International Experts' Meeting

Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant

16-20 February 2015

Vienna

Chairpersons' Summary

1. Background

The IAEA Action Plan on Nuclear Safety (the Action Plan) was unanimously endorsed by the Member States in September 2011 and set down 12 main actions and 39 sub actions with the aim of defining a program of work to strengthen the global nuclear safety framework. The Action Plan addresses a number of different issues including assessing the safety vulnerabilities of nuclear power plants, strengthening emergency preparedness and response, strengthening the effectiveness of regulatory bodies and operating organizations, improving the international legal framework, infrastructure development and capacity building and research and development (R&D).

One of these actions requests the IAEA Secretariat to organize international experts' meetings to analyze all relevant technical aspects and learn the lessons from the Fukushima Daiichi accident. In addition, another action addresses R&D and encourages all relevant stakeholders and the IAEA to utilize the results of research and development and to share them, as appropriate, to the benefit of all Member States.

In response to these two actions, the IAEA in cooperation with OECD/NEA organized an International Experts' Meeting on the topic of *Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant* on February 16-20, 2015 at the IAEA headquarters in Vienna, Austria.

This is the eighth in a series of IEMs that have been organized in the framework of the Action Plan. The first seven meetings dealt with the subjects of:

- Reactor and Spent Fuel Safety;
- Enhancing Transparency and Communication Effectiveness in the event of a nuclear or radiological emergency;
- Protection against Extreme Earthquakes and Tsunamis;
- Decommissioning and Remediation after a Nuclear Accident;
- Human and Organizational Factors in Nuclear Safety;
- Radiation Protection after the Fukushima Daiichi Accident: Promoting Confidence and Understanding;
- Severe Accident Management.

In line with the approach for the previous IEMs, the IAEA has made the presentations available on the IAEA web site and will publish a report on strengthening R&D effectiveness, summarizing the key points, conclusions and recommendations of the meetings, in due course. This Chairpersons' Summary will be a part of that report.

2. Objectives of the International Experts' Meeting

The main objective of this IEM was to provide a forum for experts from Member States and international organizations to exchange information and experience related to R&D work undertaken in the light of the Fukushima Daiichi accident. The IEM was aimed to assist

Member States in planning, implementing and collaborating their R&D activities in nuclear safety, technology and engineering both for existing NPPs and in the design of future new NPPs. The specific objectives of the IEM were to:

- Collect and disseminate information from Member States and international organizations on reactor technologies that are designed to cope with severe accidents, including those technologies already proven or under development;
- Share among Member States and international organizations the most recent information on R&D activities dealing with severe accidents;
- Discuss and assess the features and effectiveness of the technologies to prevent or mitigate severe accidents, as well as the challenges presented by these technologies;
- Identify and prioritize the R&D areas in which possible future international collaboration would be beneficial and/or necessary; and
- Summarize the current status of R&D activities in Member States on severe accidents after the Fukushima Daiichi accident.

The meeting comprised of an opening session, 6 technical sessions, 1 poster session and a closing session. The technical and poster sessions covered the topics of:

- R&D strategies after the Fukushima Daiichi accident;
- Measures to protect NPPs against external and internal events;
- Technologies to prevent/mitigate severe accidents;
- Severe accident analysis;
- Emergency preparedness and response;
- Post-accident recovery.

The IEM was attended by approximately 150 experts from 35 Member States and 5 international organizations. The participants represented NPP operating organizations, research institutes, nuclear reactor vendors, nuclear regulatory bodies and technical support organizations (TSOs). The IEM featured 75 expert presentations from keynote speakers, invited speakers, contributing speakers and posters.

These presentations strongly contributed to a framework for open and informal discussions held throughout the course of the meeting and reflected the willingness of the experts in sharing their experiences, results, lessons learned and views on future R&D activities. They also pointed to areas where R&D activities in the aftermath of the Fukushima Daiichi accident may need to be strengthened and how more effective use of the results can be made. This could be carried out under the auspices of the existing and future international arrangements for collaboration, including those of IAEA and OECD/NEA.

The IEM recognized the significant work done by the R&D community under the coordination of international organizations, such as IAEA, OECD/NEA, and EC. In addition, it provided an excellent opportunity to take stock of existing activities and examine potential future collaboration in R&D in light of the Fukushima Daiichi accident.

3. Lessons learned and recommendations

The Fukushima Daiichi accident reemphasized the need for the nuclear community to recognize the importance of properly considering low probability/high consequence beyond design basis accidents in the design and operation of NPPs. The accident also highlighted the importance of R&D in analyzing beyond design basis accidents and identifying potential prevention and mitigation measures.

It is important when identifying necessary safety related research that the underlying safety concerns that form the basis for the research is clearly identified. Specifically, the proposed

safety research needs to identify how the results will be used to make decisions regarding the safety of both operating and future NPPs.

In particular, it is recognized that probabilistic safety assessments can play a strong role in the identification of any future research needs. A probabilistic safety assessment can help identify what effect certain phenomena (such as core concrete interaction) could have on the overall risk posed by an NPP and the potential benefit if improved knowledge or models are available.

3.1 Suggested areas for additional R&D after the Fukushima Daiichi accident

Research activities after the Fukushima Daiichi accident contribute to the resolution of scientific gaps in knowledge, phenomena, expertise, infrastructure education and training. The process of identifying scientific gaps also needs to address what needs to be done at the national, regional or the international levels.

By extending its peer review services to the area of scientific and technical support capabilities, the IAEA could review the R&D infrastructure and capabilities of Member States to recommend improvements to support their nuclear programs.

