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REACTOR DYNAMICS: MEETING THE CHALLENGE

Remarks of Commissioner Nils J. Diaz
U.S. Nuclear Regulatory Commission
Before the 10th International Conference On Nuclear Engineering
Arlington, VA

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Good morning Mr. Chairman, ladies and gentlemen. It is my distinct pleasure to participate in the 10th International Conference on Nuclear Engineering. I am pleased to also welcome both the national and international participants to our nation's capital. You just missed the full bloom of our landmark cherry blossoms, an enduring gift from our ally and partner, the Nation of Japan. The blossoms' beauty is ephemeral yet they always brighten Washington's spring. The endurance of the cherry trees, through heat and cold, is relied upon to highlight spring in the capital; obviously, the trees have strong roots and are properly nurtured to yield such beautiful blossoms year after year. And so it is for American democracy, with its people nurturing its very strong roots regardless of peace or war, or economic prosperity or hardship, so our American democracy can blossom year after year. The people of America nurture our democratic society because they know that this is a government of the people, for the people, with freedom and justice for all. Our democratic society has and will endure.

I will end my talk with a discussion of regulation, but via some of the dynamics of nuclear power. First, however, I think it might be worthwhile to reminisce about a few things I have been saying and practicing the last several years, as a supporting back-ground for what I am going to present today. Here are a few selected quotes from a "couple" of speeches during my tenure as a Commissioner that are appropriate to the occasion.

"Nuclear power is a global socio-political issue and until it is treated and resolved as such, its benefits cannot be realized."

"There can be no credible regulator without a credible industry, nor can there be a credible industry without a credible regulator."

"A nuclear regulator must master the technology, a nuclear technologist must master the regulations."

“We are always inside a feedback loop, generating a positive or a negative signal. I prefer the positive output, cognizant I might have to dampen the instabilities.”

“I much prefer to think and act at the state-of-the art. I do not like to be obsolete.”

"Regulations need to result in a benefit or they will result in a loss."

"My goal is to ensure the paths are clearly marked. A path that is clear of obstacles and unnecessary impediments, with well defined processes, will provide regulatory predictability, equity and fairness."

“There is no such thing as zero risk. There is only one way to get to zero: $0 = 10^{-\infty}$

And quoting a United States Court: “The level of adequate protection, need not, and almost certainly will not, be the level of zero risk”

Now, I’d like to turn to engineering and to the dynamics of nuclear power. Engineering is the art of making science useful to mankind; it is the “reduction-to-practice” of principles for a purpose, it is the organization and orchestration of industry. Nuclear power needs to revitalize its engineering in the full meaning of the term, and I believe that is one of the key reasons for this gathering.

There are three known major, time-dependent, interplaying factors controlling the overall dynamics of nuclear power: economics, technology and regulation. Each factor, of course, is made of many independent variables. There are also two time-independent factors or requirements that have an influence on economics, technology and regulation: safety and reliability. And, outside of these coupled equations, is the important, yet elusive, influence of socio-political factors. It is a fascinating exercise to look back and analyze how each and every one of these have and continue to determine the present and future of nuclear power.

For example, in the 1960's, technology was the driving function; economics were favorable and regulation was lagging. The life of a nuclear engineer was sweet and there were few limits for proposing and researching all kinds of reactor concepts. As technology appeared to stabilize in America in the late 1960's --- more or less forced by technical realities and commercial factors --- the LWRs became the only game in town; regulation then began to catch-up, some say with a vengeance. Who can forget the head-shaking when 10 CFR Part 50 Appendices B and A were promulgated, and were soon followed by the ECCS criteria? These, and a few others, in their broad unspecificity --- or narrow specificity as the case may be --- became de-facto the LWR safety criteria. As the NRC was created in 1974 from the splitting of the Atomic Energy Commission (AEC), there was hope for regulatory and technical stability, with defense-in-depth, the Large Break LOCA and Part 100 firming up the design and operational safety landscape. Of course, something changed, and it was the economy. Then, the energy crisis of 1973-1974, which produced double-digit interest rates and inflation, and reduced electrical demand, had a completely opposite effect on the development of nuclear power than many predicted. Many thought that nuclear power would emerge as a leading economic and reliable solution to energy independence and cost predictability. Forecasts of a nuclear boom were plentiful. Instead, nuclear power was priced out of competition; growth was negative by the second energy crisis in 1978-1979, and there was no solid economic recovery. Reliability and capacity factors were then much lower

than expected and also took their toll. In 1979, the accident at TMI took center stage, and safety became an issue. Seven years later, despite the burden of the TMI Lessons Learned, recovery was again at hand when the Chernobyl disaster occurred.

That was the point of convergence of negative factors for nuclear power, when its economics, technology, regulation and safety-reliability were in question. I believe no other modern industry would have survived, yet the operating nuclear industry not only survived, but eventually prospered. The industrial challenge was clear: perform safely and economically, or face the reaper. It took many years before all the major factors achieved a level of performance that matched the expectations of a viable and economic industry.

A convergence of positive factors occurred in the middle to late 90's anchored by a safety and reliability record unparalleled in the history of nuclear power. The economic performance was good, technology was better, and regulation reached new levels of effectiveness and efficiency. Surprisingly - or perhaps not surprisingly- the industry performance gains from 1985 to 1996 were achieved without technological or regulatory breakthroughs, but by consistent, systematic improvements. The performance gains then enabled the industry to make major commitments for stabilization and prosperity, like license renewal, power uprates, and technological improvements; but all of them still bounded by the traditional design basis and accident criteria. The safety performance also enabled major regulatory improvements, like the revised 50.59 and the Reactor Oversight Process. I might add that there is one proven technological fact whose significance has been largely unnoticed: leak-before-break, but that is the topic of a future speech.

