review. If the licensee determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the licensee shall submit, in a timely fashion, an application for amendment of its combined license (and departure from a referenced design certification rule, if applicable), including necessary changes to its updated final safety analysis report and any necessary changes to the ITAAC. The amendment application must demonstrate that the acceptance criteria of paragraph (e)(1) of this section are met, and must describe any changes to the analyses, evaluations and modeling needed to support that conclusion. The application must explain either the bases for any change to ITAAC or why no changes to ITAAC are needed. The application must, if applicable, include a request for exemption from a referenced design certification rule, but need not address the criteria for obtaining an exemption. The licensee shall also submit any report required by § 52.99 of this chapter. The NRC need not address the issue finality criteria in §§ 52.63, 52.83, and 52.98 of this chapter when acting on this amendment, and shall – as part of any approved amendment issue any necessary exemption upon a finding that the exemption is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest. (vii) *Operating licenses and combined licenses after finding under § 52.103(g) of this chapter – updating and corrections.* The licensee shall review the analyses, evaluations, and modeling performed under paragraph (e) of this section for changes and errors and incorporate changes to the design, plant, operational practices, and applicable plant and industry operational experience. As appropriate, the licensee shall update the debris evaluation model and the PRA and its supporting analyses, and re-perform the evaluations of risk, defense-in depth, and safety margins to confirm that the acceptance criteria identified in paragraph (e)(1) of this section continue to be met. The licensee shall perform this review in a timely manner after a change or error is identified in the analyses, evaluations, and modeling or a change is identified in the design, plant, operational practices, or applicable plant and industry operational experience. The licensee shall perform this review even if no changes or errors are identified, by no later than 48 months after the last review. If the licensee, at any time, determines that any acceptance criterion of paragraph (e)(1) of this section is not met, then the licensee shall take action in a timely manner to bring the facility into compliance with the acceptance criteria of paragraph (e)(1) of this section. The licensee shall also report the failure to meet the long-term cooling acceptance criterion in paragraph (e)(1) of this section. The report must be prepared and submitted in accordance with, §§ 50.72, and 50.73, as applicable. Thereafter, the licensee shall submit, in a timely fashion, an application for amendment of its license, including necessary changes to its updated final safety analysis report. The amendment application must demonstrate that the acceptance criteria of paragraph (e)(1) of this section are met, and must describe any changes to the analyses, evaluations and modeling needed to support that conclusion. The amendment application for a combined license must, if applicable, include a request for exemption from a referenced design certification rule, but need not address the criteria for obtaining an exemption. The NRC need not address either the backfitting criteria in § 50.109 or the issue finality criteria in §§

	52.63, 52.83, and 52.98 of this chapter when acting on this amendment and shall, as part of any approved amendment, issue any necessary exemption upon a finding that the exemption is authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest
Comment	Paragraph (m)(4) (vii) does not include the situation where following the identification of a change or an error that causes the acceptance criteria to not be met, that the plant condition is restored to within the licensing basis, and therefore an LAR is not required
Rationale	*Action to correct an identified violation of the acceptance criteria that restores the plant to within the licensing basis should obviate the need to submit an LAR. Resolutions of degraded, non-conforming conditions are typically addressed via corrective action programs and operability assessments.*
Proposal	Include in the (vii) rule language that submittal of an LAR is not required following identification that an acceptance criteria was not met, provided that the plant condition has been restored to within the licensing basis.
Justification	*Restoring the plant condition to within the licensing basis is a sufficient resolution to a situation where the acceptance criteria have been violated.*

Table A.47: Specific Rule Language Comment 47

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(o) *Implementation*
Comment	Paragraph (e), the alternate risk-informed approach to debris, is optional. Because it is optional it is inferred that paragraph (o) is not applicable to paragraph (e) as it would not make sense to establish a compliance schedule requirement for something that is optional. For the situation where a licensee intends to submit a risk-informed approach LAR, but the LAR will not be approved by the NRC prior to the Table 1 date for that plant, a schedule exemption will be necessary.
Rationale	*Until a licensee obtains NRC approval of a risk-informed LAR that addresses the effects of debris, they will be subject to the Table 1 schedule requirement to comply with 50.46c. There may be an overlap in the Table 1 dates and the LAR approval dates, which will cause a licensee to be out of compliance. To avoid this situation a schedule exemption will be needed. The need for an exemption for this situation conflicts with the intent of including the risk-informed option in 50.46c.*
Proposal	The industry proposal for licensee submittal of a compliance plan within 180 days, or removal of Table 1 from the rule resolves this issue. Otherwise some licensees that have submitted or intend to submit a risk-informed LAR to address the effects of debris will need to submit exemption requests.
Justification	*The proposal includes two options that will resolve the identified issue. Otherwise it is likely that a number of licensees will need to request scheduler exemptions to 50.46c.*

Table A.48: Specific Rule Language Comment 48

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(o) *Implementation* (4) Operating licenses issued under this part as of **[EFFECTIVE DATE OF RULE]** must comply with the requirements of this section by no later than the applicable date set forth in Table 1 in paragraph (o) of this section. Until such compliance is achieved, the requirements of § 50.46 continue to apply.
Comment	The implementation plan should be replaced by a requirement for licensees to submit within 180 days of the effective date of the rule a plan for compliance. The NRC would review and approve the plan and manage it outside of the rule.
Rationale	*The proposed rule assumes that licensees can show compliance with the new rule by simply submitting something. Licensees must be in compliance with their Technical Specifications / COLR requirements. The new rule would unsynchronize all technical specifications from new requirements. Compliance with the new rule will only be possible at the end of licensee specific amendment reviews with acceptable safety evaluation reports.* *Prior rule making implementations have utilized licensee specific compliance planning, as well as the concept that not all aspects of a new rule need to be implemented on identical schedules.* *As a practical matter, the draft rule would likely engender large scale exemption requests. By having plant names and timelines in the rule language, any kind of change for any valid reason would require new rulemaking. This is not a desirable situation for anyone. Industry believes that the most effective way to implement the important technical considerations of the new rule is to use a plant specific compliance plan process, utilizing multiple implementation timelines as appropriate.*
Proposal	Delete paragraph (o(4)) and replace with: (4) Each licensee shall submit a plan for compliance with the requirements of 50.46c within 180 days of [EFFECTIVE DATE OF RULE].
Justification	*An implementation plan would consist of a requirement for licensees to submit a plan for compliance within 180 days of the effective date of the rule. The NRC would then review and approve each plan. The industry recommends that the plan use a living schedule based on milestones. This would allow for completion of NRC reviews along with completion of vendor and licensee activities. Management of the compliance schedule would be through normal NRC processes and would not result in exemption requests. The industry proposal would be a workable approach to scheduling the many activities over many years that will be necessary for a licensee to come into compliance.* *To facilitate the proposed approach the industry would work with NRC Staff to develop a standard template for use by licensees facilitating/standardizing individual submittals.*

Table A.49: Specific Rule Language Comment 49

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(o) *Implementation* (4) Operating licenses issued under this part as of **[EFFECTIVE DATE OF RULE]** must comply with the requirements of this section by no later than the applicable date set forth in Table 1 in paragraph (o) of this section. Until such compliance is achieved, the requirements of § 50.46 continue to apply.
Comment	The current implementation plan has only one compliance date for each track. A phased implementation plan that allows different dates for different rule requirements is more appropriate. As a minimum a separate date is required for compliance with the long-term cooling requirements.
Rationale	*The industry proposes that the implementation rule language be revised to adopt a phased implementation approach. In this manner the various requirements in the rule can be evaluated to determine a realistic schedule for compliance given industry and NRC resource limitations. In particular the new debris based core cooling requirement is considered to involve a substantial work effort by industry and there is significant regulatory uncertainty due to the unavailability of a regulatory guide.*
Proposal	NRC and industry would identify the list of requirements in 50.46c and agree on a phased implementation plan with schedules for individual or combinations of requirements. A template will be developed to standardize the industry response. As a minimum, a separate schedule for debris effects on cooling compliance is needed.
Justification	*Phased implementation plans have been used successfully for previous regulatory issues. The Enhancements to Emergency Preparedness Regulations (NRC-2008-0122 / 76 FR 72560) allowed individual compliance dates for specific sections of the revised rule. The Power Reactor Security Requirements (NRC 2008-0019 / 74FR 13926) allowed for individual compliance dates for specific requirements. Implementation of rules does not require schedule dates in the rule language. Including schedule dates is likely to generate exemption requests and needlessly consume NRC and industry resources.* *The current state of the debris effects on core cooling aspects of the rule will require a later compliance schedule as there are significant unknowns at this time.*

