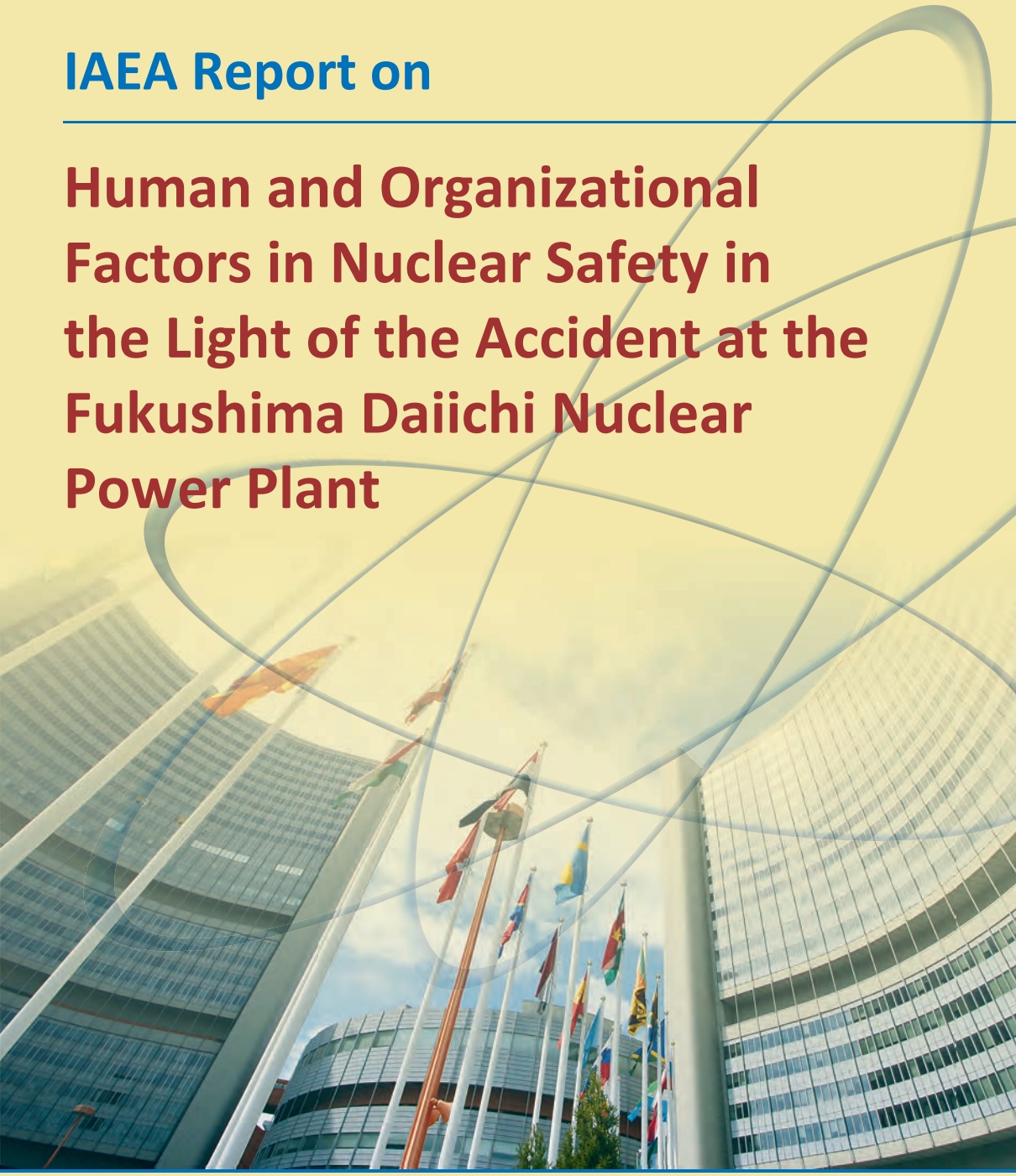
IAEA Report on

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



International Experts Meeting
21–24 May 2013, Vienna, Austria

IAEA
International Atomic Energy Agency

IAEA REPORT ON HUMAN AND ORGANIZATIONAL FACTORS IN NUCLEAR SAFETY IN THE LIGHT OF THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BRUNEI DARUSSALAM
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DOMINICA
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FIJI
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA, ISLAMIC REPUBLIC OF
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PAPUA NEW GUINEA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
RWANDA
SAN MARINO
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWAZILAND
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TOGO
TRINIDAD AND TOBAGO
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA, BOLIVARIAN REPUBLIC OF
VIET NAM
YEMEN
ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA REPORT ON HUMAN AND ORGANIZATIONAL FACTORS IN NUCLEAR SAFETY IN THE LIGHT OF THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

INTERNATIONAL EXPERTS MEETING
VIENNA, 21–24 MAY 2013

Organized in connection with the implementation
of the IAEA Action Plan on Nuclear Safety

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2014

COPYRIGHT NOTICE

Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

Printed by the IAEA in Austria
September 2014
IAEA/IEM/5

FOREWORD

By Denis Flory
Deputy Director General
Department of Nuclear Safety and Security

In response to the accident at the Fukushima Daiichi nuclear power plant, IAEA Member States unanimously adopted the Action Plan on Nuclear Safety. Under this Action Plan, the IAEA Secretariat was asked to organize International Experts Meetings to analyse all relevant technical aspects and learn the lessons from the accident. The International Experts Meetings brought together leading experts from areas such as research, industry, regulatory control and safety assessment. These meetings have made it possible for experts to share the lessons learned from the accident and identify relevant best practices, and to ensure that both are widely disseminated.

This report on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant is part of a series of reports covering all the topics dealt with in the International Experts Meetings. The reports draw on information provided in the meetings as well as on insights from other relevant IAEA activities and missions. It is possible that additional information and analysis related to the accident may become available in the future.

I am grateful to the participants of all the International Experts Meetings and to the members of the International Nuclear Safety Group (INSAG) for their valuable input.

I hope that this report will serve as a valuable reference for governments, technical experts, nuclear operators, the media and the general public, and that it will help strengthen nuclear safety.

EDITORIAL NOTE

The presentations on the attached CD-ROM (including the figures, tables and references) have not been reviewed by the editorial staff of the IAEA. The views expressed remain the responsibility of the named authors or participants. In addition, the views are not necessarily those of the governments of the nominating Member States or of the nominating organizations.

This report does not address questions of responsibility, legal or otherwise, for acts or omissions on the part of any person.

Although great care has been taken to maintain the accuracy of information contained in this publication, neither the IAEA nor its Member States assume any responsibility for consequences which may arise from its use.

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

The authors are responsible for having obtained the necessary permission for the IAEA to reproduce, translate or use material from sources already protected by copyrights.

Material prepared by authors who are in contractual relation with governments is copyrighted by the IAEA, as publisher, only to the extent permitted by the appropriate national regulations.

This publication has been prepared from the original material as submitted by the authors. The views expressed do not necessarily reflect those of the IAEA, the governments of the nominating Member States or the nominating organizations.

The IAEA has no responsibility for the persistence or accuracy of URLs for external or third party Internet web sites referred to in this book and does not guarantee that any content on such web sites is, or will remain, accurate or appropriate.

The depiction and use of boundaries, geographical names and related data shown on maps do not necessarily imply official endorsement or acceptance by the IAEA.

CONTENTS

INSAG PERSPECTIVE

This report provides an introduction to the highly complex issue of the human and organizational factors that are important to nuclear safety, focusing in particular on the interactions among individuals, technology and organizations. The report considers the role of safety culture and organizational factors, their interactions with technology, and the effect of updated and new knowledge. The aim is to stimulate discussion and thereby to improve the measures for the prevention and mitigation of severe accidents based on a 'systemic approach' as defined in the Fundamental Safety Principles[1].

Accidents rarely happen as a result of one single event, but emerge from the accumulation of malfunctions, misunderstandings, incorrect assumptions and other issues. In the past, issues related to human and organizational factors have been addressed in the same manner as purely technical issues. Consequently, the complexity of the overall system has not always been properly taken into account. The systemic approach to safety addresses the whole system by considering the dynamic interactions within and among all relevant factors of the system — individual factors (e.g. knowledge, thoughts, decisions, actions), technical factors (e.g. technology, tools, equipment), and organizational factors (e.g. management system, organizational structure, governance, resources).

Individuals and organizational and technology issues can be seen to have contributed to the accident at the Fukushima Daiichi nuclear power plant. Although numerous actions have been taken in response — for example, the formulation of guidelines, the development of decision making schemes for severe accident management, the conduct of more demanding emergency drills and exercises, the creation of regional response centres, and the identification of additional training for operating personnel — most were primarily developed to support technical solutions to the lessons learned from the accident. This report questions whether the human and organizational factors have been adequately addressed. It outlines the need to better understand the interrelationships and interactions among human, technical and organizational factors, including safety culture, in the application of a systemic approach to finding root causes. The need to guard against complacency has been highlighted by the International Nuclear Safety Group (INSAG)[2] and is further emphasized in the report.

