MEMORANDUM TO: Samuel J. Collins, Director  
Office of Nuclear Reactor Regulation  

FROM: Ashok C. Thadani, Director /RA/  
Office of Nuclear Regulatory Research  

SUBJECT: TRANSMITTAL OF TECHNICAL WORK TO SUPPORT POSSIBLE RULEMAKING ON A RISK-INFORMED ALTERNATIVE TO 10 CFR 50.46/GDC 35  

Summary  
In both SECY-01-0133 and SECY-02-0057, the staff recommended development of a possible risk-informed alternative to reliability requirements in 10 CFR 50.46/General Design Criterion (GDC) 35, as part of Option 3 for risk-informing the technical requirements of 10 CFR Part 50. Two voluntary performance-based options (one plant-specific, and one generic) were recommended that would demonstrate that the emergency core cooling system (ECCS) safety function can be reliably accomplished without assuming loss of offsite power (LOOP) coincident with a loss-of-coolant accident (LOCA), and with a single additional failure.

The purpose of this memorandum is to provide you with the technical work performed to support the potential risk-informed alternative to GDC 35. The results of this technical work indicate that:

- The staff should move forward to eliminate, on a generic basis, the ECCS design requirement for consideration of an assumed LOOP coincident with large, and possibly medium, LOCAs (based on the initial LOCA frequency estimates and conditional LOOP probabilities obtained as part of this effort, and documented in the attached report).

- A risk-informed alternative to GDC 35 which addresses overall ECCS reliability and the single failure criterion, on a plant-specific basis, is feasible. Our work indicates that there are a number of issues (which are discussed below) that would need to be addressed; in particular, since total plant risk needs to be accounted for, most licensees would need to update their probabilistic risk assessment (PRA) models to make them full-scope (i.e., address all internal and external events, and all modes of plant operation), and assess the uncertainties.

- The staff should not further pursue, on a generic basis, a risk-informed alternative to GDC 35 which addresses overall ECCS reliability and the single failure criterion, due in large part to (1) the lack of full-scope PRA models available to the staff, and (2) the significant differences between plants.

In addition, an assessment of the feasibility of the redefinition of the spectrum of pipe break sizes relevant to 10 CFR 50.46 is ongoing, and is scheduled to be completed by July 2004.
A team of NRR and RES staff has been established for the purpose of considering, proposing and delivering a new risk-informed rule.

**Background**

The Nuclear Regulatory Commission's (NRC) policy statement on probabilistic risk analysis (PRA) encourages greater use of PRA to improve safety decisionmaking and regulatory efficiency. Consistent with this policy, and with Commission approval, a study of risk-informing the technical requirements of 10 CFR Part 50 (Option 3) has proceeded. Based, in part, on input from stakeholders, the requirements for the analysis of design basis LOCAs contained in 10 CFR 50.46 and Appendix K to Part 50, and the ECCS requirements in GDC 35 were chosen as high-priority candidates for study and possible change.

An assessment of the feasibility of changes to existing ECCS-related regulatory requirements was conducted and provided to the Commission with SECY-01-0133. In SECY-01-0133 (and in SECY-02-0057, an update to SECY-01-0133) the staff recommended changes to the technical requirements of the current 10 CFR 50.46 related to acceptance criteria and evaluation model(s), and development of a possible risk-informed alternative to reliability requirements in 10 CFR 50.46/GDC 35. In addition, the staff recommended continued assessment of the feasibility of the redefinition of the spectrum of pipe break sizes relevant to 10 CFR 50.46. In these papers, the staff indicated that RES would perform the technical studies. Upon completion, the studies would be provided to NRR to support possible rulemakings.

The technical work in support of the possible changes to the ECCS acceptance criteria and evaluation models was addressed in a previous memorandum (A. Thadani to S. Collins, June 20, 2002 [ADAMS Accession No. ML021720744]), and has been provided to the Commission to support their consideration of SECY-01-0133 and SECY-02-0057. Assessment of the feasibility of the redefinition of the spectrum of pipe break sizes relevant to 10 CFR 50.46 is ongoing, and is scheduled to be completed by July 2004. This memorandum addresses the technical work regarding the proposed risk-informed alternative to the ECCS reliability requirements. It is also being forwarded to the Commission. The attached report represents the final deliverable defined in SECY-02-0057, with the exception of the long-term feasibility study on redefinition of the spectrum of pipe break sizes relevant to 10 CFR 50.46. As such, NRR should now be in a position to better determine its approach for rulemaking to implement changes to 10 CFR 50.46 and GDC 35.

