No. S-35-92
Tel. 301-504-2240

INDIVIDUAL PLANT EXAMINATIONS -- A REGULATORY PERSPECTIVE

BY KENNETH C. ROGERS
COMMISSIONER
U.S. NUCLEAR REGULATORY COMMISSION

EXECUTIVE CONFERENCE ON IPEs: RESULTS, IMPACTS, AND A NEW PARADIGM
MARCO ISLAND, FLORIDA
OCTOBER 19, 1992

INTRODUCTION

Good morning, ladies and gentlemen. I am pleased to be with you today at this Executive Conference to discuss the broad regulatory perspectives of the Commission's, Individual Plant Examinations (IPEs) initiative. I wish to compliment the organizers of this Executive Conference, Dr. Jefferies as Program Chairman, and Cordell Reed as General Chairman, for having assembled the comprehensive program ahead of us.

My remarks today will not address details of the IPE program since NRC staff and Dr. Lewis of the Advisory Committee on Reactor Safeguards (ACRS) are speakers at this conference, and can speak to specifics of IPEs and issues involved in the process. I will attempt to address some of the policy issues that confront the Commission as it considers the increasing use of risk-based methods in its regulation of the nuclear industry.

I wish to emphasize the importance that the Commission places on the topic of this Executive Conference by acknowledging the extensive participation by the NRC staff and ACRS. Dr. Harold L. Lewis, Professor Emeritus of the University of California at Santa Barbara, author of the American Physical Society's report on WASH-1400, Reactor Safety Study, and a long-standing member of the ACRS, will help to raise our consciousness to some of the real problems of probabilistic risk assessment. Professor Norman Rasmussen of Massachusetts Institute of Technology will offer a historical reflection of the winding road that got us to where we are.

Later, Dr. William Beckner of the NRC's Office of Nuclear Reactor Regulation (NRR) will discuss regulatory expectations and results, and Dr. John Flack of the Office of Nuclear Regulatory Research (RES) will comment on the quality and robustness of IPEs examined to date. Tomorrow, Stewart Ebneter, Regional Administrator of Region II, will offer a perspective on the use of IPEs by regulators. He will be followed by Dr. Beckner, on the subject of implementing plant modifications shown to be necessary or desirable from plant-specific IPEs. On Wednesday, Mr. Gary Holahan, NRR's Deputy Director, Division of System Safety and Analysis, will discuss results from the recent NRC study of shutdown risks, NUREG-1449. Together with the numerous other PRA experts on the agenda for this well-planned program, I suspect that you will hear over the next few days "everything you wanted to know but were afraid to ask" about IPEs.

Risk assessment in the regulatory management process encompasses most of the difficult issues that complicate public policy-making throughout the Government: questions about scientific data and conclusions, differing perspectives on issues within the scientific community itself, the need to make decisions on less than complete information, and powerful political forces. Probabilistic risk assessment in the IPE process is proving to be no exception.

PRA has been used increasingly since 1979 after NRC endorsement of the technique following a congressionally mandated review of Professor Rasmussen's earlier pioneering Reactor Safety Study which applied risk assessment techniques used in the aerospace industry to systematize and quantify the safety of commercial nuclear power plants. The preceding year, 1978, Professor Lewis had recommended greater use of PRA. PRAs have subsequently been performed for many U.S. nuclear plants.

New methods of severe accident analysis evolved by the mid-1980s, resulting in NRC's reassessment of risks in five commercial nuclear plants in NUREG 1150. This comprehensive effort, (which involved new techniques for uncertainty analysis based on use of expert opinion to develop probability distributions and related parameters in circumstances where insufficient analytical and experimental data existed), received international peer review and represented a major advance in the state of the PRA art.

Some of the NRC's more demanding jobs are the evaluation of licensee management, organizational knowledge and effectiveness, and operator training and skill levels. The NRC is concerned with the licensee's capability and judgment as well as the safety of the licensed facility as reflected, (in part), by an IPE. The IPE is not a complete means of accessing plant safety.

