March 3, 2000 SECY-00-0057

FOR: The Commissioners

FROM: William D. Travers /RA/
Executive Director for Operations

SUBJECT: FINAL RULE: REVISION OF PART 50, APPENDIX K, "ECCS EVALUATION MODELS"

PURPOSE:

To obtain the Commission's approval to publish a final rule in the *Federal Register* that amends 10 CFR Part 50, Appendix K, "ECCS Evaluation Models." The amendment will facilitate small but cost-beneficial power uprates for some commercial nuclear power plants.

BACKGROUND:

On October 1, 1999 (63 FR 53270), the NRC published a proposed amendment to 10 CFR Part 50, Appendix K, that would change the provision requiring emergency core cooling system (ECCS) performance analyses to assume the reactor to be operating 2 percent above licensed power. The amendment will allow licensees to adopt an alternative power level to the value stated in the rule if the alternative is sufficiently justified.

The 75-day public comment period for the proposed rule expired on December 15, 1999. During this public comment period, comments were received from four utility companies, the Nuclear Energy Institute, and Caldon, Inc., a manufacturer of flow measurement systems. All of the commenters supported the proposed rule, and no changes were made to the rule as a

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result of the comments. The comments are discussed in the *Federal Register* notice (Attachment 1).

DISCUSSION:

A licensee for a light-water nuclear power reactor is required to submit a safety analysis report that contains an evaluation of ECCS performance under postulated loss-of-coolant accident (LOCA) conditions. In § 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," the Commission requires that ECCS performance under LOCA conditions be evaluated and that the estimated performance satisfy certain criteria. Licensees may conduct an analysis that "realistically describes the behavior of the reactor system during a LOCA" (often termed a "best-estimate analysis"), or they may develop a model that conforms to the requirements of Appendix K to 10 CFR Part 50. Most ECCS evaluations are based on Appendix K requirements.

Recent licensing actions and industry plans have shown that owners of nuclear power plants intend to use instrumentation to reduce uncertainties associated with measuring reactor power, thus justifying a reduction in the power level margin assumed in Appendix K ECCS evaluations. On September 30, 1999, the NRC issued a license amendment to allow a 1-percent increase in rated power for Comanche Peak Unit 2. The power level increase was based on the previously approved exemption to the Appendix K requirement for Comanche Peak. Several licensees have indicated that they also plan to seek credit for the reduced analysis margin in ECCS evaluations. The prospect of additional exemption requests provides the impetus for the amendment of the rule.

The current rule unnecessarily restricts operation for licensees that can show that the uncertainties associated with power measurement are less than 2 percent. The revised rule gives licensees the option to use a reduced power level margin for ECCS evaluation. A potential benefit for licensees is the opportunity for power uprate, although licensees could elect to maintain the current margin of 2-percent power. However, the revised rule, by itself, does not allow increases in licensed power levels. Technical specifications include the licensed power level and several ECCS-related parameters. When licensees elect to increase the licensed power level or to make other changes to ECCS-related technical specifications on the basis of the revised rule, they must submit a license amendment request for staff review and approval. The staff considers the assumed power level to be an input parameter of the ECCS evaluation. As discussed in the section-by-section analysis in the attached *Federal Register* notice (Attachment 1), the staff expects the basis for the revised analysis parameter (i.e., the assumed power level) to be included in documentation of the evaluation model, as required by Appendix K, Part II (1)(a). Therefore, the license amendment should show the basis for the modified ECCS analysis, including the justification for reduced power measurement uncertainty, and it should be included in documentation supporting the ECCS analysis.

The 102-percent power requirement (i.e., 2 percent above licensed power) does not appear elsewhere in NRC regulations. However, it has been widely applied in the Standard Review Plan (NUREG-0800), and many safety analyses incorporate the 102-percent power level assumption. In these instances, the power level assumption is associated with power measurement uncertainty and is not expressly relied upon to provide margin to safety limits. As discussed in the regulatory analysis accompanying the rule (Attachment 2), the staff intends to

review affected Standard Review Plan sections and to evaluate the impact of the revised rule on those safety analyses. Further, the staff is considering the need for specific guidance to help licensees appropriately account for power measurement uncertainty in safety analyses. In the absence of specific guidance, the staff expects that power uprate amendment requests based on the revised rule will address the suitability of non-LOCA analyses for operation at proposed higher power levels. The staff does not anticipate the need for inspection guidance based on the rule change because implementation will likely result in power uprates that will require license amendments rather than a specific inspection initiative.

The amended rule addresses three of the four reactor safety performance goals embodied in the Draft Reactor Safety Chapter of the NRC Strategic Plan. The amended rule –

a. Maintains safety. The intent of Appendix K, to ensure sufficient margin for ECCS performance in the event of a LOCA, continues to be met and plant risk is not significantly affected by the amended rule.

b. Improves effectiveness and efficiency of reactor oversight. Without the amendment, the staff expects licensees to request exemptions from Appendix K. Granting multiple exemptions to Appendix K would be a less efficient course than amending the rule at this stage.

c. Reduces an unnecessary regulatory burden. The amended rule offers licensees an option to relax an existing requirement, thereby reducing regulatory burden. Also, the amendment offers licensees the potential for significant financial benefits.

RESOURCES:

Resources to revise any regulatory guidance (approximately a 0.4 full-time-equivalent position) are available from funds currently budgeted for this purpose. Resources to implement the rule are dependent upon the number of plants requesting power uprate, or other technical specification changes.

COORDINATION:

OGC has no legal objection to the rule. ACRS reviewed the rule and has no objection to issuing it in final form. OCFO has reviewed this Commission paper for resource impacts and has no objection to its content. OCIO has reviewed this Commission paper for information technology and information management implications and concurs in it.

RECOMMENDATION:

That the Commission:

1. Approve publication of the attached notice of final rulemaking in the *Federal Register* (Attachment 1).

2. Certify that this revised rule does not have a significant impact on a substantial number of small entities under the requirements of the Regulatory Flexibility Act [5 U.S.C. 605 (b)]. This certification is included in the attached *Federal Register* notice.

3. Note:

a. The Regulatory Analysis (Attachment 2) and the Environmental Assessment (Attachment 3) will be available in the Public Document Room.

b. The staff has determined that this action is not a major rule as defined in the Small Business Regulatory Enforcement Fairness Act of 1996 (5 U.S.C. 804 (2)) and has confirmed this determination with the Office of Management and Budget.

c. Congressional notifications will be made as required by Section 303 of the Atomic Energy Act of 1954 and the Small Business Regulatory Enforcement Fairness Act of 1996.

d. The Chief Counsel for Advocacy, Small Business Administration, will be informed of the certification regarding economic impact on small entities and the reasons for it, as required by the Regulatory Flexibility Act.

e. The rule amends information collection requirements subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501–3519) as discussed in the attached *Federal Register* notice.

f. In accordance with the National Technology Transfer Act of 1995, the staff attempted to identify voluntary consensus standards that could be used instead of the revised rule. However, an appropriate standard was not identified.

g. A press release will be issued.

h. Copies of the *Federal Register* notice will be distributed to all power reactor licensees and other interested members of the public.

/RA/

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Executive Director
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Attachments: 1. Federal Register notice
2. Regulatory Analysis
3. Environmental Assessment

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Concurrence: DOCUMENT NAME: APPKSECY.WPD

OFFICE	DSSA:SRXB	DSSA:SRXB	TECH EDIT	DSSA:SRXB	D:DSSA
NAME	JDonoghue*	RCaruso*	BCalure*	JWermiel*	GHolahan
DATE	12 / 23 / 99	12 / 28 / 99	1 / 24 / 00	2 / 15 / 00	/ /
D:DRIP	ADPT:NRR	PMAS:NRR	D:NRR*	OGC	D:RES
DMatthews*	BSheron	JSilber*	SCollins	STreby*	AThadani**
2 / 9 / 00	/ /	2 / 2 / 00	/ /	2 / 16 / 00	1 / 11 / 00
D:OE	ADM:RDB	CIO	CFO	EDO	
WBorchardt*	DMeyer**	BShelton**	JGolder**	WDTravers	
1 / 7 / 00	1 / 12 / 00	1 / 12 / 00	1 / 14 / 00	03/03/00	

* See previous concurrences **Concurred by memo

Attachment 1

Federal Register Notice

[7590-01-P]

NUCLEAR REGULATORY COMMISSION

10 CFR Part 50

RIN 3150 - AG26

Emergency Core Cooling System Evaluation Models

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is amending its regulations to allow holders of operating licenses for nuclear power plants to reduce the assumed reactor power level used in evaluations of emergency core cooling system (ECCS) performance. This amendment provides licensees the option to apply a reduced margin for ECCS evaluation or to maintain the value of reactor power that had been mandated in the regulation. This action allows interested licensees to pursue small, but cost-beneficial, power uprates and reduces unnecessary regulatory burden without compromising the margin of safety of a facility.

EFFECTIVE DATE: The rule becomes effective [*Insert 30 days following the date of FR publication*].

ADDRESSES: Documents related to this rulemaking may be examined at the NRC Public Document Room, 2120 L Street, NW. (Lower Level), Washington, D.C. Documents created or received at the NRC after November 1, 1999, are also available electronically at the NRC's Public Electronic Reading Room on the Internet at http://www.nrc.gov/NRC/ADAMS/index.html. From this site, the public can gain entry into the NRC's Agencywide Document Access and

Management System (ADAMS), which provides text and image files of NRC's public documents. For more information, contact the NRC Public Document Room (PDR) Reference staff at 1-800-397-4209, 202-634-3273, or by email to pdr@nrc.gov.

FOR FURTHER INFORMATION CONTACT: Mr. Joseph E. Donoghue, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001; telephone: 301-415-1131; or by Internet electronic mail to jed1@nrc.gov.

SUPPLEMENTARY INFORMATION:

Background

A holder of an operating license (i.e., the licensee) for a light-water power reactor is required by regulations issued by the NRC to submit a safety analysis report that contains an evaluation of emergency core cooling system (ECCS) performance under loss-of-coolant accident (LOCA) conditions. 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," requires that ECCS performance under LOCA conditions be evaluated and that the estimated performance satisfy certain criteria. Licensees may conduct an analysis that "realistically describes the behavior of the reactor system during a LOCA" (often termed a "best-estimate analysis"), or they may develop a model that conforms with the requirements of Appendix K to 10 CFR Part 50. ECCS evaluations for most currently licensed power reactors are based on Appendix K requirements. Before this revision, the opening sentence of Appendix K specified that a power level of 102 percent be assumed when conducting ECCS analyses. Licensees have proposed using instrumentation that would reduce the uncertainties associated with measurement of reactor power when compared with existing methods of power measurement. This development could justify a reduced margin between the

licensed power level and the power level assumed for ECCS evaluations. This final rule amends this provision in Appendix K and allows licensees the option of using a value lower than 102 percent of licensed power in their ECCS analyses where justified.

Several licensees have expressed interest in using updated feedwater flow measurement technology discussed later in "Calorimetric Uncertainty and Feedwater Flow Measurement" as a basis for seeking exemptions from the Appendix K power level requirement and to implement power uprates. One licensee, TXU Electric Company, obtained an exemption from the Appendix K requirement for Comanche Peak Units 1 and 2 as well as an increase in licensed power based, in part, on more accurate feedwater flow measurement capability. The prospect of additional exemption requests from other licensees provides the impetus for the final rule.

The objective of this rulemaking is to reduce an unnecessarily burdensome regulatory requirement. Appendix K was originally issued to ensure an adequate performance margin of the ECCS in the event a design-basis LOCA were to occur. The margin is provided by conservative features and requirements of the evaluation models and by the ECCS performance criteria. The original regulation did not require that the power measurement uncertainty be demonstrated, but rather mandated a 2-percent margin. The final rule allows licensees to justify a smaller margin for power measurement uncertainty. Because there will continue to be substantial conservatism in other Appendix K requirements, sufficient margin to ECCS performance in the event of a LOCA will be preserved, which is the underlying purpose of Appendix K. The final rule does not significantly affect plant risk, as discussed in the section entitled, "ECCS Evaluation Conservatism."