---

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

[2] INTERNATIONAL NUCLEAR ADVISORY SAFETY GROUP, Key Practical Issues in Strengthening Safety Culture, INSAG-15, IAEA, Vienna (2002).

An approach to safety that is based on correcting or compensating for identified weaknesses can create a system that is inadequate for situations outside the defined boundaries. There is a need to employ a complementary strategy that provides flexibility and thereby a capacity to deal with the unexpected. For example, lessons might be learned and resilient capabilities introduced in an organization based on study of the management of the extreme external hazards at the Fukushima Daini nuclear power plant. In order to develop a truly systemic approach to safety, however, there is a need to utilize expertise from other areas, such as the social and behavioural sciences.

Safety culture should remain the top priority for all organizations. Leadership and management for safety are critical in the development and maintenance of a strong safety culture. INSAG has emphasized the need to establish a safety culture in which safety is the highest priority and in which everyone involved in the nuclear enterprise accepts personal and individual responsibility for it.[3]

Attention also has to be given to national factors that can influence the development of beliefs, attitudes and values. The important point is for an organization to establish the right values and behaviours for a strong safety culture by taking into account any such national factors.

The Fukushima Daiichi accident revealed the need for a re-examination of the human and organizational factors associated with emergency planning, response and decision making. While the prime responsibility for safety must rest with the operator, a key lesson from the accident is the need for a priori clarification of the decision making process between the operator and other relevant stakeholders. This issue was also addressed at an earlier International Experts Meeting on Enhancing Transparency and Communication Effectiveness in the Event of a Nuclear or Radiological Emergency. Another important issue concerns the need for training to deal with the unexpected.

In conclusion, this report highlights three key issues that should be addressed:

(i) The traditional approach to safety should be complemented by a systemic approach that considers not only the human, organizational and technological factors that contribute to safety, but also the complexity of the interrelationships among them.

---

[3] INSAG Annual Letter of Assessment 2012, available at: http://www-ns.iaea.org/committees/files/insag/743/gc56inf-11_enINSAGlettertoDG.pdf

(ii) Regulatory oversight and assessment of nuclear power plant safety should include safety culture.

(iii) The review of the IAEA safety standards should take into account the lessons from the Fukushima Daiichi accident involving human and organizational factors.

1. INTRODUCTION

Following the accident at TEPCO's Fukushima Daiichi nuclear power plant (the Fukushima Daiichi accident), the IAEA Director General convened the IAEA Ministerial Conference on Nuclear Safety in June 2011 to direct the process of learning and acting upon lessons to strengthen nuclear safety, emergency preparedness and radiation protection of people and the environment worldwide. Subsequently, the Conference adopted a Ministerial Declaration on Nuclear Safety, which requested the Director General to prepare a draft Action Plan.[4] The draft Action Plan on Nuclear Safety (the Action Plan) was approved by the Board of Governors at its September 2011 meeting.[5] On 22 September 2011, the IAEA General Conference unanimously endorsed the Action Plan, the purpose of which is to define a programme of work to strengthen the global nuclear safety framework.

The Action Plan includes 12 main actions. One of the actions is focused on communication and information dissemination, and includes six sub-actions, one of which mandates the IAEA Secretariat to "organize international experts meetings to analyse all relevant technical aspects and learn the lessons from the Fukushima Daiichi nuclear power station accident".[6]

The International Experts Meeting (IEM) on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant was held from 21 to 24 May 2013 at IAEA Headquarters in Vienna. The IEM was convened to discuss and better understand the human and organizational factors in nuclear safety, and to identify lessons learned and best practices for improving the way that human and organizational factors are considered in the future.

The IEM was attended by over 160 experts from 41 Member States and 5 international organizations representing governmental, regulatory, operating, technical support, research and educational organizations, primarily from the nuclear community. Representatives of other high hazard industries[7] also attended. The IEM featured 46 expert presentations from keynote speakers and panellists, and provided several opportunities for open forum discussion where participants shared their experience and identified lessons learned.

---

[4] Declaration by the IAEA Ministerial Conference on Nuclear Safety in Vienna on 20 June 2011, INFCIRC/821, IAEA, Vienna (2011), para. 23.

[5] Draft IAEA Action Plan on Nuclear Safety, Report by the Director General, GOV/2011/59-GC(55)/14, IAEA, Vienna (2011).

[6] Ibid., p. 5.

[7] High hazard industries include, for example, the petrochemical, mining and aerospace industries.

The broad objective of the meeting was to gather and share knowledge and experience gained in the light of the Fukushima Daiichi accident regarding human and organizational factors. Of specific interest were the interactions between individuals, technology and organizations, and their influence on nuclear safety. The meeting was designed to focus on lessons learned and best practices, and to identify activities to further develop this area; the goal was to be more prospective than retrospective. The experts noted that accidents are not unique and that there are common factors that can be anticipated which transcend all events. There was agreement on the need to understand what these factors are and to minimize their occurrence. This was the framework for frank and open discussion throughout the meeting. The discussion reflected the experts' high level of interest in sharing their experience, lessons learned and views on future activities in the area of human and organizational factors in nuclear safety.

The IEM was organized into four plenary sessions and two parallel technical sessions, including keynote addresses, presentations and discussion periods. The following topics were considered:

— National responses to the Fukushima Daiichi accident, such as assessments of the role of safety culture, and human and organizational factors and their interaction with technology;
— Updated and new knowledge used by operating organizations, regulatory bodies and technical support organizations (TSOs), offering a broad global vision of the relevant human and organizational aspects of the Fukushima Daiichi accident with a view to stimulating discussion;
— Methods for preventing and mitigating the consequences of severe accidents based on a systemic approach to safety.

Each of the sessions was summarized, and a Chairperson's Summary was produced (see Annex A to this report).

1.1. BACKGROUND

Research on industrial accidents shows that they rarely happen as a result of a single event, but rather emerge from the accumulation of several, often seemingly trivial, malfunctions, misunderstandings, incorrect assumptions and other issues. The nuclear community has established rigorous international safety standards and concepts to ensure the protection of people and the environment from harmful effects of ionizing radiation. Defence in depth is one of these concepts. However, after the Fukushima Daiichi accident, the questions being

asked are, Why did this happen, and what can be done differently to prevent it from happening anywhere again?

The current concepts within the nuclear safety paradigm are based on a compartmentalized and linear approach aimed at identifying and correcting each weakness separately. This approach is applied when performing deterministic and probabilistic safety assessments, as these are based on cause and effect thinking that treats the different factors of the nuclear organization in a separate, linear manner. Experts in the area of human and organizational factors related to safety culture have long recognized a weakness in the current nuclear safety paradigm: the inability to fully comprehend the complex system of interacting processes, including human and organizational interactions with technology.

The systemic approach to safety works by addressing this complex system of interactions as a whole. For example, among the important factors to consider in these interactions at a nuclear power plant are those related to individuals, such as knowledge, decisions, thoughts, emotions and actions. The technical factors to consider include the physical aspects of the nuclear power plant and the range of technical tools and equipment used for operation. The organizational factors to consider include the management system, organizational structure, governance of the nuclear power plant, and human and financial resources. Taking into account the ongoing interaction between all the individual, technical and organizational (ITO) factors reveals the complexity and non-linearity of the operations at a nuclear power plant. It is necessary to better examine how the weaknesses and strengths of all these factors influence one another and to facilitate the proactive elimination of risks.

Furthermore, the complex system of interactions is broader than the nuclear power plant, and its individuals and organization. A systemic approach to nuclear safety takes into account these broader factors, such as the interactions of all other relevant stakeholders, for example, operators, vendors, regulators, contractors, TSOs, corporate organizations and international organizations. The individual actions of one organization can affect other stakeholders in a dynamic and sometimes unexpected manner. If these other organizations operate without being mindful of the impact of their actions and interactions, safety can be compromised.

1.2. OBJECTIVE

The objective of this report is to highlight the views expressed by international experts during the IEM on the influence of human and organizational factors in normal and emergency situations, including the lessons learned from the Fukushima Daiichi accident. The report identifies key areas

where human and organizational factors in nuclear safety can be strengthened as well as best practices for achieving an integrated approach to nuclear safety. The report is expected to contribute to the ongoing efforts to assist Member States in strengthening nuclear safety worldwide and constitutes an integral part of the implementation of the Action Plan.

