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Advancing Nuclear Safety
through
International Cooperation

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at the Bhabha Atomic Research Center

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Introduction

Namaste (Nahmahstay). I am very pleased to have this opportunity to visit India and to be with you today at the Bhabha Atomic Research Center (BARC).

I am struck by the many things that the United States and India share in common. Our countries have both endured periods of colonialism and had to battle to gain independence. Indeed, perhaps the most important cultural event in my country in the past century - the civil-rights struggle - employed the tools that Mahatma Ghandi had demonstrated could be so effective. Our countries are both culturally diverse and recognize the benefits and strengths that come from diversity. And we both share and draw strength from an unyielding commitment to democratic systems of government.

Our countries also share many common interests in science and technology. One such interest is in the area of space technology. We grieve together at the loss of the space shuttle Columbia and of the scientist and astronaut Dr. Kalpana Chawla. I would like to extend my heartfelt condolences to the citizens of India on the loss of this talented person. I am confident that her bravery and brilliance will serve to inspire generations of young Indians and Americans.

Another area of common interest is in the exploitation of the power of the atom for civilian purposes. Both of our nations are involved in the application of nuclear technology for the generation of electricity. It is this enterprise that is the reason for my visit and is the subject of my discussion with you today.

I know that BARC is at the center of India’s efforts in nuclear power development and your efforts are key to ensuring nuclear safety. I thus very much appreciate the opportunity to address this audience.

U.S. - Indian Nuclear Safety Cooperation

The bilateral dialogue and exchange on nuclear safety between the United States and India started almost a decade ago. In 1994, the U.S. and Indian governments announced their interest in expanding our relationship to incorporate activities in the energy field. While the primary interest at the time related to conventional energy sources, both governments recognized the value of establishing a nuclear safety dialogue. Three subjects were chosen initially: fire safety, symptom-based emergency procedures, and modifications to plant designs.

A variety of interactions to pursue these subjects occurred in the middle-1990s, including visits to operating nuclear facilities in each country and technical meetings on the projects. However, all proposed cooperation was interrupted following India_s nuclear weapons tests in May 1998.

In November 2001, President Bush met with your Prime Minister and, among other activities, agreed to the resumption of nuclear safety cooperation. This renewal reflects the recognition on both sides of the value of further enhancing our relationship. It is in this context that I very much welcomed the invitation from Chairman Sukhatme of the Atomic Energy Regulatory Board (AERB) to visit India to re-initiate our discussions. We have already agreed that the original three nuclear safety projects should be expanded to include two additional areas -- risk-informed regulation and license renewal. It is my sincere hope that this visit will act as a catalyst for meaningful cooperation between our two countries in pursuit of nuclear safety.

Recent Trends in Nuclear Power

My visit to India comes at a time when both India and the United States must confront energy issues. Both of us face the challenge of providing safe, reliable and inexpensive electric energy in order to sustain growth and prosperity. Determining the right mix of energy sources is a complicated decision that depends upon many different factors and is heavily influenced by circumstances unique to each nation. Nonetheless, as I understand it, India’s plans, like those of the United States, involve a strategy of employing a diverse portfolio of energy sources. The United States is firmly committed to the maintenance of nuclear energy as a component of its portfolio. It is my understanding that India has made a similar choice.

In making that selection, however, we both must be guided by an overriding commitment to safety. Countries around the world have demonstrated that if nuclear safety is vigorously pursued, nuclear power can safely meet energy needs. But, absent a commitment to safety, the public’s willingness to rely on nuclear power will quickly erode. Indeed, an accident anywhere in the world will affect us all and would have serious implications for the future of nuclear power everywhere.

The recent history of nuclear power in the United States teaches an important lesson that bears on the obligation to ensure safety. A dozen years ago, the overall performance of the U.S. nuclear industry was, to be quite frank, mediocre. The average plant had a capacity factor under 70 percent, which meant that economic performance was unimpressive. The safety performance of the reactors was also of concern. The average number of unplanned reactor scrams was nearly two per unit every year, which of course meant frequent challenges to safety systems. In 1990, nearly half of our nuclear plants experienced a "significant event" -- not a particularly impressive record.

With the deregulation of the electricity business in the mid-1990s, there were many who were ready not only to dismiss the possibility of new nuclear construction, but also even to predict that existing plants would be shut down before the end of their useful lives. Those who had never approved of nuclear power were probably the quickest to pronounce it doomed. But even those who took a more favorable view of the technology were concerned.