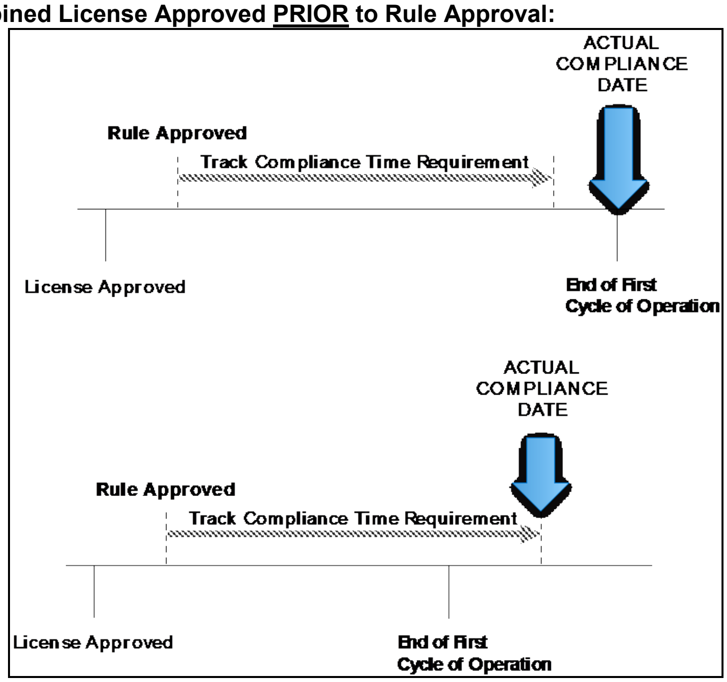
Table A.50: Specific Rule Language Comment 50

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(o) *Implementation* Table 1: Implementation Dates for Nuclear Power Plants with Operating Licenses as of [**EFFECTIVE DATE OF RULE**]. Track 1 ..... Track 2 ..... Track 3 .....
Comment	Table 1 of the FRN is based on safety margin assessments performed by the industry owners groups. Continuing validity of the reports has been the responsibility of NRR staff to update on a yearly basis. However, it must be remembered that the safety margin assessments were performed on an “operability basis.” This means that excessive conservatisms were reduced, and unreviewed/unapproved methods were used to assess adjustments stemming from NUREG-6967. As such, the safety margin assessments, audited by NRC staff, are essentially best-estimates; not licensing basis. Table 1 was developed based on best-estimate assessments. There is currently no way to know what the outcome of “Licensing Basis” calculations will be simply because there are too many unknowns at this time. Consequently, one can only guess at the amount of effort a particular plant may require going forward to achieve new rule compliance. Plants thought to be minimal effort could become significant, and vice versa. The presence of Table 1 in the rule language has the potential to cause avoidable regulatory problems. Compliance via existing regulatory processes, outside of rule language, should be adequate.
Rationale	*Eliminate avoidable regulatory problems.*
Proposal	Delete Table 1: ~~(o) *Implementation*~~ ~~Table 1: Implementation Dates for Nuclear Power Plants with Operating Licenses as of [**EFFECTIVE DATE OF RULE**].~~ ~~Track 1 .....~~ ~~Track 2 .....~~ ~~Track 3 .....~~ There are also numerous places within the FRN which cross reference Table 1; they should be removed.
Justification	*The proposed change addresses identified issues.*

Table A.51: Specific Rule Language Comment 51

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(o) *Implementation* (4) Operating licenses issued under this part as of [**EFFECTIVE DATE OF RULE**] must comply with the requirements of this section by no later than the applicable date set forth in Table 1 in paragraph (o) of this section. Until such compliance is achieved, the requirements of § 50.46 continue to apply.
Comment	As a bare minimum, delete plant names from Table 1 to allow future plant reassignment consistent with a performance-based approach, and to allow regulatory flexibility without exemption requests.
Rationale	*The industry encourages the concept of a graded implementation approach. The Table 1 proposal is a reasonable approach with the exception that including the plant names will not allow for reassignment to a different track consistent with a performance-based approach. The NRC assigned each plant to one of the tracks based on some criteria related to LOCA analysis margin and the expected analysis and licensing effort to comply with the proposed regulation. How each plant compares to the NRC criteria and the resulting track assignment can change due to LOCA reanalysis. With the plant names included in the rule a licensee desiring a track reassignment would need to submit an exemption request. NRC and licensee resources to process an exemption request are considerable and can be avoided by addressing this comment.*
Proposal	Delete the plant names in Table 1 and replace with the NRC criteria used to guide development of implementation plans.
Justification	*With the plant names deleted from Table 1 and replaced with the NRC guidance criteria used to develop implementation plans would still use a graded-approach for implementing the proposed rule will not change. The NRC can then maintain an internal list of which plants and are assigned to each track and the licensee will understand which track their plants are in. This gives the NRC the flexibility to reassign plants to other tracks for appropriate reasons without the need for the licensee to submit and the NRC to approve an exemption request.*

Table A.52: Specific Rule Language Comment 52

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	(o) *Implementation* (9) Combined licenses issued under part 52 of this chapter, before [**EFFECTIVE DATE OF RULE**] and combined licenses issued after the [**EFFECTIVE DATE OF RULE**] whose applications were docketed before [**EFFECTIVE DATE OF RULE**] must comply with this section no later than completion of the first refueling outage after initial fuel load. Until such compliance is achieved, the requirements in § 50.46 continue to apply.
Comment	The NRC is proposing that new reactors per (o)(9) may operate for the initial fuel cycle without meeting the proposed new rule requirements. This language should not require new plants to meet the rule in less time than the Track 1, 2, and 3 compliance requirements if the rule implementation is delayed. It would be possible for the initial cycle to conclude prior to Track timing requirements if rule making is delayed. The following illustrates the comment. **New or Combined License Approved <u>PRIOR</u> to Rule Approval:** 

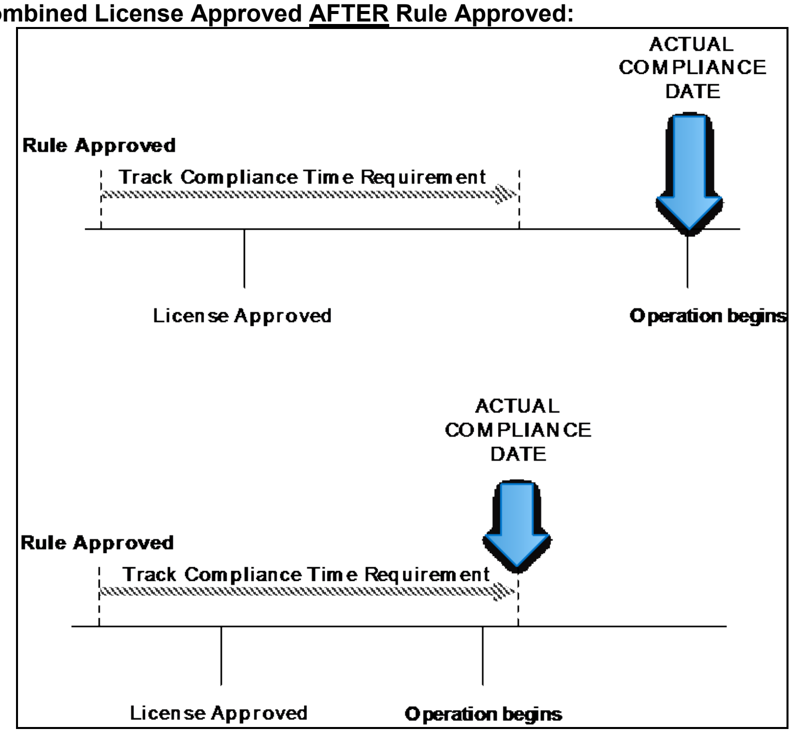
	New or Combined License Approved <u>AFTER</u> Rule Approved: 
Rationale	*Unclear timing of compliance for new plants during first fuel cycle.*
Proposal	Combined licenses issued under Part 52 of this chapter, before [EFFECTIVE DATE OF RULE] and combined licenses issued after the [EFFECTIVE DATE OF RULE] whose applications were docketed before [EFFECTIVE DATE OF RULE] must comply with this section no later than completion of the refueling outage after the first fuel cycle following [EFFECTIVE DATE OF RULE], or 12 months following [EFFECTIVE DATE OF RULE], whichever occurs later. Until such compliance is achieved, the requirements in § 50.46 continue to apply
Justification	*The change in the implementation date would allow for the COL holders of a Part 52 license to have similar period of time to come into compliance with the proposed changes, similar to timeframes associated with Track 1 Plants from the proposal*

Table A.53: Specific Rule Language Comment 53

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix A GDC 35 Emergency Core Cooling.* A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that 1) fuel and clad damage that could interfere with continued effective core cooling is prevented and 2) clad metal-water reaction is limited to negligible amounts. Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure. 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 § 50.46c
Comment	Paragraph one describes an ECCS requirement, but the standard is fuel performance.
Rationale	*As written, the standard for acceptable ECCS performance can only be assessed in the context of fuel performance. As a practical matter, fuel performance limits under LOCA are set to live within the context of the available ECCS capabilities. In light of this situation, GDC 35 should be written analogous to GDC 10.*
Proposal	Paragraph 1 rewrite: A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant, with appropriate margin, assuring specified acceptable fuel analytical limits are not exceeded during any loss of core cooling event. Specified acceptable fuel analytical limits must address both short and long term effects impacting effective core cooling and material-coolant reactions.
Justification	*Use of terminology consistent with other GDC's, while capturing the original intent. The GDC would now place the emphasis of ECCS performance where it truly belongs, which is fuel performance. The proposed §50.46c(g) then becomes what it really is: an enumeration of high level limits, directly implementing GDC 35.*