Another objective is to avoid unnecessary exemption requests. A licensee has obtained an exemption from the 2-percent margin requirement in 10 CFR Part 50, Appendix K. The final rule eliminates the need for licensees to obtain exemptions.

The final rule gives licensees the option of applying a reduced margin between the licensed power level and the assumed power level for ECCS evaluation, or maintaining the current margin of 2-percent power. As discussed in the section entitled "ECCS Evaluation Conservatism," the NRC has concluded that the 2 percent power margin requirement in the original rule appeared to be based solely on considerations associated with power measurement extant at the time of the original ECCS rulemaking. The original rule unnecessarily restricted operation for licensees that can show that the uncertainties associated with power measurement instrumentation errors are less than 2 percent.

This amendment gives licensees the opportunity to use a reduced margin if they determine that there is a sufficient benefit. Licensees may apply the margin to gain benefits from operation at higher power, or the margin could be used to relax ECCS-related technical specifications (e.g., pump flows). Another potential benefit could be in modifying fuel management strategies (e.g., possibly by altering core power peaking factors). However, the final rule, by itself, does not allow increases in licensed power levels. Because licensed power level for a plant is a license condition, proposals to raise the licensed power level must be reviewed and approved under the license amendment process. The license amendment request should include a justification of the reduced power measurement uncertainty and the basis for the modified ECCS analysis, including the justification for reduced power

measurement uncertainty, should then be included in documentation supporting the ECCS analysis (see Section-by-Section Analysis).

As licensees apply the final rule and the NRC gains experience reviewing related license amendment requests, the NRC will consider the need for specific guidance to help licensees appropriately account for power measurement uncertainty in safety analyses. In the absence of specific guidance, the NRC expects that power uprate amendment requests based on this amendment to the regulations will address the suitability of non-LOCA analyses for operation at proposed higher power levels. Licensees can refer to available instrumentation guidance such as the Instrument Society of America Standard ISA 67.04, 1982, "Safety-Related Instrumentation Used in Nuclear Power Plants," and NRC Regulatory Guide 1.105, Revision 2, "Instrument Setpoints for Safety-Related Systems."

Conservatisms in Appendix K ECCS Evaluation Model

Appendix K defines conservative analysis assumptions for ECCS performance evaluations during design-basis LOCAs. Large safety margins are provided by conservatively selecting the ECCS performance criteria as well as conservatively establishing ECCS calculational requirements. The major analytical parameters and assumptions that contribute to the conservatisms in Appendix K are set forth in Sections A through D of the rule: (A) "Sources of Heat During the LOCA" (the 102-percent power provision is a key factor), (B) "Swelling and Rupture of the Cladding and Fuel Rod Thermal Parameters," (C) "Blowdown Phenomena," and (D) "Post-blowdown Phenomena: Heat Removal by ECCS." In each of these areas, several assumptions are typically used to ensure substantial conservatism in the analysis results. For instance: under "Sources of Heat During the LOCA," decay heat is modeled on the basis of an

American Nuclear Society standard with an added 20-percent penalty, and the power distribution shape and peaking factors expected during the operating cycle are chosen to yield the most conservative results. In "Blowdown Phenomena," the rule requires use of the Moody model and the discharge coefficient that yields the highest peak cladding temperature. "Post–Blowdown Phenomena; Heat Removal by the ECCS," requires that the analysis assume the most damaging single failure of ECCS equipment.

One of several conservative requirements in Section A of the original Appendix K was to assume that the reactor was operating at 102 percent power when the LOCA occurred "to allow for *such uncertainties as* instrumentation error...." (Appendix K, Section I.A., first sentence, emphasis added). The phrase, "such as," suggested that the two percent power margin was intended to address uncertainties related to heat source considerations beyond instrument measurement uncertainties. However, the basis for the required assumption of 102 percent power (2 percent power margin) does not appear to be contained in the rulemaking record for the ECCS rules, 10 CFR 50.46 and Appendix K. These rules were adopted in 1974 (39 FR 1001; January 4, 1974), and were preceded by a formal rulemaking hearing which ultimately resulted in a Commission decision on the proposed rulemaking, CLI-73-39, 6 AEC 1085 (December 28, 1973). Neither the statement of considerations (SOC) for the final rule nor the Commission decision appear to provide specific basis for the required assumption of 102 percent power.

The SOC for the January 4, 1974, final rule discusses the 102 percent power assumption in general terms, and does not mention instrumentation uncertainty:

> The Commission believes that the implementation of the new regulations will ensure an adequate margin of performance of the ECCS should a design basis LOCA ever occur. This margin is provided by conservative features of the evaluation models and by the criteria themselves. Some of the major points that contribute to the conservative nature of the evaluations and the criteria are as follows:
>
> (1) *Stored heat*. The assumption of 102 percent of maximum power, highest allowed peaking factor, and highest estimated thermal resistance between the UO_2 and the cladding provides a calculated stored heat that is possible but unlikely to occur at the time of a hypothetical accident. While not necessarily a margin over the extreme condition, it represents at least an assumption that an accident happens at a time which is not typical. 39 FR at 1002 (first column)[1].

Thus, while the pre-accident power level assumption is connected with the modeling of the rate of heat generation after the LOCA occurs, a clear basis for the 102 percent assumed power level requirement is not provided, nor does the SOC explain whether there are other uncertainties besides instrumentation uncertainties for which the 102 percent assumed power level is intended to compensate.

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[1]This statement in the SOC was taken unchanged from Section I of the Commission's ECCS decision. See CLI-73-39, 6 AEC 1085, 1093-94 (December 28, 1973).

The Commission's decision in the ECCS rulemaking hearing also does not explain whether the 102 percent assumed power level was intended to address uncertainties other than instrumentation uncertainties. Section I of the Commission decision was the basis for the SOC discussion on the 102 percent assumed power level (See 6 AEC at 1093-94). Section III. A. of the Commission's decision, "Required and Acceptable Features of the Evaluation Model," does not offer a detailed technical basis for the power level chosen, but instead uses the language ultimately adopted in the original Appendix K rule:

> For the heat sources listed in paragraphs 1 to 4 below it shall 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 such uncertainties as instrumentation error), with the maximum peaking factor allowed by the technical specifications (6 AEC at 1100).

Thus, the Commission's decision does not shed further light on the basis for the 102 percent assumed power level, nor whether the Commission had in mind uncertainties other than those associated with the instrumentation for measurement of power level.

NRC review of the ECCS rulemaking hearing record did not disclose presentations relating to quantification of power measurement uncertainties, or the magnitude of other uncertainties that the 102 percent assumed power level may have been intended to address. The Commission decision (CLI-73-39, 6 AEC 1085, December 28, 1973) cited three documents in the rulemaking hearing record. The first, cited in the Commission decision as Exhibit 1113, was "Supplemental Testimony of the AEC Regulatory Staff on the Interim Acceptance Criteria

for Emergency Core Cooling Systems for Light-Water Cooled Power Reactors," (filed October 26, 1972). In Section 10 of the document, stored energy in the fuel was considered, specifically the expected power distributions in fuel rods. The 102-percent power analysis requirement is not discussed. The second item, cited in the Commission decision as Exhibit 1137 was "Redirect and Rebuttal Testimony of Dr. Donald H. Roy on Behalf of Babcock & Wilcox," (October 26, 1972) in which the characteristic of the decay heat release following reactor shutdown was discussed. In this document, the 102-percent assumption is associated with the predicted decay heat generation rate. The over-power condition is associated with a "design-basis maneuvering operation," but the basis for the value of power chosen for the analysis (i.e., 102 percent) is not disclosed. Finally, in the "Concluding Statement of Position of the Regulatory Staff – Public Rulemaking Hearing on: Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Cooled Nuclear Power Reactors," April 16, 1973 (the Concluding Statement), the power level assumption is included as part of the proposed rule itself. The proposed rule language clearly states that the power level assumption is to "allow for instrumentation error." The term "such as" does not appear here. It is unclear when or why the proposed language in this regard was changed to its current form. The power level assumption is mentioned again in the Concluding Statement indirectly in association with power level changes before the LOCA and the effect on decay heat generation. But it is discussed most directly with regard to initial stored energy in the fuel. In the discussion on stored energy, the 102-percent assumption is attributed to "uncertainties inherent in the measurement of the operating power level of the core," (page 144 of the Concluding Statement). Reasons for choosing 102-percent as the value are not discussed.

When Appendix K was first issued, as is the case today, the thermal power generated by a nuclear power plant was determined by steam plant calorimetry, which is the process of performing a heat balance around the nuclear steam supply system (called a calorimetric). The heat balance depends upon measurement of several plant parameters, including flow rates and fluid temperatures. The differential pressure across a venturi installed in the feedwater flow path is a key element in the calorimetric measurement. Licensees have proposed using instrumentation other than a venturi-based system to obtain feedwater flow rate for calorimetrics. The lower uncertainty associated with the new instrumentation is information that was apparently not available during the original Appendix K rulemaking.

In view of the regulatory history for Appendix K, the Commission now believes that the 2-percent margin embodied in the requirement for a 102-percent assumed power level in Appendix K was based solely on uncertainties associated with the measurement of reactor power level.

Reduction in 102 Percent Assumed Power Level

The Commission believes that other requirements of Appendix K modeling contain substantial conservatisms of much greater magnitude than the 2 percent margin embodied in the requirement for a 102 percent assumed power level. This point was discussed in "Conservatisms in Appendix K ECCS Evaluation Model," above.

The Commission is also aware of new information gained since the 1974 rulemaking which shows that the Appendix K model contains additional conservatisms not recognized in 1974. Evidence from experiments designed to simulate LOCA phenomena suggest that these

conservatisms added hundreds of degrees Fahrenheit to the prediction of peak fuel cladding temperature than would actually occur during a LOCA. The significant conservatism was necessary when the rule was written because of a lack of experimental evidence at that time with respect to the relative effects of analysis input parameters, including pre-accident power level. Since that time, there has been substantial additional research on LOCA. NUREG-1230, "Compendium of ECCS Research for Realistic LOCA Analysis," December 1988, contains the technical basis for improved understanding of LOCA progression and ECCS evaluation gained after the ECCS rule was issued. The NUREG includes a discussion of the basis for uncertainties in detailed fuel bundle power calculations as part of the consideration of overall calculational uncertainty inherent in best-estimate evaluations. Chapters 7 and 8 of the NUREG include consideration of the changes in licensed power level that could result from application of best-estimate evaluation methods. The discussion includes an estimated sensitivity of predicted peak clad temperature (PCT) associated with changes in pre-accident power level. From that estimate, the NRC expects peak cladding temperature changes of approximately 15°F to result from 1-percent changes in plant power level that could result from the final rule.

In view of: (i) substantial conservatisms known in 1974 that were embodied in the Appendix K requirements for ECCS evaluations, (ii) new information developed since the 1974 rulemaking which shows additional conservatism in the Appendix K modeling requirements beyond that understood by the Commission when it adopted the 1974 rule, and (iii) the relative insensitivity of the calculated clad temperatures to assumed power level, the Commission concludes that it is acceptable to allow a reduction in the currently-required 102 percent power level assumption if justified by the actual power level measurement instrumentation uncertainty.

Accordingly, the Commission is amending the Appendix K requirement for an assumed 102 percent power level. This amendment allows a licensee to use an assumed power level of less than 102 percent (but not less than 100 percent), if the licensee has determined that the uncertainties in the measurement of core power level justifies the reduced margin.

Calorimetric Uncertainty and Feedwater Flow Measurement

The NRC staff has approved an exemption to the 102-percent power level requirement for Comanche Peak Units 1 and 2. The basis for the action is application of upgraded feedwater flow measurement technology at the plant. As indicated, the prospect of additional licensees requesting similar action has prompted the final rule. Other methods, systems, or analyses could be used as the basis for demonstrating reduced power measurement uncertainty.

In most nuclear power plants, operators obtain a continuous indication of core thermal power from nuclear instruments that provide a measurement of neutron flux. The nuclear instruments must be periodically calibrated to counteract the effects of changes in flux pattern, fuel burnup, and instrument drift. Steam plant calorimetry, which is the process of performing a heat balance around the nuclear steam supply system (called a calorimetric), is used to determine core thermal power and is the basis for the calibration. The differential pressure across a venturi installed in the feedwater flow path is a key element in the calorimetric measurement. Some plants use this calorimetric value directly to indicate thermal power; the nuclear instruments are used as anticipatory indicators for transients and for reactivity adjustments made with the control rods.