This report provides an overview of the knowledge shared and experience gained in the light of the Fukushima Daiichi accident concerning human and organizational factors, and summarizes the discussions at and conclusions of the IEM. The concept of systemic safety, and the interactions between individuals, technology and organizations, and their influence on nuclear safety, are presented. The report also describes activities of the IAEA Secretariat directed at enhancing the understanding of the human and organizational aspects of nuclear safety and draws upon relevant IAEA guidance[8].

The IEM sought to identify means to improve and strengthen human and organizational aspects of nuclear safety in operating organizations and regulatory bodies. Some of this information was presented by experts as best practices developed in response to previous nuclear events that are being used to strengthen safety culture across the nuclear community. The means being used to improve the application of defence in depth at nuclear power plants from a management and organizational perspective were also presented. The IEM provided a forum for all this information to be discussed within the framework of the interactions between individuals, technology and organizations and their influence on nuclear safety.

By bringing together the lessons learned to date concerning the influence of human and organizational factors during all phases of the operation of a nuclear power plant, and by making them available to Member States, this report is expected to contribute to further strengthening nuclear safety and enhancing confidence in the peaceful uses of nuclear energy.

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standard Series No. GS-G-3.1, IAEA, Vienna (2006).

2. LESSONS LEARNED IN THE UNDERSTANDING OF THE CONCEPTS OF HUMAN AND ORGANIZATIONAL FACTORS IN NUCLEAR SAFETY

The importance of human factors in nuclear safety was highlighted by the Three Mile Island accident in 1979. That accident led the nuclear community to acknowledge the role of non-technical aspects of nuclear operations. Moreover, the visibility of areas such as training, procedures and adherence to those procedures increased, as efforts to prevent a similar type of event were initiated in many countries around the world.

The accident at the Chernobyl nuclear power plant in 1986 drew attention to the important role of safety culture, and of management and organizational factors in nuclear safety. The summary report of the post-accident review meeting on the Chernobyl accident by the IAEA's International Nuclear Safety Advisory Group (now known as the International Nuclear Safety Group (INSAG)) noted that: "The root cause of the Chernobyl accident, it is concluded, is to be found in the so-called human element."[9]

The role of well defined processes within a management system was seen as the most important part of ensuring that all human and organizational factors could be identified and managed. In 1991, INSAG defined the concept of 'safety culture'[10] to enable nuclear managers to understand the need to prioritize nuclear safety throughout their organizations, in both technical and non-technical areas.

Subsequent events across the nuclear community highlighted the critical role that human and organizational factors play in nuclear safety. Significant corrosion of the reactor vessel head of the Davis-Besse nuclear power plant was discovered in 2002. The root cause analysis of the situation identified a poor safety culture as the primary reason that the operating organization allowed such a condition to develop.[11] Other organizations started to ask questions to determine what type of safety culture they had and whether they were susceptible to the same types of issues. Additionally, the safety requirements established in The Management System for Facilities and Activities (IAEA Safety Standards

---

[9] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Summary Report on the Post-accident Review Meeting on the Chernobyl Accident, Report by the International Nuclear Safety Advisory Group, Safety Series No. 75-INSAG-l, IAEA, Vienna (1986).

[10] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Safety Culture, Safety Series No. 75-INSAG-4, IAEA, Vienna (1991).

[11] NUCLEAR REGULATORY COMMISSION, Davis-Besse Reactor Pressure Vessel Head Degradation: Overview, Lessons Learned, and NRC Actions Based on Lessons Learned, Rep. NUREG/BR-0353, Rev. 1, NRC, Washington, DC (2008).

Series No. GS-R-3)[12] require the integration of all elements of the management system. While the idea of taking a systemic view of safety has existed for some time, the Fukushima Daiichi accident magnified the need for an approach that views safety as an outcome of the interaction between individuals, technology and organizations. However, confusion persists among many in the nuclear community regarding these concepts, and the need for clarity and understanding in this regard is one of the lessons learned that was identified by the IEM participants.

2.1. INTEGRATED APPROACH TO SAFETY

A review of major human induced disasters in a number of countries and in different industries yields insights into several of the human and organizational factors involved in their occurrence.[13] Some of these factors relate to failures in:

— Design or technology;
— Training;
— Decision making;
— Communication;
— Preparation for the unexpected;
— Understanding of organizational interdependencies.

Individually, any of these failures can prevent an organization from being proactive in trying to continuously improve nuclear safety. When occurring together in some combination, they become the root causes of accidents. The root causes of nuclear accidents share much in common with the causes of accidents experienced in other industries, and the nuclear community can draw on this experience as a source of lessons learned.

The National Diet of Japan's report on the Fukushima Daiichi accident[14] concluded that the accident should not be considered solely the result of extreme

---

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

[13] ROBERTS, K., "Why catastrophic accidents are not unique", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

[14] THE FUKUSHIMA NUCLEAR ACCIDENT INDEPENDENT INVESTIGATION COMMISSION, The Official Report of the Fukushima Nuclear Accident Independent Investigation Commission: Executive Summary, The National Diet of Japan, Tokyo (2012); available at: http://www.nirs.org/fukushima/naiic_report.pdf

natural events but also as a human induced accident that was, at least in part, preventable. A review of some of the lessons learned[15,16] indicates that the Fukushima Daiichi accident fits into the framework of experience from other major human induced disasters, involving factors such as:

— Inadequate knowledge and training related to severe accidents (training failure);
— A lack of regulatory independence and the existence of a complex 'chain of command' (failure to deal with organizational interdependencies);
— A lack of cross-functional discussions (communication failure);
— A belief that a severe accident and loss of defence in depth was unlikely (failure of imagination);
— A failure to expect the unexpected;
— Underestimation of tsunami height (design or other technological failure);
— A failure to consider the need to strengthen safety measures (decision making failure).

The perception that several of these factors were not very important or were of a very low probability of occurrence led to the conclusion that they did not need to be addressed.[17] These factors were not considered from a systemic perspective, even though they were associated with the potential for very serious consequences if they did occur.

Human and organizational factors are often considered as discrete variables in that they are commonly viewed as separate and identifiable issues in the cause of an event. Examples include lack of training, incorrect procedures, poor decision making and ineffective communication. While these factors may very well play a separate and significant role in an operational failure, it is often a combination of several human, organizational and technological factors that leads to events and accidents.

---

[15] KAWANO, A., "Lessons of TEPCO's Fukushima accident from human and organizational aspects and challenges for nuclear reform", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

[16] OSHIMA, K., "Nuclear safety human and organizational factors: Lessons from Fukushima", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

[17] KANEKO, S., "Changes in the regulatory authority in the area of human and organizational factors as a function of the Fukushima Accident", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

The complexity of nuclear power plant operating organizations has been increasing, with higher standards of safety, downward pressure on resources, increased regulatory requirements, and the accumulation of information and operating experience. Consequently, to ensure that safety is maintained in this complex environment, a complementary approach to safety is needed, taking into account the combination and interaction of all factors in the operation of a nuclear power plant. Organizations are trying to understand how to pragmatically implement an integrated management system that includes human and organizational factors, concepts and ideas.

Many of the experts participating in the IEM indicated that most of the activities being carried out in response to the Fukushima Daiichi accident were developed to support solutions to technical issues. However human and organizational factors play a significant role in these activities, including:

— The development of additional regulatory requirements on human and organizational factors;
— The development of additional expectations and guidance;
— The development of decision making schemes to support actions for severe accident management situations;
— The planning and conduct of more demanding and unannounced emergency drills and exercises;
— The creation of regional response centres;
— The identification of additional specific training for operating personnel;
— The development of communications coordination;
— The strengthening of the safety and security interfaces.

In this light, a significant question raised at the IEM was whether the issues relating to human and organizational factors that came to light during the Fukushima Daiichi accident have been comprehensively addressed in their own right and not just considered as part of solutions to other technical issues. In response, it was argued that the nuclear community needs to better understand how a systemic approach to safety, with its emphasis on the interrelationships and interactions of the human, technical and organizational factors, including safety culture, can explain some of the root causes of the accident. Interrelationships and interactions that need to be considered are those:

— Among staff at nuclear power plants;
— With staff at the designated emergency centre;
— With corporate headquarters;
— With the regulatory body;

— With the government;
— With the local and international communities.

By considering this information, the complexity of the interactions that affected the accident can be better understood and used to identify important lessons for preparing to deal with such unexpected situations. Additionally, the understanding and recognition of the importance of human and organizational factors by leaders in the organizations is critical to their successful application to a nuclear power programme.

