United States Nuclear Regulatory Commission
Office of Public Affairs
Washington, DC 20555
Phone 301-415-8200 Fax 301-415-2234
Internet:opa@nrc.gov

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NOTE TO EDITORS:

The Nuclear Regulatory Commission has received three reports from its Advisory Committee on Reactor Safeguards. The reports, in the form of letters, provide comments on:

-- Proposed regulatory guidance related to the implementation of 10 CFR 50.59 (changes, tests and experiments).

-- Risk-based regulatory acceptance criteria for plant-specific application of safety goals.

-- Establishing a benchmark on risk during low-power and shutdown operations.

Copies of the reports are available through the NRC's Office of Public Affairs and the Public Document Room in Washington, D.C.

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ACRSR-1691

April 8, 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Jackson:

SUBJECT: PROPOSED REGULATORY GUIDANCE RELATED TO IMPLEMENTATION OF 10 CFR 50.59 (CHANGES, TESTS AND EXPERIMENTS)

During the 440th meeting of the Advisory Committee on Reactor Safeguards, April 3-4, 1997, we met with representatives of the NRC staff and the Nuclear Energy Institute (NEI) regarding SECY-97-035, "Proposed Guidance Related to Implementation of 10 CFR 50.59 (Changes, Tests and Experiments)." We discussed the staff's approach to clarifying guidance for implementing 10 CFR 50.59 and proposed options for resolving policy issues.

Conclusions and Recommendations

We recommend that SECY-97-035, as now formulated, not be issued for public comment. We recommend, instead, additional NRC and industry interaction regarding this matter before the proposed guidance in SECY-97-035 is issued for public comment.

Discussion

The industry and staff have over 30 years of experience in implementing 10 CFR 50.59. Over this time, the staff has identified concerns in only a small subset of situations evaluated under 10 CFR 50.59. In SECY-97-035, the staff stated the following with regard to the current process and industry implementation of NSAC-125:

> Although the staff has not endorsed NSAC-125, it has concluded, as discussed in the April 15, 1996, memorandum from James M. Taylor to Chairman Jackson, that NSAC-125 has given the nuclear power industry a reasonable foundation to establish a process that will, in most instances, produce effective evaluations related to changes to plant design or procedures. Changes of

significance are highly likely to be identified by the licensee through implementation of the NSAC-125 guidance. Inspection results have confirmed that the quality of the evaluations of changes has improved since licensees began implementing the NSAC-125 guidance. However, the NSAC-125 guidance is not a requirement for any licensee, and each licensee develops its own program for performing the required evaluations under 10 CFR 50.59.

The staff also found that difficulties arise in the licensee's day-to-day use of the 10 CFR 50.59 process when the staff and licensee have a different understanding and different expectations for implementation of the rule. The staff, therefore, is proposing additional regulatory guidance in SECY-97-035 to reduce the potential for deficiencies in implementing 10 CFR 50.59. Since the staff appears to agree that when the NSAC-125 guidance has been implemented properly it has generally resulted in satisfactory safety evaluations, it would seem more effective to work with the industry to build on NSAC-125. The goal would be for the staff to endorse an appropriate version of NSAC-125 with exceptions, as needed. It is our understanding that the industry has attempted to improve on NSAC-125 through the development of draft guideline NEI 96-07, "Guidelines for 10 CFR 50.59 Safety Evaluations." These improvements may well address many of the present concerns.

Sincerely,

/s/

R. L. Seale
Chairman

References:

1. SECY-97-035, Memorandum dated February 12, 1997, from H. L. Thompson, Jr., Acting Executive Director for Operations, NRC, for the Commissioners, Subject: Proposed Regulatory Guidance Related to Implementation of 10 CFR 50.59 (Changes, Tests and Experiments).
2. Memorandum dated April 15, 1996, from James M. Taylor, Executive Director for Operations, NRC, to Shirley Ann Jackson, Chairman, NRC, Subject: Action Plan for Improvements to 10 CFR 50.59 Implementation and Oversight.
3. Electric Power Research Institute, Nuclear Safety Analysis Center, NSAC-125, "Guidelines for 10 CFR 50.59 Safety Evaluations," June 1989.
4. Nuclear Energy Institute, NEI 96-07, draft Revision A, "Guidelines for 10 CFR 50.59 Safety Evaluations," July 1996.

