

International Experts Meeting

Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant

21-24 May 2013

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. The Action Plan sets down 12 Actions and 39 sub actions with the aim of defining a programme of work to strengthen the global nuclear safety framework.

One of these actions deals with *communication and information dissemination* with the objective of enhancing transparency and effectiveness of communication and improve dissemination of information. This action specifically requests the IAEA Secretariat to organize international experts' meetings (IEMs) to analyze all relevant technical aspects and learn the lessons from the Fukushima Daiichi nuclear accident. In response to that request, an IEM was held on 21-24 May 2013, at the IAEA headquarters in Vienna, Austria on the topic of Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant.

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

- Reactor and Spent Fuel Safety;
- Enhancing Transparency and Communication Effectiveness;
- Protection against Extreme Earthquakes and Tsunamis; and,
- Decommissioning and Remediation after a Nuclear Accident.

2. The International Experts' Meeting

The objectives of this IEM was to

- Identify the means to improve and strengthen human and organizational aspects of nuclear safety in operating and regulatory organizations;
- Analyze best practices from the responses to previous nuclear events that are being used to improve and strengthen safety culture;
- Exchange information on the interactions between individuals, technology and organizations and their influence on nuclear safety

- Evaluate the means currently being used to improve defense in depth at nuclear facilities from an organizational perspective; and,
- Identify potential priority areas for research and development.

The IEM was attended by approximately 155 experts from 40 Member States and 4 international organizations. The participants represented governmental, regulatory, operating, technical support, research and educational organizations. The IEM featured 46 expert presentations from keynote speakers along with invited speakers, contributing speakers and posters. The presentations established a framework for the frank and open discussions held throughout the course of the meeting. These discussions reflected the high level of interest among the experts in sharing their experiences, lessons learned and views on future activities in the area of Human and Organizational Factors (HOF).

The meeting comprised plenary sessions and parallel sessions covering the topics of:

- Update on Fukushima two years later;
- Human and organizational factors in nuclear safety;
- Influence of culture on the management for safety; and,
- Lessons learned.

In line with the approach for the previous IEMs, the IAEA has made all the presentation material available on the IAEA web site and will publish a report in due course. This Summary will be a part of that report.

This IEM focused on the Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant. At the initial plenary session it was pointed out that Article 12 of the Convention on Nuclear Safety stresses the importance of the consideration of human factors for the safety of nuclear installations. One of the first points that this meeting highlighted is the need for the clarification of the concepts of human factors, the interaction of individual, technological and organizational factors (ITO) and safety culture.

The IAEA is preparing a comprehensive report on the Fukushima Accident. The participants of this meeting stressed that this report needs to address the human and organizational factors including the safety culture aspects of the accident as crosscutting issues. Participants expressed the need for the world to learn from the Fukushima Daiichi accident and it was clear from the experts from Japan that they were ready to share their knowledge and experiences.

From the presentations and subsequent discussions it was noted that many countries have taken numerous actions in the area of HOF in response to the Fukushima accident. However, these HOFs have been primarily developed to support technical solutions. The question remains if there are further lessons to be learned from a systemic safety perspective.

The information presented by the speakers and the issues raised during the question and answer and panel discussions were categorized into several topics.

Systemic safety through an integrated approach

The Fukushima accident was a wakeup call for the nuclear community to recognize the complexity of safety and to respect the entire systems interaction of ITO. The complexity of nuclear organizations is increasing and different and more unique approaches are needed to ensure safety is maintained. The Fukushima accident was avoidable according to presentations from Japan.

Several considerations were identified during the meeting for the development of an integrated approach to safety. In particular, the need to complement the traditional approach to safety with an ITO systemic approach was emphasized. The participants suggested that this approach might include the use of “stress tests” for human and organizational factors and the further exploration of non-technical aspects to safety. Future analyses should include ITO considerations in an integrated way.

To implement such an integrated approach diverse competencies are necessary to work together to further enhance safety including the need to study both what creates success and what creates failure.

One type of integrated approach that was discussed during the IEM is the holistic safety approach. This approach capitalizes on understanding the strengths as well as the vulnerabilities in all factors influencing nuclear safety and can be used to inspire and motivate people to respond appropriately particularly when faced with the unexpected.

Safety culture

Recently, significant efforts have been spent on HOF and safety and organizational culture, but there appears to be a need for further development and application. Some factors have not been considered in understanding safety culture and there needs to be a greater sensitivity to more practical and implementable ways for high level managers to effect cultural change.