Human and organizational factors need to be considered in all phases of a nuclear power programme. Especially important is the consideration of human and organizational factors at the very beginning, during the process of nuclear power plant design. The human–system interface — including both the immediate interaction of the individual with the technology and anticipated future work situations — needs to be prepared by the nuclear power plant designers in collaboration with the future plant operators. An analysis of the potential influence of the human and organizational factors on specific aspects of nuclear power plant design and the level of risk involved must be conducted in advance of construction or manufacturing of components and systems. This analysis will allow the implementation of a graded approach[18] to the integration of human–system interfaces based on the level of calculated risk.

As discussed, many Member States have taken action to implement the lessons learned from the Fukushima Daiichi accident. Most of these actions have been in the area of technical factors. The IEM participants agreed that a national approach to responding to the lessons learned needs to include a strategy for addressing human and organizational factors. For those Member States embarking on a nuclear power programme, it is important to establish a strategy for human and organizational factors from the earliest stages of programme development. This issue was highlighted in the INSAG Annual Letter of Assessment 2010,[19] which stated that: "The major lesson that a new operator should learn is the need and challenge of establishing and maintaining a safety culture — that is, an overriding commitment to safety at all levels of the operation." The importance of IAEA support in this area to these Member States was clearly recognized at the IEM.

---

[18] For a system of control, such as a regulatory system or a safety system, a graded approach is a process or method in which the stringency of the control measures and conditions to be applied is commensurate, to the extent practicable, with the likelihood and possible consequences of, and the level of risk associated with, a loss of control.

[19] INSAG Annual Letter of Assessment 2010, available at: http://www-ns.iaea.org/committees/insag.asp

The IEM participants emphasized that an integrated approach to safety through consideration of the interaction of ITO systems is needed to complement the more traditional approach to safety. The concept of a systemic approach to safety represents a new way of thinking about safety for some Member States and even for some IAEA activities and services.

2.1.1. Paradigm shift

The need to guard against complacency with respect to nuclear safety was widely recognized among the IEM participants. In the traditional way of thinking about nuclear safety, there is the belief that a 'perfect system' is achievable.[20] In this paradigm, the strategy for ensuring nuclear safety is based on the idea that, by identifying and predicting weaknesses in a system, these weaknesses can be corrected or compensated for 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 the system becomes for situations that might occur outside the defined boundaries of that specific situation. Flexibility is essential to be able to adapt to the unexpected and guard against the belief that all situations have been anticipated.

Many of the systems that have been developed for nuclear power plant operation contain safety features that appear to work well almost all of the time. This can create a sense of complacency on the part of the individuals involved in nuclear power plant operation. Vigilance and constant attention are required at all levels of an organization and by all stakeholders. Without recognizing the need for vigilance and attention, small and previously hidden factors can develop and may cause the systems not to function as intended. A false sense of security based on defence in depth, redundant safety features, complexity and the idea that accidents require multiple failures can all result in complacency. This complacency may prevent the search for and identification of latent factors that may exist in a particular system.

A complementary strategy to ensure flexibility within a system is to include learning from successful normal operations to enhance an organization's resilience so that it is better prepared to deal with the unexpected. During normal operations, the resilient organization takes time to understand and recognize complexity, uncertainty and unpredictability. The organization does not spend a lot of time trying to imagine the uncertainty but rather aims to be prepared for it and to create ways within its successful operation to prepare for the unexpected.

---

[20] PARIÈS, J., "Why a paradigm shift in thinking is needed", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

The resilient organization is one that quickly realizes deviation from normal operations and has the ability to make even the toughest and least popular decisions and to manage the margins in which it can manoeuvre. The resilient organization knows how far it can push its boundaries because it has learned from successful normal operations how flexible its systems are. This type of thinking and strategizing represents a paradigm shift away from the traditional way that organizations try to manage the unexpected to maintain safety. The traditional strategy is to identify what could go or has gone wrong. What is required for the paradigm shift is a different, complementary vision of how the organization will approach unexpected situations. This does not require the implementation of totally different practices or solutions; rather, it requires a focus on what the organization does well. In particular, the organization will need to focus on what it does to maintain its successful operation and to capitalize on those behaviours and processes in the event of an unexpected situation.

One integrated approach discussed by the IEM participants was the systemic approach to safety and what, in one presentation, was referred to as holistic safety[21]. Holistic safety looks at the individual, technology and the organization in an integrated manner. The holistic approach capitalizes on understanding the strengths as well as the vulnerabilities for all factors influencing nuclear safety. A shared understanding of the organization's strengths and weaknesses can inspire and motivate people to respond appropriately, particularly when faced with the unexpected. Individuals in the organization know and believe in what has to be done and can undertake a cooperative and collaborative effort to do what is necessary in a relatively quick and efficient way.

2.1.2. Need for interdisciplinary expertise

In order to develop such a systemic approach to safety, expertise in the social and behavioural sciences needs to be utilized to complement the existing and more traditional approach to safety. The social and behavioural sciences provide inputs and perspectives that differ from those of technical disciplines, and specialists in safety culture, human factors, human factors engineering, organizational factors and systemic safety, among others, are required. The expertise that these individuals bring to an organization differs from that of individuals within the organization who may be interested in, or believe they have expertise in, these topics by virtue of their experience. The education and training of experts in the social and behavioural sciences is based on scientific theory and

[21] WARD, J., "The ARPANSA approach to promoting holistic safety", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

research. Some of the human and organizational factor and safety culture experts at the IEM expressed the view that their competencies and expertise are not always recognized by those outside the social and behavioural sciences, which is often many of the people they work with on a daily basis.

The IEM participants also expressed the view that the technical staff and managers of operating organizations, regulatory bodies and vendors need to be trained in, at least, the principles of human and organizational factors, to properly incorporate these factors into their routine activities. Training and information on human and organizational factors also need to be provided to each functional team within an organization — for example, managers who will ensure the implementation of a human and organizational factors strategy; process specialists who will integrate the human and organizational factors approach into the organization's processes; and trainers and operational experience specialists. Contractors and subcontractors should also be able to benefit from the same training on human and organizational factors that is given to the operating organization's employees. This is especially important in changing work environments such as during construction, decommissioning and major outages of nuclear facilities.

In addition, the need to include more information on human and organizational factors in engineering education programmes was identified by the IEM participants. Expanding the engineering curriculum to include knowledge about human and organizational factors will increase the acceptance and value of this information.

IEM participants noted that there has been a lack of behavioural science expertise and expertise on human factors in many of their own organizations. The absence of such expertise in event investigations has often resulted in a weakness in the identification of the human and organizational factors in the subsequent causal analysis. Many of the participants representing regulatory bodies acknowledged the lack of social and behavioural science expertise in their organizations. As a consequence, standards and guidance are often weak in addressing these areas. One of the lessons learned from the Fukushima Daiichi accident was the need for a more integrated approach to safety, with experts on human and organizational factors from the social and behavioural sciences working together with engineers and other scientists.

2.2. SAFETY CULTURE

Safety culture is defined as the assembly of characteristics and attitudes in an organization and in individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their

significance.[22] In 2012 the INSAG Chairman, in a letter to the IAEA Director General[23], emphasized the importance of safety culture and the need to improve its understanding and implementation. In spite of all the recent efforts, there is still room for improvement in understanding the concept of safety culture and implementing it effectively worldwide in the management of all nuclear power plants.

At the IEM, the participants discussed the efforts being made to improve safety culture worldwide and the need for its further development and application. In particular, influencing factors such as organizational culture and other, broader issues may not always have been considered in the steps undertaken to understand and strengthen safety culture. The participants considered the need for more practical and more easily implemented ways for managers to strengthen safety culture.

One way for all members of an organization to have the same reference for their vision of a strong safety culture is for managers to be present in the work environment in order to experience the reality of the work that people in their organization are doing. As newcomer countries initiate efforts to develop their nuclear power programmes, support in the application of safety culture is very important. The governments, regulatory bodies, operating organizations and all other relevant stakeholders in these countries will benefit from support in understanding the importance of a strong safety culture and how it can be ensured. Nuclear power plant vendors also have an important role to play in this area. The importance of prioritizing nuclear safety in situations where nuclear power plants may be part of a larger, non-nuclear organization also needs to be reinforced.

While some Member States are embarking on new nuclear power programmes or are expanding existing ones, a few are phasing out their nuclear power programmes or are decommissioning individual nuclear power plants. Some of these actions are in response to the Fukushima Daiichi accident; others are due to the ageing of first generation nuclear power plants that are at the end of their design operating lifetime and whose further operation would not be cost effective. The impact on safety culture of the phasing out of a national nuclear power programme was considered during the IEM. In particular, the importance of maintaining a strong safety culture and a high level of safety performance by

---

[22] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection — 2007 Edition, IAEA, Vienna (2007).