What we have witnessed instead is a remarkable turnaround in performance. Both NRC and the industry have given focused attention to improving plant performance. As a consequence of these efforts, average capacity factors have risen to above 90 percent today. In economic terms, these statistics mean that the production cost of nuclear-generated electricity is now less than either coal or natural gas, its major competitors. And contrary to the early decommissioning of the nuclear plants that some people foresaw, one utility after another has applied, or has signaled its intention to apply, for extension of its license.

The important point, however, is that safety performance has improved in parallel with economic performance. The average number of scrams per plant is a quarter of what it was in 1990. We also see a marked improvement in operational safety, with rates of safety system challenges and failures less than half of the 1990 figures, and a remarkable reduction in the number of significant events -- down by more than a factor of 10 from the levels of 1990. And other performance indicators, including collective radiation exposure to plant personnel, have also shown dramatic improvement.

I believe that there is an important lesson that is revealed by this history. Strong economic performance and strong safety performance go hand-in-hand with each other. The reason is not hard to understand: both stem from attention to detail, to focused attention on the reliability of plant equipment, and to a demand for superlative performance from staff. Efforts to ensure safe operations thus do not conflict with strong economic performance, but rather serve to enhance it. Safety demands a reliable plant and only a reliable plant can contribute to the bottom line.

Although the overall trends in safety in the United States are favorable, there is another recent episode that teaches another important lesson. Good performance in the aggregate in not enough: every link in the chain must be strong. As many of you may know, we have recently required that our pressurized water reactors undertake the examination of the nozzles in the reactor pressure vessel heads because of growing concerns about the possibility of circumferential cracking. In the course of undertaking the required inspection at the Davis-Besse Plant in Ohio, the licensee discovered severe head corrosion. The entire depth of the vessel head had been eaten away over a region the size of a pineapple so that only the stainless steel cladding served to preserve the reactor pressure boundary. Although the safety systems would have been able to cope with the event if the cladding had failed, this is one of the more serious safety incidents in our recent history.

A detailed examination into the incident reveals the dangers of complacency. Davis-Besse had previously been considered one of our better plants. Because operations had proceeded smoothly in the past, plant staff did not bring to the job the constant vigilance that nuclear technology requires. Several warning signs - including the clogging of the containment air coolers and of the filters on containment radiation monitors - were ignored. Moreover, there is evidence that pressures for production were being given higher priority than concern for safety. In short, the root-cause evaluation found pervasive problems with safety culture at the plant. The results of that inattention have been an outage that has continued for more than a year, increased public concern about the plant, including demands for permanent shutdown, and hundreds of millions of dollars in expenses for repairs and upgrades.

There is an important lesson that we all should draw from this incident. Safe operations cannot be assumed, but must be the result of focused and continuing attention. Safety must remain the highest priority. Every person in the plant -- from the top manager to lowest level maintenance worker -- must be vigilant and must bring a questioning attitude to every task.

Let me now turn to some of the topics that have been identified for proposed cooperation.

Risk-Informed Regulation

First, let me discuss the topic of risk-informed regulation. Our regulatory system was largely put in place in the early years of commercial nuclear operations. The system has served us well. It is premised on conservatism in design, defense-in-depth, high standards of quality assurance, and comprehensive training. However, nearly 2000 reactor-years of operating experience and some 25 years of progress in the development of probabilistic risk assessment (PRA) now provide the data and the tool to refine our regulatory approach.

Our basic aim is to use risk insights to *complement* the existing deterministic approach. We take this incremental approach in recognition of the uncertainties in PRA analysis and the reality that we cannot impose a wholly new regulatory system to operating plants. This complementary aspect explains why the NRC refers to its actions as being "risk-informed" and not "risk-based." We do not intend to jettison the existing regulatory system, but instead to use risk insights as a tool for its modification and improvement.

We see several benefits in this approach. First, risk insights focus attention on the areas of highest safety priority, thereby strengthening our regulatory process. Risk insights can cut both ways -- justifying increased regulatory requirements in some cases and reductions in others. Let me emphasize a fundamental point: the elimination of regulatory requirements that do not affect safety can itself improve safety by encouraging increased attention to those requirements that are important. Thus both the reduction of requirements and the addition of requirements on the basis of risk considerations serve to enhance safety overall.

Second, risk-informed reform enables the reduction of unnecessary regulatory burden. For example, recent risk-informed initiatives concerning in-service inspection and testing have allowed licensees to focus their resources on highly risk-significant systems and components, while systems and components that are less risk-significant receive less attention, consistent with their lower safety influence. Similarly, the improved standard technical specifications reduce the regulatory burden on both the licensee and the regulator without adverse risk impacts by generally allowing more appropriate surveillance testing and longer times to correct problems before requiring a plant to change modes. These allowances help to reduce the number of unnecessary scrams, power reductions, and plant shutdowns. Ultimately, these activities serve both to reduce needless cost and to increase safety.