ACRSR-1694

April 11, 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Jackson:

SUBJECT: RISK-BASED REGULATORY ACCEPTANCE CRITERIA FOR PLANT-SPECIFIC APPLICATION OF SAFETY GOALS

In our December 6, 1996 meeting with the Commission, we committed to provide an example of how risk-acceptance criteria could be developed directly from the Safety Goals. Additionally, in a Staff Requirements Memorandum dated January 14, 1997, the Commission asked for our views on the relationship between the concept of "adequate protection," as used in the NRC regulations, and the NRC Safety Goals, from the standpoint of level of risk.

During the 440th meeting of the ACRS, April 3-4, 1997, we completed our deliberations on plant-specific application of NRC Safety Goals and the relationship between the concept of "adequate protection" and the Safety Goals. In our November 18, 1996 report on this subject, we stated that "the safety goals and subsidiary objectives can and should be used to derive guidelines for plant-specific applications." We noted that full-scope Level 3 probabilistic risk assessments (PRAs) would be necessary to use the quantitative health objectives (QHOs) directly to assess the acceptability of plant-specific risk. We also stated that this assessment of risk could be done in terms of the QHOs, along with the core damage frequency (CDF), or in terms of the CDF and large, early release frequency (LERF).

This report further discusses the need for plant-specific application of risk-acceptance criteria and the appropriateness of these criteria being derived from the Safety Goal QHO on early fatalities. The additional comments to this report provide examples of approaches that could be used to quantify lower tier acceptance criteria (i.e., LERF, or CDF and conditional containment

failure probability) that will ensure that the early fatality QHO is met at each site. Quantification of the LERF at each site is needed to ensure the appropriateness of the choice of the LERF acceptance criterion proposed in draft Regulatory Guide DG-1061 and draft Standard Review Plan sections that support risk-informed, performance-based regulation.

Need for Plant-Specific Application

The Safety Goal Policy Statement makes it clear that the QHOs and the subsidiary goal on CDF were intended only to provide standards for the NRC to judge the overall effectiveness of its regulatory system. The Policy Statement specifically precludes enforcement of the Safety Goals on a plant-specific basis.

In the development of draft Regulatory Guide DG-1061 and the associated draft Standard Review Plan sections in support of risk-informed, performance-based regulation, the staff has found it necessary to propose risk-acceptance guidelines that can be applied on a plant-specific basis. These guidelines would be used, along with other considerations and inputs, for making judgments on the acceptability of requested changes to a licensee's current licensing basis. Reviewing plant-specific license amendments by using risk-acceptance guidelines is a positive action toward risk-informed, performance-based regulation.

We also note that, in the longer term, the Commission may want to consider having a quantified acceptable risk level to replace the current concept of "adequate protection." This risk level could eventually serve as an objective risk-acceptance criterion for many enforcement decisions.

Risk-Informed, Performance-Based Regulation

The Commission has directed the staff to increase the use of PRA in the regulatory process. We have endorsed this because we believe that a risk-informed, performance-based regulatory approach will lead to increased coherence in the regulatory system, to enhanced decision-making ability, and to technically defensible bases for granting regulatory relief.

A risk-informed, performance-based regulatory system ought not be implemented without the existence of top-level risk-acceptance criteria. The obvious choices for these criteria are the NRC Safety Goal QHOs. As it is the responsibility of the NRC to license individual plants and ensure adequate protection, there seems to be no alternative to plant-specific applications.

Relationship Between Adequate Protection and the Safety Goals

Currently, licensing acceptance criteria are embodied in the concept of "adequate protection." With this concept, a plant that is licensed and complies fully with the applicable rules and

regulations, is considered to meet the "adequate protection" standard. "Adequate protection" embodies protection of public health and safety against threats that can be quantified in terms of risk as well as threats, such as sabotage and diversion of special nuclear material, for which the risk cannot now be quantified. In the discussion that follows, the nonquantifiable aspects of adequate protection are set aside. Since there are many ways in which plants can be designed and operated within the confines of the regulations, the natural result is a spectrum of risk levels across the population of operating plants. This conclusion is consistent with the results of the recent Individual Plant Examination Program. Since each licensed plant must, by definition, provide adequate protection, the licensed plant that poses the highest level of risk places a bound on the quantified level of risk to be associated with "adequate protection."

Within the spectrum of risk, it is likely that there are plants with risk levels above the Safety Goals and other plants with risk levels below. If this is indeed the case, a single risk level that bounds "adequate protection" would be a risk level greater than the Safety Goal level. For those plants with risk levels below the Safety Goals, the difference between the plant risk and the Safety Goals can be viewed as margin. It is from some portion of this margin that plant-specific regulatory relief could be granted. For those plants with risk levels greater than the Safety Goals, the challenge will be to eventually reduce their risk to below the Safety Goal level within the confines of the backfit rule.