Table A.54: Specific Rule Language Comment 54

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix A GDC 35 Emergency Core Cooling.* A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that 1) fuel and clad damage that could interfere with continued effective core cooling is prevented and 2) clad metal-water reaction is limited to negligible amounts. Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure. 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 § 50.46c
Comment	Paragraph three: GDC's are high level criteria. As such there is no need for them to make specific pointers to lower level rules.
Rationale	*As written, the proposed language is overly specific for this level of criteria. Allowing for different assessment methods can be done in a more generic manner.*
Proposal	Paragraph 3 rewrite: Safety system and fuel performance, due to debris and associated effects may be evaluated using deterministic or risk-informed methods consistent with applicable requirements of implementing rules.
Justification	*Keeps the GDC at a high level, without reference to specific rules, which are subject to change. Still provides the basis for risk-informed approach within §50.46c.*

Table A.55: Specific Rule Language Comment 55

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix A GDC 38 Containment Heat Removal System.* A system to remove heat from the reactor containment shall be provided. The system safety function shall be to reduce rapidly, consistent with the functioning of other associated systems, the containment pressure and temperature following any loss-of-coolant accident and maintain them at acceptably low levels. Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure. 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 § 50.46c.
Comment	Paragraph three: GDC's are high level criteria. As such there is no need for them to make specific pointers to lower level rules.
Rationale	*As written, the proposed language is overly specific for this level of criteria. Allowing for different assessment methods can be done in a more generic manner.*
Proposal	Paragraph 3 rewrite: Safety system performance, due to debris and associated effects may be evaluated using deterministic or risk-informed methods consistent with applicable requirements of implementing rules.
Justification	*Keeps the GDC at a high level, without reference to specific rules, which are subject to change. Still provides the basis for risk-informed approach within §50.46c.*

Table A.56: Specific Rule Language Comment 56

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix A GDC 41 Containment Atmosphere Cleanup.* Systems to control fission products, hydrogen, oxygen, and other substances which may be released into the reactor containment shall be provided as necessary to reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment following postulated accidents, and to control the concentration of hydrogen or oxygen and other substances in the containment atmosphere following postulated accidents to assure that containment integrity is maintained. Each system shall have suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) its safety function can be accomplished, assuming a single failure. The effects of debris on system safety function following occurrence of the postulated accidents may be evaluated in accordance with all requirements applicable to the risk-informed approach in § 50.46c.
Comment	Paragraph three: GDC's are high level criteria. As such there is no need for them to make specific pointers to lower level rules.
Rationale	*As written, the proposed language is overly specific for this level of criteria. Allowing for different assessment methods can be done in a more generic manner.*
Proposal	Paragraph 3 rewrite: Safety system performance, due to debris and associated effects may be evaluated using deterministic or risk-informed methods consistent with applicable requirements of implementing rules.
Justification	*Keeps the GDC at a high level, without reference to specific rules, which are subject to change. Still provides the basis for risk-informed approach within §50.46c.*

Table A.57: Specific Rule Language Comment 57

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix K* In its entirety
Comment	The detailed technical content of Appendix K is more suited to a regulatory guide.
Rationale	*The detailed technical content of Appendix K has legacy issues and changes desired by the industry that would be more efficiently addressed by moving the detailed content to a new regulatory guide ("Conservative ECCS Evaluation Models"). Future revisions could then also be more efficiently included. This would also be consistent with the technical guidance for the best-estimate ECCS evaluation models in Regulatory Guide 1.157.*
Proposal	Move the technical details in Appendix K to a new regulatory guide. Potential language for a regulatory guide is shown in Appendix E of this document.
Justification	*Streamlining Appendix K by moving the technical details to a new regulatory guide would allow for more efficient revisions to address legacy or newly identified issues and appropriate changes which would fall out from the proposed rulemaking.* *Appendix K could still reside in the rule, but just contain one or two sentences indicating that details regarding an acceptable, conservative model are available in regulatory guidance. That way, any existing rules, guidance, and/or other documents such as safety evaluations and safety evaluation reports would not be orphaned by loss of an appropriate cross reference.* *Bring Appendix K language purpose into alignment with 50.46c assumption of scope, (e.g., documentation, and changes to Cathcart-Pawel).*

Table A.58: Specific Rule Language Comment 58

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix K (1)(A)(5)* Metal-Water Reaction Rate paragraph
Comment	Allow the Cathcart-Pawel correlation to be used with Appendix K ECCS evaluation models.
Rationale	*The Cathcart-Pawel correlation is proposed as an allowable option for the NRC-proposed cladding embrittlement methodology. It should be an option to Baker-Just correlation throughout the ECCS evaluation models.*
Proposal	Allow use of the Cathcart-Pawel correlation in Appendix K and/or Baker-Just.
Justification	*The proposed change would allow use of the Cathcart-Pawel correlation in Appendix K ECCS evaluation models. This change would be simplified by the proposed move of Appendix K to a regulatory guide.*

Table A.59: Specific Rule Language Comment 59

Reference	FRN 79-56, Part II, 10 CFR Parts 50 and 52, Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria Proposed Rule, Nuclear Regulatory Commission Federal Register Notice, pages 16106 thru 16146, publication dated March 24, 2014. *(ADAMS Accession No. ML12283A174)*
Statement	*10 CFR 50, Appendix K (1)(A)(5)* Decay Heat paragraph
Comment	Add a long-term decay heat model to Appendix K.
Rationale	*The uncertainty in the decay heat is less during the time period of interest for the long-term cooling evaluation. The 1.20 conservative factor is not justified for all periods.*
Proposal	Allow use of an ANS decay heat standard plus uncertainty for long-term cooling evaluations.
Justification	*The proposed change would reduce unnecessary conservatism in decay heat model for the long-term cooling evaluation. The proposed change would remain sufficiently conservative for the long-term period of interest where the uncertainty is lower. Excessive conservatism in the decay heat model can lead to requiring operator actions to perform system realignments for boric acid precipitation mitigation earlier than necessary. Additional time for operator actions lowers the risk and improves safety.*

Appendix B: *Long-Term Cooling Guidance Proposal*

Table of Contents

I. PURPOSE

The NRC proposed §50.46c rulemaking includes new requirements for post-LOCA long-term cooling. The applicable paragraphs of the rule are the following:

- (b) *Definitions:* The definition of debris evaluation model refers to phenomena important to long-term cooling and that the model must demonstrate mitigation of debris effects during the recirculation period.
- (e) *Alternate risk-informed approach for addressing the effects of debris on long-term core cooling*: This paragraph has the requirements to apply for NRC approval of a risk-informed application using a debris evaluation model and the PRA.
- (g)(1)(v) *Long-term cooling*: This paragraph specifies the analytical limit (acceptance criterion) as being a peak cladding temperature that corresponds to the ductile-to-brittle transition for the cladding. This limit must be determined using an NRC-approved experimental technique.

Compliance with the proposed §50.46c rule language related to long-term cooling will be difficult without additional information. The purpose of this appendix is to provide background on the current method of compliance with the existing rule, to summarize the technical issues, and to discuss the issues that concern the industry regarding implementation of the proposed rule. The industry proposes that the NRC develop a long-term cooling regulatory guide to clarify NRC expectations on the scope of long-term cooling analysis that is necessary to comply with §50.46c, and to describe a methodology that is acceptable to the NRC. This is needed to define the technical scope and reduce regulatory uncertainty.

This appendix focuses on the current operating fleet. However, the recommended regulatory guide needs to address the passive advanced reactor designs and small modular reactors.

II. BACKGROUND

This section provides background on the current method of compliance with the long-term cooling requirements of the existing rule. References 1, 2, and 3 are the sources of much of the information.

In the current rule, paragraph (b)(5) states the requirements for long-term cooling:

> "*Long-term cooling*. After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core."

Also, Appendix K, paragraph (D)(6) specifies acceptable models for BWR spray cooling.

The fuel vendors all demonstrate compliance, in part, by showing the ECCS can supply sufficient cooling water in the long-term to remove decay heat and maintain the fuel temperatures at an acceptably low value. For PWR fuel, compliance also involves demonstrating that boric acid precipitation does not occur and boric acid plateout on the cladding and coolant channel blockage are prevented. For BWR fuel, compliance also involves demonstrating the core spray system, along with the ECCS, removes decay heat and maintains the core temperature at an acceptably low value. The effects of debris on core cooling are a subject of recent research and testing via a GSI-191 program with the owners groups.

III. TECHNICAL ISSUES

This section presents the technical issues related to long-term cooling that need to be addressed in the proposed regulatory guide, or in any future rule language and statement of considerations, (some difficulties could be eliminated by allowing risk-informed for all time periods):

Definition of Long-Term Cooling Period

The scope of the long-term cooling evaluation begins with specifying the start and the end of the long-term cooling period. This may need to be different for PWRs and BWRs, and even different for various PWR and BWR designs. Therefore, the fuel vendors and the licensees will define the long-term cooling period in their methodology submittals. The start of the long-term cooling period may be defined as 1) the time of core quench, 2) the end of the computer simulation of the blowdown, refill, and reflood phases, or 3) the time of realignment of the ECCS for the recirculation phase. The end of the long-term period may be considered as the time at which there is no consequence to terminating operation of the ECCS. That would suggest that the decay heat can be passively transferred to the containment without operation of the ECCS.