Finally, risk-informed initiatives help to improve communication among the NRC, the nuclear industry, and the public. The careful consideration of risk provides the means for the systematic and principled examination of the foundations of regulatory action. This enhances public acceptance because the reasons for and benefits of regulatory change are more transparent.

Nonetheless, although I see great benefits from our efforts to advance a risk-informed approach, I cannot deny that there have been problems. The shift from a traditional prescriptive, deterministic approach toward a risk-informed approach has challenged both the NRC and the regulated industry. The new approach requires rethinking the foundations of the existing regulatory system. Moreover, our regulatory requirements are intricately interconnected, so all of the implications of change must be carefully evaluated.

Perhaps the most fundamental challenge in implementing the new approach is the need for a strong foundation for risk-informed decision making. In this connection, the NRC recently issued guidance on PRA quality for public comment. The PRA models, methods, and data must be of high quality and the scope must be sufficient to capture the essential phenomena. For example, NRC and industry research efforts are underway to include human reliability in PRA models.

Various risk-informed rule changes are underway. These include possible changes to our rules governing special treatment requirements (the special requirements governing safety-related equipment; 10 CFR 50.69, passim), combustible gas control (50.44), emergency core cooling systems (50.46), and pressurized thermal shock (50.61). Although the efforts to use risk insights to revise our regulatory system have proceeded somewhat more slowly than we initially anticipated, we continue to believe the potential gains in developing a more consistent and rational regulatory structure are worth pursuing.

We welcome the opportunity to share our experiences in using risk insights to modernize and improve our regulatory system with you.

Fire Safety

Another area for cooperation is fire safety. In November 2002, the NRC published a proposed voluntary rule concerning fire-protection requirements for light water reactors. The rule would adopt, with certain exceptions, a standard promulgated by the National Fire Protection Association (NRPA) as a performance-based alternative to NRC_s existing fire protection regulations. The draft standard reflects a significant departure from the deterministic and relatively inflexible traditional approach. The endorsement of this consensus standard in NRC regulations will permit licensees to change their licensing basis by adopting advances in fire science, such as fire modeling, and probabilistic risk assessment in their approach to fire protection. This will also help to facilitate the resolution of long-standing issues by using risk as a metric for deciding on appropriate courses of action.

License Renewal

Another area of cooperation relates to license renewal. The NRC is authorized by statute to issue operating licenses to nuclear plants for a period of 40 years. This term was originally based on economic considerations, rather than a technical assessment of the length of time that the plants could operate safely. Accordingly, the act also allows the NRC to extend operating licenses.

The increasing need for electric power and the improved performance of nuclear power plants over the past decade have caused many of our licensees to consider renewing their licenses, instead of decommissioning their plants as the plants near the end of the 40-year license term. Our efforts in license renewal focus on providing assurance that licensees will manage the aging of long-lived passive structures and components. We focus on passive components because we have determined that the performance of active components is adequately controlled by the regulatory system that applies during operations. The NRC also assesses the scope and impact of environmental effects that would be associated with license renewal of U.S. plants.

In order to meet the requirements for license renewal, licensees must develop aging management programs that focus on prevention, mitigation, condition monitoring, or performance monitoring. In some instances, licensees may implement more than one type of aging management program to ensure that the aging effects are adequately addressed. Our report on generic aging lessons-learned describes programs for aging management that the NRC has determined are acceptable on a generic basis.

I know that you too are confronted with aging reactors and I hope that our efforts to maintain safety margins will be useful to you.

Design Issues

The fourth area of cooperation is that related to the modification of plant designs. Our discussions will consider aging effects, leak-before-break in piping systems, and safety enhancements to Boiling Water Reactors (BWRs).

Our research program on plant aging focuses on the integrity of systems, structures, and components. Our efforts emphasize the degradation of passive components, such as pressure boundary components, electrical cable insulation, and containment integrity. This effort bears particularly on license renewal, as I have just mentioned. However, we also look for age-related degradation of some active components, such as degradation of motor-operated valve performance stemming from age-related hardening of lubricants or increased friction due to corrosion product buildup. Consistent with the agency_s general focus on using risk concepts in decision making, we are incorporating consideration of the aging of components into PRAs.