[23] Communication dated 24 August 2012 from the Chairman of the International Nuclear Safety Group (INSAG), GC(56)/INF/11, IAEA, Vienna (2012), available at: http://www-ns.iaea.org/committees/files/insag/743/gc56inf-11_enINSAGlettertoDG.pdf

both the operating organization and the regulatory body was emphasized. The impact on human and organizational factors, as well as safety culture during the transition from the operating to the decommissioning stage of the lifetime of a nuclear power plant, also need to be considered.

Leadership and management for safety are fundamental to the development and maintenance of a strong safety culture.[24] There is a responsibility on the part of the leadership of an organization to develop, implement, communicate, model and reinforce the values and behaviours that reflect the high priority given to safety in their organization. Organizations as a whole can recognize and improve their focus on human and organizational factors, but the leadership must engage in behaviours that will help to ensure a strong safety culture. For example, even the best methodologically based training programmes need to be accompanied by appropriate information to reinforce the values and behaviours important for safety; even the best procedures require an environment that promotes a questioning attitude; and operational decision making processes need to involve all appropriate individuals. It is the responsibility of leaders to ensure that all of these factors are considered. Experience to date indicates that many of the gaps identified during the assessment of safety culture in organizations are associated with top level management's leadership and implementation of behaviours important to creating and maintaining a strong safety culture. An effective way for an organization to understand the traits and behaviours that are important for a strong safety culture is to conduct a safety culture self-assessment. Various methods for safety culture self-assessment were discussed at the IEM.

It was recognized by the IEM participants that the IAEA has considerable experience in working with the concept of safety culture. The importance of strengthening the central role of the IAEA in promoting nuclear safety culture worldwide was highlighted at the Fukushima Ministerial Conference on Nuclear Safety in 2012.[25] The experts at the IEM were informed that the IAEA has developed a self-assessment methodology that is currently being used by operating organizations and regulatory bodies in several Member States. A more systematic approach to the review of safety culture[26] has been incorporated

---

[24] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

[25] Fukushima Ministerial Conference on Nuclear Safety, 15–17 December 2012: Report by the Director General, GOV/INF/2013/2, IAEA, Vienna (2013), available at: http://www.iaea.org/Publications/Documents/Board/2013/govinf2013-2.pdf

[26] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Culture in the Maintenance of Nuclear Power Plants, IAEA, Safety Report Series No. 42, IAEA, Vienna (2005).

into IAEA services such as the Operational Safety Review Team (OSART) and Integrated Regulatory Review Service (IRRS) peer reviews. In addition, practical guidance has been produced to develop and strengthen safety culture[27] and to establish regulatory oversight of safety culture[28]. The guidance highlights the systemic approach to safety by considering the interactions of the individual, technology and the organization to ensure a strong safety culture.

2.2.1. Influence of broader factors

The consideration of other, broader factors that can influence safety culture is necessary because of the contribution that these factors may make to developing beliefs, attitudes and values. These broader factors generally have not been considered, and many of the IEM participants acknowledged the need to address them. These broader factors can determine the attitudes of individuals towards authority and their loyalty and endurance during a crisis, emergency or accident, as well as the interorganizational relationship with contractors, regulators, government and international organizations.

The influence of broader factors on the development and maintenance of safety culture can only be described, not assessed. There is no normative framework for these factors, only for safety culture. How an organization and its leaders achieve a strong safety culture in the light of these broader factors will vary. The important point to consider is whether the organization can achieve the values and behaviours that are necessary for a strong safety culture. Examples of the impact of broader factors on communicating the importance of human and organizational factors were presented at the IEM. The use of national historical icons to explain the importance of human performance tools has been effective in promoting the understanding and use of these tools by workers at nuclear power plants.

---

[27] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Culture in Pre-operational Phases of Nuclear Power Plant Projects, IAEA Safety Report Series No. 74, IAEA, Vienna (2012).

[28] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Oversight of Safety Culture in Nuclear Installations, IAEA-TECDOC-1707, IAEA, Vienna (2013).

3. LESSONS LEARNED IN THE RELATIONSHIP BETWEEN THE REGULATOR AND THE OPERATING ORGANIZATION

Consideration of the relationship between the regulator and the operating organization with respect to human and organizational factors is relatively new. Consideration of the role of the regulator in the area of safety culture is also new, and in many Member States this role is still not well defined. The aspect of the regulator and licensee relationship that was most discussed among the IEM participants was the influence of the regulatory body's culture on the safety culture of the operating organization. Different approaches to enhancing the relationship between the regulatory body and the operating organization were presented and provide a basis for better understanding this relationship. Examples were also presented demonstrating the benefits of the regulator and operator working in partnership to explore and agree on the key elements of a strong safety culture and effective approaches to systemic thinking before any regulatory guidance or requirements are issued.

3.1. NATURE OF THE RELATIONSHIP

The nature of the relationship between the regulatory body and the operating organization varies among Member States. In some cases where the nuclear industry is owned and operated by the State, the regulatory body and the operating organization may be reporting to the same ministry or branch of government. Additionally, if the regulatory body reports to the ministry that is responsible for the production and promotion of the country's energy supplies, a conflict can exist that may impact the decisions that affect safety. One issue highlighted by the Fukushima Daiichi accident was that the regulatory body needs to be independent and free of these types of reporting relationship.

Independence in reporting relationships does not imply isolation. Good communication is still required between the different organizations and with the other stakeholders. There needs to be a cooperative working environment among all organizations. While independence and professionalism are to be maintained, there needs to be good discussion among the experts from each of the different stakeholder organizations. While this may appear to be asking the regulatory body to take a slightly different approach when it is interacting with the licensee, mutual understanding and respect between the regulatory body, the licensee and the public must be the foundation for the development of a strong safety culture for a country's nuclear industry. Experts from Japan noted that the

need for regulatory reform has been recognized and that, to rebuild its safety culture, Japan must work from the bottom up to rebuild the trust between all the organizations.

The discussions at the IEM indicated that, while some Member States have specific regulations in the area of human and organizational factors and safety culture, others do not have such regulatory requirements. Where these requirements exist, some Member States recognize that they need to be strengthened. Many of the experts expressed the view that, from a regulatory perspective, safety culture is difficult to regulate or should not be regulated at all. However, safety culture is an issue that should be part of the regulatory body's engagement with the operating organization, and it needs to be fostered and competently addressed.

The safety culture of the regulatory body has a significant influence on the safety culture of the operating organization. Consequently, the regulatory body needs to conduct an assessment of its own culture, to improve the effectiveness of its performance and to assist in its relationship and interaction with the licensees. The results of these assessments will form the basis of an informed dialogue between the regulatory body and the operating organization to ensure that there is a mutual understanding of safety culture issues outside the framework of compliance and enforcement activities. Safety culture should be an object for self-reflection on the part of the regulatory body. In order for all organizations to have a strong safety culture, the elements of the integrated approach to safety have to exist. The interdependence of the different stakeholders must be acknowledged in order to understand how any of the organizations behave.

4. LESSONS LEARNED IN THE ROLE OF HUMAN AND ORGANIZATIONAL FACTORS IN EMERGENCY PREPAREDNESS AND RESPONSE

Emergency preparedness and response is not a new activity for the nuclear community. It is part of the Safety Fundamentals[29] identified by the IAEA and addressed in the IAEA Safety Requirements on Preparedness and Response

[29] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

for a Nuclear or Radiological Emergency (IAEA GS-R-2)[30]. Nuclear facilities have an emergency plan and conduct training and exercises based on that plan. The Fukushima Daiichi accident demonstrated the need for a re-examination of some of the key elements of emergency preparedness and response and the scope of related training. In particular, it again was evident that the roles and responsibilities of the various stakeholders need to be clearly defined and well communicated. Issues between the operating organization, the regulatory body, the government and the public had an impact on the emergency response to the accident. To ensure the effectiveness of well defined roles and responsibilities, an integrated approach to training in emergency preparedness and response becomes critical. The use of lessons learned and operating experience must be incorporated into the training. Additionally, a systemic approach to safety requires the integration of all the factors that need to be considered, including the human, organizational and technical factors. The role of safety culture and the impact it has on behaviour during an emergency also need to be evaluated.

4.1. ROLES AND RESPONSIBILITIES

One of the topics most discussed among the IEM participants was responsibility for decision making concerning the emergency situation. During the Fukushima Daiichi accident, this was an issue between the operator, the regulator and, eventually, the Government. The prime responsibility for safety must rest with the operator.[31] In some Member States, there is a belief that the regulatory body should have the authority to take the final decisions; in other Member States this is not the case. There is a clear need for well defined roles and responsibilities for decision making among the regulatory body, the operator and any other stakeholders that may be involved during an emergency situation. These responsibilities and the authority for decision making in an emergency need to be agreed and exercised at the preparedness stage to allow for an effective response once an emergency occurs. A key lesson learned from the Fukushima Daiichi accident was that, as the decision making responsibilities and authority had not been clarified, individuals who did not have the appropriate technical expertise or complete information about the situation were making significant decisions that in some cases were inappropriate or incorrect. The decisions were based on

[30] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

[31] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

different priorities and were not necessarily made with a clear understanding of the nuclear safety implications.