The consideration of national cultural aspects in any efforts associated with safety culture is necessary and this has generally not been examined. Every Member State needs to ask what exists in their national culture that can potentially hinder a strong safety culture. An analysis of national cultures and the identification of characteristics that may affect safety culture can also take advantage of beneficial national characteristics.

Support for newcomer countries was identified as very important in the application of the concept of safety culture. This support is needed by regulators, licensees and all other relevant stakeholders of these countries. Nuclear power plant vendors also have an important role to play in this area. The importance of emphasizing the priority of safety in situations where NPP’s may be part of a larger, non-nuclear organization must also be reinforced.

Relationships with contractor organizations are greatly influenced by national culture especially where there are multi-national contractor organizations. There is a need for effective

leadership to promote a strong safety culture. Most participants emphasized that the influence of the regulatory culture on licensee culture must be considered and understood. Consequently, regulators, as well as operators, should undertake safety culture self-assessments. The results of these assessments should form the basis for an informed dialogue between the regulator and the operator to ensure mutual understanding safety culture issues outside the framework for compliance and enforcement activities. Some Member States presented examples of the safety culture self-assessments performed by their regulatory bodies which the IEM considered to be good practices.

The impact of the phasing out of a national nuclear energy programme on the safety culture of nuclear organizations was considered during the IEM. In particular the importance of maintaining a strong safety culture and a high level of safety performance by both the regulatory body and the licensees during such phase outs was emphasized. Additionally, the impact of the transition from operations to decommissioning on HOF and safety culture was discussed.

Training and Learning Organizations

One proactive method to prevent accidents and improve safety performance is effective training. Training serves multiple purposes for an organization. It helps in the building of competencies, and creating trust and respect for individuals within the organization as well as for their external stakeholders. There is a need for a strong organizational infrastructure to create the most effective training.

There is a need to train for the unexpected by enhancing traditional training methods in order to increase the capabilities to cope with these situations. More realistic drills are useful for uncovering issues such as need for improved training of staff, for simplification of instructions and for improved communication with stakeholders. The participation of all stakeholders, including government organizations, in emergency drills and exercises was considered to be essential.

International/regional cooperation is critical for Member States to learn from each other on all aspects of human and organizational factors and also across different industries. The Fukushima accident opened a window of opportunity for learning and change. The nuclear community must act before the window closes with the passage of time, or identify the means to keep the window open.

Organizational relationships

The clarity of roles and responsibilities for command including control in decision making in the event of a nuclear emergency is essential. It is very important to have clear lines of command at all national levels, including the highest levels of government.

The decision making process can often be influenced by competing and conflicting priorities amongst decision makers at different levels. The NPP operator must be responsible and have knowledge and authority for safety at all times in all situations. Responsibility to make decisions outside of agreed or defined procedures should be only to ensure the protection of people and to prevent the failure of the last barrier for ensuring confinement. This helps to ensure effectiveness of severe accident management strategies.

Various means of cooperation between the regulator and the licensees were discussed. Several Member States regulatory bodies are seeking the licensees for feedback on the regulatory body's safety culture and their approach to human and organizational factors. There is also a need for clarity and procedures for information sharing and disclosure to the public. The necessity to harmonize different frameworks/approaches for safety culture and its assessment across the various stakeholders at the national and international level was discussed.

Complacency

There was wide recognition amongst the IEM participants of the need to guard against complacency. There is a need to complement the current paradigm of safety thinking because the current strategy is based on the idea that a "perfect system" is achievable. This implies that by identifying and predicting weaknesses, we can correct and/or compensate for these weaknesses to maintain safety. There is a need to understand that the more perfect the system that is developed for a specific situation, the more inflexible (or more brittle) the system becomes outside the bounds of this situation. Flexibility is essential to be able to adapt to the unexpected. A complementary strategy is to include learning from successful normal operations to enhance resilient capabilities in an organization to be prepared for the unexpected.

The experts from Japan presented the view that the Fukushima accident was avoidable. There has been a belief that a severe accident such as the Fukushima accident "could not happen here" and this attitude has a significant influence on safety culture. Operators and regulators must look at what can be learned from Fukushima, rather than 'distancing themselves by differentiation. Risk management is an important element of safety culture, and organizations both on the operator and regulatory sides have sometimes managed risk for their own convenience. A false sense of security in defense in depth, redundant safety features, complexity and the multiple failures that are needed for accidents can all result in complacency.