The following list of topics without any order of importance that were identified as areas either ongoing or for future R&D:

- Source term estimation, in particular, fast running tools for source term evaluation and inverse modelling;
- Rapid evaluation of direct atmospheric transport of radionuclides (in particular fission products);
- Accident tolerant fuels;
- Spent fuel pool and fuel assembly accident phenomenology;
- Fire hazards and their impact during severe accidents;
- Hydrogen generation, transport prediction and risk management;
- Alternative ultimate heat sink;
- Containment cooling and venting under severe accident conditions;
- Risk of breach of the containment by corium-concrete interactions;
- Multi-unit site risk assessment and risk management;
- Interaction of a molten corium jet with water;
- Degraded core cooling capability
- Performance of passive safety systems' ;
- Innovative and robust instrumentation in absence of on-site power and in a harsh environment;
- Human and Organisational factors "centres of excellence";
- Non-linear soil-structure interaction effects on the calculation of seismic forces on components and structures;
- Development of multi-physics/multi-scale simulation tools for severe accident analysis and their validation and verification;
- Ageing management;
- Innovative detector and techniques to locate the melted core in the reactor pressure vessel and in the containment (e.g. by the use of muons);
- Decommissioning-related R&D such as using data from the Fukushima Daiichi reactors to understand the behaviour of systems structures and components;
- Debris removal – robotics;
- High resolution weather forecasts;

- Reactor core damage progression;
- Instrumentation performance under severe accident conditions;
- Spent fuel pool under severe accident conditions.

3.2 Sharing of information on R&D activities through international collaboration

The IEM made clear that understanding the behavior of NPPs under a spectrum of accident conditions, including severe accidents needs to be promoted for ensuring nuclear safety worldwide.

This meeting was a good opportunity to collect and share information on who is doing what and why (i.e. what is the final goal of the R&D program/project at all levels from facility to international levels). Programmes for R&D related to the Fukushima Daiichi accident in many Member States have already been completed or are currently in progress. It was agreed that an outcome of this IEM was a starting point for further discussion identifying potential future R&D activities.

Additionally, safety improvements made in response to the Fukushima Daiichi accident need to be shared and appropriately made available to all Member States. In addition, it would be useful to identify research programmes and specialized facilities addressing beyond design basis accident-related issues (including severe accidents, prevention and mitigation) particularly the programmes open to international collaboration. It is recommended to IAEA to take the lead in both of these efforts.

The IAEA is requested to continue to organize meetings focusing on the evaluation of the performance engineered safety features, through balanced use of deterministic and probabilistic approaches, particularly the assessment of low probability yet high consequence events.

The IAEA needs to continue to strengthen the coordinated research programme framework and to ensure effective dissemination of research information to enhance nuclear safety worldwide.

The IAEA needs to continue to encourage networking and scientific cooperation between Member States. International coordination of research strategies should be a focus area between IAEA, OECD/NEA, EC and relevant R&D organizations, to maximize synergies and effectiveness of research activities.

This also requires the IAEA to provide a platform for closer cooperation worldwide of research organizations, regulators, designers, vendors, utilities, operators, TSOs, and the different owners groups (such as BWR, PWR, CANDU, and VVER) to exchange information and best practices, while respecting the different roles and independence of the various stakeholders/bodies.

3.3 Integrate lessons learned from the Fukushima Daiichi accident into new R&D activities.

In light of the lessons learned from the Fukushima Daiichi accident it is important to continue to:

- Develop and disseminate assessment tools that allow a rapid and reliable estimation of doses to the public after nuclear accidents;
- Provide better assurance that assessment tools can incorporate the results of monitoring of environmental media to improve predictions;
- Apply research results, and in particular Fukushima-related R&D results, in ways that result in measurable improvements in safety;

- Encourage the publishing and wide dissemination of the results of R&D activities.

Research by regulatory bodies and/or their associated TSOs, is essential for providing sound technical bases for regulatory decision making. Cooperation and collaboration among regulatory bodies, utilities, TSOs, owners groups is also important for effective utilization of resources and for maximizing the results in research led by the regulatory bodies. However it was recognized at the IEM that this should not be done at the expense of regulatory independence.

4. Concluding remarks

In addition to the recommendations provided earlier in this report, the following are overarching conclusions:

- This IEM was considered as a good opportunity for discussing how to organize a platform for continuous exchange of information. It was noted that the IAEA plays a crucial role in assisting its Member States to prepare their capability to respond to severe accidents.
- Many Member States have robust research programs either underway, planned or completed that are designed to address issues highlighted by the Fukushima Daiichi accident.
- There are many areas where more R&D would be desirable and in many instances this is country specific. However, there are no major R&D gaps that require immediate international attention in the light of the Fukushima Daiichi accident.
- IAEA needs to continue work with its Member States to continue to coordinate R&D activities to support their R&D efforts, along with OECD/NEA, EC and other organizations.
- The IAEA was encouraged to continue to provide, with the assistance of the other international bodies, a forum for discussions on R&D for strengthening nuclear safety.
- The IAEA has a central role in collecting and disseminating Fukushima Daiichi related R&D information to Member States. Therefore the IAEA is recommended to provide a summary of these ongoing research activities and document in an appropriate manner.
- The IAEA needs to consider developing a program to identify and address the needed R&D activities in light of the Fukushima Daiichi accident.
- The Fukushima Daiichi accident will provide opportunities to the international community to strengthen long term research program to learn about severe accidents and associated decommissioning activities.