As you may be aware, there is increasing use of risk assessment methodology in federal regulatory decision-making. Risk assessment is of major interest to the White House's Office of Science and Technology Policy, which established the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) in 1989. FCCSET provides the federal government a strong interagency forum for discussing the scientific and technological dimensions of important issues, so that science and technology can be integrated with the policy-making process.

An ad hoc working group on risk assessment has been established under FCCSET, and the NRC is an active participant in this working group. The group presently is examining the uniformity in methodology, assumptions, and key data employed in risk assessments performed in the federal government. Over a dozen federal agencies are preparing white papers for FCCSET review on their agency's use of risk assessment methodology. Clearly, the use of PRAs is increasing within the federal sector, and the IPE program represents the largest industry-financed application of the methodology to date.

NRC IPE PROGRAM

As you may recall, the Commission's current safety policy, "Safety Goals for the Operations of Nuclear Power Plants," was published in August 1986 after much deliberation and public interaction. While the policy does not specify required numbers for core melt frequency, emergency core cooling system unavailability, or other performance characteristics, it does set forth qualitative safety goals and high level, subtier, quantitative objectives to protect the public. More recently, the Commission has opined that a core damage frequency of less than 1 in 10,000 per year of reactor operation appears to be a useful subsidiary benchmark for making judgements about the adequacy of existing regulations -- the provision of "reasonable assurance" of "adequate protection."[1]

On this basis, if each of the current population of approximately 100 plants had a calculated core damage frequency approximating this overall mean value [i.e., 1 x 10 EXP (-4) per reactor year], it would imply the overall occurrence of such events, on average, at a frequency of about once in a hundred years, a time interval larger than the expected lifetime of any single plant. (Uncertainties in the calculation of core damage frequency could affect this time interval.) The Commission's Advanced Reactor Policy Statement does not establish a more severe standard than the Safety Goal Policy. The Advanced Reactor Policy Statement states that the

[1] Samuel J. Chilk, Secretary, U.S. Nuclear Regulatory Commission, 1990.

> "Commission expects, as a minimum, at least the same degree of protection of the public and the environment that is required for current generation LWRs. For the longer term, the Commission expects designs to provide enhanced margins of safety."

These policies have encouraged the development of a supporting probabilistic regulatory framework for IPEs as well as other performance-based or risk-based requirements.

The safety initiative which is the subject of this conference, the IPE program, stems from another Commission policy statement of wide significance -- the Severe Accident Policy Statement. As you are aware, the Individual Plant Examination Program (IPE), has as its purpose the identification of potentially undiscovered vulnerabilities of individual U.S. plants through the application of probabilistic risk assessment techniques by each licensee. The assessment being made by nearly all licensees is a Level I Probabilistic Risk Assessment with a Level II evaluation of containment performance consistent with Generic Letter 88-20, and its Supplements. Approximately 37 licensees will have completed 50 IPEs on 72 individual plants by the end of this year and submitted them to the NRC for review.

An underlying Commission concern is that the lack of standardization in current U.S. nuclear plants could result in unrecognized design or operational vulnerabilities. The Commission thinks that the IPE program could identify any such vulnerabilities and improve the licensee's understanding of them from an operations point of view. The IPEs as Level 1 PRAs would also evaluate challenges to the containment systems, permitting an assessment of containment conditional failure probability from internal initiating events.

The IPE program should also serve to extend both NRC staff's and industry's knowledge of plant capabilities. This improved knowledge should lead to payoffs in the development of better, performance-based rules, as well as guides for their implementation. Examples may include guidance for the new maintenance and license renewal rules and proposed shutdown risk requirements based on outage configuration management. Improvements in safety and operability should result.

Thus far, the results from the IPE program have been generally quite favorable. In the few instances to date where individual plant vulnerabilities have been discovered by this process, the licensees responsible have voluntarily acted to correct the deficiencies so as to reduce the estimated core damage frequency to an acceptable range consistent with the Safety Goal and the inherent uncertainty of the PRA technique. Dr. Flack will speak to the quality of IPEs later this afternoon.

RECENT NRC PRA-RELATED ACTIVITIES

The NRC is striving to extend its capabilities in PRA. An NRC internal PRA Working Group has been established by the Executive Director for Operations (EDO) with participation by the four technical Offices,[2] and the Office of Personnel (which is responsible for PRA training). Staff initiatives are continuing to develop and implement performance-based guides and regulations. Examples include:

-- Risk-based allowable outage times, surveillance test intervals, and outage configuration management as part of risk-based Technical Specifications.