Roles and responsibilities concerning the communication of information during an emergency also need to be clearly defined. Consideration has to be given to the need to provide information to the public and to all stakeholders during an emergency, even when specific information is not yet available or the information available is associated with great uncertainty. One lesson learned from the Fukushima Daiichi accident was that the lack of information during the accident had an impact on the relationship between the various stakeholders, including the international community, and contributed to the public's lack of trust in the operating organization and its ability to manage the situation. These issues were more thoroughly addressed in the International Experts Meeting on Enhancing Transparency and Communication Effectiveness in the Event of a Nuclear or Radiological Emergency[32].

Often forgotten are the contractors working in the operating organization and their role in the event of an emergency situation. The roles and responsibilities of contractors working at a nuclear facility in an emergency need to be well defined at the preparedness stage to allow for protection of the contractors, as appropriate. While the prime responsibility for safety during an emergency rests with the operating organization, to ensure the most effective emergency response, relevant contractors may need to be recognized as part of the emergency preparedness and response system. Contractors are to be instructed or trained, as appropriate, on how to respond in an emergency. Instructions should include information on alarms and sirens and the actions to be taken, such as mustering and accounting, and the use of protective equipment, if necessary. However, those contractors who may have a role and responsibilities in emergency response should be designated as emergency workers in advance of the emergency, and appropriate protection, including training, provided to them.

When many of the contractors left the Fukushima Daiichi site during and after the accident, the site employees were unable to carry out many of the contractors' responsibilities and lacked the experience or equipment to undertake key emergency mitigatory actions. As was evident during the Fukushima Daiichi accident, the employees of the nuclear power plant had never had the responsibility for, or training in carrying out, the contractors' tasks, which created an additional burden on top of their already extremely difficult job. This is an aspect that needs to be considered by all organizations in the future.

---

[32] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Report on the International Experts Meeting on Enhancing Transparency and Communication Effectiveness in the Event of a Nuclear or Radiological Emergency, IAEA, Vienna (2012), available at: http://www.iaea.org/newscenter/focus/actionplan/reports/enhancetransparency2012.pdf

4.2. ROLE OF TRAINING

Training is one of the processes that an organization can use to communicate and internalize its values and standards. In the area of emergency preparedness and response, training is a key element of the organization's capability to respond to an event, as is recognized in IAEA GS-R-2[33]. Member States have formalized training in emergency response that includes various levels of involvement by all appropriate stakeholders. The IEM participants indicated that this training needs to include the top management of all stakeholder organizations, addressing their roles and responsibilities in an emergency response. The lessons learned from the Fukushima Daiichi accident indicate that the highest ranking individuals may be involved in the emergency response and therefore need to be part of the emergency preparedness arrangements for such an event.

Drills and training exercises are an essential mechanism for training staff to deal with emergency situations. However, it was noted during the IEM that drills and training exercises are usually preplanned and announced, and use expected rather than unexpected scenarios. These drills and training exercises also need to cover beyond design basis events and to include all responsible parties; they may also involve multiple countries. Many IEM participants indicated that, ideally, drills and training exercises will be held at regular intervals, sometimes unannounced, and be carried out in as close to 'real time' as possible. They should include those scenarios that are the most demanding for human resources, with the minimum complement of station personnel, but they need to be appropriately focused on operation, with the aim of balancing resources, operating needs and routine training. Exercises that require thinking 'outside the box' can be useful in raising awareness about the organization's safety culture and enabling any safety issues to be identified and addressed.

In addition to preparedness, another role of training in emergency preparedness and response is to help all the parties involved to develop trust in and respect for each other, based on a good level of technical and engineering capability. Having individuals take part in the same type of training increases their credibility with one another in an actual emergency situation. Shared training also provides opportunities for operators to obtain information about all of the potential protective actions to improve safety in an emergency from those who conduct research on these topics.

---

[33] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

4.3. USE OF OPERATING EXPERIENCE

In thinking about lessons learned and operating experience, the tendency is usually to ask the question, Can we learn from the experience or event? A more pertinent question to ask would be, What could we learn from the experience or event? This is because all such situations — successes as well as failures — provide some form of learning. There is a need to train for the unexpected by enhancing traditional training methods, as described in Section 4.2, in order to increase organizations' capabilities to cope with these situations. In the paradigm shift discussed previously, identifying and replicating strengths and success factors can be considered a focus of organizational learning, to create resilient capabilities for unexpected situations — that is, learning from what was done well, not just from what was done badly.

There has been great interest on the part of the Japanese experts in sharing the lessons learned. A particular example from the Fukushima Daiichi accident that could contribute to learning within the new safety paradigm is the success experienced at the Fukushima Daini nuclear power plant. The key elements of this success identified by the experts were the establishment of a well prioritized and clear strategy by the management of the Fukushima Daini nuclear power plant and communication of that strategy to all personnel. This allowed the organization to move directly to achieving the goals of the strategy during the emergency situation. Additionally, organizational integrity was maintained during the emergency situation by using a command and control structure to deal with the simultaneous damage of multiple units. The presence of a large number of individuals from the operating staff who had worked at the plant during the construction and commissioning stages and who had a better knowledge of the plant than their counterparts at Fukushima Daiichi did of that plant was also identified as being extremely valuable. Most importantly, good teamwork had already been developed prior to the accident.[34]

The IEM participants discussed the difficulties in extracting the root causes of the accident related to human and organizational factors that would be beneficial for organizational learning. It is difficult to gather reliable information on root causes related to human and organizational factors, particularly because working level human and organizational factor errors often have their root causes in decisions made at the leadership level. The need for a systematic analysis of human and organizational factors associated with accidents, along with an

[34] GRAUF, E., "Managing an emergency situation on site, theory and real life — A plant manager's view", paper presented at IAEA IEM on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, Vienna, 2013.

appropriate system for coding accidents to facilitate their analysis and to extract data and general trends, was identified. To accomplish this type of analysis, it is crucial that human and organizational factor specialists be included in event investigation teams. Existing initiatives in this area include the IAEA/NEA International Reporting System for Operating Experience (IRS) database and the European Commission's Human Factor Analysis and Classification System.

5. BEST PRACTICES

Various efforts to address the human and organizational factors that influence nuclear safety were described by the IEM participants. Some activities were a direct result of the Fukushima Daiichi accident; others were initiatives that organizations had decided to implement prior to the accident.

5.1. BEST PRACTICES FOR ADDRESSING TECHNICAL ISSUES

Efforts resulting from the Fukushima Daiichi accident in the area of human and organizational factors were most often included in addressing technical issues that needed to be corrected. Examples include:

— Improvements with regard to decision making and consideration of the use of tools to support decision making in emergency response;
— Consideration of human and organizational factors in the planning, conduct and evaluation of emergency drills and exercises;
— Organizational changes, including recognition of the need for the independence of the regulatory body;
— Identification of additional training, including understanding resilience, for operating personnel;
— New communication interfaces and arrangements with all stakeholder organizations.

Several activities presented by the IEM participants appeared to be focused on addressing the human and organizational factors in nuclear safety without necessarily being directed toward supporting a technical solution. These types of initiative can serve as a good start for thinking about a systemic approach to safety and the paradigm shift that is needed in order to be better prepared for the unexpected.

5.2. BEST PRACTICES IN OPERATING ORGANIZATIONS

IEM participants from operating organizations identified issues in the area of human and organizational factors that they were addressing. Areas that were mentioned frequently and that are good topics for discussion in any organization included:

— Identifying ways to ensure that safety is a top priority;
— Objectively assessing efforts to strengthen safety and widely informing staff about safety initiatives;
— Proactively introducing resources to ensure safety;
— Questioning whether safety culture is a high enough priority;
— Continuously improving maintenance management to ensure safety and establishing closer cooperation with manufacturers and contractors;
— Establishing and maintaining the trust of local communities;
— Recognizing the efforts of personnel to protect and ensure the safety of the public, the workers and the plant.

