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Mr. Yukiya Amano, Director General
International Atomic Energy Agency
Wagramer Strasse 5
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Dear Director General Amano:

I am writing in my capacity as Chairman of the International Nuclear Safety Group ("INSAG"). Our terms of reference state that INSAG should provide "recommendations and opinion on current emerging safety issues" to the IAEA and others. During my term as Chairman, I have customarily sought to fulfill this obligation not only through the various INSAG reports, but also with an annual letter. My past letters are available on the INSAG website at http://goto.iaea.org/insag. This correspondence constitutes this year's installment.

It has now been over six years since the accident at Fukushima site. The accident has resulted in extensive efforts by the entire nuclear community to apply lessons from the accident and to strengthen the nuclear safety regime. The community has benefitted in this connection from the comprehensive report issued by you and its associated technical reports.[1] This letter will comment on three deep aspects of the response to the accident. I focus on these matters because they reflect the continuing need to learn from the accident and never to be complacent.

Beyond Design Basis Accidents.

The Fukushima accident has served as the stimulus for the reexamination of the intellection foundations of the nuclear safety system. In the early years of

[1] IAEA, The Fukushima Daiichi Accident (2015) (http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1710-ReportByTheDG-Web.pdf)

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nuclear power, and in the absence of experience, regulatory systems were established with a focus on certain "design-basis accidents." These were postulated events that a nuclear plant was to accommodate on the basis of engineering features, such as the capability through supplemental systems to continue to cool the core in the event of a large pipe break in the reactor coolant system. This approach was accompanied through a variety of safety-enhancing elements, including: a philosophy of defense in depth, reflected in layers of independent prevention and mitigation capability; the redundant and diverse means to respond to events; the avoidance of vulnerability to a single equipment failure; conservative engineering design and strict compliance with conservative engineering codes; stringent quality-assurance standards in construction; and attention to configuration management, training, maintenance, and operational requirements. Continuous learning to improve safety has been a hallmark of the nuclear industry, such as through the application of lessons from operating experience,[2] and through the development of sophisticated analysis techniques (Probabilistic Risk Assessment) to assess potential vulnerabilities and thereby guide efforts to improve safety further.

Although regulators and operators were conscious of the need to have a capability to prevent or mitigate beyond-design-basis accidents ("BDB accidents") in the period before the Fukushima accident, the effort has become more central in its aftermath. One of the consequences of the accident has been the addition of installed or mobile equipment at plants around the globe to provide increased capacity to satisfy essential safety functions, such as the need for electrical power or cooling water, regardless of the circumstances. My focus here, however, is on the efforts to integrate a capacity to respond to BDB accidents into the regulatory system in a consistent and formal way so as to assure the expansion of the scope of protection beyond that provided by the traditional approach.

In 2016 the IAEA updated its specific safety standard for design of a nuclear power plant ("NPP"). IAEA, Safety of Nuclear Power Plants: Design, No. SSR-2/1 (Rev. 1) (2016) (http://www-pub.iaea.org/MTCD/publications/PDF/Pub1715web-46541668.pdf). This standard includes not only the traditional requirements governing

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[2] For a fuller discussion of operating experience, *see* INSAG, Improving the International System for Operating Experience Feedback (2008, INSAG-23) (http://www-pub.iaea.org/MTCD/publications/PDF/Pub1349_web.pdf); Letter from R.A. Meserve to Y. Amano (Aug. 2013) (http://www-ns.iaea.org/committees/files/insag/743/2013AnnualAssessmentLetter.pdf)

design-basis accidents (Requirement 19), but also a capacity "to withstand, without unacceptable radiological consequences, accidents that are either more severe than design basis accidents or that involve additional failures" (Requirement 20). These so-called "design-extension conditions" are intended to assure that "the possibility of conditions arising that could lead to an early radioactive release or a large radioactive release is 'practically eliminated'." A footnote explains such conditions may be considered to have been "practically eliminated" if "it would be physically impossible for the conditions to arise or if these conditions could be considered with a high level of confidence to be extremely unlikely to arise."

The IAEA design standard thus now clearly encompasses a requirement to avoid unacceptable radiological consequences from BDB accidents. Probabilistic Risk Assessment is sufficiently mature as to provide a sophisticated means for informed judgment as to the likelihood of BDB events. (Admittedly, there are difficult challenges in making such judgments in the case of extreme external events. *See* R.A. Meserve to Y. Amano (July 2015) (http://www-ns.iaea.org/committees/files/insag/743/INSAGLetter2015.pdf).) But there remain important questions on which judgment and further experience are necessary. For example, what probability level defines the boundary for an event that can be deemed to be "extremely unlikely"? And, should financial cost be part of the calculus? On this latter point, there are differences among regulators. In the United States, for example, cost and benefits are weighed in determining whether to impose additional requirements once "adequate protection" has been achieved. 10 C.F.R. 50.109. By contrast, in Japan cost is not an explicit factor in regulatory decisions. In most European countries there is a qualitative evaluation of the benefits and drawbacks of additional requirements.