-- Prioritization of the risk importance of maintenance activities, development of optimization of maintenance periods, control of initiating event frequencies, and review of NUMARC's Industry "Guidelines" for Plant Maintenance and NRC's endorsement of the "Guidelines under the Maintenance Rule;

-- Development of diesel generator reliability test criteria for the Station Blackout Rule;

-- Prioritizing aging stressors or contributors as to risk importance, and developing a risk-based aging control program as part of the plant aging program of the License Renewal Rule, and

-- Assuring conformance of NRC's High Level Waste Rule with the revised EPA Probabilistic Standard.

-- Initiation of a program to revise current prescriptive requirements considered marginal to safety to be more performance oriented.

Not surprisingly, in these activities a number of methodological and policy issues have arisen. Let me share some with you.

We are all aware of the difficulty in attempting the translation of quantitative risks from PRA into qualitative terms which are interpretable to the public.

---

[2] The Offices of Nuclear Reactor Regulation, Nuclear Regulatory Research, Analysis & Evaluation of Operational Data, and Nuclear Material Safety & Safeguards.

Alvin Weinberg in a recent speech[3] notes that the public's attitude toward risk as reflected in their willingness to purchase a $ 10 EXP(+7) lottery ticket with the probability of winning being much less than 10 EXP(-7), does not deter people from buying the ticket. This being the case, Weinberg asks "would the public be persuaded to accept a nearby commercial nuclear reactor plant with the assurance that the probability of a major radioactive release is less than 10 EXP(-7)?" He (and I) judge not, based on the extraordinary earlier controversy surrounding the siting of nuclear reactors. Yet if a renewal of nuclear power with advanced reactors is to occur, certainly some reactors would have to be located at sites other than existing ones. Perhaps Professor Lewis, can offer his perspective on this issue.

We are all aware that public reaction usually exceeds what we technologists would expect based on the PRA quantitative measures of the risk significance of nuclear plants. Risk analysts at MIT, have shown that both risk conversion and compensation factors must be applied to estimate public risk tolerance if one is to account for public bias against risks that are either unfamiliar (a factor of 10), catastrophic (a compensating factor of 30), involuntary (a factor of 100), uncontrollable (a factor of 5 to 10), or have immediate consequences (a factor of 30).[4] Should we as regulators take into account the public's evident use of risk compensation factors in assessing tolerable risks? Perhaps Professor Rasmussen might offer us an opinion on this point.

We also suspect that the public's expectation is that all technologies improve with time as additional artifacts of applied science and engineering become better understood through research and experience. Examples with which we are all familiar include automobiles, public transportation, and commercial aircraft. The safety of these artifacts of our technological society continually improves. Should regulators formally recognize the reductions achievable in probabilistic risks of core melt frequency of advanced nuclear reactors? I see no reason why we should not, provided a sufficient time period has passed to permit orderly, consistent incorporation into regulations of increased scientific and technological knowledge in improvements

---

[3] Weinberg, Alvin M., "Social Institutions and Nuclear Energy", Seoul, Korea, August, 1992.

[4] Litai, D., "A Risk Comparison Methodology for the Assessment of Acceptable Risk," Ph.D. Thesis (1980), Department of Nuclear Engineering, Massachusetts Institute of Technology, Cambridge, MA.

in materials and design become industry standards. Perhaps Cordell Reed would wish to offer his opinion on this question.

With the present size of commercial reactors, a deterministic argument can no longer be made of the integrity of the large and complex containment structure of conventional LWRs. Since Professor Rasmussen's Reactor Safety Study of 1975, the PRAs that have been performed have revealed that core melt frequencies range from 10 EXP(-3)/yr to 10 EXP(-5)/yr, with a median core damage frequency of approximately 5 x 10 EXP(-5)/yr.[5] For the entire world deployment of approximately 300 LWRs operating at the time of the Reactor Safety Study, on a first principles basis the probability of a core melt was the product of 300 reactors and the median frequency, or approximately 1.5 x 10 EXP(-2)/yr. Is this an acceptable global risk today with only a probabilistic statement possible on containment integrity? Has the nuclear industry become "hostage" to probabilistic safety analysis for its existing and evolutionary non-passive safety plants?