The system in use at Comanche Peak Units 1 and 2 is the Leading Edge Flowmeter (LEFM), manufactured by Caldon, Inc. The LEFM system is an ultrasonic flow meter that measures the transit times of pulses traveling along parallel acoustic paths through the flowing fluid. LEFM technology has been employed in non-nuclear applications, such as petroleum, chemical, and hydroelectric plants for several years. This operating experience will provide reliability data, supplementing data from nuclear applications. Additional information on the Comanche Peak Appendix K exemption and on the Caldon, Inc. LEFM system appears in safety evaluations issued by the NRC staff on March 8, 1999, and May 6, 1999.

ABB Combustion Engineering has expressed interest in the final rule because its flow-measuring system, known as Crossflow (which is also an ultrasonic flow-measuring device), is under NRC review and is expected to be part of a licensee amendment request for power uprate in the near future.

Public Comment

In the proposed rulemaking (64FR53270; October 1, 1999), the NRC sought comments from the public on four issues related to the revision of Appendix K. The NRC received comments from four utility companies, the Nuclear Energy Institute (NEI), and Caldon, Inc., manufacturer of the LEFM system. All of the commenters supported the proposed rule. NEI and Caldon offered comments on the four issues that the Commission included in the proposed rule. NEI and the New York Power Authority commented on several other issues as well.

The issues that accompanied the proposed rule were:

1. The current rule states that the required 2-percent analysis margin is to account for "*such* uncertainties *as* instrumentation error...." (emphasis added). This suggests that the 2-percent margin was intended to account for other sources of uncertainty in addition to instrumentation error. However, explicit documentation of the basis for the value of the margin does not appear to be contained in the rulemaking record for the original 1974 ECCS rulemaking. The Commission was interested in whether there were other sources of uncertainty, relevant to sources of heat following a LOCA, that should be considered when licensees seek to reduce the margin in the Appendix K requirement for assumed power.

As discussed in the section entitled, "Conservatisms in Appendix K ECCS Evaluation Model," the Commission considered the rulemaking historical record for Appendix K and concluded that instrument uncertainty was likely the only source of uncertainty that was to be accounted for by the 2-percent margin. NEI and Caldon have not identified other sources of uncertainty, relevant to sources of heat following a LOCA, that are connected with the power level assumption.

2. Were there rulemaking alternatives to the proposed rule that were not considered in the regulatory analysis?

The Commission considered rulemaking alternatives in the accompanying regulatory analysis. The alternatives were (i) no rule change, (ii) removal of the 102 percent requirement while requiring justification of a power level margin, (iii) the approach taken in the amended rule to maintain the 102 percent requirement and offer the option to reduce the margin, (iv) elimination of the power level margin, and (v) broad revision of Appendix K addressing all

analysis requirements. Additional alternatives were not identified in the comments received for the proposed rule.

3. What criteria should be used for determining whether a proposed reduction in the 2 percent power margin has been justified, based upon a determination of instrumentation error? For example, should a demonstrated instrumentation error of 1 percent in power level be presumptive of an acceptable reduction in assumed power margin of 1 percent?

The comments from NEI on this point emphasized that any criteria developed to evaluate proposed reductions in ECCS analysis power margin should be based only on the instrumentation error associated with power measurement. NEI said that the conservatism inherent in the ECCS analysis requirements embodied in Appendix K provide sufficient margin to maintain safety so that instrumentation uncertainty should be the only basis for the power level assumption. The comments also stated that the overall impact on safety should be considered and that degradation in safety should not be allowed.

The Commission agrees that the main criteria determining the suitability of proposed power level margin reductions should be the details associated with uncertainties in power level measurement. The Commission also agrees that the overall impact on plant safety should be considered, preferably in a risk-informed manner. However, the commenter contended that a lower probability of exceeding the analyzed power level translates to an overall improved level of safety at a facility. The Commission does not necessarily equate a lower probability of exceeding an analysis limit with improved safety for facilities that obtain approvals to increase reactor thermal power or make other changes based on the amendment. For example, when

plants obtain power uprates in conjunction with the relaxation in the amended rule, other factors come into play that may reduce the overall margin of safety, albeit probably only slightly for the small power increases anticipated with the amendment. Such changes in safety margin, if small and controlled, can be acceptable in light of other substantial conservatisms or associated risk-related information.

Caldon offered detailed comments on this issue. Their comments went beyond general instrumentation uncertainty considerations by proposing a list of criteria that appeared to be based on application of the LEFM to power measurement at a plant. Although the Commission considers the criteria provided by Caldon to be helpful, the Commission is not yet prepared to formalize any criteria for evaluating reductions in the power level margin for ECCS analysis. The safety evaluations associated with the Appendix K exemption and power uprate for Comanche Peak granted to TXU Electric Company set forth basic review criteria, including many of those proposed by Caldon. In those reviews, the NRC staff referred to available instrumentation guidance such as the Instrument Society of America Standard ISA 67.04, 1982, “Safety-Related Instrumentation Used in Nuclear Power Plants,” and NRC Regulatory Guide 1.105, Revision 2, “Instrument Setpoints for Safety-Related Systems.”

The NRC staff intends to gain further experience with licensee proposals that pursue the relaxation offered by the amendment before deciding whether a regulatory guide providing detailed acceptance criteria needs to be developed. Licensee proposals may involve use of advanced flow measurement systems or other approaches to determine the level of power measurement uncertainty and to reduce it. However, the Commission does not believe that

generic acceptance criteria should be too closely based on any particular measurement technology or analysis method.

4. How should the rule address cases in which licensees determine that power measurement instrument error is greater than 2 percent?

Both NEI and Caldon offered comments on this issue. Caldon maintained that current regulatory processes provide a sufficient basis for dealing with such situations. NEI recommended that licensees should conduct Appendix K ECCS evaluations at rated thermal power level plus the value of power measurement uncertainties, regardless of the magnitude of the uncertainty. The comments clearly stated that this position also applies for uncertainties determined to be greater than 2 percent. NEI considered the need for licensees to ensure that safety analyses are valid for their facility. According to NEI, if the required margin for power level measurement were found to be insufficient to account for actual uncertainty levels, then licensees must take appropriate action, including lowering the operating power level. NEI offered alternatives for licensees to accommodate uncertainties above 2 percent, including demonstration that the PCT margin for a facility could accommodate greater-than-expected uncertainty. Also, NEI indicated that other conservatisms in Appendix K methodologies could be applied to “offset” the excessive power measurement uncertainty.

The Commission agrees that licensees who find that the power measurement uncertainty for their facilities is greater than expected should take action to ensure that their plant is operated within the assumptions used in safety analyses. This follows from the requirement in 10 CFR 50 Appendix B, Section III, “Design Control.” The Appendix B

requirement states that design control measures will be applied to items such as accident analyses, and that design changes shall be subject to design control measures. Therefore, licensees must take action if the power measurement uncertainty is greater than typically expected or as determined in a plant-specific analysis. The expected magnitude of uncertainty at a facility could be the 2-percent margin that is preserved in the final rule, or it could be based on a plant-specific analysis supporting a smaller value. As already considered, the basis for the value in the rule is not clearly illuminated in the rulemaking history of Appendix K. However, the Commission believes that the Appendix K value represents a typical value for power measurement uncertainty, unless demonstrated otherwise for a particular facility.

The Commission does not believe that it is necessary to allow application of safety margins based on other conservative factors in an Appendix K ECCS evaluation to offset excessive uncertainties discovered in power measurement for a plant. By proposing to use safety margin "offsets" to justify higher-than-expected power measurement uncertainties, NEI is proposing an alternative to Appendix K ECCS evaluation methods already permitted by § 50.46. The Commission considers the available analysis alternatives offered by § 50.46 (i.e., those based on Appendix K and the so-called best estimate methods) to offer sufficient flexibility to licensees without introducing large complexities to the review and approval process that could be anticipated if Appendix K were to be applied in a "piecemeal" fashion.

The Commission originally instituted the ECCS evaluation requirements with the understanding that substantial conservatisms existed. Later, the relative contributions of various conservative factors were estimated on a largely generic basis to demonstrate the feasibility of best-estimate evaluations. However, when the revisions to § 50.46 were

considered in 1988, the Commission deliberately maintained two distinct options: (i) licensees could use the method defined by Appendix K; or (ii) they could develop a best-estimate approach. The alternatives discussed in the NEI comment can be accommodated by a licensee using the best-estimate option offered by § 50.46, rather than applying Appendix K in a "piecemeal" fashion.

On the basis of the "best-estimate" alternative to Appendix K requirements available in § 50.46, the Commission takes the position that Appendix K requirements should not be applied in a "piecemeal" fashion, as discussed in the NEI comment. Rather than searching for customized adjustments to Appendix K requirements, licensees should develop a "best-estimate" method, as permitted in § 50.46. The Commission position does not present licensees with an onerous burden. Licensees discovering that actual power measurement uncertainty at their plant is greater than the uncertainty assumed in safety analysis can take corrective action to address the problem while continuing plant operation. For example, plant power level may be reduced while the problem is addressed. Therefore, in the final rule the Commission has not adopted the NEI approach of applying offsetting uncertainties.

The comments received from NEI addressed four additional areas:

1. Uncertainties from additional heat sources. NEI commented that utilities would be able to use the amended rule to reduce the decay heat input used in Appendix K evaluations. NEI proposed that licensees could use the power measurement uncertainty to, "ensure that the expected decay heat bounds the full rated plant power plus the uncertainty value."

The NEI comment expands the scope of the proposed revision to Appendix K, bringing into consideration decay heat uncertainty, which is a separate analysis requirement in the rule. The Commission agrees that the decay heat level used in the Appendix K analysis could be reduced commensurate with a lower assumed power level. However, the reduced power level assumption must be justified by an acceptable analysis of the power measurement uncertainty. Also, the decay heat level used in the analysis must continue to meet the requirement in Appendix K (I) (A) (4), "Fission Product Decay." Discussion of the uncertainty involved with decay heat value required by Appendix K (I) (A) (4) is beyond the scope of this rulemaking. Licensees who wish to address the uncertainty of the decay heat level in their ECCS analysis should develop a "best-estimate" method which addresses uncertainties of all of the ECCS analysis parameters.

2. Consistency among NRC documents. NEI pointed out that other Commission documents besides Appendix K contain the 1.02 power level multiplier. In the regulatory analysis accompanying the rule, the Standard Review Plan sections and Regulatory Guide 1.49 are listed as part of the current regulatory framework considered during the rulemaking.

The NRC staff agrees with the comment that changes to guidance documents may be necessary and will make the necessary revisions to these documents to maintain consistency with the amended rule.

3. Requirement for upgrade to feedwater flow measurement. NEI commented that the proposed rule appeared to be based upon application of upgraded feedwater flow technology. NEI recommended that the rule or associated guidance make clear that availability of the

relaxation offered by the final rule is not restricted to licensees applying upgraded flow measurement technology.

The preamble for the proposed rule does indeed discuss application of improved flow measurement technology. This discussion is appropriate because this new technology is the impetus for the exemption granted to one licensee and is a key justification for the Commission action in amending the current rule. In the section, “Calorimetric Uncertainty and Feedwater Flow Measurement,” the Commission pointed out that methods other than application of improved flow measurement technology could be used as the basis for demonstrating reduced power measurement uncertainty. Also, in its discussion of the Caldon comments on issue number 3, the Commission acknowledged that licensee proposals may involve use of advanced flow measurement systems or other approaches. To prevent misinterpretation of the rule, the Section-by-Section analysis has been modified to reiterate that other methods not considered in the rulemaking could be used to justify a reduced power measurement uncertainty allowance. Although various approaches to reduce the uncertainty involved with PCT calculation may be used, the only uncertainty considered under this amendment is that associated with power level measurement.