Deterministic vs. Risk-Informed Evaluation of Effects of Debris

The proposed rule language includes the alternate risk-informed approach to evaluate the effects of debris on long-term cooling. There may different requirements for the analysis of long-term cooling depending on the deterministic or the risk-informed approach. The regulatory guidance needs to consider each separately. For example, any acceptance criterion for a deterministic approach must be met, whereas a risk-informed approach would allow the acceptance criterion to be exceeded for low-probability scenarios. Also, it would not be necessary for the deterministic and the risk-informed acceptance criteria to be the same. The requirement for conservative assumptions versus realistic assumptions for both licensing approaches needs to be defined.

Design-Specific Considerations

The differences in PWR and BWR designs, in ECCS design, and in fuel/cladding design need to be addressed in the proposed regulatory guidance. As an example, the figure-of-merit / analytical limit / acceptance criteria may be different for different cladding alloys. Another example is the extended core uncovery phase for BWRs may have different core spray requirements for different BWR designs. Also, boric acid precipitation control measures are different for the fleet of PWR designs.

Open Issues

The issues associated with long-term core cooling must be identified to determine the scope of evaluation. The following issues are in scope:

a) All pipe break locations and sizes (transition break size implications)
b) The start of the long-term cooling phase

c) Adequacy of ECCS flow to match the decay heat boil-off including spillage and the assumed single failure.
d) ECCS flow interruption due to realignment or other causes
e) Boric acid precipitation for PWRs
f) Core re-uncovery due to loop seal effects for PWRs
g) Spray cooling for BWRs
h) Long-term effects of debris including chemical effects
i) Operator actions

Phenomena / PIRT

For each of the accident scenarios related to long-term cooling, the thermal-hydraulic and fuel thermal-mechanical phenomena of interest need to be identified. A typical approach used in the industry is to conduct a PIRT. PIRT results would guide long-term cooling model development, identify additional testing needed, and contribute to selection of appropriate figures-of-merit / analytical limits / acceptance criteria.

Decay Heat

A key consideration in the regulatory guidance for long-term cooling is specifying the decay heat model. Whereas the Appendix K requirement for 120% of the 1971 ANS standard decay heat model is suitable for short-term LOCA analyses, a more realistic yet conservative decay heat model is justified for long-term cooling analyses. The required uncertainty should be appropriate for the time period of interest and should correspond to the model chosen (e.g., most recent ANS standard, NUREG-1230, etc.).

Figures-of-Merit / Analytical Limits / Acceptance Criteria

The proposed §50.46c rule language has a peak cladding temperature as the analytical limit for long-term cooling. Furthermore, this limit is to be based on testing. Design-specific considerations suggest that one limit may not be valid or sufficient. Also, parameters other than cladding temperature may be more appropriate.

Testing

The proposed rule requires the peak cladding temperature analytical limit correspond to the ductile-to-brittle transition for the cladding material determined using an NRC-approved experimental technique. The future regulatory guide should describe in general terms the scope of an acceptable testing program. This would involve testing cladding specimens that have been subjected to a LOCA heatup and quench cycle, and then a defined long-term temperature profile. In addition the possible mechanisms of cladding degradation/failure to be tested require identification. The BWR core spray testing programs previously approved by NRC should be included by reference as acceptable testing programs. The issues identified above and the high-importance phenomena resulting from the PERT process should be evaluated for needed testing.

IV. IMPLEMENTATION ISSUES

Implementation issues related to compliance with the proposed long-term cooling requirements involve both NRC and industry activities. The proposed regulatory guide will inform the licensees of the scope of activities required for compliance, and an approach acceptable to the NRC. Additional regulatory guidance is needed, similar to the power uprate licensing (e.g. RS-001 and RIS 2002-03), to standardize and bring efficiency to the development by industry and review by NRC of a large volume of §50.46c long-term cooling submittals. A revision to the SRP would also be needed at some point.

The industry proposes to maintain the current rule language at least until the regulatory guide is available and the technical issues have been addressed. The current rule language is expected to remain compatible with the future regulatory guide and the new long-term cooling methodologies that will be developed by the industry and submitted for NRC review and approval.

V. SUMMARY

This appendix provides industry input on the content of a future regulatory guide on long-term cooling. The regulatory guide will serve to reduce regulatory uncertainty and provide fuel vendors and licensees with the information needed to undertake programs that will comply with the regulations.

VI. REFERENCES

1. Flaig, Kurt, "Long-Term Cooling Issues," PWROG presentation at June 25, 2014 NRC public meeting on 50.46c *(ADAMS Accession No. ML14176A067)*

2. Fink, David, "Review of Current PWR Post-LOCA Long-Term Cooling Compliance Methods," Westinghouse presentation at June 25, 2014 NRC public meeting on 50.46c *(ADAMS Accession No. ML14176A068)*

3. Muftuoglu, Kurshad, "BWR LOCA Long-Term Cooling Aspects," GE Hitachi presentation at June 25, 2014 NRC public meeting on 50.46c *(ADAMS Accession No. ML14176A066)*

Appendix C: *Issues Regarding Change Management and Reporting Guidance*

C.I. Introduction

Reporting requirements respecting changes to, and errors in, ECCS evaluation models and application of those models, have long been a source of confusion. Misconceptions have arisen, in part, from the language used in the 1988 revision to § 50.46 adding reporting requirements without full consideration of industry and NRC change management practices (e.g., failing to define when an assessment of cumulative effects of changes and errors should be re-zeroed). Licensee practices with respect to the level of detail in written reports, as well as industry and NRC practices related to the management of margins to NRC acceptance criteria, have likewise led to inconsistent reporting format and content, and occasional miscommunication between licensees and the NRC.

Industry review of the draft § 50.46c rule suggests that, absent a common understanding and standardization of change management and reporting practices, an even greater potential for misconceptions, miscommunication, and regulatory uncertainty will exist in the future. This conclusion is based on both the increased scope of the draft rule, and the actual draft rule language and its similarities/differences relative to the current § 50.46.

For example, the draft rule replaces “estimates” of PCT effects with “demonstrations,” but does not define what constitutes an acceptable demonstration. The draft rule also removes language existing in § 50.46 for “other action” in lieu of reanalysis, suggesting certain types of corrective actions would no longer be acceptable to NRC staff. There is a noted trend to the proposed § 50.46c relative to the exiting § 50.46 – the draft rule appears to shift from features, methods, and evaluations that are “acceptable” to “NRC approved.” The trend suggests a much greater level of formality, and burden of proof, regarding compliance with requirements. It also implies proposed reporting requirements may no longer play a meaningful role where almost every “feature” would reside in a prior approval frame of reference.

From a different perspective, 10 CFR Part 50 already contains different mechanisms to address change management and reporting (e.g., § 50.59, 50.72, 50.73, 50.55(e), etc.). Regarding change management and reporting, why should § 50.46c be uniquely different from other licensing basis analysis?

C.II. Discussion

To address the perceived need for standardization, the industry requests the NRC issue an additional Regulatory Guide as part of the § 50.46c rulemaking process, which could endorse an industry guidance document addressing change management and reporting practices. This would be analogous to the approach taken by NRC and industry when § 50.59 was revised in 1999, and the NRC subsequently issued Regulatory Guide 1.187, Guidance for Implementation of 10 CFR 50.59, Changes, Tests, and Experiments, to endorse NEI 96-07, Revision 1, Guidelines for 10 CFR 50.59 Implementation.”

In the present case, however, industry recommends both the Regulatory Guide and the industry guidance document be issued concurrent with the final § 50.46c rule, to assure a high level of consistency between the two documents and the final rule language.

Although the proposed guidance document had not yet been developed as of the date of submission of written comments on the draft § 50.46c rule to NRC, issues have emerged as a result of numerous discussions between NEI personnel, fuel vendor personnel, and industry representatives to the Electric Power Research Institute (EPRI) Regulatory Technical Advisory Committee (Reg-TAC), and as a result of several NRC public meetings on the draft § 50.46c rule. See, for example, Reference 1 (ML14175A162), which summarizes data relative to docketed industry § 50.46 reports of changes and errors, and which offers several options for future reporting practices. The following bullets summarize the industry position at the present time:

1) The industry guidance document would be similar in format, content, and level of detail as appears in NEI 96-07, Revision 1, Guidelines for 10 CFR 50.59 Implementation.

2) The rule language should be modified to provide effective change management and control of activities that affect plant design and operation, with a particular focus on fuel cladding, Emergency Core Cooling System (ECCS) evaluation models, risk-informed debris evaluation models, plant-specific input parameters used in ECCS performance demonstrations, and associated systems, structures, and components. The use of language analogous to that already used in § 50.59 would also effectively address crud and oxide effects in response to PRM-50-84 (i.e., Mark Leyse petition), without introducing the phrase "operation inconsistent with the evaluation model" as the NRC proposes in the draft rule.

3) Reporting requirements, if necessary beyond those such as § 50.72, or § 50.73, should be modified to replace annual reports of changes and errors with biennial reports, consistent with the approach taken during the 1999 revision of § 50.59. Licensees should have the option of fulfilling the biennial reporting requirement by including the pertinent information in another licensee-controlled document (e.g., UFSAR), provided that document is submitted no less frequently than biennially to the NRC.

4) Reporting requirements, if necessary beyond those such as § 50.72, or § 50.73, should be modified to no longer include a 30-day reporting requirement for significant changes and errors. Instead, reporting of information that the NRC staff may require to maintain cognizance should be determined on the basis of screening and evaluation, using new criteria in the rule and clarifying information in the industry guidance document, and a report should then be required if it did not pass the screening and evaluation process. The time frame for reporting should be extended to 60 days or more, consistent with its safety significance relative to § 50.73 reporting requirements.

