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FROM: John W. Craig
Assistant for Operations, OEDO

SUBJECT: INSAG PROPOSED STATEMENT ON MAINTAINING KNOWLEDGE...IN NUCLEAR SAFETY

The International Nuclear Safety Advisory Group (INSAG) is currently developing papers on several topics of importance to the use of nuclear technology. Attached is a letter from A.J. Baer, INSAG to Mr. M. El Baradei, Director General, IAEA and a statement on the subject topic. The statement is being proposed by INSAG to the Director General as appropriate for discussion at the General Conference in 2001.

Attachment: As stated

cc: W. Travers, EDO (w/attachment)
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Maintaining Knowledge, Training, and R&D Infrastructure in Nuclear Safety

A Statement by the International Nuclear Safety Advisory Group (INSAG)

INTRODUCTION

Like all major successful technological ventures, nuclear power owes its successful development to a strong underpinning of research and to keeping a constant pool of expertise, which has contributed to a good safety record worldwide as well as economic success. Elements of this underpinning must remain robust if safe nuclear power is to remain an option. Safety in this context must be viewed in its broadest sense. Safety research and expertise should be directed not only to topics related to the safety associated with plant performance and operation and accident prevention, but also towards protection of workers and the public from radiation exposure and protection of the environment from accidental releases of radioactive material. This research should also be directed to the safety of nuclear fuel cycle facilities and facilities which have potential risk of causing radiation exposure and to the management of nuclear waste at an acceptable level of safety in short as well as long term.

This statement derives from previous INSAG Reports addressing the need for and benefits derived from research and development. INSAG-12 stated the following principle:

> *Organizations concerned ensure that operating experience and the results of research relevant to safety are exchanged, reviewed and analyzed, and that lessons are learned and acted upon.*

And developed the following conclusions:

> *. . . research and development activities are needed to maintain knowledge and competence within organizations that support or regulate nuclear power plant activities.*
>
> *Nuclear research and development is an essential element of nuclear plant safety and its continued support is very important. . . . co-operative research on an international scale to reach a common understanding on major safety issues is a important way to avoid duplication of efforts and to reduce costs.*

In recent years, funding for long-term strategic activities such as research and development, preserving corporate knowledge, and maintaining technical expertise have been reduced in many countries. Industry funding by the designers and operators has reduced as a result of beliefs that the research needed for the initial design of plants has been completed; a lack of commitment to build new plants, the effect of de-regulation and a highly competitive market place; and with a preoccupation with short-term profitability and shareholder interests at the expense of long-term programs such as research.

Government funding has reduced, as a result of skepticism both within some governments and parts of the public about nuclear power as a sustainable source of energy; and the belief in some governments that as a maturing technology, industry should be the primary source of research and development funding in the future. Because of the poor image that nuclear energy has had in some countries, the teaching of nuclear technology and nuclear safety at the universities has also diminished considerably. It follows that new researchers are not entering such programs, thus raising concerns about the continuity of knowledge even in universities.

The nuclear power program in any country represents a significant investment. That investment can be expected to be valuable to society for 60 years or more -- provided that the plants are well maintained and upgraded throughout their life, that operating experience and new research results are utilized in continual improvement in plant safety and economics, and that the safety authority retains both the capability to assess their safety, and to make soundly based decisions on their continued operation.

This required a continued investment in safety research by both industry -- to meet their responsibility of ensuring safe operation -- and by government to ensure the regulatory organization has the competence and independence to meet its responsibility. If capabilities are not maintained by both the industry and the regulatory organization, the safety of nuclear facilities may deteriorate.

PURPOSE

The purpose of this paper is to emphasize the importance of maintaining nuclear research and education capabilities, especially with regard to safety aspects, so that nuclear safety may be maintained in IAEA member countries, and to alert member countries of the potential for significant negative impacts if the research, development and education infrastructure is not maintained.

DISCUSSION

Since the beginning of the development of nuclear power, safety considerations have been of paramount concern. Thus, safety research efforts have been widely supported by government, design organizations and electrical utilities, operating organizations, research institutions and universities. The results gained from research have been used to form important technical bases for new designs, safety developments and regulatory programs. Therefore, many safety research programs have been supported and organized by several IAEA member countries.

Progress of Safety Research

The role of safety research has never lost its importance, but its scope and emphasis have changed as challenges to safety have arisen. Examples of past successes in safety research that have permitted the industry to grow, maintain public confidence through well founded designs and operating limits and, particularly, through sound regulatory practices. Examples of the enhancement of the regulatory process as a result of research in several countries include the emergency core cooling research of the 1970s; the probabilistic safety research of the

1980s that led to the technical advances and the use of probabilistic techniques in safety decision-making ; and, in the 1990s, the ageing research improved the understanding of material properties and behavior and provided a knowledge base for considering the safety implications of long-term operation of plants sometimes beyond their initial design in numerous countries. Other examples include the improved understanding of thermal-hydraulic phenomena that led to approval of advanced light water reactor (LWR) designs, understanding of severe accident source terms, the improved reactor inspection and oversight process, and the effective accident management schemes and emergency plans. Research has enabled sound design, operational and regulatory decisions and to provide a strong oversight of licensee activities. However, in the absence of perceived growth in a number of countries where significant nuclear power development has taken place, there is a significant danger of stagnation or even decline in the research and educational infrastructure.