5.3. BEST PRACTICES IN THE RELATIONSHIP BETWEEN THE REGULATORY BODY AND THE LICENSEE

Efforts to address the relationship between the regulatory body and the licensee included:

— The development of additional regulatory requirements, expectations and guidance on human and organizational factors;
— The regulatory body providing licensees the authority at the preparedness stage to perform activities in emergency situations that may be outside the existing operating procedures and regulatory requirements but that are necessary in order to mitigate consequences;
— The regulatory body and the licensee holding joint dialogues about safety culture;
— The development of an integrated approach to safety by the regulatory body to enable dialogue on topics beyond compliance and regulation;
— Enhanced efforts by the regulatory body to go out in the field and engage the licensee in conversations at the working level about safety practices and policies;
— Efforts supporting safety culture self-assessment by the regulatory body and the sharing of that information with licensees.

Many other efforts were discussed, some of which are mentioned in other parts of this report; further details are included in the Chairperson's Summary (see Annex A).

6. RECOMMENDATIONS

A number of recommendations were identified during the IEM whose implementation, if considered appropriate, could help to enhance the support and assistance to Member States in strengthening human and organizational factors in nuclear safety. These recommendations can be categorized into three major areas: a systemic approach to safety; activities related to the regulatory body; and IAEA safety standards.

6.1. SYSTEMIC APPROACH TO SAFETY

Several considerations for the development of a systemic approach to safety were identified during the IEM. In particular, participants identified the need to complement the traditional approach to safety with a systemic approach that considers not only the human, organizational and technological factors that contribute to safety but also the complexity of the interrelationships between them. It was recommended that:

— Guidance and training materials be developed for all elements of human and organizational factors, safety culture, organizational culture, management systems, the interaction of individual, technological and organizational factors, in existing, expanding and new nuclear programmes, to ensure that a systemic approach to safety is developed, integrated and maintained.
— Guidance be developed on the management of organizational changes, including those in response organizations, taking into consideration the lessons learned from the Fukushima Daiichi accident.
— Guidance be developed based on state of the art research on organizational resilience.
— Guidance and training materials be developed on enhancing the integration of supplier and contractor organizations into the operating organization's human and organizational factor practices and processes.
— A methodology be developed for the implementation of 'stress tests' related to human and organizational factors.

— Existing approaches to the determination of the early symptoms of a declining safety culture be identified and practical training materials be developed to help organizations determine such a trend.
— Guidance be developed on successful management of ‘near misses’ and events analysing such cases using a systemic approach to safety.
— Additional information about the specific human and organizational factors involved in the events at the Fukushima Daiichi and Daini nuclear power plants be collected and shared with the international nuclear community.
— Meetings be conducted on topics related to:
  • Possible harmonization of the definitions of and approaches to the areas of human and organizational factors and safety culture used by the IAEA and other national and international organizations;
  • Need for competence in the human and organizational factors area in all operating organizations and the integration of human and organizational specialists into multidisciplinary teams for all event investigations and analyses;
  • Similarities between nuclear and other high risk industries (e.g. aviation, chemical) in the area of human and organizational factors and safety culture.

6.2. ACTIVITIES RELATED TO THE REGULATORY BODY

Various means of cooperation between the regulatory body and the licensees were discussed during the IEM. It was recommended that:

— Guidance and training materials be developed on an integrated oversight and assessment programme for national regulatory bodies that will include all aspects of management, human and organizational factors, safety culture, and engineering.
— Training materials be developed and support provided to regulatory bodies to enable them to conduct self-assessments in the area of safety culture.
— Guidance be developed on the regulatory oversight of licensees’ safety culture.
— Technical Meetings be conducted on topics related to:
  • Influence of regulatory approaches on the licensees’ safety culture;
  • Regulatory oversight of organizational resilience;
  • Need for competence in the human and organizational factors area of regulatory bodies.

6.3. IAEA SAFETY STANDARDS

The IEM participants recommended that the IAEA consider reviewing its current safety standards with respect to guidance on human and organizational factors and revising them, as necessary, taking into consideration the lessons learned from the Fukushima Daiichi accident.

7. CONCLUSIONS

The IEM participants considered the Fukushima Daiichi accident to be not just a disaster triggered by natural events or a technically based disaster, but also a human induced disaster. The accident, like others before it, highlighted the weaknesses in addressing human and organizational factors so as to prevent nuclear accidents from occurring, or to mitigate their consequences if they do occur. One of the major lessons learned from the Fukushima Daiichi accident, as discussed by the IEM participants, is that the nuclear community needs to better understand and implement an integrated, or systemic, approach to safety.

The interaction of human, organizational and technical factors across all stakeholder organizations and between different levels inside each organization must be evaluated and understood for each phase of the nuclear facility life cycle. Those interactions will occur within the broader scope of the culture of the organization, and in this way will reflect the organization's safety culture. The safety culture exists within the context of the organizational culture and broader external factors that must be considered in any assessment.

Risk management is an important element of safety culture. A false sense of security in measures such as defence in depth, redundant and complex safety features, and 'managed' risk can all result in a sense of complacency:

> "[T]he key [to improving safety] will always be constant vigilance, as there is no room for complacency or anything less than a total commitment to improving safety. The establishment of a robust and enduring safety culture is crucial."[35]

[35] Fukushima Ministerial Conference on Nuclear Safety, 15–17 December 2012: Report by the Director General, GOV/INF/2013/2, IAEA, Vienna (2013), available at: http://www.iaea.org/Publications/Documents/Board/2013/govinf2013-2.pdf

With a systemic approach to safety that analyses the human, organizational and technical factors, an organization can be better prepared for an unexpected event. Nuclear safety will also depend on people's attitudes and behaviour.

Experts from the behavioural sciences, and the related research, need to be better utilized in the efforts to understand and apply a systemic approach to safety. Different disciplines within the behavioural sciences need to be involved, and it must be recognized that these experts are as educated and experienced in their areas of expertise as are the experts from areas such as engineering, physics and chemistry who have already contributed much to the nuclear community.

There has been a belief across the nuclear community that a severe accident such as occurred at the Fukushima Daiichi nuclear power plant 'could not happen here'. This attitude has a significant influence on the safety culture of an organization. Operators and regulators need to carefully consider what can be learned from the Fukushima Daiichi accident. This accident opened a window of opportunity for learning and change and improvement; the nuclear community must act before the window closes with the passage of time.

Annex A

CHAIRPERSON'S SUMMARY[1]

International Experts Meeting on 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

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 improving dissemination of information. This action specifically requests the IAEA Secretariat to organize international experts meetings (IEMs) to analyse all relevant technical aspects and learn the lessons from the accident at the Fukushima Daiichi nuclear power plant. In response to that request, an IEM was held on 21–24 May 2013, at 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;
— Decommissioning and remediation after a nuclear accident.

The objectives of this IEM were to:

— Identify the means to improve and strengthen human and organizational aspects of nuclear safety in operating and regulatory organizations;

[1] The opinions expressed in this Summary — and any recommendations made — are those of the Chairperson and do not necessarily represent the views of the IAEA, its Member States or other cooperating organizations.

— Analyse 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 defence in depth at nuclear facilities from an organizational perspective;
— Identify potential priority areas for research and development.

The IEM was attended by around 160 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 presentations from invited speakers and 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 experience, lessons learned and views on future activities in the area of human and organizational factors (HOFs).

The meeting comprised plenary sessions and parallel sessions covering:

— An update on Fukushima two years after the accident;
— HOFs in nuclear safety;
— Influence of culture on the management for safety;
— Lessons learned.

In line with the approach of 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 (ITO) factors and safety culture.

The IAEA is preparing a comprehensive report on the Fukushima Daiichi accident. The participants in this meeting stressed that this report needs to address the HOFs, including the safety culture aspects, of the accident as cross-cutting 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 experience.

From the presentations and subsequent discussions, it was noted that many countries have taken numerous actions in the area of HOFs in response to the Fukushima Daiichi accident. However, these HOFs have primarily been developed to support technical solutions. The question remains as to whether 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 Daiichi accident was a wake-up call for the nuclear community to recognize the complexity of safety and to respect the entire systems interaction of ITOs. The complexity of nuclear organizations is increasing, and different and more unique approaches are needed to ensure that safety is maintained. The Fukushima Daiichi accident was avoidable, according to the presentations of experts 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 HOFs and the further exploration of non-technical aspects of 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 they are faced with the unexpected.

SAFETY CULTURE

Recently, significant efforts have been spent on HOFs 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[2] 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 its national culture that could 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 being very important in the application of the concept of safety culture. This support is needed by regulators, licensees and all stakeholders in 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 nuclear power plants 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 multinational 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 of 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 HOFs and safety culture was discussed, including HOFs in decommissioning.

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 in creating trust and respect for

[2] Reference to ‘national culture’ should be understood to reflect the summary views of the Chairperson only and not to reflect the views or mandate of the IAEA.

individuals within the organization as well as for 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 vulnerabilities to natural hazards, the need for improved training of staff, the simplification of instructions and 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 concerning all aspects of HOFs and also across different industries. The Fukushima Daiichi 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 a means to keep the window open.