Regulatory Transparency

The unquantified "adequate protection" concept is not well understood by the general public because the public is unfamiliar with the regulatory process, the body of nuclear regulations, and associated underlying technical bases. We believe that a long-term objective of replacing the "adequate protection" concept with a well articulated and quantified "acceptable level of risk" if achievable, would enhance the public's understanding and acceptance of the regulatory process and would lead to a more uniform level of protection for all individuals living in the vicinity of nuclear plants.

We note that the use of risk-acceptance criteria such as the QHOs will add stability to the regulatory process. This is because the Safety Goals are determined primarily from considerations of societal risk, while the NRC rules and regulations, which are now used to specify adequate protection, change with time as our understanding of reactor safety issues evolves.

Safety Goals as Risk-Acceptance Criteria

It is our opinion that the QHOs are the appropriate choices for risk-acceptance criteria for plant-specific applications. The Safety Goals are the expression by NRC for "how safe is safe enough." In our opinion, this is what risk-acceptance criteria ought to be. As we stated in our August 15, 1996 report, the subsidiary CDF goal should be elevated to the status of a fundamental goal. Elevating the CDF subsidiary goal to the status of a fundamental goal can be considered as a defense-in-depth principle that provides balance between prevention and mitigation.

The early fatality QHO generally controls the risks from nuclear plant operations. Our understanding of risk associated with low-power and shutdown operations, or accidents initiated by external events in which emergency response is impeded, is not yet sufficient to draw definitive conclusions concerning the limiting QHO in these situations.

Additional comments by ACRS Member T. S. Kress are presented below.

Sincerely,

/s/

R. L. Seale
Chairman

Additional Comments by ACRS Member T. S. Kress

While I agree completely with the Committee's report, I think it could be augmented in two respects. First, it could make it clearer that, with respect to plant-specific application of the Safety Goals, we are making two related, somewhat radical proposals —— the second more so than the first:

1) That lower tier risk-acceptance criteria (CDF and LERF), now being proposed in Draft Regulatory Guide DG-1061 for use in making decisions regarding requested changes to a licensee's current licensing basis, be derived directly from the prompt fatality QHO and be of such value as to bound all current sites.

2) That, in the long run for enforcement purposes, the prompt fatality QHO be considered as the quantification of a risk level to replace "adequate protection."

Second, guidance on how lower tier criteria are to be derived from the QHO is needed. Consequently, I am including two attachments to these additional comments (one developed by me and a complementary one developed by ACRS Senior Fellow Rick Sherry). These provide examples of how to more rigorously derive the lower tier criteria. It is suggested that the staff consider these for use if the first proposal above is to be implemented.

Attachments:
1. Kress, T. S., "Risk-Based Regulatory Acceptance Criteria for Plant-Specific Application of Safety Goals," March 1997
2. Sherry, R. R., "Methodology for Estimating Offsite Early Fatality Risk in the Absence of a Level 3 PRA," March 1997

References:
1. Staff Requirements Memorandum dated January 14, 1997, from John C. Hoyle, Secretary, NRC, to John T. Larkins, Executive Director, ACRS, Subject: Meeting with ACRS, 9:30 A.M., Friday, December 6, 1996, Commissioners' Conference Room.

2. Report dated November 18, 1996, from T. S. Kress, Chairman, ACRS, to Shirley Ann Jackson, Chairman, NRC, Subject: Plant-Specific Application of Safety Goals.
3. Report dated August 15, 1996, from T. S. Kress, Chairman, ACRS, to Shirley Ann Jackson, Chairman, NRC, Subject: Risk-Informed, Performance-Based Regulation and Related Matters.
4. U.S. Nuclear Regulatory Commission, NUREG-1560, Volume 1, Part 1, "Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance," Summary Report, Draft Report for Comment, October 1996.
5. U.S. Nuclear Regulatory Commission Draft Regulatory Guide, Draft DG-1061, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Current Licensing Basis," dated February 28, 1997 (Predecisional).
6. U.S. Nuclear Regulatory Commission, Draft Standard Review Plan Chapter 19, Revision L, "Use of Probabilistic Risk Assessment in Plant-Specific,
Risk-Informed Decisionmaking: General Guidance," dated March 3, 1997 (Predecisional).