3. Elements discussed during the IEM to improve safety

- Recommendations for IAEA to review/develop:
 - Guidance and training material for the integration of all elements of HOF, safety culture, organizational culture, management system, ITO, in existing and new nuclear programmes to ensure that the systemic approach is developed and maintained;

- An integrated oversight/assessment program for national regulatory bodies to include all aspects of management/ HOF/ engineering to see operating organizations performance in a holistic way;
 - The current guidance in IAEA safety standards of HOF aspects considering experience following the Fukushima accident and revise as necessary;
 - Guidance on management of organizational changes, including emergency organizations, taking into consideration the lessons learned from the Fukushima accident;
 - Guidance on organizational resilience, based on state-of-the art research;
 - Guidance documents and training material on enhancing the integration of supplier organizations into the operators HOF practices/processes;
 - A methodology for the implementation of 'stress tests' addressing HOF;
 - Existing approaches on early symptoms of declining safety culture and produce practical training material;
 - Training and support to regulatory bodies for conducting self-assessment and for the regulatory oversight of licensees' safety culture; and,
 - Successful handling of "near misses" and events and share the results with the international community.
- Recommended topics for further discussion:
 - IAEA and other national and international organizations to work more closely and harmonize their approaches and definitions in the area of HOF and safety culture;
 - The influence of regulatory approaches on the licensees' safety culture;
 - Management of contractors during accident and emergency conditions;
 - Regulatory oversight of organizational resilience;
 - More facts and data about the specific HOF aspects of the events at Fukushima Daiichi and Daini would be valuable;
 - Ensure that the NPP organization has the knowledge and authority for safety at all times in all situations;
 - Decision making in crisis situations;
 - Implementation of 'stress tests in the area of HOF;
 - Implementation of safety culture self-assessments by the regulatory bodies and evaluate how their safety culture impacts the operating organizations;
 - Human factors as an important contributor to safety and effectiveness of nuclear facilities;
 - Integration of HOF specialists, in the case of events, into multi-disciplinary teams from the initial phase of analysis;
 - Competence in HOF area of regulatory bodies and operating organizations
 - Interaction between Nuclear and other high-risk industries (e.g. aviation, chemical, etc.) in the area of HOF and safety culture

4. Human and Organizational Factors in Nuclear Safety (Parallel Session IVA) - Co-Chairperson's Summary

Throughout the session dedicated to Human and Organizational Factors (HOF) in Nuclear Safety, a number of key issues were addressed by the panellists and discussed with the experts. These key issues identified the approaches and concrete tools to help strengthen human and organizational factors as a key component of nuclear safety and how they could be better integrated from the design stage through decommissioning of nuclear facilities. These issues were presented from various perspectives, including regulatory bodies, operators, technical support organizations, research and design organizations, education institutions and individual experts in the field.

The presentations and subsequent discussions highlighted that many Member States have taken numerous actions in the area of HOF in response to the Fukushima accident. These actions include changes in legislation regarding the functions and independence of the regulatory body, development of additional HOF regulatory requirements, expectations and guidance, development of prioritization of decisions and to support decisions in severe accident management situations. Other activities include the HOF considerations emergencies such as the planning and conduct of emergency drills and exercises, the creation of regional response centres, organizational changes, identification of specific training (including resilience training) for operating personnel, communications arrangements, and emergency/ security interface. However, these considerations of HOF have primarily been developed to support technical solutions and a significant question raised by the experts was whether HOF have been comprehensively addressed.

Parallel Session IV A considered four main issues.

Leadership Aspects

- The experts considered that the understanding of, and commitment to, the importance of HOF aspects by leaders is critical to successful integration of HOF into a nuclear power programme.
- Decisions taken at a high (leadership) level can have an important influence on applying an appropriate response to accidents.