The NRC has completed a variety of research programs that address pipe breaks. The results also have provided the technical bases for flaw acceptance criteria in the ASME Code and for a regulatory guide that is under development addressing leak-before-break analysis methods. Today, we are applying these methods in situations related to pressure vessel head penetration evaluations, such as predicting the catastrophic failure of the penetrations and the leak rates associated with cracks in the housings of control rod drive mechanisms.

The last design-related topic involves issues that are specifically related to boiling water reactors (BWRs). After the Three Mile Island (TMI) accident, the NRC took a number of actions to improve safety at our plants. Although TMI was a pressurized water reactor (PWR), we included BWRs in many of the actions we took. For example, the BWRs were required to address anticipated transients without scram (ATWS), station blackout (SBO), and severe accident management.

We welcome the opportunity to discuss these areas and learn from your experience.

Emergency Operating Procedures

The fifth area for cooperation is that of emergency operating procedures (EOPs). Following the TMI accident, it was recognized that significant improvements in emergency operating procedures were needed. The event revealed that control room operators were confused and made errors during the course of the event, in large part because operators were expected to categorize the type of event that was underway as the first step in response. We concluded that a different approach was necessary. Operators should instead address the symptoms of the event and take the actions necessary to cope with the conditions that they observe. As a result, the emergency operating procedures were rewritten in accordance with symptom-based guidelines. The NRC reviewed the procedures for each nuclear power plant licensee prior to their implementation and then conducted follow up inspections.

As a result of the TMI event, it was also recognized that control room operators could be faced with conditions that are indicative of a severe accident, such as the onset of fuel damage and loss of core cooling. It was determined that severe accident management guidelines (SAMGs) should be provided to supplement the emergency operating procedures and to guide operator actions. Insights from probabilistic risk assessments (PRAs) and severe accident research were used in the development of these guidelines in order to ensure that the recommended actions would best address the risk presented by the conditions observed. These guidelines were also integrated with the existing emergency response plans for each plant to ensure consistent interpretation of symptoms and associated actions.

In sum, I believe that the five topic areas for cooperation reflect matters about which we have considerable experience to share. We also look forward to the insights from your work on these same problems. We are very hopeful that our joint efforts will serve to strengthen the connections between our two Nations.

The Importance of a Strong Independent Regulator

I would like to conclude my remarks by providing my perspective on how best to achieve the objective we both seek -- the enhancement of nuclear safety. The prime obligation for safety must be placed on the licensee. But there also must be a strong and effective regulator. We see several key attributes to regulatory effectiveness.

First, an effective regulator must obviously have programs in place to monitor licensee performance. The NRC seeks to accomplish the monitoring function through its Reactor Oversight

Process. This effort, which involves on-site and regional staff, utilizes a combination of performance indicators and inspections to accomplish the monitoring function. We seek to use risk insights in focusing our inspection efforts on those aspects of plant performance that are most important safety. In fact, we have revised the whole program in recent years to achieve this objective.

Second, an effective regulator needs tools to detect adverse trends and precursor events. The NRC accomplishes this through its programs to evaluate accident sequence precursors and operational events. There must be a continuing questioning attitude by both the licensee and the regulator to assess the true significance of operating experience and to ensure that the signs of a possible problem are detected before that problem can ripen into an event. The Davis-Besse episode has served to reinforce the importance of this capability.

Third, decisions should be reached through public processes and with the benefit of public input. Given the concerns about nuclear technology, decisions that are made behind closed doors are suspect. Moreover, the public has a stake in these decisions and the views of all stakeholders should be heard.

Fourth, there is the need to maintain technical competence. A nuclear power program in any country represents a significant commitment, including a commitment to invest in the workforce. This has been an increasing challenge in the United States because our educational institutions are not providing sufficient numbers of graduates in relevant technical fields. And, of course, that work force must be trained and retrained so as ensure the maintenance of the necessary skills and questioning attitude.

Finally, we believe that there are great benefits that derive from independence. The NRC does not have any responsibility for activities involving the promotion of nuclear power. In our country, the responsibility for the promotion or development of nuclear power falls to the Department of Energy. The NRC's sole duty is to ensure through regulatory oversight that nuclear technology is used in a way that protects public health and safety and the environment. The establishment of a strong, independent, and technically competent regulator helps to ensure that there is no compromise in the achievement of nuclear safety.

Conclusion

As I hope these remarks have conveyed, we welcome the opportunity to work with our counterparts in India to learn your perspectives on ensuring safety. I am sure that we both will benefit from the examination of each other's experiences. Thank you for allowing me to join you today.