ACRSR-1696

April 18, 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Jackson:

SUBJECT: ESTABLISHING A BENCHMARK ON RISK DURING LOW-POWER AND SHUTDOWN OPERATIONS

This report is to draw attention to the critical need for developing an understanding of risk posed by low-power and shutdown operations at nuclear power plants. This need is apparent as a result of: (1) repeated events during these modes of power plant operations, (2) changes being made in plant operations in response to economic forces, and (3) the ongoing NRC initiative to develop risk-informed, performance-based regulation. We believe it is essential that the NRC staff undertake a quantitative examination of risk during low-power and shutdown operations at representative nuclear power plants. That is, the NRC staff needs to establish a high-quality benchmark on risk during low-power and shutdown operations comparable to that which it has derived for risk during power operations from the NUREG-1150 study [Ref. 1] and other sources. The benchmark for risk during low-power and shutdown operations should address the following:

- a representative range of plant types,
- all phases of low-power and shutdown operations,
- accidents initiated by internal fires and other external events,
- human performance, the unusual source term, radionuclide dispersal, and on-site populations that will affect the predictions of accident consequences, and
- uncertainties to a depth similar to that done for the risk benchmark for power operations.

A substantial effort will be required to develop the technical capabilities to conduct this benchmark risk analysis. Results of the benchmark risk analysis may suggest the need for refinements to the Commission's Safety Goals. In particular, the Commission may find from the results that it wants to specify limits on the tolerable durations of plant configurations that pose very high risks.

Our recommendation for a detailed benchmark analysis is based on the results of scoping risk studies done by the staff contractors [Refs. 2,3], the continuing string of worrisome events at plants during low-power and shutdown operations, and assessments of the risk significance of plant events by the Office for Analysis and Evaluation of Operational Data. The staff's contractors have done limited analyses of risk during one phase of shutdown operations at a pressurized water reactor with a subatmospheric containment [Ref. 2] and one phase of shutdown operations at a Mark III boiling water reactor [Ref. 3]. Results of these studies show that even when the risk for a short period of shutdown operations is normalized over a full calendar year, the risk is a significant fraction of the risk calculated for the same plant during power operations:

Boiling Water Reactor

	Power Operations	Shutdown Operations*
Mean Core Damage Frequency	4.1×10^{-6}	2.1×10^{-6}
Mean Early Fatality Risk	8.2×10^{-9}	1.4×10^{-8}
Mean Latent Cancer Fatality Risk	9.5×10^{-4}	3.8×10^{-3}

* Plant Operating Mode 5 (cold shutdown) only.

Pressurized Water Reactor

	Power Operations	Shutdown Operations*
Mean Core Damage Frequency	4.1×10^{-5}	4.2×10^{-6}
Mean Early Fatality Risk	2.0×10^{-6}	4.9×10^{-8}
Mean Latent Cancer Fatality Risk	5.2×10^{-3}	1.6×10^{-2}

* Mid-loop operation only.

These partial results, however, may not adequately reflect current operating practices. The industry has instituted new guidelines [Ref. 4] for low-power and shutdown operations that are intended to reduce risk. Several licensees are using software such as the Electric Power Research Institute's ORAM (Outage Risk Assessment and Management) to plan activities during low-power and shutdown operations. These software tools are based on risk insights derived from simplified probabilistic risk assessments. If the NRC staff is to provide effective safety oversight of low-power and shutdown operations, the staff will have to understand the technical bases of the software tools and the approximations in risk assessments that have been used to develop these tools. The availability of benchmark risk assessments for low-power and shutdown operations for representative plants akin to the benchmark risk assessments for power operations appears to be essential for the development of this understanding.

Despite the new guidelines and software tools developed by the nuclear power industry for low-power and shutdown operations, events that reveal safety vulnerabilities of the plants continue to occur. Among the more recent of these events are:

- The Wolf Creek plant was in a "hot shutdown" condition when activities involving the residual heat removal system created a flow path that allowed approximately 9,200 gallons of reactor coolant to transfer to the refueling water storage tank. Had this draining not been promptly terminated, the operability of the emergency core cooling system would have been compromised. The Accident Sequence Precursor Analysis indicated that this event had a high conditional core damage probability [Ref. 5]. The scoping studies of shutdown risk, however, suggested that a "hot shutdown" condition was of such a low risk significance that it did not merit quantification.

- Loss of core cooling was threatened by the formation of a nitrogen bubble in the reactor coolant system at the Haddam Neck plant as a result of an improper valve lineup. Injection of high-pressure nitrogen into the reactor vessel continued for over three days while the plant was in a "cold shutdown" condition. The water level in the reactor vessel was believed to have been displaced three feet below the vessel flange [Ref. 6].

- At the Cooper plant, about 10,000 gallons of water was inadvertently lost from the refueling cavity because a submerged valve was opened to the main steam line drains. It took over an hour for operators to identify the source of the loss of coolant inventory [Ref. 7].