Enhancing Competencies and Learning Mechanisms

Training

- The experts considered that technical staff and managers in relevant organizations such as operators, regulatory bodies and vendors should be trained in the principles of HOF to progressively embed consideration of HOF into their routine activities.
- Training on HOF and safety culture may include: e-learning tools, tests, workshop and knowledge sharing mechanisms, simulators and simulation developed with automation specialists. Training methods may need to be adapted to the national culture whilst retaining the focus on nuclear safety culture. In some Member States, traditional images or icons are used in posters to facilitate rapid understanding and memorization of the key messages.
- Training and information on HOF should also be targeted at each functional team within an organization. For example, for managers who should ensure the deployment of the HOF strategy and attribute the means for its implementation; process specialists who can integrate the HOF approach into organizations processes; and trainers and operational experience specialists.
- Contractors and sub-contractors' employees should be able to benefit from safety culture/ HOF training that is harmonized with the training provided to the employees of the operator particularly in changing working environments such as during the construction and decommissioning of nuclear facilities.
- Drills and exercises are an essential mechanism to train staff to deal with emergency situations. They should cover beyond basis events and include all responsible parties/ organizations/ governmental agencies and may also involve other countries. Drills should be regular, real-time, worst case scenarios (including those most demanding in terms of human resources), with minimum complement of the station only, un-announced, but keeping in mind appropriate focus on operation (balance on resources, operating needs and routine training). 'Think out of the box' exercises in training programme can help raise awareness on safety culture issues and address them.

Competence

- The competence in HOF of regulatory bodies and operating organizations varies largely and some organizations do not have sufficient competence in this area.
- HOF experts may have various backgrounds and specialities. Specialists working on HOF comprise behavioural scientists, psychologists, sociologists as well as engineers and previous managers, who have been educated in HOF area. This issue raised numerous questions and comments from the experts regarding the appropriate composition of HOF expertise.
- The development of dedicated educational programmes should be encouraged. In some Member States a specific post graduate programme has been developed in HOF in liaison with the nuclear industry.
- Some Member States have one HOF specialist in each of their NPPs and a large team of specialists in its corporate organization and its research and development centre.

Organisational learning and knowledge sharing

- The experts emphasized the need for a strong oversight capability of HOF for the life-time of an NPP from initial design to completion of decommissioning. The experts recommended that IAEA should develop guidance for regulatory oversight of human factors programmes.
- The experts commented on the tendency of the nuclear industry to focus only from learning from failures. It was strongly recommended that the focus should be broadened to also facilitate learning from successes. For example, when analysing "near miss" events, the success factors for why the

near-miss did not escalate should be examined as well as the root causes of the event. It was suggested that IAEA should promote and encourage this approach.

- Some experts stated that more attention should be given to ensure that effective feedback on event reporting is provided. This will influence and improve the event reporting culture. The experience with the analysis of events from other industries should be used such as aviation.

Evaluation of Human and Organizational Performance

Evaluation tools

- The experts considered that the use of structured tools to assess and enhance human and organizational performance should be promoted. There is a need to elaborate guidelines for developing self-assessment of human performance using a matrix approach and involving HOF specialists. Employees should be encouraged to take part in self-assessment exercises.
- Drills and exercises can help to identify valuable lessons for human and organizational performance including identifying training needs and equipment issues.
- Methods of analysis of human and organizational performance should include post-accident analysis, pre-accident risk assessment and the use of 'event trees'.

Use of Operating Experience

- Experts at the IEM discussed the difficulties in undertaking investigations of the HOF root causes of accidents. There was considerable discussion on the approach to gathering reliable information on HOF root causes, particularly as working level HOF errors often have their root cause in decisions made at the leadership level. The need for a systematic analysis of HOF associated with accidents was emphasized, along with the importance of using an appropriate system for coding accidents to facilitate their analyses and to extract data and general trends. It was considered that nuclear event investigations are often not sufficiently focused on identifying the latent root causes related to HOF and leadership. As a result, it is important that human performance engineering or HOF specialists should be included in the event investigation teams.
- Existing initiatives include the IAEA International Reporting System for Operating Experience (IRS) database on organizational causal factors and the European Commission Human Factor Analysis and Classification System.

Establishing a HOF Strategy

General

- A national approach in responding to lessons learned from Fukushima accident should be promoted as a good practice. For example, this could include legal agreement to support interventions for the "incident site" to effect a long-term response to protect people and the environment."
- The experts emphasized the importance of the embarking countries taking into account HOF aspects from a very early stage. They recognized the importance of the support provided by the IAEA for this purpose. The experts considered that the vendor-countries also have a very important role in supporting the embarking countries.
- Utilization of the results from relevant research should be used when developing HOF strategies and implementation of technical and organizational improvements.

Integration of HOF in the Design Process

- The experts discussed the importance of integrating HOF into the design process. The man-machine interaction and anticipation of the future work situations should be prepared by the designer in cooperation with the operators taking full account of HOF aspects.
- Analysis of the potential HOF influence on specific design aspects and of the level of risk involved must be carried out in advance and should allow to implement a graded approach.
- To better convey information, the preparation of simple instructions (less time consuming) for consideration of HOF in design should be promoted.
- Early engagement and communication between regulators and licence applicants during the new build phase, particularly for HOF requirements is very important.