4. Reportability under 10 CFR 50.46(a)(3). NEI cited the Section-by-Section analysis of the proposed rule, where the Commission stated that, “estimated changes in ECCS performance due to final analysis inputs are reported under Sec. 50.46 (a)(3), at least annually.” NEI recommended clarification of the statement to reflect an interpretation of § 50.46 so as to relate only to evaluation model parameters, but not to plant design parameters. NEI contended that plant parameters change from cycle to cycle and that changes in PCT caused

by plant specific input parameter changes to design information fall outside the scope of reportability under 10 CFR 50.46(a)(3).

Although the Commission accepts that the results of ECCS evaluations could change as a result of cycle specific variations in model inputs, the Commission does not agree with NEI on this point. In their comment, NEI drew a distinction between design inputs and model inputs to ECCS evaluations. The amended rule does not change the reporting requirements of 10 CFR 50.46 for changes to ECCS evaluations. The regulations are clear on the definition of an ECCS evaluation model and when reports are required. 10 CFR 50.46 (c)(2) defines ECCS evaluation models and provides a list of the elements including, “one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as...values of parameters, and all other information necessary to specify the calculational procedure.” In other words, the ECCS evaluation model is comprised of the computer code or codes, the input parameters (including plant-specific design parameters), and the calculational results. The Commission should be informed as described in 10 CFR 50.46(a)(3) when even a relatively small change to the calculational framework is made, especially when the PCT result is affected. As discussed in the statement of considerations to the September 16, 1988, final rule (53 FR 35996), the Commission needs to be cognizant of such changes to be able to confirm licensee or vendor assessments of the significance of the changes and to ensure that approved models continue to be used.

10 CFR 50.46 (a)(ii) contains an unambiguous requirement that changes to the ECCS evaluation must be reported at least annually: “For each change to or error discovered in an acceptable evaluation model or in the application of such a model that affects the temperature

calculation, the applicant or licensee shall report the nature of the change or error and its estimated effect on the limiting ECCS analysis to the Commission at least annually as specified in § 50.4." Therefore, on the basis of the definition of an evaluation model in § 50.46, the Commission does not accept the distinction made by NEI between "model parameters" and "design parameters." Based on the requirements of § 50.46, changes to the ECCS evaluation model under the amended Appendix K rule which affect the temperature calculation must be reported at least annually.

The comments from one licensee, the New York Power Authority (NYPA), considered two areas not already discussed:

1. Other potential benefits. NYPA commented that licensees could seek benefits other than increasing licensed power under the amended rule. The commenter offered two examples of such benefits - revised containment analyses conducted at power levels below 102 percent power and relaxation of operating restrictions on ultimate heat sink temperatures.

The Commission agrees that licensees could request the relaxation offered by the amended rule while not pursuing a power level increase. In the Background section the Commission recognized that other benefits are available to licensees and that power level increase is just one option. The examples offered by the NYPA comments may be suitable to a licensee, depending on plant characteristics and plant-specific safety analyses.

2. Changes to technical specifications. NYPA interpreted statements in the proposed rule to suggest that licensees pursuing the relaxation offered in the amendment would need to change their plant technical specifications to include a limiting condition for operation for new

feedwater flow instrumentation. Further, the comments suggested that clarification was needed to address when license amendments were required for changes associated with the rule.

In the Section-by-Section Analysis, the Commission discusses technical specification modifications that might be necessary when a power measurement uncertainty reduction is used in safety analyses. Typically, when an ECCS methodology is changed, a revision is made to the technical specification list of references associated with plant safety analysis methods. Technical specifications for nuclear power plants do not contain explicit requirements for feedwater flow instrumentation. The Commission does not believe that technical specification requirements for feedwater flow instruments are necessary for licensees to use the relaxation offered by the amended rule. Clarification regarding this point has been added to the Section-by-Section Analysis.

Section-by-Section Analysis

Appendix K to Part 50 — ECCS Evaluation Models (I)(A) - Sources of heat during the LOCA

This section is amended by removing words from the first sentence in the section to specifically associate the power level requirement with instrumentation error, and by adding a sentence immediately following the first sentence in the section. The new sentence indicates that licensees may assume a power level lower than 102 percent, but not less than 100 percent, if the proposed lower alternative value can be shown to account for core thermal power measurement instrumentation uncertainty. Licensee proposals may involve use of advanced flow measurement systems or other approaches to determine the level of power measurement uncertainty and to support reduction of the power level assumption. Only the uncertainty associated with power level measurement is considered in this amendment.

Appendix K, Part II (1)(a) requires that the values of analysis parameters or their basis be sufficiently documented to allow NRC review. The requirement applies to all analysis input parameters, including those related to other plant instrumentation, such as temperature and pressure. Changes to other inputs are documented in the same manner as the power measurement uncertainty would be documented under the final rule. NRC review and approval is not needed to change a parameter in an approved ECCS evaluation model unless the change is associated with technical specification or license condition modfications, or a final safety analysis report change not covered by § 50.59, “Changes, tests and experiments.” Estimated changes in ECCS performance due to revised analysis inputs are reported under § 50.46 (a)(3), at least annually. As discussed in the Statement of Considerations for a final rule amending Appendix K (53 FR 36001; September 16, 1988), the annual reports keep NRC apprised of changes. This should ensure that the NRC staff can evaluate a licensee’s assessment of the significance of changes and maintain cognizance of modifications made to NRC-approved evaluation models. The licensee must include revised parameters and other changes in the ECCS evaluation model as required by § 50.46 (a)(3) when a single change or an accumulation of changes is expected to affect peak cladding temperature by 50°F or more. The basis for the revised analysis parameter (i.e., the assumed power level) should be included in documentation of the evaluation model, as required by Appendix K, Part II (1)(a).

Licensees could take advantage of the amended rule without a change to technical specifications or to the plant license by simply updating the ECCS analysis and following the reporting requirements of § 50.46. However, in most cases the NRC expects that the analysis supporting the power measurement uncertainty, as well as the description of the relevant instrumentation and associated plant-specific parameters involved in the uncertainty analysis,

would be submitted for NRC review and approval before being used. These requests are expected because most licensees have adopted Generic Letter 88-16, “Removal of Cycle-Specific Parameter Limits from Technical Specifications.” The generic letter provided guidance for licensees to transfer cycle-specific parameters from their technical specifications to a Core Operating Limits Report (COLR). Licensees following the generic letter guidance added an administrative requirement to their technical specifications that specifically identifies NRC-reviewed and approved methods used to determine core operating limits (e.g., topical reports). Because a number of core operating limits are based on LOCA analysis results, ECCS evaluation methods are included in the technical specification list. Therefore, most licensees opting to use the relaxation in the final rule will need to amend technical specifications to include a reference to an NRC-approved topical report that includes the uncertainty analysis justifying reduced power measurement uncertainty. However, a technical specification requirement specifically related to feedwater flow measurement system operability is not needed.

An additional technical specification consideration for licensees pursuing changes based on the final rule could involve nuclear instrument (NI) requirements. Existing plant technical specifications include surveillance requirements to calibrate the power range NIs based on the calorimetric measuring reactor thermal power. The NIs provide the indication of reactor power used as an input for safety systems. Licensees obtaining the relaxation offered in the final rule are expected to change some operating parameter of the plant, whether it be power level, required ECCS flow, etc. By incorporating the justification of reduced uncertainty in power measurement in the basis for their ECCS analysis, licensees would be placing a condition on an input to the calorimetric. The NI calibration required by the plant licensee would then be based

on a calorimetric assuming the reduced power measurement uncertainty. If, for some reason, during the course of plant operation the reduced uncertainty did not apply (e.g., the new feedwater flow meter was no longer operating), the calorimetric would no longer be a valid source of calibration for the NIs. Licensees would need to take action to maintain compliance with their technical specification, for example, by using an alternate input to the calorimetric. The power measurement uncertainties associated with the alternate input would then apply and the plant would need to adjust its operating condition (possibly lower its operating power level) to satisfy the final rule and to maintain the validity of applicable safety analyses. A change to technical specifications for NIs is not required in this situation.

Referenced Documents

Copies of GL-88-16, and CLI-73-39, and "Supplemental Testimony of the AEC Regulatory Staff on the Interim Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Cooled Power Reactors," and "Redirect and Rebuttal Testimony of Dr. Donald H. Roy on Behalf of Babcock & Wilcox," and "Concluding Statement of Position of the Regulatory Staff – Public Rulemaking Hearing on: Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Cooled Nuclear Power Reactors," and NRC safety evaluations are available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street, NW. (Lower Level), Washington, D.C. GL-88-16 is also available via the Internet at http://www.nrc.gov/NRC/GENACT/GC/index.html#GL.

NUREG-1230 is available from the Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082 Washington, DC 20013-7082 or from the National Technical Information Service, Springfield, VA 22161.

Voluntary Consensus Standards

The National Technology Transfer Act of 1995, Pub. L. 104-113, requires that Federal agencies use technical standards that are developed or adopted by voluntary consensus standards bodies unless the use of such a standard is inconsistent with applicable law or otherwise impractical. In this final rule, the NRC provides holders of operating licenses for nuclear power plants the option of reducing the assumed reactor power level used in ECCS evaluations. This action constitutes a modification to an existing government-unique standard, 10 CFR Part 50, Appendix K issued by the NRC on January 4, 1974. The NRC is not aware of any voluntary consensus standard that could be adopted instead of the government-unique standard. The NRC considered using a voluntary consensus standard. However, an appropriate standard was not identified.

Finding of No Significant Environmental Impact: Availability

The NRC has determined under the National Environmental Policy Act of 1969, as amended, and the NRC's regulations in Subpart A of 10 CFR Part 51, that this regulation is not a major Federal action significantly affecting the quality of the human environment and, therefore, an environmental impact statement is not required.

The action is likely to result in relatively small changes to ECCS analyses or to the licensed power of nuclear reactor facilities. The NRC staff expects that no significant environmental impact will result from the final rule, because licensee actions based on the rule should not significantly increase the probability or consequences of accidents; no changes will be made in the types of any effluents that may be released off site; and there should be no significant increase in occupational or public radiation exposure. Therefore, there are no

significant radiological environmental impacts associated with the action. The action does not involve non-radiological plant effluents and has no other environmental impact. Therefore, there are no significant non-radiological environmental impacts associated with the final rule.

The determination of the environmental assessment is that there will be no significant offsite impact on the public from this action. Also, the NRC has committed itself to complying in all its actions with Executive Order (E.O.) 12898, "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations," dated February 11, 1994. The NRC has determined that there are no disproportionately high and adverse impacts on minority and low-income populations. The NRC uses the following working definition of environmental justice: *Environmental justice* means the fair treatment and meaningful involvement of all people, regardless of race, ethnicity, culture, income, or educational level with respect to the development, implementation and enforcement of environmental laws, regulations, and policies. In the letter and spirit of E.O. 12898, the NRC requested public comments on environmental justice considerations or other questions related to this rule, but none were received.

Paperwork Reduction Act Statement

This final rule increases the burden on licensees opting to use a reduced power level assumption for ECCS analysis (i.e., below 102 percent) to include the change in their annual report required under 10 CFR 50.46 (a)(3)(ii). The public burden to modify the annual report is estimated to average one-half hour per response. The estimated public burden for record keeping, analysis, and other effort associated with this information collection will be included in the Office of Management and Budget FY2000 Information Collection Budget. Existing

requirements were approved by the Office of Management and Budget, approval number 3150-0011.

Public Protection Notification

If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

Regulatory Analysis

The Commission has prepared a regulatory analysis on this regulation. Copies of the regulatory analysis may be obtained as indicated in the "ADDRESSES" section.

Regulatory Flexibility Certification

As required by the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission certifies that this final rule does not have a significant economic impact on a substantial number of small entities. This final rule would affect only the licensing and operation of nuclear power plants. The companies that own these plants do not fall within the definition of “small entities” found in the Regulatory Flexibility Act or within the size standards established by the NRC in 10 CFR 2.810.

Backfit Analysis

The NRC has determined that the backfit rule in 10 CFR 50.109 does not apply to this final rule and that a backfit analysis is not required for this amendment because the change does not involve any provisions that impose backfits as defined in 10 CFR 50.109(a)(1). The

final rule establishes an alternative approach for ECCS performance evaluations that may be voluntarily adopted by licensees. Licensees may continue to comply with existing requirements in Appendix K. The final rule does not impose a new requirement on current licensees and therefore, does not constitute a backfit as defined in 10 CFR 50.109(a)(1).