As we enter a new century, we must be concerned about potential complacency in our approach to plant safety. While there is ample evidence of improving industry performance, we are also experiencing dynamic industry changes resulting from an increasingly competitive economic environment and a stagnating or declining infrastructure, with margins between electrical supply and demand shrinking and electrical demand rapidly increasing in certain IAEA member countries. This situation is aggravated by the decreasing trends in research funding. Additional challenges to the infrastructure stem from renewed interest in reactors and fuel cycles that are proliferation-resistant, the use of enhanced safety through simple passive systems, the implementation of emerging technology (e.g., digital instrumentation and control) and the potential for new plants utilizing novel concepts (e.g., new fuel materials) being constructed, all of which require research by designers and operators to develop the concepts, and by governments to ensure safety authorities are able to insure that safety is thoroughly considered before approval is granted.

International experience also indicates that the more utility staff are involved in the application of the knowledge gained from research to the design, operation, and maintenance of an individual plant, the more safety is improved. This application of knowledge gained from research is a way to improve staff competency and to maintain the knowledge base at the plant.

Requirements of Safety Research

Safety research by both industry and regulatory organizations can only develop and prosper where several conditions are satisfied. Although the challenges may be changing, those requirements remain critical to maintain the necessary research infrastructure:

(1) Necessary technical expertise in all safety disciplines must be maintained through a vigorous educational process. This is particularly true of those disciplines which are specific to nuclear facilities, such as nuclear science and engineering, reactor physics, and radiation-related health physics, and studies of the unique problems associated with the chemistry, materials, and thermal-hydraulic performance of both new and existing reactors.

(2) Analytical tools and techniques must be maintained and further enhanced to better quantify safety margins and thus facilitate better decisions.

(3) Experimental facilities must be maintained to provide data to elucidate basic physical processes, to confirm and validate mathematical models used in analytical tools, and to respond to new problems as they develop.

(4) The development of a constant pool of safety experts requires educational institutions firmly rooted in the pursuit of excellence with state of the art knowledge of research in all disciplines related to safety. This can be kept up only if research institutions are maintained and only if they are actively involved in research activities, pushing the bounds of the state of the art, and if employment opportunities exist. In some cases, this may be achieved by in-house training of scientists and engineers who lack direct education and training in nuclear safety. Unless one is convinced of the need to maintain a cadre of safety experts and without the facilities that are required to act on this conviction, the infrastructure will wither, and the talent pool will be continuously depleted.

(5) Major nuclear research projects do play a significant role. They are of prime importance for attracting capable scientists and engineers who may otherwise be absorbed by faster growing new technologies that appear more attractive.

(6) To achieve the public confidence necessary for continued development of nuclear technology, the public demands a mature regulator possessing the necessary tools and expertise to monitor performance and assess the potential for unintended consequences, and to ensure there is no undue risk to the public. These tools must address concerns related to long-term waste management and radiation effects as well as reactor safety. The public must also be confident that operators and workers at nuclear facilities are competent and expert in both generating power and preserving safety.

New Challenges

Even though a good safety level for nuclear facilities and applications has been achieved in most countries, there are also areas where improved knowledge will be necessary to efficiently and effectively regulate and operate the current fleet of reactors as they age, and to provide the scientific and technical basis for the development of innovative nuclear reactors and novel means for high level waste management and disposal. History indicates that new issues will continue to emerge from operational experience, and an enterprising and dynamic industry will continue to propose innovative initiatives to improve economics while maintaining safety. A questioning environment is necessary in industry and in regulation to evaluate and resolve problems as they arise. Further, new designs are being proposed which have many characteristics that differ from those of the current fleet of plants. Availability of knowledgeable and well trained human resources is necessary to sustain and improve the safety of nuclear

power and provide effective regulation of it through all its phases from research and conceptual design, through operation, to waste management and decommissioning.

Examples of areas where novel emerging issues of these types have already been identified are provided below. For each example listed, and for all other areas that may be identified in a comprehensive evaluation, emphasis must be placed on understanding the uncertainties involved and highlighting those needing attention; as well as the role of risk information in identifying safety and regulatory needs.

Economic conditions are leading to extension of the operating cycle, higher fuel burnup and increased power levels. Initiatives have been identified in several IAEA member countries to explore use of mixed oxide fuel either because of non-proliferation considerations or to recycle fuel to use it more efficiently. These are being evaluated by the regulatory authorities in member states. The combined effect of these considerations must be evaluated to determine the overall safety impact.

Economic deregulation has many influences on plant performance and could have the potential to lead to degradation of existing safety principles if the impacts of deregulation on plant performance, both equipment and operator, are not fully understood and monitored by the plant operator and an independent regulator to provide early warning of a change in organizational culture. Similarly, extending the effective operating life of nuclear power plants will bring great economic benefits, but requires effective programs for mitigating or managing the deleterious effects of plant ageing.