Promotion of Adaptive Behaviour in case of Emergency

- During the discussions on HOF issues associated with emergencies, some Member States reported on a move from rule based procedures to knowledge based guides to better manage severe accident. These were considered to allow for a higher degree of flexibility and efficiency.
- Staff support in the case of an accident should include: prioritization matrix (if shortage of staff), training flexibility and emotional support.
- Some experts highlighted the need for the deployment of support equipment in case of emergency to be made as simple as possible to avoid relying on highly specialised staff and rather being able to employ immediately available human resource. In addition easily comprehensible guidance on the prioritization of decisions, with appropriate authority, to support decisions in SAM situations should be developed

5. Topics for Further Investigation

- IAEA should develop guidance for the regulatory oversight of licensees' human factors programme.
- IAEA should review the current guidance on HOF aspects in IAEA safety standards in light of the Fukushima accident.
- IAEA should review and update guidance on management of organizational changes, including emergency organizations in light of the Fukushima accident.
- IAEA should provide training and support to regulatory bodies for conducting self-assessment and for the regulatory oversight of licensees' safety culture.
- IAEA should promote and encourage the analysis of the successful handling of near misses and events.
- In the case of events, HOF specialists should be integrated into multi-disciplinary teams from the initial phase of analysis
- Both regulatory bodies and operating organizations should have sufficient competence in HOF area.
- Experience from other high-risk industries such as aviation and chemical should be utilized.

6. Influence of Culture on the Management for Safety (Parallel session IVB) -Co-Chairperson's Summary

This parallel session included presentations from experts from regulatory bodies, operating organizations and others that led to discussions in a very open and collaborative atmosphere. I would like to thank all participants for their valuable contributions.

The main conclusions from the technical exchanges during this session can be summarized as follows.

Accidents in different domains have been shown to have common factors. Nuclear energy poses unique risks which create special responsibilities for the operator and regulatory body; however the systemic root causes of nuclear accidents share much in common with other industries and the nuclear industry can and should learn from experience in other high reliability industries in addition to nuclear such as oil and gas, petrochemicals, aviation, etc.

The IAEA should provide training and publications on the anatomy of real accidents to illustrate the interactions between the human, organisational and technological aspects that cause accidents. It is also important to highlight the different entities that comprise 'the national nuclear system' and their interactions such as government, regulator, companies, and individual workers.

Leadership and management for safety is important. Managers often say after an accident they did not know what was going on, but their job is to know what is going on.

National culture is a factor that may shape nuclear safety culture. In some cases, safety culture in nuclear organisations appears to transcend national culture. In other cases national culture appears to influence safety culture. Safety culture assessments should consider the influence of national cultural traits. The IAEA is encouraged to support self-assessments of national cultural influences of safety management.

The application of expertise in human and organizational factors needs to be recognised as an important resource to contribute to a systemic safety approach to nuclear safety. Many organisations lack a good balance between technical and behavioural science skills. IAEA is encouraged to assist in clarifying the competencies required by regulatory bodies and operators in the domain of behavioural and organisational science.

IAEA should include in safety standards requirements and guidance for the use of human and organisational competence to optimise safety of facilities and activities in normal and accident situations. To the extent practicable, the standards should use common terms and definitions for ITO concepts.

Operating experience is an important source of learning. The effectiveness of the learning loop needs to be scrutinised in the light of research. Currently the focus of organisational learning is on reacting to problems and events; however, an approach of identifying and replicating strengths and success factors should also be considered to create resilience capabilities for unexpected situations.

Regulatory bodies should undertake assessments of safety culture within their own organisations in order to improve the effectiveness of their organisation's performance and to assist reflection on their relationship and interaction with the licensees. The IAEA is encouraged to hold a technical meeting to share experiences on regulatory body safety culture assessments.

The IAEA should continue to develop guidance on effective methods for oversight of safety culture in operating organisations. The document should include examples of good practices implemented by

other regulators.

Responsibilities for incident command and advisory roles in a crisis situation or an accident involving a nuclear facility follow various models in different organisations. Clear roles and responsibilities and decision-making in critical situations are of key importance for safety and need to be predefined. More knowledge is needed of the strengths and weaknesses of different models. The IAEA is encouraged to develop guidance on effective crisis management with special focus on ITO aspects. This guidance should be developed taking account of the relevant competencies.

Recent research in the areas of High Reliability Organizations should be integrated into methods and standards for practical application.