Small Business Regulatory Enforcement Fairness Act

In accordance with the Small Business Regulatory Enforcement Fairness Act of 1996, the NRC has determined that this action is not a major rule and has verified this determination with the Office of Information and Regulatory Affairs of OMB.

List of Subjects in *10 CFR Part* 50

Antitrust, Classified Information, Criminal Penalties, Fire Protection, Intergovernmental Relations, Nuclear Power Plants and Reactors, Radiation Protection, Reactor Siting Criteria, Reporting and Recordkeeping Requirements.

PART 50 — DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

1. The authority citation for Part 50 continues to read as follows:

AUTHORITY: Sections 102, 103, 104, 105, 161, 182, 183, 186, 189, 68 Stat. 936, 937, 938, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2132, 2133, 2134, 2135, 2201, 2232, 2233, 2236, 2239, 2282); secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846).

Section 50.7 also issued under Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851). Section 50.10 also issued under secs. 101, 185, 68 Stat. 955, as amended (42 U.S.C. 2131,

2235), sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332). Sections 50.13, 50.54(dd), and 50.103 also issued under sec. 108, 68 Stat. 939, as amended (42 U.S.C. 2138). Sections 50.23, 50.35, 50.55, and 50.56 also issued under sec. 185, 68 Stat. 955 (42 U.S.C. 2235). Sections 50.33a, 50.55a, and Appendix Q also issued under sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332). Sections 50.34 and 50.54 also issued under sec. 204, 88 Stat. 1245 (42 U.S.C. 5844). Sections 50.58, 50.91, and 50.92 also issued under Pub. L. 97-415, 96 Stat. 2073 (42 U.S.C. 2239). Section 50.78 also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Sections 50.80–50.81 also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Appendix F also issued under sec. 187, 68 Stat. 955 (42 U.S.C. 2237).

2. Appendix K to Part 50 is amended by revising the introductory paragraph of I. A., “Sources of heat during the LOCA,” to read as follows

Appendix K to Part 50 — ECCS Evaluation Models

I. 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.

* * * * *

Dated at Rockville, Maryland, this__ day of _____, 2000.

For the Nuclear Regulatory Commission.

_____

Annette Vietti-Cook,
Secretary of the Commission.

Attachment 2

Regulatory Analysis

REGULATORY ANALYSIS
REVISED 10 CFR PART 50, APPENDIX K

Alternate Power Level Assumption for ECCS Evaluations

IX. STATEMENT OF THE PROBLEM

Part 50, Appendix K, "ECCS Evaluation Models," contains a requirement that safety analyses used for evaluating the performance of the emergency core cooling system (ECCS) under loss-of-coolant accident (LOCA) conditions be conducted at 102 percent of the licensed power for the plant. The provision appears to have been intended to account for uncertainties attributable to instrumentation error. Licensees have proposed using instrumentation that would reduce the uncertainties associated with measurement of reactor power, thus allowing justification of a reduced margin between the licensed power level and the power level assumed for ECCS evaluations. One licensee has used a reduced ECCS analysis margin to facilitate a small, cost-beneficial increase to licensed power. If the uncertainties associated with power measurement instrumentation errors can be shown to be sufficiently small, then the current rule unnecessarily restricts operation. Therefore, the objective of this rulemaking is to allow the reduction of an unnecessarily burdensome regulatory requirement.

A. Background

A holder of an operating license (i.e., the licensee) for a light-water power reactor is required by regulations issued by the NRC to submit a safety analysis report that contains an evaluation of emergency core cooling system (ECCS) performance under accident conditions. In § 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," the Commission requires that ECCS performance under loss-of-coolant accident (LOCA) conditions be evaluated and that the estimated performance satisfy certain criteria. Licensees may conduct an analysis that "realistically describes the behavior of the reactor system during a LOCA" (often termed a "best-estimate analysis"), or they may develop a model that conforms with the requirements of Appendix K to 10 CFR Part 50. The majority of ECCS evaluations are based on Appendix K requirements. The opening sentence of Appendix K establishes the requirement to conduct ECCS analyses at a specified power level: "It shall 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 such uncertainties as instrumentation error)." Licensees have proposed utilizing instrumentation that would reduce the uncertainties associated with measurement of reactor power, thus allowing justification of a reduced margin between the licensed power level and the power level assumed for ECCS evaluations. The revised rule changes this provision in Appendix K, thereby allowing licensees the option of using a value lower than 102 percent of the licensed power in their ECCS analyses.

Several licensees have expressed interest in using updated feedwater flow measurement technology (see Section IV, "Calorimetric Uncertainty and Feedwater Flow Measurement") as a basis for seeking exemptions from the Appendix K power level requirement and to implement power uprates. One licensee, TXU Electric Company, has obtained an exemption from the Appendix K requirement for Comanche Peak Units 1 and 2 and has received approval for an increase in licensed power based on more accurate feedwater flow measurement capability. The prospect of additional exemption requests from other licensees provides the impetus for changing the rule.

The amendment gives licensees the option to apply a reduced margin between the licensed power level and the assumed power level for ECCS evaluation, or they could maintain the current margin of 2-percent power. The amendment provides licensees the opportunity to pursue voluntary power uprates without the need to reconsider ECCS evaluations, although the basis for the assumed power for ECCS analysis would change. Some licensees could benefit from the change without increased licensed power through revisions to their ECCS evaluations at a lower assumed power level.

As presented in this regulatory analysis, the industry could realize a significant financial benefit through this relaxation. The intent of the rule, to assure margin to ECCS performance in the event of a LOCA, is still honored and plant risk will not be significantly affected under the amended rule.[2] However, the impact of raising the licensed power level for a plant must be evaluated on a plant-specific basis.

B. Existing Regulatory Framework

Appendix K to 10 CFR Part 50 was written to define conservative analysis assumptions for ECCS performance evaluations during design-basis LOCAs. Large safety margins are provided by conservatively selecting the ECCS performance criteria as well as conservatively establishing ECCS calculational requirements. One conservative calculational requirement is to assume that the reactor is operating at 102-percent power when the LOCA occurs. The first section of Appendix K establishes the requirement to conduct ECCS analyses at a specified power level, along with other heat-source assumptions. As stated parenthetically in the current rule, the power level requirement is imposed to account for uncertainties, including instrument error.

The 102-percent power requirement does not appear elsewhere in NRC regulations, but it has been widely applied in guidance documents. The tables that follow list sections of the Standard Review Plan (SRP) (Reference 2) that contain the 102-percent power requirement. The first table shows SRP sections that incorporate the 102-percent value, but that offer the possibility that a smaller value could be justified. The second table shows those SRP sections that give the 102-percent value without an alternative. The staff intends to review the affected SRP sections and will evaluate the impact of the revised rule on those safety analyses. Further, the staff is considering the need for specific guidance to help licensees appropriately account for power measurement uncertainty in safety analyses

The only regulatory guide containing the 102-percent power requirement is Regulatory Guide 1.49, “Power Levels of Nuclear Power Plants” (Reference 3).

SRP Sections Containing the 102-percent Power Margin With an Option

SRP Section	Title

[2]NRC reviews of extended power uprates for two boiling water reactors (much greater than 1-percent increases) did not identify significant risk increases. The NRC staff has taken the position that risk evaluations are not expected to accompany applications for marginal licensed power increases (Reference 1).

15.2.6	Loss of Non-emergency AC Power to the Station Auxiliaries
15.2.7	Loss of Normal Feedwater Flow
15.3.1–15.3.2	Loss of Forced Reactor Coolant Flow, Including Trip of Pump and Flow Controller Malfunctions
15.3.3–15.3.4	Reactor Coolant Pump Rotor Seizure and Reactor Coolant Pump Shaft Break
15.4.3	Control Rod Misoperation (System Malfunction or Operator Error)
15.5.1–15.5.2	Inadvertent Operation of ECCS and Chemical and Volume Control System Malfunction That Increases Reactor Coolant Inventory
15.6.1	Inadvertent Opening of a PWR Pressurizer Relief Valve or a BWR Relief Valve
15.6.5	Loss-of-Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary

SRP Sections Specifying the 102-percent Power Requirement

SRP Section	Title
6.2.1.3	Mass and Energy Release Analysis for Postulated Loss-of-Coolant Accidents
6.2.1.4	Mass and Energy Release Analysis for Postulated Secondary System Pipe Ruptures
15.1.1–15.1.4	Decrease in Feedwater Temperature, Increase in Feedwater Flow, Increase in Steam Flow, and Inadvertent Opening of a Steam Generator Relief or Safety Valve
15.2.1–15.2.5	Loss of External Load, Turbine Trip, Loss of Condenser Vacuum, Closure of Main Steam Isolation Valve (BWR), and Steam Pressure Regulatory Failure (Closed)
15.4.6	Chemical and Volume Control System Malfunction That Results in a Decrease in Boron Concentration in the Reactor Coolant (PWR)

This amendment is not part of the proposed effort to revise Part 50 on a risk-informed basis, as described in SECY-98-300 (Reference 4). A risk-informed revision of Appendix K requirements, if undertaken, would involve a broad review of all ECCS analysis requirements and acceptance criteria.

II. OBJECTIVE OF THE FINAL RULE

The objective of this rulemaking is to remove an unnecessary regulatory requirement. Appendix K was issued to ensure an adequate performance margin of the ECCS in the event a design-basis LOCA were to occur. The margin is provided by conservative features and requirements of the evaluation models and by the ECCS performance criteria. The existing regulation does not require that the power measurement uncertainty be demonstrated, presupposing that the mandated margin is sufficient to account for uncertainties expected to be involved with measuring reactor power. By allowing a smaller margin for power measurement uncertainty, this amendment does not violate the underlying purpose of Appendix K.

A secondary objective is to avoid unnecessary exemption requests. The staff has previously sought rule changes to avoid the prospect of multiple exemption requests. In SECY-96-147 (Reference 5), the staff took steps to revise regulations that were associated with large numbers of recurring exemption requests. In the cases addressed in SECY-96-147, the rules were being changed as a result of recurrent exemptions, which indicated an inadequacy in a regulation. In the case of this change to Appendix K, the staff is anticipating recurrent exemptions and has determined that revising the rule at this early stage is the best course.

An economic benefit is a strong consideration for licensees. The economic benefit of an increase in licensed power can be considered in terms of replacement energy cost savings for utilities that no longer need to purchase the additional power generated as a result of a power uprate. Of course, plant-specific features and situations change the estimated benefit for any given plant either more or less favorably. Factors influencing the decision of a utility to upgrade a plant vary, and a plant-specific cost-benefit analysis would be required to determine whether a specific facility should pursue the uprate.

Under the final rule, some licensees could realize savings without seeking a power uprate. By revising their ECCS analysis based on a lower assumed power level, licensees could gain margin that could lead to less stringent requirements for LOCA mitigation system (i.e., ECCS) performance or in core thermal limits.

III. ALTERNATIVE APPROACHES

Rulemaking Options

The staff considered the following options:

- No Rule Change
  Instead of instituting a rule change, the regulation could be maintained in its current form and multiple exemptions to the existing regulation could be granted under 10 CFR 50.12. A short-term benefit to this approach would be that the NRC would avoid the costs of changing the rule and of implementing the revision. However, in the long term, this is not a satisfactory alternative from the standpoint of regulatory efficiency.

  Each exemption request would need to be reviewed in accordance with the criteria of 10 CFR 50.12 in addition to reviewing its technical merits. The exemption request review would be handled as a separate regulatory step from the review of a power uprate request for each application, as is the case with the pending exemption request for Comanche Peak Units 1 and 2. Applying this process to a series of exemption requests would be an unnecessary expenditure of NRC and licensee resources, an expenditure not encountered under an amendment to a rule.

- Option 1
  Maintain the provision requiring an analysis margin to account for uncertainty in power measurement, but remove the specification of the 2-percent value for the margin. Licensees would then need to propose and justify the value used for their analysis.