As stated in both SECY-01-0133 and SECY-02-0057, two voluntary performance-based options were recommended that would demonstrate that the ECCS safety function can be reliably accomplished without assuming loss of offsite power coincident with a LOCA, and with a single additional failure. One option involves a plant-specific approach, where licensees would demonstrate ECCS safety function reliability commensurate with LOCA frequency, consistent with NRC-specified risk guidelines. The other option involves a generic approach in which the staff defines, by plant group, a representative PRA model, and then uses the model to identify alternative ECCS configurations that meet established risk guidelines.
Summary of Technical Evaluation

The attached report is intended to evaluate the plant-specific and generic options for implementing a change to GDC 35. Earlier this year we forwarded to you a draft report providing the technical work to support the plant-specific approach to a risk-informed alternative to 10 CFR 50.46, specifically in regard to the ECCS reliability requirements contained in GDC 35 of Appendix A to 10 CFR Part 50 (S. Newberry to D. Matthews, May 7, 2002). The attachment to this memorandum is the final version of the report providing the technical work to support consideration of both the plant-specific and generic approaches to a risk-informed alternative to 10 CFR 50.46/GDC 35.

Technical work was performed by RES in a number of principal areas, a summary of which follows:

- **Risk guidelines/thresholds for assessing reliable ECCS safety function.** The recommended acceptance measures to be used for the risk-informed alternative to the ECCS reliability requirements are core damage frequency (CDF) and large early release frequency (LERF). The recommended acceptance guidelines for currently operating reactors are as follows: (1) the total plant (i.e., full-scope PRA) CDF and LERF threshold values should be established at $10^{-4}$/yr and $10^{-5}$/yr, respectively, and (2) the CDF and LERF acceptance guidelines in RG 1.174 should be used to limit any risk increase.

- **LOCA frequencies.** Interim LOCA frequencies have been estimated based on an informal, in-house expert elicitation for use in performing calculations to assess the feasibility of the generic approach to establish ECCS reliability requirements commensurate with the frequency of challenges to the system (described below). The result of the elicitation was that the estimated frequencies in NUREG/CR-5750 ("Rates of Initiating Events at U.S. Nuclear Power Plants: 1987-1995") were increased by a factor of approximately two for large-break LOCAs (due primarily to consideration of aging-related failure mechanisms), up to a factor of approximately four for small-break LOCAs (due primarily to consideration of aging-related failure mechanisms and inclusion of non-pipe-break LOCAs). These interim LOCA frequencies are provided in Table 4.1 of the attached report. Consistent with SECY-02-0057, RES has implemented a more formal expert elicitation process to obtain more robust LOCA frequencies in the time frame projected for possible rulemaking.

- **Conditional probability of a LOOP given a LOCA.** A method for plant-specific estimation of conditional LOOP probability given a LOCA is proposed, since typical PRAs do not account for the dependence between a LOCA (or any reactor trip) and a consequential LOOP. The proposed method, which could be incorporated into a regulatory guide, assesses the probability of consequential LOOP caused by both transient (grid-related) factors and plant-centered factors (failures of plant electrical equipment).

In addition, a set of proposed generic values for the conditional LOOP probability following a LOCA ($\sim 2 \times 10^{-2}$) and following a non-LOCA reactor trip ($\sim 2 \times 10^{-3}$) have been developed. These have been used in performing calculations to assess the feasibility of the generic approach, and could also be provided as an option for use by licensees under the plant-specific approach.
• **Generic plant grouping.** An approach for establishing plant groups is provided. The approach considers several factors for placing plants into generic groups, and includes development of a representative configuration for each identified plant group. A description of the representative configuration for the BWR class 3/4 plants is provided.