In sum, the capacity to respond to BDB events has been significantly enhanced in the aftermath of the Fukushima accident. But important questions remain to be resolved as the regulatory requirements evolve to encompass BDB events.

Focus of the Regulatory System.

The Great East Japan Earthquake exacted a devastating toll on human life -- over 15,000 people were lost as a result of the earthquake and the tsunami. It is noteworthy in this connection, however, that no short-term radiation-related health effects were observed among workers or the public as a consequence of the Fukushima Daiichi accident and several assessments have concluded that no long-term radiation-related health effects are expected to be discernible among members of the public or among workers in the future. [3]

Nonetheless, there were devastating effects of the Fukushima accident. There have been non-radiation-related health consequences, including depression and suicides, among those who were evacuated from their homes and were barred from return. And the economic and the social costs arising from the accident on Japanese society have been severe. The decommissioning and cleanup cost is formidable and hardship has been endured by many, including in particular the evacuees. The accident resulted in the eventual shutdown of reactors that had provided 30 percent of Japan's power needs, requiring efforts to reduce electricity demand and imposing incremental fossil fuel costs in the early years on the order to $35-40B/year. This increased the cost of electricity and, because fossil fuels are imported to Japan, caused a trade deficit. Moreover, it resulted in increased emissions of greenhouse gases.

In short, although regulatory systems are focused on avoiding radiation-related health effects, the principal adverse consequences of the Fukushima accident arose from the accident's environmental, social and economic impacts. I conclude that the focus of regulatory systems is perhaps misdirected. By way of example, the Fukushima Daiichi accident showed that the non-radiation- related effects of evacuation deserve greater attention, particularly for elderly and vulnerable people. The full implications of a change in regulatory focus remain to be fully explored. Certainly regulatory assessments should include more consideration of environmental, social and economic impacts.

[3] See, e.g., UNSCEAR White Paper, Developments Since the 2013 UNSCEAR Report on the Levels and Effects of Radiation Exposure Due to the Nuclear Accident Following the Great East-Japan Earthquake and Tsunami, 17-20 (2015) (http://www.unscear.org/docs/publications/2015/UNSCEAR_WP_2015.pdf); IAEA Director General, The Fukushima Daiichi Accident, 13-14, 120-35 (2015) (http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1710-ReportByTheDG-Web.pdf); WHO, Health Risk Assessment from the Nuclear Accident after the 2011 Great East Japan Earthquake and Tsunami, Based on a Preliminary Dose Estimation, 92 (2013) (http://apps.who.int/iris/bitstream/10665/78218/1/9789241505130_eng.pdf?ua=1),.

Safety Culture.

The various engineering and procedural changes to respond to the Fukushima accident have served to improve safety. But no matter how we re-engineer the reactors, there is no room for complacency or anything short of a laser-like focus on safety. Despite all the design and procedural improvements that we introduce, systems will still fail in unanticipated ways and people will make mistakes. Thus, the constant vigilance of an enduring safety culture is essential.

This means that all those involved in the nuclear enterprise must make safety the highest priority. Such a culture is established by demonstrating a total commitment to safety by word and deed, by assuring that issues impacting safety are promptly addressed and corrected, by developing knowledge and understanding of all effects and phenomena that might compromise the safety of the plants (including by active exchange of know-how and experience), by nurturing a sense of personal responsibility for safety by all those involved in nuclear operations, by educating all personnel of an individual obligation to raise safety concerns, and by protecting anyone who raises such an issue from retaliation. The establishment of such a culture is perhaps the hardest and most essential element of the response to the Fukushima accident.

There are special roles for the regulator and the operator. The regulator cannot identify all the potential safety issues in the design and operation of a nuclear power plant and should not be seen to have that role. Instead, the operator must take the prime responsibility to find and address safety issues. The regulator should establish an environment, through constant review and challenge, to ensure the operator is vigorously fulfilling its responsibilities. Although they have different roles, the regulator and the operator must both be fully engaged in ensuring and enhancing a robust safety culture. New entrants face a particular challenge in building such a culture from the beginning of their involvement with a nuclear power plant.

I raise safety culture in the context of this letter because of the natural human tendency to think that the lessons from Fukushima have been learned, that the responses have been completed, and that it is time to move on. In fact, the Fukushima accident reinforces the reality that maintenance of an appropriate safety culture is an enduring responsibility. The devastating consequences of the accident should remain a continuing stimulus to assure the existence of a culture in which safety is the highest priority.

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As always, please feel free to contact me if INSAG can offer assistance on this or other matters.

Best regards.

Very truly yours,

Richard A. Meserve