  This option is not preferred because it would not meet backfit criteria. Although it could provide relief to licensees that seek to reduce the margin, it would constitute a backfit on those licensees that would not wish a change from the currently required value but would nonetheless be required to justify a value. Because the change is expected to have negligible risk impact, there is no basis for a compliance or adequate protection backfit for this option.

- Option 2

Allow licensees the option to justify a smaller margin between licensed power and the assumed power level for ECCS analysis for their plant or to maintain the current margin now mandated.

This is the preferred option. Making this change to the rule gives licensees the opportunity to benefit from a reduced margin by demonstrating that power measurement uncertainty is sufficiently small. Licensees would pursue a change if there is a sufficient benefit relative to the effort to justify the change in a license amendment request. Licensees could gain benefits from operation at higher power or relax ECCS-related technical specifications. In such cases, licensees would need to justify the reduced power measurement uncertainty as part of the license amendment request. Other licensees may elect to revise the ECCS analyses for their facility and seek benefits without increasing licensed power. Maintaining the current Appendix K requirements is not adverse to safety and should be permitted as an option.

- Option 3
  Eliminate the requirement for a margin between power level and assumed power.

  This option is not preferred. The staff would need to investigate the feasibility of eliminating the requirement for an assumed power margin for analysis. Without a required analysis margin, licensees could seek benefits without addressing power measurement uncertainties. Justification for this option would involve demonstrating the acceptability of not accounting for any uncertainties behind the 2-percent power analysis margin. The technical effort involved in this option is probably not justifiable since a generic demonstration of the safety implications would be more costly than for option 2, and there is no safety benefit relative to option 2.

- Option 4
  Broadly revise Appendix K, addressing several conservative requirements.

  The staff considered addressing several of the calculational requirements in Appendix K with the objective of reducing excessive conservatism. This would be a long-term effort, which, if pursued, would not avoid the exemption requests expected in the shorter term. Further, given the existing option in 10 CFR 50.46 for licensees to apply best-estimate methodology to avoid Appendix K conservatism, and the substantial staff resource effort entailed in a broad Appendix K revision, the staff decided that this was not a preferred option.

IV. EVALUATION OF VALUES AND IMPACTS

Since the final rule does not in itself change any plant configurations or operating parameters, the staff evaluated likely benefits that licensees would seek to achieve from the revised rule. Those licensees electing to use the option afforded by the revised rule to pursue licensed power level increases for their plants are likely to realize the largest financial benefits as a result of the revised rule. Therefore, the evaluation that follows emphasizes the costs and savings associated with a small (i.e., approximately 1 percent) increase in licensed power. However, as discussed in the Decision Rationale section, there are only slight differences between the costs and benefits associated with the options evaluated by the staff. Therefore, the main decision

criteria became regulatory efficiency impacts of a large number of exemption requests that would be faced without a rulemaking and the desire to complete a timely rulemaking.

In conducting the evaluation, the staff followed the "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," NUREG/BR-0058, Revision 2 (Reference 6), including the use of a 7-percent rate to adjust values to 1999 dollar values. First, benefits and costs are identified for the revised rule, then the overall effect is evaluated for each of the rulemaking alternatives considered. The values and impacts associated with rulemaking option 1 were not evaluated, because it was eliminated from staff consideration in view of backfit ramifications. Therefore, the evaluation that follows covers options 2 through 4 compared to the no-rulemaking alternative. The staff considered the no-rule-change alternative as the base case. In the event the rule was not revised, numerous exemption requests were anticipated that would be similar to the exemption already approved for Comanche Peak.

Previously, the staff concluded that marginal power increases have little risk significance (see Reference 1). Therefore, the staff considered value impact attributes related to health effects and property loss resulting from accidents to be unchanged by the revised rule. Also, the financial benefits under each option evaluated are equivalent. As a result, the attributes contributing to the final selection of a rulemaking alternative are limited to regulatory efficiency implications. When data were readily available, the staff made quantitative approximations for the factors. However, the evaluation was eventually qualitative, since the benefit of regulatory efficiency maintained by avoiding large numbers of exemptions is difficult to quantify.

A. Values

1. Savings to Licensees

Licensees who want to use the option offered by the revised rule could realize a significant economic benefit from an increase in licensed power. The benefit realized by a particular licensee will be influenced by a number of factors, including the market price of electricity, generating costs, and the mix of generating assets within the utility (i.e., types of units: nuclear, fossil, etc.). The staff estimated licensee savings under two sets of assumptions: replacement power cost savings and generation cost savings.

a. Replacement Power Cost Savings

On a purely replacement-power-cost-savings basis, the staff assumed that demand for electricity will increase such that any increase in generation by nuclear units will be purchased. Naturally, the validity of this assumption could be affected by market factors and the particular situation of the utility considered. However, based on the average annual increase in utility electric production from 1990 to 1998 for all sources (about 1.7 percent - see Reference 7) and a generally greater annual increase by nuclear units, use of added nuclear generating capacity of 1 percent appears to be a reasonable assumption. The licensee's benefit is considered on an average-plant basis using 1998 data from Reference 7. The retail price of electricity sold by electric utilities during 1998 averaged 6.74 cents per kilowatt-hour. Using the total amount of electricity produced in 1998 by nuclear generation, 674 billion KWH (reflects an industry-wide capacity factor of 70 percent for 103 operating units) and assuming a typical power increase of 1 percent to be achievable from the revised rule, the annual increase in electrical output for a single unit would be about 65.4 million KWH. Using these values, a unit could save about

$4.4 million annually in replacement power costs, or $453 million for all operating units. However, increased power generation incurs some additional costs for the utility. The generating cost for nuclear power units during 1995 (Reference 8) was $19.23 per MWH (this value includes fuel, operation, and maintenance costs). For the average plant being considered, the increased generation would add about $1.7 million in annual costs (adjusted to 1999 value). Therefore, the net benefit for the average unit would be the difference between the replacement power savings and this additional generation cost, or $2.7 million. Over the average remaining lifetime of a U.S. nuclear power plant (about 17 years), the savings would be approximately $26 million (in 1999 dollars). The average lifetime does not account for expected license renewals.

b. Generation Cost Savings

This estimate assumes that a utility would use the increase in nuclear generating capacity gained from a 1-percent power uprate to reduce the amount of power generated by units that are more costly to operate. No benefit from the sale of additional power is included in this scenario because the utility is assumed to sell the same overall amount of electricity after the nuclear unit power uprate. Comparison of power generating costs in Reference 8 shows that gas and oil-fueled units had higher generating costs than nuclear units, while coal-fueled units had the lowest costs. It is reasonable to assume that a utility with units fueled by various means would use increased nuclear generating capacity to reduce more costly means of generation. Therefore, the staff assumed that a utility would apply the increased capacity of the average nuclear unit considered above to reduce the power generation by gas and oil-fueled units. The staff assumed that the reduction would be split evenly between the two types of units. Applying generation cost data from Reference 8, power generation costs from gas and oil-fueled units would decrease by about $2.7 million, which is offset by the increase in costs of power generated by the nuclear unit of $1.7 million, yielding a net savings for the utility of about $1 million annually. Over the average lifetime of a U.S. nuclear power plant (17 years), the savings would amount to $9.8 million (discounted to 1999).

These scenarios represent a range of the benefits that licensees may expect if they choose to pursue the power uprate afforded by the revised rule. A variety of factors could change the results for any particular utility, but the staff expects that for those licensees in a position to pursue power uprate, the results would fall in the range between the two scenarios considered above, or between $1 million and $2.7 million annually.

The magnitude of the benefit from a license change not involving power uprate and the manner by which it would be applied are subject to plant-specific considerations. Licensees may decide to seek a change in technical specifications for ECCS systems based on revised analyses, rather than to increase licensed power. In other cases, licensees might pursue benefits by altering core performance characteristics based on the revised ECCS evaluation. There is a wide range of possible scenarios and such savings would probably only add slightly to the industry savings realized from eventual power uprates. Therefore, the staff did not attempt to quantify the savings for plants that might make changes to their ECCS evaluations but would not seek power uprates.

2. Savings to NRC

The monetary savings realized by the NRC through rulemaking are expected to be modest, in that they lie only in the difference between processing license amendments for power uprates or other license changes associated with the revised rule and processing exemption requests along with similar license amendment requests. The costs of processing amendment requests and exemptions are discussed later.

There is also a benefit from improved regulatory efficiency, because multiple exemption requests need not be considered under the revised rule.

B. Impacts

1. Costs to Licensees

Licensees electing to pursue the benefit offered by the final rule would incur costs of upgrading plant instrumentation that provide the basis for the improved accuracy in power measurement. There are also several costs incurred by those licensees seeking a benefit from the final rule. These include the resource investment to conduct analyses to support a license amendment request, whether it is a power uprate or other technical specification change, and costs associated with submitting the license amendment to the NRC. Finally, there are costs incurred to implement the changes to the plant to allow operation at higher power.

For this evaluation, the staff assumed that the acquisition and installation costs for an ultrasonic flowmeter or for other changes that licensees could make to improve the accuracy of thermal power measurement would be part of the overall power uprate cost. Costs of analyses to support a power uprate amendment request would be approximately $5 million, based on effort claimed by industry to support other power uprate requests (Reference 9). Some of these expenses could decrease as future applicants will realize efficiencies based on experience gained by earlier applicants. The staff also considered approximate values for both licensee and NRC costs that are available from NUREG/CR-4627 (Reference 10), which presents a cost estimate for a “complicated” technical specification change. For this assessment, the staff assumed that the analysis and submittal to justify a smaller assumed power margin incur costs equivalent to such a “complicated” amendment. Making adjustments for the period since 1988 when NUREG/CR-4627 was published, the licensee’s cost to justify a smaller assumed power margin could be about $75,000. Thus, using these estimates, each licensee would expend at least $75,000 to use a reduced analysis margin, and those licensees seeking the power uprate would incur costs of about $5 million.

The staff estimates the licensee’s cost of plant modifications to accommodate a small power uprate to be in the range of $5 million to $10 million, which accounts for hardware, procedural changes, and personnel training costs. This estimate is based on licensee power uprate cost estimates ranging from $150/KWe to $2250/KWe (Reference 11).[3] The staff used the higher cost information in the analysis to ensure that licensee costs would not be underestimated.

2. Costs to NRC

[3] The cost values from Reference 3 are in 1985 dollars. The total cost of $5 million to $10 million given here is a current value.

NRC realizes costs under any of the scenarios considered in this evaluation. The costs for review and processing of license amendments or exemptions, as well as revisions to guidance documents and rulemaking costs themselves, are considered next.

NRC licensing action costs are based on dollar values, rather than on staff full-time-equivalent positions, given in NUREG/BR-0184 (Reference 12) for the expected NRC staff effort to implement new requirements and on a so-called complicated technical specification amendment review discussed earlier. NUREG/CR-4627 estimates that such a review would entail an NRC cost of $42,000, adjusted to present value. Assuming that the NRC cost to review the proposed power margin reduction is comparable to that required for a power uprate amendment, the cost for each would be in the range of $42,000. Thus, the NRC would incur a cost of $42,000 for each proposed margin reduction, and an additional $42,000 to process each request for a power uprate.

NRC costs to revise the rule and update review guidance were estimated by the staff. The rulemaking costs vary depending on the scope of the rule revision considered. The costs associated with the current rulemaking activity are not included in the costs for that rulemaking option because those resources have been expended and can not be retrieved. The current rulemaking costs are used only to account for common activities among the options that would be considered completed if another rulemaking alternative were now pursued. Revision of associated guidance documents is estimated to be a one-time cost of about 0.4 FTE, or about $54,000. To supplement the generic information discussed above, the staff also surveyed the NRC staff resources used for relatively recent licensing actions that might be representative of staff activity associated with the revised rule, such as exemption requests and similar power uprate requests. This survey formed the basis of the staff's assumption that an Appendix K exemption request would require about 7 weeks of staff effort, valued at approximately $21,000 (assuming $75 per hour for staff effort).

Savings might be realized as more exemption requests are approved and if generic submittals were made to address those facilities of similar design; however, the staff would need to ensure that plant-specific features for certain facilities did not invalidate the generic assessment. Thus, some review would still be needed for each request.