Events during low-power and shutdown operations are consuming significant staff resources. At our meeting on December 5, 1996, we were told that more than 50 percent of recent events requiring Augmented Inspection Teams have occurred when plants were in low-power or shutdown conditions. Human errors during these conditions appear to be especially probable. A number of incidents that have occurred during low-power and shutdown conditions are reviewed in the report NUREG/CR-6093 [Ref. 8]. This report concluded that factors influencing operator actions are different from those typically regarded as important during full-power operations and states that: "Unlike full-power operations, large numbers of multiple concurrent tasks are possible during LP&S (low-power and shutdown) conditions. This has implications for both the PRA (probabilistic risk assessment) modeling process and the HRA (human reliability assessment) quantification process."

We are concerned that this situation will be exacerbated as the industry moves to longer cycle times with less frequent opportunities to exercise its low-power and shutdown operating procedures. The situation may also be exacerbated by industry efforts to shorten the duration of low-power and shutdown operations by increasing the intensity of activities during these periods. The industry will want to relieve burdens during outages by doing some maintenance while the plant is operating. For the staff to approve a trade-off between maintenance "on-line" and maintenance during outages, it will have to consider risk. To do this, the staff will have to gain an understanding of risk during low-power and shutdown operations commensurate with its understanding of risk during power operations.

The staff is now embarked on an effort to develop risk-acceptance criteria for providing regulatory relief to licensees. Staff judgments on these matters are based on a firm foundation concerning event probabilities during power operations derived both from the Individual Plant Examinations done by licensees and from its own benchmarking risk studies reported in NUREG-1150. There is no comparable basis for making judgments concerning the accident probabilities and risk during low-power and shutdown operations. At present, there is no defensible regulatory basis to determine the extent to which results obtained for power operations ought to be augmented to account for risk of low-power and shutdown operations. A more complete understanding of risks during all phases of nuclear plant operations is essential to ensure that regulations address real, significant risks and do not impose ad hoc measures to correct discovered deficiencies in the hope that these measures will also address risk-significant issues.

We believe it is essential for the success of the Commission's effort to adopt risk-informed, performance-based regulation that a more complete understanding of the full spectrum of risk be

established on a defensible technical basis. This more complete understanding is needed now as pivotal decisions are being made on the implementation of risk-informed, performance-based regulation. We do not believe that existing scoping analyses or further scoping efforts will establish adequate benchmarks concerning risk during low-power and shutdown operations. This is especially so in light of evidence that time-dependent human performance is important. Significant efforts may be needed to establish new risk assessment methods and to understand phenomena associated with core damage events and the dispersal of radioactivity during these phases of plant operations. We are confident that areas of substantial uncertainty will arise in the assessment of risk during low-power and shutdown operations. Defensible quantification of these uncertainties will require the same type of effort that was needed to quantify uncertainties in risk during power operations.

It will take time to develop a usefully complete understanding of risk during low-power and shutdown operations. We recommend that a well-planned, deliberate effort with realistic time schedules and extensive peer review be undertaken first to develop methods and technologies that may be needed and then to benchmark risk during low-power and shutdown operations.

Sincerely yours,

/s/

R. L. Seale
Chairman

References:

1. U.S. Nuclear Regulatory Commission, NUREG-1150, Vol. 1, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," December 1990.
2. U.S. Nuclear Regulatory Commission, NUREG/CR-6144, BNL-NUREG-52399, Vol. 1, Brookhaven National Laboratory, "Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry, Unit 1," Summary of Results, October 1995.
3. U.S. Nuclear Regulatory Commission, NUREG/CR-6143, SAND93-2440, Vol.1, Sandia National Laboratories, "Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1," Summary of Results, July 1995.
4. NUMARC 91-06, Nuclear Management and Resources Council, Inc., "Guidelines for Industry Actions to Assess Shutdown Management," December 1991.
5. U.S. Nuclear Regulatory Commission, Information Notice 95-03, Supplement 1, "Loss of Reactor Coolant Inventory and Potential

Loss of Emergency Mitigation Functions While in a Shutdown Condition," dated March 25, 1996.

6. U.S. Nuclear Regulatory Commission, Information Notice 94-36, Supplement 1, "Undetected Accumulation of Gas in Reactor Coolant System," November 1996.
7. U.S. Nuclear Regulatory Commission, AEOD/S96-02, "Assessment of Spent Fuel Pool Cooling," September 1996.
8. U.S. Nuclear Regulatory Commission, NUREG/CR-6093, "An Analysis of Operational Experience During Low Power and Shutdown and a Plan for Addressing Human Reliability Assessment Issues," June 1994.