   This approach is analogous to that used for § 50.59; and beneficial from the standpoint of allowing changes having no more than a minimal impact on public health and safety to be made without prior NRC approval. This approach would also remove the requirement for licensees to evaluate the cumulative effect of multiple changes or errors, by effectively re-base lining each time an evaluation is performed. A similar benefit was observed following industry adoption of NEI 96-07, Rev. 1.

5) Reporting of breakaway oxidation test results on a reload batch basis, as proposed by NRC in the draft rule language, should be replaced by a requirement for each licensee to describe acceptable controls for fuel fabrication and procurement in the FSAR (as updated). Such controls would thus become part of the current licensing basis for the facility.

C.III. Stakeholders

There are three stakeholders that should be involved in the preparation of the industry guidance document and NRC Regulatory Guide, namely fuel vendors, licensees, and NRC staff. These stakeholders represent those parties responsible for evaluation model development and maintenance, evaluation model use in generic and plant-specific analyses, and regulatory oversight of plant design and operation. Coordination of guidance document development would be provided by NEI, with support from industry.

C.IV References

1. Medek, David, "Reporting Requirements, Corrective Actions, and Change Management" NEI presentation, June 25, 2014, *(ADAMS Accession No. ML14175A162)*

Appendix D: *Industry Proposed Rule Language*

Note: This version shows the industry proposed rule language that includes the preferred approach to resolution of industry comments detailed in Appendix A.

§ 50.46c Emergency core cooling system performance during loss-of-coolant accidents (LOCA)

(a) Applicability. The requirements of this section apply to the design of a light water nuclear power reactor (LWR) and to the following entities who design, construct or operate an LWR: each applicant for or holder of a construction permit under this part, each applicant for or holder of an operating license under this part (until the licensee has submitted the certification required under § 50.82(a)(1) to the NRC), each applicant for or holder of a combined license under part 52 of this chapter, each applicant for a standard design certification (including the applicant for that design certification after the NRC has adopted a final design certification rule), each applicant for a standard design approval under part 52 of this chapter, and each applicant for or holder of a manufacturing license under part 52 of this chapter, provided that the entity has not submitted to the NRC a certification of permanent cessation of operations required under §§ 50.82(a)(1) or 52.110(a)(1) of this chapter.

(b) *Definitions*. As used in this section:

Breakaway oxidation, for zirconium-alloy cladding material, means the fuel cladding oxidation phenomenon in which weight gain rate deviates from normal kinetics. This change occurs with a rapid increase of hydrogen pickup during prolonged exposure to a high temperature steam environment, which promotes loss of cladding ductility.

ECCS evaluation model means the calculational framework for evaluating the behavior of the reactor system (including fuel) during a postulated LOCA. It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information (but excluding plant-specific inputs) necessary to specify the calculational procedure.

Risk-informed debris evaluation model means the calculational framework used to quantify the impact of debris generation, transport, sump head loss, in-vessel effects, and other phenomena important to long- term cooling. The risk-informed debris evaluation model is used, along with the probabilistic risk assessment (PRA), to quantify the portion of core damage frequency and large early release frequency attributable to debris.

Cladding means the material structure separating fuel from coolant that provides a barrier inhibiting fission product transport to the coolant.

Crud means any foreign substance deposited on the surface of the fuel cladding prior to the LOCA.

Reload batch means the entirety of un-irradiated fuel assemblies or bundles that are loaded into a reactor during refueling. A full reload batch could include multiple fuel types from multiple vendors, as well as lead fuel/test assemblies.

(c) *Relationship to other NRC regulations.* The requirements of this section are in addition to any other requirements applicable to an emergency core cooling system (ECCS) set forth in this part, except as noted in this paragraph. The analytical limits established in accordance with this section, with cooling performance calculated in accordance with an NRC approved ECCS evaluation model, are in implementation of the general requirements with respect to ECCS cooling performance design set forth in this part, including in particular Criterion 35 of Appendix A to this part. If the effects of debris on core cooling are evaluated using a risk-informed method as described in paragraph (e) of this section, then this method and results can be relied upon to demonstrate compliance with other requirements of this part as allowed by this section and requested in the application, including Appendix A Criteria 38 and 41.

(d) *Emergency core cooling system performance.*

(1) *ECCS performance criteria.* Each LWR must be provided with an ECCS designed in accordance with GDC 35 to satisfy the following performance requirements in the event of, and following, a postulated loss-of- coolant accident (LOCA). The demonstration of ECCS performance must comply with paragraph (d)(2) of this section:

(i) System performance during and following the LOCA event does not exceed the specified acceptable fuel analytical limits for the fuel design used for ensuring acceptable performance as defined in paragraph (g).

(ii) The ECCS provides sufficient coolant so that decay heat will be removed for the extended period of time required by the long-lived radioactivity remaining in the core to comply with the cooling criterion of paragraph (g)(1)(v).

(2) ECCS p*erformance demonstration*. ECCS performance must be demonstrated using an ECCS evaluation model meeting the requirements of either paragraph (d)(2)(i) or (d)(2)(ii), of this section, and satisfy the analytical requirements of paragraph (d)(2)(iii), (d)(2)(iv), and (d)(2)(v) of this section. Paragraph (e) of this section may be used for consideration of debris described in paragraph (d)(2)(iii) of this section. The ECCS evaluation model must be reviewed and approved by the NRC.

(i) *Realistic ECCS evaluation model.* A realistic ECCS evaluation model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and NRC-approved analytical limits, there is a high level of probability that the limits would not be exceeded.

(ii) *Conservative ECCS evaluation model*. Alternatively, a conservative ECCS evaluation model may be developed using the acceptable features of Appendix K to this part and associated regulatory guidance.

(iii) *Core geometry and coolant flow*. The ECCS evaluation model must address calculated changes in core geometry and must consider those factors that may alter localized coolant flow in the core or inhibit delivery of coolant to the core. The effects of debris must be included in the ECCS evaluation model, or in a separate model, on a deterministic basis. A licensee may evaluate effects of debris using a risk-informed approach to demonstrate ECCS performance, as specified in paragraph (e) of this section.

(iv) *LOCA analytical requirements*. ECCS performance must be demonstrated for a range of postulated loss-of-coolant accidents of different sizes, locations, and other properties, sufficient to provide assurance that the most severe postulated loss-of-coolant accidents have been identified. ECCS performance must be demonstrated for the accident, and the post-accident recovery and recirculation period.

(v) *Modeling requirements for fuel designs: uranium oxide or mixed uranium-plutonium oxide pellets within zirconium-alloy cladding*. If the reactor is fueled with uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding, then the ECCS evaluation model must address the fuel system modeling requirements in paragraph (g)(2) of this section.

(3) *Required documentation.* Upon implementation of this section in accordance with paragraph (o) of this section, the documentation requirements of this paragraph apply and supersede the requirements in Appendix K to this part, section II, "Required Documentation."

(i)(A) A description of each ECCS evaluation model must be furnished. The description must be sufficiently complete to permit technical review of the analytical approach, including the equations used, their approximations in difference form, the assumptions made, and the values of all parameters or the procedure for their selection, as for example, in accordance with a specified physical law or empirical correlation.

(B) A complete listing of each computer program, in the same form as used in the ECCS evaluation model, must be furnished to the NRC upon request.

(ii) For each computer program, solution convergence must be demonstrated by studies of system modeling or noding and calculational time steps.

(iii) Appropriate sensitivity studies must be performed for each ECCS evaluation model, to evaluate the effect on the calculated results of variations in noding, phenomena assumed in the calculation to predominate, including pump operation or locking, and values of parameters over their applicable ranges. For items to which results are shown to be sensitive, the choices made must be justified.

(iv) To the extent practicable, predictions of the ECCS evaluation model, or portions thereof, must be compared with applicable experimental information.

(v) Elements of ECCS evaluation models reviewed will include technical adequacy of the calculational methods, including: for models covered by paragraph (d)(2)(ii) of this section, compliance with required features of section I of appendix K to this part; and, for models covered by paragraph (d)(2)(i) of this section, assurance of a high level of probability that the performance criteria of paragraph (d)(1) of this section would not be exceeded.

(vi) For operating licenses issued under this part as of [EFFECTIVE DATE OF RULE], required documentation of this section must be submitted to demonstrate compliance per the implementation process described in paragraph (o) of this section.

(e) *Alternate risk-informed approach for addressing the effects of debris on core cooling.*

A licensee may submit a request to use risk-informed alternatives to address the effects of debris on core cooling. The request must be in the form of an application for license amendment under § 50.90 of this chapter. The Director of the Office of Nuclear Reactor Regulation, or designee of the Director, may approve the application if the Director or designee determines that the proposed alternatives:

(i) Satisfy the performance goals, performance objectives, and performance criteria related to nuclear safety and radiological release;

(ii) Maintain safety margins;

(iii) Maintain defense-in-depth; and

(iv) Include an acceptable program for monitoring the risk-informed approach and notifying NRC of the impact of changes and errors.