Life extension, decommissioning, the introduction of new technology, and the aging workforce all pose unique challenges in the area of human performance. We must be prepared to understand these challenges and develop means to measure, monitor and trend organizational and management performance with regard to safety as well as individual human performance.

New reactor concepts (e.g., Pebble Bed Modular Reactor, advanced LWRs) are under development that appear to have advantages in both economics and safety over existing plants. Where there is a reasonable prospect that such new designs may be proposed to a country's regulatory authority, it is essential that the regulatory authority prepare in advance for such a proposal, ensuring it has the proper mix of technical skills and experimental facilities to thoroughly evaluate the safety of such new designs.

Similarly, in the fuel cycle, new concepts are under consideration for both the enrichment of new fuel and the disposal of radioactive waste and research expertise is needed. The application of risk analysis techniques to nuclear materials manufacturing/processing facilities is well underway, but these facilities differ from reactors and it may be necessary to adopt a different technique for risk assessments.

The analysis of the risk associated with both interim above-ground storage of spent fuel and the transportation of high level waste to final repositories requires detailed analyses of cask designs and evaluation of material behavior. Similarly, the long-term storage of radioactive waste will

require monitoring as operational information begins to be assembled. Experience from reactors and other industries using advanced technology indicates operational observations may require mid-course corrections by the regulatory body as well as by the operator of the facility to maintain safety.

New enrichment/recycle approaches as well as consideration of transmutation of high level waste will require careful evaluation of the need for safety research in parallel with developmental analyses.

The complexities of these techniques, and the complex safety, non-proliferation, and operational concerns will require a cadre of safety experts to evaluate future research needs. We must be prepared to understand these challenges and develop means to measure, monitor and trend organizational and management performance with regard to safety as well as individual human performance. Adequate research must be conducted to understand these new technologies, their associated risks to public health and safety, the uncertainty in the risk estimates, and to evaluate where controls are needed for public protection or where further research is needed to reduce uncertainties.

The support of the educational infrastructure is a specific and primary responsibility of government. Industry can and does support educational institutions in partnership with government. This pattern can be seen in aeronautical engineering, chemical, electronic, biochemistry and other high technical fields of endeavor which are vital to the long-term interests of a country. Nuclear engineering is no different in principle; it is, however, passing through a difficult period which needs to be addressed promptly and with vigor.

CONCLUSION

If the infrastructure is not maintained, there will be a steady decrease in expertise, and, thus, in capability to respond to new challenges. The lead time in developing replacement educational opportunities is very long, because most institutions will require indication of an enthusiastic pool of potential students before investing in new infrastructure, and potential students may look elsewhere if the excitement associated with a vibrant analytical and experimental program and a growing career field do not exist. Once lost, it would require massive resource inputs from many IAEA member countries to attempt to re-establish the infrastructure, as it did when nuclear technology was in its infancy. The result could be a downward spiral where expertise is lost, influence of the technical community on the decision-making process is diminished, and complacency, fed by diminished technical capability, begins to exert a strong influence. Such a situation could be a harbinger of future accidents. In this context, it should also be recalled that governments that are parties to the Convention on Nuclear Safety are committed to take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life (Article 11 of the Convention). Maintaining the necessary supporting research infrastructure is indeed, in the opinion of INSAG, such an appropriate step.

Given the above, INSAG has the following recommendations:

- *In order to maintain and further enhance the safety of nuclear facilities and protect workers and the public and the environment from radiation exposure, safety research infrastructure (experimental facilities, highly competent staff and modern analytical tools) must be maintained and supported by the responsible government organizations as well as by the operating organizations and manufacturers. This should include international networking, cooperation, including joint funding of centers of excellence, that educate people, and that have facilities and equipment for use in nuclear research.*

- *Education in nuclear science and technology needs to be stabilized in order to keep the human resources in safety science at a sufficient level. Part of the research infrastructure should be maintained at universities. There is a concern that deterioration of the research infrastructure may lead over time to a deterioration in safety which the public will not tolerate. National and international bodies have a key role to play in ensuring the skills and capabilities required by the nuclear industry and its regulators are available and that the basic infrastructure required to do this is provided for.*

- *Maintaining the safety of nuclear facilities, a pool of expertise, and the level of safety research is a common concern of IAEA member states and therefore, to the extent practical, research facilities and research data should be shared in joint research programs by IAEA member countries.*

- *The Nuclear Energy Agency is actively engaged in this effort. It has recently published two important reports dealing respectively with research capabilities and facilities, and with major research programs at risk. Following up on the conclusions of these reports, the NEA continues to review safety research needs, and organizes and sponsors internationally funded projects which contribute to maintaining key research facilities and teams. However, it is important that such efforts encompass all other countries having nuclear power programmes. IAEA and NEA could explore this further.*

- *More frequent interactions among research managers in the member states should be considered to ensure full advantage is being taken of the joint expertise and equipment available world-wide. Results of national research programs should always be made public and broadly shared. This will improve public confidence and ensure current regulatory processes reflect the current state of knowledge.*