C. Health, Safety, and Environmental Effects

In the Appendix K exemption recently approved for Comanche Peak, the instrumentation manufacturer (Caldon, Inc.) claims that a safety benefit will be achieved by using the instrument even during operation at a higher power level. The vendor quantified the benefit in terms of the probability that the power level of the plant will exceed the licensed level at the initiation of the accident. Although the staff does not dispute the claim of a safety benefit, the overall safety impact of an increase in licensed power depends on a variety of plant-specific factors.

A slightly higher power level (i.e., about 1 percent) will result in a slight increase in decay heat load, but is not expected to affect the success criteria and required response time of ECCS equipment and the available operator response time following transients and accidents. In NUREG-1230 (Reference 13), the staff considered the risk impact of changes associated with the revised ECCS rules, including power increases, and determined that a power change of 5 percent or less had little risk significance.

In Reference 1, the staff discussed its consideration of the risk impact from BWR extended power uprates, which are much greater than the marginal power change expected under the revised rule. In these cases, the staff concludes that extended power uprates are expected to only slightly affect the risk profile of a plant. In Reference 1, the staff judged that marginal power uprates, of about 1 percent, were not expected to require an assessment of the risk impact on the plant. However, licensees requesting increased licensed power must demonstrate on a plant-specific basis that deterministic requirements are satisfied (e.g., those based on the general design criteria of Appendix A to Part 50).

D. Comparison of Alternatives

The operating reactor population used for this assessment was 103 units as of December 1998. An assumption common to each option considered is that those licensees wanting to pursue power uprate afforded by an amendment to the rule would do so shortly after issuance of the final rule. Assuming the amendment is issued in final form during 2000, the average remaining plant lifetime is approximately 17 years, not accounting for expected license extensions.

Not all licensees are expected to seek a power uprate under the final rule. As described earlier, some would seek only to revise the ECCS analyses for their facility. For the purpose of this evaluation, the costs and benefits for these licensees are not considered because a large range of options is involved and because the staff found that the final rule was justified by limiting the benefits to those plants seeking power uprate. For this evaluation, the staff assumed an approximately even split of the nuclear plant population between these two categories of 50 plants whose licensees sought a power uprate, and 53 plants whose licensees were not seeking a power uprate. If only 50 plant licensees pursue a marginal power uprate, they would share an annual benefit ranging from $50 million to $135 million, based on the two scenarios considered earlier.

The table entitled, “Cost Estimates for Rulemaking Options,” located at the end of this section, summarizes the staff’s cost estimates used in its comparison of the alternatives. For each alternative, the staff assumed that the costs applied to 50 plants, as indicated in the table. Note that the high estimate for licensee costs for power uprate is used in the table and that the NRC costs comprise salaries, benefits, and contract support.

1. No-Rule-Change Alternative

If the current requirement remains in place and no amendment is permitted, the staff expects that a significant number of licensees will pursue exemption requests, following the example of Comanche Peak. Licensees for at least 19 plants have expressed their interest to NRC in the staff review of the Caldon, Inc. ultrasonic system. It is not clear how many of these licensees, or if others, would eventually pursue exemption requests. The staff assumed that if licensees determined that the relaxation had financial benefits for them, then those licensees would seek the benefit whether or not the rule is amended. The licensee costs to support exemption and amendment requests were discussed earlier. The staff used values of $75,000 and $5 million, respectively. Also, costs for implementing the power increase total about $10 million. The typical NRC cost to review exemption requests were discussed earlier and are estimated to be about $21,000 per request. Added to this cost is the NRC cost to review the justification for the reduced power level margin of $42,000. The licensee and NRC costs associated with the

power uprate would be the same as those considered for the 1-percent power increase assumed for options 2 and 3, about $42,000.

2. Option 2

Under option 2, the change is not mandatory. Therefore, each licensee would first determine whether an investment to reduce the analysis margin is justified in light of the potential benefits. Licensees opting to obtain a power uprate or other license amendment must conduct an analysis to justify a reduced assumed power margin, and then prepare license amendments to obtain a power uprate or technical specification change.

The costs for these activities were discussed earlier and are considered the same as in the no-rule-change case, although some savings may be expected because an exemption request is not involved. The NRC would incur a cost of $42,000 for each proposed margin reduction, and an additional $42,000 to process each request for a power uprate. The staff estimated that the rulemaking effort for option 2 would require 0.9 FTE or about $122,000. This cost is not included in the decision rationale to chose a rulemaking option because these resources have been expended at the final rulemaking stage. The value is used to offset the costs of rulemaking activities common among the options to show the actual resource implications at the final rulemaking stage. Once the current regulation is changed, any NRC SRP sections and regulatory guides that use the currently required value for assumed power margin would have to be revised to remain consistent with the regulations. These costs totaling $54,000 were discussed earlier.

3. Option 3

Under this option, as in option 2, those licensees seeking a higher licensed power level, or other benefit, would incur costs. The costs would be associated with revising plant technical specifications and conducting those analyses necessary to amend the license to operate at a higher power level. These costs are the same as those considered in option 2.

Under this option, the NRC assumes a much greater burden in that the rulemaking to eliminate a requirement, versus its modification, would be expected to entail a significant amount of technical and administrative effort compared to option 2. For instance, the NRC staff would probably use contractor assistance to help develop the technical basis for the revised rule. A protracted review of the revision would be expected and would entail significant staff costs. NRC costs are estimated on the basis of the previous value for the staff review of a licensing-basis revision, or about $84,000 for each licensee submittal, and a one-time NRC cost of $1.4 million assumed for the staff analysis of the generic issues and rulemaking involved to eliminate the requirement. This cost would be divided between staff effort and contractor services, as appropriate. Rulemaking costs associated with option 2 of about $100,000 are not included in the total NRC cost for this option.

4. Option 4

Under this option, the staff would revise several parts of Appendix K, and some plants could then decide to seek higher licensed power levels under the revision. Because a more far-reaching rule change would reduce conservatisms by more than just a change to the power measurement conservatism, a greater potential benefit should be expected. Thus, for this

option, the staff assumed that plants might realize a 5-percent power uprate if Appendix K were broadly revised. The licensee costs involved with such a power uprate for a facility could be expected to be somewhat more than costs assumed for the 1-percent change. The staff assumed that the costs to support and then implement such a change would roughly double, to about $10 million and $20 million per plant, respectively. The NRC rulemaking and review costs for this option are more difficult to estimate, but an increase to about $5 million for a multi-year rulemaking effort requiring extensive technical support is reasonable. The differential of $100,000 associated with the option 2 rulemaking is relatively small and is not considered here. The NRC cost to review each more extensive amendment would also roughly double to about $100,000. Thus, each licensee's cost would total about $27 million, and the NRC would incur costs of as high as $10 million for the overall effort involved. This option would also take much longer to implement than the others.

E. Backfit Considerations

The NRC has determined that the backfit rule in 10 CFR 50.109 does not apply to this amended regulation and that a backfit analysis is not required for this change because the revised rule does not involve any provisions that would impose backfits as defined in 10 CFR 50.109(a)(1). This revised rule amends the NRC's regulations by establishing an alternate requirement that licensees may voluntarily adopt.

F. Impacts on Other Programs, Other Agencies

The only potential impact the staff foresees is that further changes to Appendix K could result from the proposed risk-informed review of 10 CFR Part 50, discussed in SECY-98-300.

Cost Estimates for Rulemaking Options (1999 dollars)

Option[1]	No. of Plants	Licensee Costs (per plant)			Licensee Total (each option)	NRC Costs			NRC Total (each option)	OVERALL TOTAL
						(per plant)		(generic)		
		Request Margin Change	Request Power Uprate	Effect Power Uprate		Process Margin Change	Process Power Uprate	Rule & Guide Changes		
No Rule Change	50	$75K[2]	$5M	$10M	$754M	$63K[2]	$42K	--	$5.3M	$759M
2	50	$75K	$5M	$10M	$754M	$42K	$42K	$54K	$4.3M	$758M
3	50	$75K	$5M	$10M	$754M	$42K	$42K	$1.4M	$5.6M	$760M
4	50	--	$10M	$20M	$1.5B	--	$100K	$5M	$10M	$1.51B

Notes: 1. Options 2 and 3 consider a 1-percent power uprate; option 4 involves a 5-percent power uprate. Option 1 was not considered in the value-impact analysis.
2. Costs of preparing/reviewing the exemption request are included.

V. DECISION RATIONALE

The safety impact of options 2 and 3 is essentially equivalent to the baseline, or no-rule-change alternative, because licensees for 50 plants are expected to submit exemption requests for the relief offered by the revised rule, if it were not issued. The staff has previously determined that there is negligible risk impact from a marginal increase in licensed power; therefore, public health and safety and common defense and security continue to be adequately protected. Therefore, the staff considered value impact attributes related to health effects and property loss resulting from accidents to be unchanged by the revised rule.

Cost and benefit estimates are summarized in the table that follows. Differences in overall costs between options 2 and 3 and the no-rule-change alternative are small, and these values should be assumed equivalent. Also, the financial benefits under each option evaluated are equivalent. As a result, the attributes contributing to the final selection of a rulemaking alternative were limited to regulatory efficiency implications. When data were readily available, the staff made quantitative approximations for the factors. However, the evaluation was eventually qualitative, since the benefit of regulatory efficiency maintained by avoiding large numbers of exemptions is difficult to quantify.

The preferred rulemaking alternative is option 2. The no-rule-change alternative could not be eliminated on the sole basis of overall cost considerations. The staff then considered NRC precedent for revising rules to eliminate or avoid excessive numbers of exemption requests as a basis for narrowing the choices to options 2, 3, and 4. Although a broad revision to Appendix K (option 4) could provide greater relief from ECCS analysis requirements (benefits are assumed to increase proportionally compared to the 1-percent power increase), such a change could not be completed in the short term. The NRC is currently prioritizing such a revision along with other changes expected to be pursued to revise Part 50 on a risk-informed basis. Option 3 would take longer to implement than option 2 because of the more involved technical justification that would be required, as discussed earlier. Also, the NRC costs are expected to be somewhat greater for option 3. The anticipated benefits of the two remaining options are the same.

Decision Rationale Summary

Option	No. of Plants	Cost			Benefit	
		Licensees	NRC	Total	Annual	Lifetime
No Rule Change	50	$754M	$5.3M	$759M	$50M–135M	$488M–$1.3B
2	50	$754M	$4.3M	$758M	$50M–135M	$488M–$1.3B
3	50	$754M	$5.6M	$760M	$50M–135M	$488M–$1.3B
4	50	$1.5B	$10M	$1.51B	$250M–675M	$2.4B–6.6B

The industry has expressed its intention of submitting numerous requests for exemption from Appendix K to ease the assumed power level requirement. The exemption requests could be avoided or minimized by an expeditious rulemaking. In the interest of regulatory efficiency, the staff is revising the rule now, rather than proposing more involved action that will take much longer to implement. The simple revision contained in option 2 eliminates an unnecessary regulatory burden with little potential for adverse risk impact, and can be achieved relatively quickly.

VI. IMPLEMENTATION

The final rule will become effective 30 days following publication in the Federal Register.

VII. REFERENCES

1. U.S. Nuclear Regulatory Commission, Letter from EDO to ACRS, “Staff Response to ACRS Letter of July 24, 1998 on General Electric Nuclear Energy Extended Power Uprate Program and Monticello Nuclear Generating Plant Extended Power Level Increase Request,” September 14, 1998.

2. U.S. Nuclear Regulatory Commission, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” NUREG-0800, Washington, D.C., July 1981.

3. U.S. Nuclear Regulatory Commission, “Power Levels of Nuclear Power Plants,” Regulatory Guide 1.49, Revision 1, Washington, D.C., December 1973.

4. U.S. Nuclear Regulatory Commission, “Options for Risk-Informed Revisions to 10 CFR Part 50—‘Domestic Licensing of Production and Utilization Facilities’,” SECY-98-300, Washington, D.C., December 23, 1998.

5. U.S. Nuclear Regulatory Commission, “Planning for Pursuing Regulatory Improvement in the Area of Exemptions Granted to Regulations,” SECY-96-147, Washington, D.C., July 1, 1996.