(f) [Reserved]

(g) *Fuel system designs: uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding.*

(1) *Fuel performance criteria.* Fuel consisting of uranium oxide or mixed uranium-plutonium oxide pellets within cylindrical zirconium-alloy cladding must be designed to meet the following requirements:

(i) *Peak cladding temperature*. Maximum cladding temperature shall not exceed the basis of the acceptable embrittlement analytical limit, or a high level of probability of not exceeding the acceptable embrittlement analytical limit for models covered by paragraph (d)(2)(i).

(ii) *Cladding integral time at temperature*. Maximum local cladding oxidation shall not exceed an acceptable analytical limit. Embrittlement limits shall, as a minimum, be a function of cladding hydrogen uptake and experimental temperature basis.

(iii) *Breakaway oxidation.* The total accumulated time that the cladding is predicted to remain above a temperature at which the zirconium-alloy has been shown to be susceptible to breakaway oxidation shall not be greater than a limit that corresponds to the measured onset of breakaway oxidation for the zirconium-alloy cladding material based on an NRC-approved experimental technique. The limit must be approved by the NRC.

(iv) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from fuel cladding oxidation in a water/steam environment shall not exceed an acceptable analytical limit.

(v) *Post-quench core cooling*. After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

(2) *Fuel system modeling requirements*. The ECCS evaluation model required by paragraph (d)(2) of this section must model the fuel system in accordance with the following requirement:

(i) If an oxygen source is present on the inside surfaces of the cladding at the onset of the LOCA, then the effects of oxygen diffusion from the cladding inside surfaces must be considered in the ECCS evaluation model.

(ii) The thermal effects of crud and oxide layers that accumulate on the fuel cladding during plant operation must be evaluated.

(h) [Reserved]

(i) [Reserved]

(j) [Reserved]

(k) *Use of fuel in reactor*. A licensee may not load fuel into a reactor, or operate the reactor, unless the licensee either determines that the fuel meets the requirements of paragraph (g) of this section, or complies with technical specifications governing lead test assemblies in its license. Fuel assemblies and cladding on site prior to 60 months after [EFFECTIVE DATE OF RULE] are not required to comply with the new requirements of paragraph (g).

(l) *Authority to impose restrictions on operation*. The Director of the Office of Nuclear Reactor Regulation or the Director of the Office of New Reactors may impose restrictions on reactor operation if it is found that the evaluations of ECCS cooling performance submitted are not consistent with the requirements of this section.

(m) *Corrective actions and reporting*. The licensee must submit for NRC review and approval a program for notifying NRC of the impact of changes and errors in the ECCS evaluation models and use of the models.

(n) [Reserved]

(o) *Implementation*

(1) Construction permits issued under this part after [**EFFECTIVE DATE OF RULE**] must comply with the requirements of this section at their issuance.

(2) Operating licenses issued under this part that are based upon construction permits in effect as of **[EFFECTIVE DATE OF RULE]** (including deferred and reinstated construction permits) must comply with the requirements of this section. Until compliance is achieved, the requirements of § 50.46 continue to apply.

(3) Operating licenses issued under this part after **[EFFECTIVE DATE OF RULE]** must comply with the requirements of this section.

(4) Each licensee shall submit a plan for compliance with the requirements of § 50.46c within 180 days of **[EFFECTIVE DATE OF RULE]**.

(5) Standard design certifications, standard design approvals, and manufacturing licenses under part 52 of this chapter, whose applications (including applications for amendment) are docketed after **[EFFECTIVE DATE OF RULE]**, and new branches of these certifications whose applications are docketed after **[EFFECTIVE DATE OF RULE]** must comply with this section at their issuance.

(6) Standard design certifications under part 52 of this chapter issued before **[EFFECTIVE DATE OF RULE]** must comply with this section by the time of renewal.

(7) Standard design certifications, standard design approvals, and manufacturing licenses under part 52 of this chapter issued after **[EFFECTIVE DATE OF RULE]** whose applications were pending as of **[EFFECTIVE DATE OF RULE]** and new branches of certifications issued after **[EFFECTIVE DATE OF RULE]** whose applications were pending as of **[EFFECTIVE DATE OF RULE]** must comply with this section by the time of renewal.

(8) Combined license applications under part 52 of this chapter whose applications are docketed after **[EFFECTIVE DATE OF RULE]** must comply with this section.

(9) Combined licenses issued under part 52 of this chapter, before **[EFFECTIVE DATE OF RULE]** and combined licenses issued after the **[EFFECTIVE DATE OF RULE]** whose applications were docketed before **[EFFECTIVE DATE OF RULE]** must comply with this section no later than completion of the refueling outage after the first fuel cycle following **[EFFECTIVE DATE OF RULE]**, or 12 months following **[EFFECTIVE DATE OF RULE]**, whichever occurs later. Until such compliance is achieved, the requirements in § 50.46 continue to apply.

Appendix E: *Proposed Regulatory Guide for a Conservative ECCS Evaluation Model*

Required and Acceptable Features of the Evaluation Models

A. Sources of heat during the LOCA. For the heat sources listed in paragraphs I.A.1 to 4 of this appendix it must be assumed that the reactor has been operating continuously at a power level at least 1.02 times the licensed power level (to allow for instrumentation error), with the maximum peaking factor allowed by the technical specifications. An assumed power level lower than the level specified in this paragraph (but not less than the licensed power level) may be used provided the proposed alternative value has been demonstrated to account for uncertainties due to power level instrumentation error. A range of power distribution shapes and peaking factors representing power distributions that may occur over the core lifetime must be studied. The selected combination of power distribution shape and peaking factor should be the one that results in the most severe calculated consequences for the spectrum of postulated breaks and single failures that are analyzed.

1. The Initial Stored Energy in the Fuel. The steady-state temperature distribution and stored energy in the fuel before the hypothetical accident shall be calculated for the burn-up that yields the highest calculated cladding temperature (or, optionally, the highest calculated stored energy.) To accomplish this, the thermal conductivity of the UO2 shall be evaluated as a function of burn-up and temperature, taking into consideration differences in initial density, and the thermal conductance of the gap between the UO2 and the cladding shall be evaluated as a function of the burn-up, taking into consideration fuel densification and expansion, the composition and pressure of the gases within the fuel rod, the initial cold gap dimension with its tolerances, and cladding creep.

2. Fission Heat. Fission heat shall be calculated using reactivity and reactor kinetics. Shutdown reactivities resulting from temperatures and voids shall be given their minimum plausible values, including allowance for uncertainties, for the range of power distribution shapes and peaking factors indicated to be studied above. Rod trip and insertion may be assumed if they are calculated to occur.

3. Decay of Actinides. The heat from the radioactive decay of actinides, including neptunium and plutonium generated during operation, as well as isotopes of uranium, shall be calculated in accordance with fuel cycle calculations and known radioactive properties. The actinide decay heat chosen shall be that appropriate for the time in the fuel cycle that yields the highest calculated fuel temperature during the LOCA.

4. Fission Product Decay. The heat generation rates from radioactive decay of fission products shall be assumed to be equal to 1.2 times the values for infinite operating time in the ANS Standard (Proposed American Nuclear Society Standards—"Decay Energy Release Rates Following Shutdown of Uranium-Fueled Thermal Reactors." Approved by Subcommittee ANS-5, ANS Standards Committee, October 1971). This standard has been approved for incorporation by reference by the Director of the Federal Register. A copy of the standard is available for inspection at the NRC Library, 11545 Rockville Pike, Rockville, Maryland 20852-2738. The fraction of the locally generated gamma energy that is deposited in the fuel (including the cladding) may be different from 1.0; the value used shall be justified by a suitable calculation.

5. Metal-Water Reaction Rate. The rate of energy release and hydrogen generation~~, and cladding oxidation~~ from the metal/water reaction shall be calculated using the Baker-Just equation (Baker, L., Just, L.C., "Studies of Metal Water

Reactions at High Temperatures, III. Experimental and Theoretical Studies of the Zirconium-Water Reaction," ANL-6548, page 7, May 1962). This publication has been approved for incorporation by reference by the Director of the Federal Register. A copy of the publication is available for inspection at the NRC Library, 11545 Rockville Pike, Two White Flint North, Rockville, Maryland 20852-2738. Cladding oxidation from the metal-water reaction shall be calculated using the Cathcart-Pawel correlation. The reaction shall be assumed not to be steam limited. For rods whose cladding is calculated to rupture during the LOCA, the inside of the cladding shall be assumed to react after the rupture. The calculation of the reaction rate on the inside of the cladding shall also follow the Cathcart-Pawel correlation ~~Baker-Just equation~~, starting at the time when the cladding is calculated to rupture, and extending around the cladding inner circumference and axially no less than 1.5 inches each way from the location of the rupture, with the reaction assumed not to be steam limited.

6. Reactor Internals Heat Transfer. Heat transfer from piping, vessel walls, and non-fuel internal hardware shall be taken into account.

7. Pressurized Water Reactor Primary-to-Secondary Heat Transfer. Heat transferred between primary and secondary systems through heat exchangers (steam generators) shall be taken into account. (Not applicable to Boiling Water Reactors.)

B. Swelling and Rupture of the Cladding and Fuel Rod Thermal Parameters

Each evaluation model shall include a provision for predicting cladding swelling and rupture from consideration of the axial temperature distribution of the cladding and from the difference in pressure between the inside and outside of the cladding, both as functions of time. To be acceptable the swelling and rupture calculations shall be based on applicable data in such a way that the degree of swelling and incidence of rupture are not underestimated. The degree of swelling and rupture shall be taken into account in calculations of gap conductance, cladding oxidation and embrittlement, and hydrogen generation.