The S curve of nuclear power plant dynamics had turned and is now approaching an asymptote. For example, capacity factors are in the 90 percent range (see attached figure). The only way to get out of asymptotic behavior, i.e., to improve performance, is to change either the equations or the constants in the equations. No small fiddling with parameters will affect an asymptotic curve. So, if this nation needs now a new system of equations to improve the safety and overall performance of nuclear power, to serve the people in improving energy independence, the economy and the environment, what is available?

Allow me a break in thought. Life is full of trade-ins, and as you can see, as I lose technical competence, I gain historical perspective.

There are a few lessons above that should not be lost to an engineer seeking to reduce to practice what has been learned.

- the safety and reliability of nuclear power are necessary conditions for its existence and growth
- capital intensive nuclear power can grow better on predictable economic conditions, (low interest rates, low inflation, favorable market, etc.)
- a "level playing field" is needed from a socio-political perspective, and issue under the purview and leadership of Senators Craig, Domenici, Murkowski, and others
- and lastly, the technology and the regulatory framework must be in-phase, compatible and predictable.

It is obvious that the development and sustainability of nuclear power requires careful attention to all of these factors, so that society can benefit the most. Since the engineering of these dynamics is beyond a regulator's scope of activities, I am going to concentrate on the last point: the need to have in-phase, compatible and predictable technology and regulation. Let me up the ante: the need is to achieve and maintain state-of-the-art technology and regulation, with a built-in capability to upgrade both by quantifiable discrete steps, without significant lag by the regulator, so the next improved state-of-the-art technology and regulatory framework levels can be reached effectively and efficiently.

Why is there a need to have a built-in capability to upgrade technology and regulations in discrete steps? One answer has unfolded recently in the US: most existing nuclear power plants in the US are expected to operate for 60 years, an eternity in the on-going technological revolution. And new nuclear power plants might be designed and constructed for even longer periods of time.

I can offer many other reasons. For example, the Large Break LOCA is no longer useful as the dominant accident sequence, and neither defense-in-depth nor the design basis have allowed for significant technological and regulatory innovation.

Does it make sense to operate in 2002 with technological and regulatory constraints 30 or 40 years old? Of course not; no matter how conservative you are - I am particularly conservative myself. It is not good regulatory policy - nor is it good business - to ignore the new goods or not to discard the not so good old ones.

I say it will make even more sense to think of new deployable nuclear technologies and their regulatory framework in non-rigid design basis terms, but as time-dependent upgradable systems --- both hardware, software and management systems --- that are safer, better, more reliable and more economical for the country and its people. I believe that there is a need for dynamically, strongly coupled technological and regulatory systems, that can stand the test of time because they change with time, and they are developed in-phase, using similar wavelengths. I maintain that the independence of a regulator is exercised at decision-making time and suffers not from a proactive regulatory development that is technology-based.

My friends, that is why I advocate risk-informed and performance-based regulation for nuclear power . A risk-informed, and performance-based regime is more quantifiable and more amenable to change as scientific knowledge, engineering, technological and regulatory know-how increase. It is time to think and eventually implement regulatory policies that are as dynamic as the country needs, policies that do not hamper or delay, but serve the people, based on reasonable assurance of protection of public health and safety. The key is that reasonable is not a stagnant criterion but one that is dynamic and quantifiable. And therein lies the challenge, to solve the coupled technological and regulatory equations simultaneously, while maintaining independent regulatory decision- making conducive to reasonable protection.

We have experienced what happens when regulation is imposed after the fact on a technology being deployed. It was not possible to do it any other way thirty years ago. But it is now possible to jointly develop nuclear technology and its regulatory framework. There is relevant and extremely valuable experience that has been gained from the Advanced Reactors certification program. This program allows for the resolution of substantive technological and regulatory issues during pre-application and application process. It produced better reactors with minimal patchwork requirements. This experience is the right stepping stone for a new way of doing things.

A totally new and complete risk-informed and performance-based regulatory regime is needed now to address the possible deployment of new reactors in the U.S.A. I applaud the Department of Energy initiative to work in partnership with the NRC and industry to develop a requisite and innovative regulatory framework, serving safety and reliability. But it is time to be bold and ask what more can we do for our country, to allow technological and regulatory innovation to be inserted, as needed, at the beginning, the middle or the end of the process, whether designing, building or operating. The tools exist, they are not perfect but they are good.

I said I would finish with a discussion of my views on regulation.

Regulation is a tool of society to frame what society needs, in an orderly, equitable and fair manner. I believe that the role of regulation is to provide a meaningful and useful framework for the protection of rights and the discharge of responsibilities in the areas of health, safety and the environment. Regulation is done only for the people, with their best interests as their essential objective; it is done for the common good, with full consideration of the national interest.

Regulation does not make you safe; the safe execution of the regulated activity does.

Good regulation provides for the proper exercise of democratic and free market processes to enhance the common good. It is established to provide a framework that allows for the conduct of individual, industrial, commercial, financial, and other activities. Although all regulations restrict, regulation should not deter beneficial activities, but frame them and guide them. Regulation must be dynamic and keep pace with the technology it regulates. Thus, the minimal amount of regulation that achieves the objective is best for our society.

I know you know I was supposed to talk about consolidation. I really did, mixed with integration and modulation.