6. U.S. Nuclear Regulatory Commission, “Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission,” NUREG/BR-0058, Revision 2, Washington, D.C., November 1995.

7. U.S. Department of Energy, Energy Information Agency, “Electric Power Monthly,” DOE/EIA-0226(99/04), Washington, D.C., April 1999 (available at www.eia.doe.gov).

8. Utility Data Institute, “1995 Production Costs—Operating Steam-Electric Plants,” UDI-2011-96, Washington, D.C., September 1996.

9. “Plant Uprates Seen as Cheap Way to Meet Competitive Pressures,” *Nucleonics Week*, Vol. 36, No.38, September 21, 1995.

10. U.S. Nuclear Regulatory Commission, “Generic Cost Estimates,” NUREG/CR-4627, Rev. 2, Washington, D.C., February 1992.

11. Westinghouse Corporation, Letter from E.P. Rahe, to Dr. D.F. Ross, NRC, “LOCA Margin Benefits,” February 8, 1985.

12. U.S. Nuclear Regulatory Commission, “Regulatory Analysis Technical Evaluation Handbook,” NUREG/BR-0184, Washington, D.C., January 1997.

13. U.S. Nuclear Regulatory Commission, “Compendium of ECCS Research for Realistic LOCA Analysis,” NUREG-1230, Washington, D.C., December 1988.

Attachment 3

Environmental Assessment

ENVIRONMENTAL ASSESSMENT

REVISED 10 CFR PART 50, APPENDIX K

This document examines the environmental impacts of NRC's regulatory actions in accordance with 10 CFR Part 51, for a rulemaking addressing NRC's current emergency core cooling systems (ECCS) evaluation requirements for nuclear power reactors. NRC is modifying these requirements, which are contained in Appendix K to 10 CFR Part 50. The rule provides a voluntary option for licensees to apply a reduced margin between the licensed power level and the assumed power level for ECCS evaluation. The currently required analysis margin is 2 percent of licensed reactor power.

NRC's regulations for implementing Section 102(2) of the National Environmental Policy Act of 1969 (NEPA), as amended, are contained in Subpart A of 10 CFR Part 51. These regulations require that an environmental impact statement or an environmental assessment be prepared for all licensing and regulatory actions that are not classified as "categorical exclusions" in accordance with 10 CFR 51.22(c) and are not identified in 10 CFR 51.22(d) as other actions not requiring environmental review.

This document presents the findings of NRC's environmental assessment of the final rule.

Identification of the Action

A holder of an operating license (i.e., the licensee) for a light-water power reactor is required by regulations issued by the NRC to submit a safety analysis report that contains an evaluation of ECCS performance under accident conditions. Section 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," requires that ECCS performance under loss-of-coolant accident (LOCA) conditions be evaluated and that the estimated performance satisfy certain criteria. Licensees may conduct an analysis that "realistically describes the behavior of the reactor system during a LOCA" (often termed a "best-estimate analysis"), or they may develop a model that conforms with the required and acceptable features of Appendix K to 10 CFR Part 50. Most ECCS evaluations are based on Appendix K requirements. The opening sentence of Appendix K establishes the requirement to conduct ECCS analyses at a specified power level: "It shall 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 such uncertainties as instrumentation error)."

The final rule gives licensees the option to apply a reduced margin between the licensed power level and the assumed power level for ECCS evaluation. The current margin of 2 percent power may be maintained, if preferred. If licensees can show that the uncertainties associated with power measurement instrumentation errors are less than 2 percent, and a smaller margin can be justified, then the current rule unnecessarily restricts operation of some facilities by limiting their ability to operate at higher power levels, and in other cases by imposing unnecessary requirements on ECCS performance.

Appendix K to 10 CFR Part 50 was written to define conservative analysis assumptions for ECCS performance evaluations during design-basis LOCAs. Large margins for important safety parameters were provided by conservatively selecting the ECCS performance criteria as

well as conservatively establishing ECCS calculational requirements. The staff has long recognized that Appendix K incorporated substantial conservatisms and previously had considered methods that would acceptably reduce safety margins. The conservatisms were necessary when the rule was written because of a lack of experimental evidence at that time. When the NRC adopted changes to 10 CFR 50.46 to allow "best-estimate" modeling, it concluded that experimental evidence gained since the original rule was implemented and analysis advances allowed the consideration of alternative approaches. In the final rule, the staff is extending the application of its understanding of ECCS evaluation conservatism to allow relaxation of one of several conservative analysis features.

The current analytical approach of assuming 102 percent of licensed power for ECCS evaluation is adequate to protect public health and safety; therefore, the NRC does not intend to backfit a change to the regulation on operating reactors. Because the amendment does not constitute a backfit, the bases for current ECCS evaluations must be preserved. Therefore, the provision retains the current requirement as an option for licensees.

Need for the Action

The objective of this rulemaking is to allow the voluntary relaxation of an unnecessarily burdensome regulatory requirement. Appendix K was issued to ensure an adequate performance margin of the ECCS in the event a design-basis LOCA were to occur. The margin is provided by conservative features and requirements of the evaluation models and by the ECCS performance criteria. By allowing a smaller margin for power measurement uncertainty, the revised rule does not undermine the underlying purpose of Appendix K.

A secondary objective is to avoid unnecessary exemption requests. The staff has previously sought rule changes to avoid the prospect of multiple exemption requests. In the case of this change to Appendix K, the staff is anticipating recurrent exemptions and has determined that revising the rule at this early stage is the best course.

Environmental Impacts of the Action

The final rule modifies an analysis assumption for ECCS evaluation, not actual LOCA effects. Use of a reduced power margin alone cannot affect core damage frequency, the large early release frequency, or actual accident release consequences. The actual accident sequence and progression of a LOCA are not changed unless the licensee modifies its facility. However, the final rule may have indirect effects on the environment by allowing licensees to pursue changes to their facilities such as increases to licensed power.

The most obvious change a licensee might pursue under the final rule is to increase the licensed power of the facility without conducting ECCS evaluations at a higher power level. Licensees requesting higher licensed power levels are required to assess environmental effects of the change. However, the NRC expects only negligible effects on the environment from small power level changes, such as those that are likely to result from the revised rule. The NRC previously considered the effects of small increases in licensed power level and concluded that such changes would present little change in risk. In NUREG-1230 (Reference 2), the staff considered the risk impact of changes associated with the revised ECCS rules allowing best-

estimate analyses, including power increases, and determined that a power level increase of 5 percent or less had little risk significance. This conclusion was, in part, based on the staff's estimate that a small power level increase would only slightly increase the fission product inventory. Also, the staff judged that a slightly higher power would not appreciably alter the potential for LOCAs or affect predicted accident progression.

The staff also considered the risk impact from boiling water reactor extended power uprates, which are much greater than the marginal power change expected under the revised rule. In these cases, the staff concluded (Reference 3) that extended power uprates are expected to only slightly affect the risk profile of a plant. The staff also stated that marginal power uprates, of about 1 percent, were not expected to require an assessment of plant risk.

An overall affect of a power uprate for a large number of plants is the possible increase in the amount of spent fuel generated by operating at higher power. For the purposes of this assessment, the staff assumed a linear relationship between power level and amount of fuel discharged, and a 1-percent power level increase for 50 plants. Using information on predicted fuel discharges contained in the "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (Reference 4), the staff estimated that a marginal power increase for half the operating plants would amount to a total of approximately 70 additional discharge fuel bundles per year. This is less than the number of fuel bundles discharged during a typical reactor refueling for a plant. There is a potential cumulative effect associated with the anticipated annual increase in discharged fuel. However, it is not considered significant in light of the cumulative level of all fuel discharges during the lifetime of an operating facility.

Under the final rule, some licensees could realize savings without seeking power uprates. By revising their ECCS analysis based on a lower assumed power level, licensees could gain margin that could lead to a relaxation in requirements for LOCA mitigation system (i.e., ECCS) performance or in core operating parameters. Changes to technical specifications requirements for ECCS system performance will require license amendments and licensees will need to determine environmental impacts. In these cases involving relatively small changes to ECCS analyses, the staff expects that no significant environmental impact would result.

The action, as well as its indirect and cumulative effects, would not increase the probability or consequences of accidents; no changes are being made in the types of any effluents that may be released off site; and there is no significant increase in occupational or public radiation exposure. Therefore, there are no significant radiological environmental impacts associated with the change. The action does not involve non-radiological plant effluents and has no other environmental impact. Therefore, there are no significant non-radiological environmental impacts associated with the action.

Alternatives to the Action

As required by Section 102(2)(E) of the NEPA (42 U.S.C.A. 4332(2)(E)), the NRC has considered possible alternatives to the action. The staff considered the following rulemaking options: (1) maintain the provision requiring an analysis margin to account for uncertainty in

power measurement but remove the specification of the 2-percent value for the margin and require licensees to assess power measurement uncertainty; (2) eliminate the requirement for a margin between power level and assumed power, disregarding power measurement uncertainty; and (3) broadly revise Appendix K, addressing several conservative parameters.

The alternative of retaining the existing assumed power requirement (i.e., no-action alternative) would essentially have the same environmental impact as rulemaking alternatives 1 and 2 if licensees pursued exemptions from the current Appendix K requirement. Under the no-action alternative, licensees could also consider the more costly alternative of implementing a best-estimate ECCS evaluation under § 50.46. However, fewer licensees are expected to take this course, because if there currently were sufficient benefit, they would have already done so. The potential power increase under a best-estimate evaluation is expected to be greater than the marginal power increase associated with the revised rule. However, the fewer licensees that would use this option reduces the resulting overall environmental impact. The staff assumed that the environmental impact for either scenario under the no-action alternative would be roughly equivalent.

The environmental effects for the first two alternatives would be roughly equivalent, because about the same number of licensees would seek benefits under any change that would allow a relaxation in the requirement. The main distinction between these alternatives is the course taken to revise the rule. But the end result is the same, in that a marginal power increase would be an indirect result. As discussed earlier, the staff considers marginal power increases to present little risk on a plant-specific basis and the overall effect of increased spent fuel generation is considered small.

The final rulemaking option, to broadly revise Appendix K requirements, could allow greater increases in licensed power for operating plants. However, since there is not a clear understanding of the magnitude of the changes that might result, the staff can only speculate that such a revision would lead to power uprates somewhat greater than those expected under the revised rule. The resulting power increases may be commensurate with those associated with previous changes considered by the staff, such as those discussed in NUREG-1230, which were not considered risk-significant.

Therefore, none of the alternatives considered by the staff is expected to significantly affect the environment.

Agencies and Persons Consulted

The NRC developed the final rule and this environmental assessment. The proposed rule was published in the *Federal Register* for all interested parties to review. The NRC sent this environmental assessment to all State liaison officers for comment. No substantive comments were received.

Finding of No Significant Impact

On the basis of the environmental assessment, the Commission concludes that the action will not have a significant effect on the human environment. Accordingly, the Commission has determined not to prepare an environmental impact statement for the action.

Also, the NRC is committed to following Executive Order 12898, "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations," dated February 11, 1994. Since there are no significant offsite impacts on the public from this action, the NRC has determined that there are no disproportionately high and adverse impacts on minority and low-income parties. The NRC uses the following working definition of environmental justice: *Environmental justice* means the fair treatment and meaningful involvement of all people, regardless of race, ethnicity, culture, income, or educational level with respect to the development, implementation and enforcement of environmental laws, regulations, and policies.

References

1. *Code of Federal Regulations*, Title 10, Chapter I, Parts 50 and 51.

2. U.S. Nuclear Regulatory Commission, "Compendium of ECCS Research for Realistic LOCA Analysis," NUREG-1230, Washington, D.C., December 1988.

3. U.S. Nuclear Regulatory Commission, Letter from EDO to ACRS, "Staff Response to ACRS Letter of July 24, 1998 on General Electric Nuclear Energy Extended Power Uprate Program and Monticello Nuclear Generating Plant Extended Power Level Increase Request," September 14, 1998.

4. U.S. Nuclear Regulatory Commission, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," NUREG-1437, Volume 1, Washington, D.C., May 1996.