The calculations of fuel and cladding temperatures as a function of time shall use values for gap conductance and other thermal parameters as functions of temperature and other applicable time-dependent variables. The gap conductance shall be varied in accordance with changes in gap dimensions and any other applicable variables.

C. Blowdown Phenomena

1. Break Characteristics and Flow.

a. In analyses of hypothetical loss-of-coolant accidents, a spectrum of possible pipe breaks shall be considered. This spectrum shall include instantaneous double-ended breaks ranging in cross-sectional area up to and including that of the largest pipe in the primary coolant system. The analysis shall also include the effects of longitudinal splits in the largest pipes, with the split area equal to the cross-sectional area of the pipe.

b. Discharge Model. For all times after the discharging fluid has been calculated to be two-phase in composition, the discharge rate shall be calculated by use of the Moody model (F.J. Moody, "Maximum Flow Rate of a Single Component, Two-Phase Mixture," Journal of Heat Transfer, Trans American Society of Mechanical Engineers, 87, No. 1, February, 1965). This publication has been approved for incorporation by reference by the Director of the Federal Register. A copy of this publication is available for inspection at the NRC Library, 11545 Rockville Pike, Rockville, Maryland 20852-2738. The calculation shall be conducted with at least three values of a discharge coefficient applied to the postulated break area, these values spanning the range from 0.6 to 1.0. If the results indicate that the maximum clad temperature for the hypothetical accident is to be found at an even lower value of the discharge coefficient, the range of discharge coefficients shall be extended until the maximum clad temperatures calculated by this variation has been achieved.

c. End of Blowdown. (Applies Only to Pressurized Water Reactors.) For postulated cold leg breaks, all emergency cooling water injected into the inlet lines or the reactor vessel during the bypass period shall in the calculations be subtracted from the reactor vessel calculated inventory. This may be executed in the calculation during the bypass period, or as an alternative the amount of emergency core cooling water calculated to be injected during the bypass period may be subtracted later in the calculation from the water remaining in the inlet lines, downcomer, and reactor vessel lower plenum after the bypass period. This bypassing shall end in the calculation at a time designated as the "end of bypass," after which the expulsion or entrainment mechanisms responsible for the bypassing are calculated not to be effective. The end-of-bypass definition used in the calculation shall be justified by a suitable combination of analysis and experimental data. Acceptable methods for defining "end of bypass" include, but are not limited to, the following: (1) Prediction of the blowdown calculation of downward flow in the downcomer for the remainder of the blowdown period; (2) Prediction of a threshold for droplet entrainment in the upward velocity, using local fluid conditions and a conservative critical Weber number.

d. Noding Near the Break and the ECCS Injection Points. The noding in the vicinity of and including the broken or split sections of pipe and the points of ECCS injection shall be chosen to permit a reliable analysis of the thermodynamic history in these regions during blowdown.

2. Frictional Pressure Drops. The frictional losses in pipes and other components including the reactor core shall be calculated using models that include realistic variation of friction factor with Reynolds number, and realistic two-phase friction multipliers that have been adequately verified by comparison with experimental data, or models that prove at least equally conservative with respect to maximum clad temperature calculated during the hypothetical accident. The modified Baroczy correlation (Baroczy, C. J., "A Systematic Correlation for Two-Phase Pressure Drop," Chem. Enging. Prog. Symp. Series, No. 64, Vol. 62, 1965) or a combination of the Thom correlation (Thom, J.R.S., "Prediction of Pressure Drop During Forced Circulation Boiling of Water," Int. J. of Heat & Mass Transfer, 7, 709-724, 1964) for pressures equal to or greater than 250 psia and the Martinelli-Nelson correlation (Martinelli, R. C. Nelson, D.B., "Prediction of Pressure Drop During Forced Circulation Boiling of Water," Transactions of ASME, 695-702, 1948) for pressures lower than 250 psia is acceptable as a basis for calculating realistic two-phase friction multipliers.

3. Momentum Equation. The following effects shall be taken into account in the conservation of momentum equation: (1) temporal change of momentum, (2) momentum convection, (3) area change momentum flux, (4) momentum change due to compressibility, (5) pressure loss resulting from wall friction, (6) pressure loss resulting from area change, and (7) gravitational acceleration. Any omission of one or more of these terms under stated circumstances shall be justified by comparative analyses or by experimental data.

4. Critical Heat Flux.

a. Correlations developed from appropriate steady-state and transient-state experimental data are acceptable for use in predicting the critical heat flux (CHF) during LOCA transients. The computer programs in which these correlations are used shall contain suitable checks to assure that the physical parameters are within the range of parameters specified for use of the correlations by their respective authors.

b. Steady-state CHF correlations acceptable for use in LOCA transients include, but are not limited to, the following:

(1) W 3. L. S. Tong, "Prediction of Departure from Nucleate Boiling for an Axially Non-uniform Heat Flux Distribution," Journal of Nuclear Energy, Vol. 21, 241-248, 1967.

(2) B&W–2. J. S. Gellerstedt, R. A. Lee, W. J. Oberjohn, R. H. Wilson, L. J. Stanek, "Correlation of Critical Heat Flux in a Bundle Cooled by Pressurized Water," Two-Phase Flow and Heat Transfer in Rod Bundles, ASME, New York, 1969.

(3) Hench-Levy. J. M. Healzer, J. E. Hench, E. Janssen, S. Levy, "Design Basis for Critical Heat Flux Condition in Boiling Water Reactors," APED-5186, GE Company Private report, July 1966.

(4) Macbeth. R. V. Macbeth, "An Appraisal of Forced Convection Burnout Data," Proceedings of the Institute of Mechanical Engineers, 1965-1966.

(5) Barnett. P. G. Barnett, "A Correlation of Burnout Data for Uniformly Heated Annuli and Its Uses for Predicting Burnout in Uniformly Heated Rod Bundles," AEEW-R 463, 1966.

(6) Hughes. E. D. Hughes, "A Correlation of Rod Bundle Critical Heat Flux for Water in the Pressure Range 150 to 725 psia," IN-1412, Idaho Nuclear Corporation, July 1970.

c. Correlations of appropriate transient CHF data may be accepted for use in LOCA transient analyses if comparisons between the data and the correlations are provided to demonstrate that the correlations predict values of CHF which allow for uncertainty in the experimental data throughout the range of parameters for which the correlations are to be used. Where appropriate, the comparisons shall use statistical uncertainty analysis of the data to demonstrate the conservatism of the transient correlation.

d. Transient CHF correlations acceptable for use in LOCA transients include, but are not limited to, the following:

(1) GE transient CHF. B. C. Slifer, J. E. Hench, "Loss-of-Coolant Accident and Emergency Core Cooling Models for General Electric Boiling Water Reactors," NEDO-10329, General Electric Company, Equation C-32, April 1971.

e. After CHF is first predicted at an axial fuel rod location during blowdown, the calculation shall not use nucleate boiling heat transfer correlations at that location subsequently during the blowdown even if the calculated local fluid and surface conditions would apparently justify the reestablishment of nucleate boiling. Heat transfer assumptions characteristic of return to nucleate boiling (rewetting) shall be permitted when justified by the calculated local fluid and surface conditions during the reflood portion of a LOCA.

5. Post-CHF Heat Transfer Correlations.

a. Correlations of heat transfer from the fuel cladding to the surrounding fluid in the post-CHF regimes of transition and film boiling shall be compared to applicable steady-state and transient-state data using statistical correlation and uncertainty analyses. Such comparison shall demonstrate that the correlations predict values of heat transfer co-efficient equal to or less than the mean value of the applicable experimental heat transfer data throughout the range of parameters for which the correlations are to be used. The comparisons shall quantify the relation of the correlations to the statistical uncertainty of the applicable data.

b. The Groeneveld flow film boiling correlation (equation 5.7 of D.C. Groeneveld, "An Investigation of Heat Transfer in the Liquid Deficient Regime," AECL-3281, revised December 1969) and the Westinghouse correlation of steady-state transition boiling ("Proprietary Redirect/Rebuttal Testimony of Westinghouse Electric Corporation," USNRC Docket RM-50-1, page 25-1, October 26, 1972) are acceptable for use in the post-CHF boiling regimes. In addition, the transition boiling correlation of McDonough, Milich, and King (J.B. McDonough, W. Milich, E.C. King, "An Experimental Study of Partial Film Boiling Region with Water at Elevated Pressures in a Round Vertical Tube," Chemical Engineering Progress Symposium Series, Vol. 57, No. 32, pages 197-208, (1961) is suitable for use between nucleate and film boiling. Use of all these correlations is restricted as follows:

(1) The Groeneveld correlation shall not be used in the region near its low-pressure singularity,

(2) The first term (nucleate) of the Westinghouse correlation and the entire McDonough, Milich, and King correlation shall not be used during the blowdown after the temperature difference between the clad and the saturated fluid first exceeds 300 °F,

(3) Transition boiling heat transfer shall not be reapplied for the remainder of the LOCA blowdown, even if the clad superheat returns below 300 °F, except for the reflood portion of the LOCA when justified by the calculated local fluid and surface conditions.

c. Evaluation models approved after October 17, 1988, which make use of the Dougall-Rohsenow flow film boiling correlation (R.S. Dougall and W.M. Rohsenow, "Film Boiling on the Inside of Vertical Tubes with Upward Flow of Fluid at Low Qualities," MIT Report Number 9079 26, Cambridge, Massachusetts, September 1963) may not use this correlation under conditions where nonconservative predictions of heat transfer result. Evaluation models that make use of the Dougall-Rohsenow correlation and were approved prior to October 17, 1988, continue to be acceptable until a change is made to, or an error is corrected in, the evaluation model that results in a significant reduction in the overall conservatism in the evaluation model. At that time continued use of the Dougall-Rohsenow correlation under conditions where nonconservative predictions of heat transfer result will no longer be acceptable. For this purpose, a significant reduction in the overall conservatism in the evaluation model would be a reduction in the calculated peak fuel cladding temperature of at least 50 °F from that which would have been calculated on October 17, 1988, due either to individual changes or error corrections or the net effect of an accumulation of changes or error corrections.