I suggest the answer to this question is: yes it is acceptable since society tolerates events that have equivalent or higher risks of failure. Dams have been documented by ORNL researchers to fail with a probability of approximately 10 EXP(-4)/yr even when constructed to modern civil codes and standards. Yet public attitudes toward risk seem to refute such inter-risk comparisons; the public appears to intuitively apply risk compensation factors to establish their own risk tolerance when risks are perceived to be unfamiliar, potentially catastrophic, involuntary or uncontrollable, or have immediate consequences (as the MIT research has shown). Perhaps Professors Rasmussen or Lewis might comment.

Recent European studies have considered an advanced LWR reactor design in which assured integrity of a "super-containment", even under severe accidents, would be a principal goal. As I understand the design objectives, emphasis would be on mitigation of core damage as a subsidiary event, rather than prevention of core damage as the primary design objective. The studies seem to suggest that the public neither understands nor necessarily is concerned about what goes on inside the containment structure, as long as the regulatory authority can assure them on a deterministic basis that the fission product inventory can be

---

[5] I have not included the reactors designed by the former Soviet Union since many are uncontained and each arguably has an <u>a priori</u> core melt median frequency greater than 1.5 x 10 EXP(-5)/yr.

"contained", even under accident conditions.[6] While I do not subscribe to this reasoning (largely because the probabilistic risk genie is already out of the bottle), the authors of the studies may understand their public better than we understand ours. This leads me to the question: Is it reasonable for licensees and the NRC to expect the public to understand the IPE process probabilistic results? Perhaps Dr. Jefferies might comment.

As an industry, we face common problems of statistical uncertainty pertaining to the not well-defined failure probability distributions of many Structures, Systems, and Components (SSCs) in current plants, not to mention those still on the drawing boards. While we can readily assess the sensitivity of a core damage frequency to uncertainties using current PRA techniques and 486 personal computers, we still lack a robust knowledge base which would permit development of the underlying probability distributions for many SSCs from which to derive the needed probability of failures, the failure rates, and the times to failure of these SSCs. Does the credibility of our resulting IPEs suffer from these deficiencies, or have we enough experience to comfortably muddle through with what we have? Have we recognized the important -- if not vital -- role of the statistician in the field of probabilistic risk assessment in the push to complete the IPE program? Perhaps Dr. Mariani of American Nuclear Insurers could offer his opinion on this point.

Imperfect knowledge of Common Mode Failures (CMFs) is another issue which is of concern to the regulatory community. While an analytical methodology exists for assessing the potential risk significance of CMFs, we must recognize that very likely not all potential CMFs are accounted for in IPEs. This is an area for continuing research, but further progress in this area has usually been slow and typically has come by way of "experience" -- (accidents by another name)! Perhaps later this afternoon Mr. Egan of Shaw-Pittman will elaborate on prudence as an important element of a successful IPE.

Finally, how are we to treat human reliability; in particular, errors of commission rather than omission? What is it that we need to know; what is the practical effect of our not knowing? Can we evaluate the uncertainty that imperfect knowledge of human reliability poses for the IPE program? How can we explain this acknowledged gap in our knowledge to an anxious public? While

---

[6] Ebil, J., et al., "An Improved Design Concept for Next Generation PWR Containments", Proceedings of the Fifth Workshop on Containment Integrity, NUREG/CP-0120, SAND92-0173, Washington, D.C., May 12-14, 1992.

there is a paper on human reliability, I hope there will be an opportunity for further discussion of this important issue from the floor.

I believe the questions and issues I have cited will serve to provide you with an appreciation of the regulator's dilemmas. I believe there is more that we all must do to increase the role of PRA as a significant, major tool in shaping the regulatory regime of the future. Risk-based initiatives have and will play a major role in future regulatory decisions; clearly, these initiatives will lead to further regulatory applications. However, the fields of risk assessment and information data base development, at this time, are simply not sufficiently robust and substantive to provide bases for all regulatory decisions. As further progress in the underlying sciences of risk analysis and applied statistics is made, and experience is gained on current risk-based initiatives, an increasing portion of the present regulatory structure as well as new regulations would be expected to incorporate risk assessment methodology.