• **Initial generic calculations.** A modified version of the Peach Bottom SPAR 3i model was used to reflect the representative configuration for the BWR 3/4 plant group. Calculations using this model were used to (1) confirm that the base case of the model met the recommended acceptance guidelines, and (2) evaluate alternative ECCS configurations, technical specifications, and design basis requirements. These calculations indicate that for the representative model, the recommended acceptance guidelines:
  - are met only with credit for non-ECC injection systems (e.g., control rod drive hydraulic system or reactor core isolation cooling system),
  - can be met even with relaxation of allowed outage times for some ECCS equipment (assuming some credit for non-ECC injection systems),
  - can be met even with reduced ECCS redundancy (assuming some credit for non-ECC injection systems), and
  - may be met even if a plant is not designed to mitigate a large or medium LOCA and a coincident LOOP.

• **Uncertainties.** A discussion of the treatment of uncertainty is provided in the attached report (Sections 3.1.3, 4.1 and 5.5). Because of the way the acceptance guidelines were developed, the appropriate numerical measures to use in the initial comparison of the PRA results to the acceptance guidelines are mean values. The mean values referred to are the means of the probability distributions that result from the propagation of the uncertainties on the input parameters and those model uncertainties explicitly represented in the model. The treatment of uncertainty is consistent with the guidance in RG 1.174.\(^1\)

A more detailed description of the technical work performed in each of the above technical areas is provided in the attached report. Note that neither the report, nor the technical work it is based on, address reactor security implications.

**Perspectives on Possible Changes to GDC 35**

With respect to the plant-specific approach, our work indicates that the approach continues to be feasible. Use of such a plant-specific reliability design requirement in GDC 35 has the potential to improve the coherence between design requirements, operational requirements, and oversight processes (e.g., recent work on technical specifications, the Maintenance Rule, and the Reactor Oversight Program, respectively). In addition, this approach could be implemented in other regulatory requirements that now use the single failure criterion as a way

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\(^1\)Additional guidance on treatment of uncertainties is being developed and is expected to be included in the next revision of the framework for risk-informing 10 CFR Part 50. This additional guidance could be used to support any possible rulemaking associated with risk-informing the ECCS reliability requirements.
of ensuring high functional reliability, and could be of value in new requirements for advanced reactor designs.

There are, however, technical issues to be considered with respect to the plant-specific approach which could impact its practicality, including the availability of data required for plant-specific assessment of the conditional probability of LOOP given LOCA (or the appropriateness of the method used to obtain generic probabilities), and accounting for uncertainty not explicitly propagated in the PRA model. In addition, we have not looked at implementation issues, which could also affect the practicality of this approach. Lastly, a potential policy issue exists regarding the appropriateness of the recommended acceptance guidelines for a fundamental rule change, including consideration of appropriate margin for these guidelines, and the appropriateness of using less than full-scope PRA models.

With respect to the generic approach, some issues were identified which may make the generic approach impractical (discussed in Section 5 of the attached report). Of most concern are limitations in the scope and adequacy (for this application) of the plant PRA models available to the staff.

Whether or not the generic approach, as detailed in the attached report, is found to be practical, the staff should pursue the possible elimination of the LOCA-LOOP design requirement on a generic basis. Using the technical work on generic LOCA frequencies and conditional LOOP probability described above, we should be able to provide an adequate basis, generically, that the frequency of LOCAs for certain break size categories (e.g., large or medium), when combined with the conditional probability of a consequential LOOP, is below an NRC-established frequency threshold. By focusing only on event frequency, such an approach would not be subject to the current limitations in the scope and adequacy of the plant PRA models available to the staff. Considering the low estimated LOCA-LOOP frequency (particularly for large LOCAs) and the potential for unquantified benefits (e.g., reduced demands for rapid response by valves, pumps and diesel generators) and other mitigating factors (e.g., available time for operator recovery actions), we support moving forward with this option.

Next Steps

As discussed in SECY-02-0057, one or more rulemakings may result from the technical work described in the June 20, 2002, memorandum and here. We have included resources for technical support for such rulemakings in our proposed FY2003 and FY2004 budgets. As your rulemaking plans become more clear, we will use the PBPM process to assess the need for and sufficiency of these resources. We will continue to support the NRR/RES working group that has been formed for the purpose of considering, proposing and delivering a new risk-informed rule.
If you or your staff have any questions on the RES technical work, please contact the following:

**ECCS reliability requirements (GDC 35):**
- Alan Kuritzky 415-6255

**ECCS acceptance criteria and evaluation models:**
- Steve Bajorek 415-7574

**Redefinition of spectrum of break sizes:**
- Rob Tregoning 415-6657

Attachments: As stated

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