6. <u>Pump Modeling</u>. The characteristics of rotating primary system pumps (axial flow, turbine, or centrifugal) shall be derived from a dynamic model that includes momentum transfer between the fluid and the rotating member, with variable pump speed as a function of time. The pump model resistance used for analysis should be justified. The pump model for the two-phase region shall be verified by applicable two-phase pump performance data. For BWR's after saturation is calculated at the pump suction, the pump head may be assumed to vary linearly with quality, going to zero for one percent quality at the pump suction, so long as the analysis shows that core flow stops before the quality at pump suction reaches one percent.

7. Core Flow Distribution During Blowdown. (Applies only to pressurized water reactors.)

a. The flow rate through the hot region of the core during blowdown shall be calculated as a function of time. For the purpose of these calculations the hot region chosen shall not be greater than the size of one fuel assembly. Calculations of average flow and flow in the hot region shall take into account cross flow between regions and any flow blockage calculated to occur during blowdown as a result of cladding swelling or rupture. The calculated flow shall be smoothed to eliminate any calculated rapid oscillations (period less than 0.1 seconds).

b. A method shall be specified for determining the enthalpy to be used as input data to the hot channel heatup analysis from quantities calculated in the blowdown analysis, consistent with the flow distribution calculations.

D. Post-Blowdown Phenomena; Heat Removal by the ECCS

1. Single Failure Criterion. An analysis of possible failure modes of ECCS equipment and of their effects on ECCS performance must be made. In carrying out the accident evaluation the combination of ECCS subsystems assumed to be operative shall be those available after the most damaging single failure of ECCS equipment has taken place.

2. Containment Pressure. The containment pressure used for evaluating cooling effectiveness during reflood and spray cooling shall not exceed a pressure calculated conservatively for this purpose. The calculation shall include the effects of operation of all installed pressure-reducing systems and processes.

3. Calculation of Reflood Rate for Pressurized Water Reactors. The refilling of the reactor vessel and the time and rate of reflooding of the core shall be calculated by an acceptable model that takes into consideration the thermal and hydraulic characteristics of the core and of the reactor system. The primary system coolant pumps shall be assumed to have locked impellers if this assumption leads to the maximum calculated cladding temperature; otherwise the pump rotor shall be assumed to be running free. The ratio of the total fluid flow at the core exit plane to the total liquid flow at the core inlet plane (carryover fraction) shall be used to determine the core exit flow and shall be determined in accordance with applicable experimental data (for example, "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Final Report," Westinghouse Report WCAP-7665, April 1971; "PWR Full Length Emergency Cooling Heat Transfer (FLECHT) Group I Test Report," Westinghouse Report WCAP-7435, January 1970; "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Group II Test Report," Westinghouse Report WCAP-7544, September 1970; "PWR FLECHT Final Report Supplement," Westinghouse Report WCAP-7931, October 1972).

The effects on reflooding rate of the compressed gas in the accumulator which is discharged following accumulator water discharge shall also be taken into account.

4. Steam Interaction with Emergency Core Cooling Water in Pressurized Water Reactors. The thermal-hydraulic interaction between steam and all emergency core cooling water shall be taken into account in calculating the core reflooding rate. During refill and reflood, the calculated steam flow in unbroken reactor coolant pipes shall be taken to be zero during the time that accumulators are discharging water into those pipes unless experimental evidence is available regarding the realistic thermal-hydraulic interaction between the steam and the liquid. In this case, the experimental data may be used to support an alternate assumption.

5. Refill and Reflood Heat Transfer for Pressurized Water Reactors.

a. For reflood rates of one inch per second or higher, reflood heat transfer coefficients shall be based on applicable experimental data for unblocked cores including FLECHT results ("PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Final Report," Westinghouse Report WCAP-7665, April 1971). The use of a correlation derived from FLECHT data shall be demonstrated to be conservative for the transient to which it is applied; presently available FLECHT heat transfer correlations ("PWR Full Length Emergency Cooling Heat Transfer (FLECHT) Group I Test Report," Westinghouse Report WCAP-7544, September 1970; "PWR FLECHT Final Report Supplement," Westinghouse Report WCAP-7931, October 1972) are not acceptable. Westinghouse Report WCAP-7665 has been approved for incorporation by reference by the Director of the Federal Register. A copy of this report is available for inspection at the NRC Library, 11545 Rockville Pike, Rockville, Maryland 20852-2738. New correlations or modifications to the FLECHT heat transfer correlations are acceptable only after they are demonstrated to be conservative, by comparison with FLECHT data, for a range of parameters consistent with the transient to which they are applied.

b. During refill and during reflood when reflood rates are less than one inch per second, heat transfer calculations shall be based on the assumption that cooling is only by steam, and shall take into account any flow blockage calculated to occur as a result of cladding swelling or rupture as such blockage might affect both local steam flow and heat transfer.

6. <u>Convective Heat Transfer Coefficients for Boiling Water Reactor Fuel Rods Under Spray Cooling</u>. Following the blowdown period, convective heat transfer shall be calculated using coefficients based on appropriate experimental data. For reactors with jet pumps and having fuel rods in a 7 x 7 fuel assembly array, the following convective coefficients are acceptable:

a. During the period following lower plenum flashing but prior to the core spray reaching rated flow, a convective heat transfer coefficient of zero shall be applied to all fuel rods.

b. During the period after core spray reaches rated flow but prior to reflooding, convective heat transfer coefficients of 3.0, 3.5, 1.5, and 1.5 Btu-hr–1-ft–2 °F–1 shall be applied to the fuel rods in the outer corners, outer row, next to outer row, and to those remaining in the interior, respectively, of the assembly.

c. After the two-phase reflooding fluid reaches the level under consideration, a convective heat transfer coefficient of 25 Btu-hr–1-ft –2 °F–1 shall be applied to all fuel rods.

7. <u>The Boiling Water Reactor Channel Box Under Spray Cooling</u>. Following the blowdown period, heat transfer from, and wetting of, the channel box shall be based on appropriate experimental data. For reactors with jet pumps and fuel rods in a 7 x 7 fuel assembly array, the following heat transfer coefficients and wetting time correlation are acceptable.

a. During the period after lower plenum flashing, but prior to core spray reaching rated flow, a convective coefficient of zero shall be applied to the fuel assembly channel box.

b. During the period after core spray reaches rated flow, but prior to wetting of the channel, a convective heat transfer coefficient of 5 Btu-hr– 1-ft– 2°F– 1 shall be applied to both sides of the channel box.

c. Wetting of the channel box shall be assumed to occur 60 seconds after the time determined using the correlation based on the Yamanouchi analysis ("Loss-of-Coolant Accident and Emergency Core Cooling Models for General Electric Boiling Water Reactors," General Electric Company Report NEDO-10329, April 1971). This report was approved for incorporation by reference by the Director of the Federal Register. A copy of the report is available for inspection at the NRC Library, 11545 Rockville Pike, Rockville, Maryland 20852-2738.

The following information is deleted as it was rolled-up into the FRN proposed 50.46c language

~~II. Required Documentation~~

~~1. a. A description of each evaluation model shall be furnished. The description shall be sufficiently complete to permit technical review of the analytical approach including the equations used, their approximations in difference form, the assumptions made, and the values of all parameters or the procedure for their selection, as for example, in accordance with a specified physical law or empirical correlation.~~

~~b. A complete listing of each computer program, in the same form as used in the evaluation model, must be furnished to the Nuclear Regulatory Commission upon request.~~

~~2. For each computer program, solution convergence shall be demonstrated by studies of system modeling or noding and calculational time steps.~~

~~3. Appropriate sensitivity studies shall be performed for each evaluation model, to evaluate the effect on the calculated results of variations in noding, phenomena assumed in the calculation to predominate, including pump operation or locking, and values of parameters over their applicable ranges. For items to which results are shown to be sensitive, the choices made shall be justified.~~

~~4. To the extent practicable, predictions of the evaluation model, or portions thereof, shall be compared with applicable experimental information.~~

~~5. General Standards for Acceptability—Elements of evaluation models reviewed will include technical adequacy of the calculational methods, including: For models covered by § 50.46(a)(1)(ii), compliance with required features of section I of this Appendix K; and, for models covered by § 50.46(a)(1)(i), assurance of a high level of probability that the performance criteria of § 50.46(b) would not be exceeded.~~