IMPACTS ON PLANT OPERATIONS FROM PRAs AND IPEs

Some plant configurations and operating practices have been modified already as a result of PRA's at existing plants. The plants affected include one NUREG 1150 plant and some other plants which have completed their IPE's. Numerous plant specific modifications resulted from much earlier NRC initiatives as RSSMAP, IREP, and individual PRAs, and included use of firewater as an alternate source of injection and containment cooling. A generic example is modifications to the BWR Mark I containment design to incorporate venting capability under severe accident conditions. Early IPE findings by some licensees disclosed operational vulnerabilities to which the licensees on their own initiative readily found cost-effective corrective measures.

One additional issue of appropriate methodology remains: the satisfactory treatment of the seismic hazard curve and seismic design. The concern is with establishing a defensible treatment of low probability but high consequence seismic events. This has been approached to a large degree through the use of expert judgment. The Commission believes that on-going efforts of the Electric Power Research Institute (EPRI), the Department of Energy (DOE), and NRC using margins evaluations are now appropriately addressing the problem.

BROAD IMPLICATIONS OF THE IPE PROGRAM

I believe that the IPE program will serve to: advance regulatory risk-based initiatives (such as Risk-based Technical Specifications), assist in implementation of the Maintenance Rule, lead to possible reexamination of elements of the License Renewal Rule, and result in discovery of possible undetected problems in existing plant designs.

The IPE program should aid in improving NRC effectiveness as well in the following ways:

- Improve our evaluations of troubled licensee (problem plant) performance using risk-based measures,

- Improve our understanding of human reliability issues,

- Improve our ability to contribute to the public's understanding of issues by articulating probabilistic as well as deterministic safety considerations, and by translating quantitative risks into qualitative terms and measures.

SUMMARY AND CLOSURE

In closing, let me summarize my main points:

-- The NRC must evaluate not only the "static" design of current licensed plants via the IPE/IPEEE process, but licensee management capability, operator knowledge and skills, and plant material readiness.

-- The IPE/IPEEE program is arguably the single most effective nuclear plant risk assessment process that industry and the NRC have been able to devise to provide quantitative measures of a plant's resilience to internal and external initiators of potential severe core damage for the large number of individual nuclear power plant designs in the U.S.

-- Activities of the NRC's PRA Working Groups when completed, together with completion of the IPE/IPEEE reviews, should result in improved staff knowledge and capabilities of the uses (and potential misuses) of probabilistic risk assessment.

-- Evidence to date from the IPEs that have been received and reviewed by the staff indicate that most plants are acceptably safe and pose no unusual vulnerabilities that were either unidentified or incorrectly assessed. In the few instances where this was not the case and one or more vulnerabilities were discovered through the IPE process, the licensees have voluntarily undertaken corrective actions.

-- Many examples exist in which risk-based methods have been used in the development of NRC rules, regulations, and guides. These are expected to continue. Upon the staff's response to a Commission request to analyze industry's risk-based initiative, the Commission may launch a program to revise current prescriptive requirements (considered marginal to safety) to be more performance oriented.

-- There are institutional impediments associated with the introduction of new forms of regulation, and risk-based regulation will prove to be no exception. A key requirement, however, is that appropriate measures be considered to assure public understanding of the new regulatory process during its implementation phase.

-- Compelling arguments can be made for retention of certain deterministic regulatory requirements together with the adoption of new risk-based requirements. The two can and probably must coexist in an acceptable and effective regulatory regime.

-- Industry and the NRC have more to do to resolve identified problems and further improve the practice of risk assessment methodology, thereby enabling this tool to be used for more effective regulation and reduction of regulatory economic burdens, where possible, on the licensee community.

-- I believe that NRC and industry are on the right track in the use of IPE/IPEEEs, and that as professionals, we can work together to improve the regulatory process with new risk methodology tools.

I appreciate your attention, and I wish you a most successful conference. Thank you.