ORGANIZATIONAL RELATIONSHIPS

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 among decision makers at different levels. The nuclear power plant operator must be responsible and have the necessary knowledge and authority for safety at all times in all situations. Responsibility for making decisions outside of agreed upon or defined procedures should be only to ensure the protection of people and to prevent the failure of the last barrier for ensuring confinement. A good practice presented at the meeting was for the operator to seek pre-approval from the regulator if there is a need to go outside regulatory requirements. This helps to ensure effectiveness of severe accident management strategies.

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

COMPLACENCY

There was wide recognition among 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 Daiichi accident was avoidable. There has been a belief that a severe accident such as the Fukushima Daiichi 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 the Fukushima Daiichi accident, rather than 'distancing themselves by differentiation'. Risk management is an important element of safety culture, and organizations on both the operator and the regulatory sides have sometimes managed risk for their own convenience. A false sense of security in defence in depth, redundant safety features, complexity and the multiple failures that are needed for accidents can all result in complacency.

Elements discussed during the IEM to improve safety included a number of recommendations.

Recommendations that the IAEA consider reviewing or developing:

— Guidance and training materials for the integration of all elements of HOFs, safety culture, organizational culture, the management system and ITO factors in existing and new nuclear programmes to ensure that the systemic approach is developed and maintained;
— An integrated oversight/assessment programme for national regulatory bodies, to include all aspects of management/HOFs/engineering to see operating organizations' performance in a holistic way;
— The current guidance in IAEA Safety Guides on HOF aspects considering experience following the Fukushima Daiichi accident, with revisions, as necessary;
— Guidance on management of organizational changes, including emergency organizations, taking into consideration the lessons learned from the Fukushima Daiichi accident;
— Guidance on organizational resilience, based on state of the art research;

— Guidance documents and training materials on enhancing the integration of supplier organizations into the operators HOF practices/processes;
— A methodology for the implementation of ‘stress tests’ addressing HOFs;
— Existing approaches on early symptoms of declining safety culture, with the production of practical training materials;
— Training and support to regulatory bodies for conducting self-assessment and for the regulatory oversight of licensees’ safety culture;
— Successful handling of near misses and events and the sharing of results with the international community.

Recommended topics for further discussion:

— National and international organizations to work more closely and harmonize their approaches and definitions in the area of HOFs 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 event in the Fukushima Daiichi and Daini would be valuable;
— Ensuring that the nuclear power plant 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 HOFs;
— Implementation of safety culture self-assessments by the regulatory bodies and evaluation of how their safety culture impacts the operating organizations;
— Human factors as an important contributor to engineering, safety and effectiveness of nuclear facilities;
— Integration of HOF specialists, in the case of events, into multidisciplinary 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) in the area of HOFs and safety culture.

Marta Ziakova
24 May 2013

Annex B

CONTENTS OF THE ATTACHED CD-ROM

The following papers and presentations from the International Experts Meeting on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant are available on the attached CD-ROM.

RELATED DOCUMENTS

Programme of the International Experts Meeting on Human and Organizational Factors in Nuclear Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant

Opening Remarks
D. Flory
Deputy Director General and Head of the Department of Nuclear Safety and Security, International Atomic Energy Agency (IAEA)

Opening Remarks
A. Bychkov
Deputy Director General and Head of the Department of Nuclear Energy, International Atomic Energy Agency (IAEA)

Co-Chair Conclusions for Parallel Technical Session IV-A
K. Heppell-Masys
Canadian Nuclear Safety Commission (CNSC), CANADA

Report by Co-Chairperson
I. Grant
Federal Authority for Nuclear Regulation (FANR), UNITED ARAB EMIRATES

Chairperson's Summary Report
M. Ziakova
ÚJD SR, SLOVAKIA

Closing Remarks
D. Flory
Deputy Director General and Head of the Department of Nuclear Safety and Security, International Atomic Energy Agency (IAEA)

PRESENTATIONS

Plenary Session I (Tuesday): Update on Fukushima Two Years Later

Keynote Presentations

Update on Nuclear Safety Action Plan with respect to Human and Organizational Factors
G. Caruso
International Atomic Energy Agency (IAEA)

Why Catastrophic Accidents Are Not Unique
K. Roberts
Center for Catastrophic Risk Management, University of California, Berkeley, USA

Lessons of TEPCO's Fukushima Accident from Human and Organizational Aspects and Challenges for Nuclear Reform
A. Kawano
Tokyo Electric Power Company (TEPCO), JAPAN

Nuclear Safety Human and Organizational Factors: Lessons from Fukushima
K. Oshima
Nuclear Regulation Authority (NRA), JAPAN

Plenary Session II (Wednesday): Human and Organizational Factors in Nuclear Safety

Keynote Presentations

Why a Paradigm Shift in Thinking Is Needed
J. Pariès
Dédale, FRANCE

The ARPANSA Approach to Promoting Holistic Safety
J. Ward
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), AUSTRALIA

Managing the Unexpected
J. Laaksonen
State Atomic Energy Corporation 'Rosatom', RUSSIAN FEDERATION

Invited Speakers

Changes in the Regulatory Authority in the Area of Human and Organizational Factors as a Function of the Fukushima Accident
S. Kaneko
Nuclear Regulation Authority (NRA), JAPAN

How to Continuously Improve Cultural Traits for the Management of Safety
A. Daniels
Institute of Nuclear Power Operations (INPO), USA

Plenary Session III (Wednesday): Influence of Culture on the Management for Safety

Leadership and Management for Safety
J. Zlatnansky
Slovenské elektrárne, SLOVAKIA

Implications of the Fukushima Accident from a Regulatory Perspective
C. Ryser
Swiss Federal Nuclear Safety Inspectorate (ENSI), SWITZERLAND

Regulatory Oversight of Human Factors with a New Initiative for Safety Culture in Korea
Y. S. Choi
Korea Institute of Nuclear Safety (KINS), REPUBLIC OF KOREA

How Did Individual and Organizational Use of Probability and Risk Assessment at TEPCO Contribute to the Fukushima Accident?
H. Drumhiller
World Association of Nuclear Operators, USA

The Role of Human and Organisational Factors in Unexpected and Extreme Situations: Contribution of the NEA/CSNI Working Group on Human and Organisational Factors (WGHOF)
D. Tasset
Nuclear Energy Agency (OECD-NEA)

Parallel Technical Session IV-A (Thursday): Human and Organizational Factors in Nuclear Safety

Interactive Training: A Methodology for Improving Safety Culture
C. Rusconi
Nuclear Plant Management Company (SOGIN), ITALY

A TSO's Practice in China after the Fukushima Daiichi NPP Accident
S. Li
Research Institute of Nuclear Power Operation (RINPO), CHINA

Importance of Human Performance to Safety in Complex Industries
J.C. Higgins
Brookhaven National Laboratory (BNL), USA

Integration of Accident Management Strategies into Station Operation
F. Dermarkar
Ontario Power Generation (OPG), CANADA

Regulatory Challenges in the Interaction of Individuals, Technology and Organizations in the Management of Safety
J. Arunan
Atomic Energy Regulatory Board (AERB), INDIA

Who Should Have Been in Charge of Decision Making under Extreme Conditions?
R. Kubota
Japan Nuclear Energy Safety Organization (JNES), JAPAN

Interaction between Individuals, Technology and Organizations in Nuclear Facilities and Organizations — Today and in the Future
A. Wahlström
Swedish Nuclear Fuel and Waste Management Company (SKB), SWEDEN

Analysis of Events Related to Human and Organizational Factors Using Different Coding Systems
M. Stručić
Joint Research Centre (EC/JRC)

How to Take into Account Human and Organizational Factors in Nuclear Design?
V. Lagrange
Électricité de France (EdF), FRANCE

The Lessons from Fukushima Daiichi in Human and Organizational Factors as Applied within a Nuclear Decommissioning Organization
H. Rycraft
Magnox, UNITED KINGDOM

Managing an Emergency Situation on Site, Theory and Real Life — A Plant Manager's View
E. Grauf
IAEA Consultant, GERMANY

ONR's Approach for Ensuring a Licensable Organization for the UK's New Build Projects
P. Ackroyd
Office for Nuclear Regulation (ONR), UNITED KINGDOM

Parallel Technical Session IV-B (Thursday): Influence of Culture on the Management for Safety

System Safety — The Common Factors. The Influence of Culture on the Management of Safety: Examples from Different Industries
L. Kecklund
MTO Safety, SWEDEN

Efforts towards Safety Culture in KEPCO
S. Otsuka
Kansai Electric Power Co. (KEPCO), JAPAN

KHNP Activities for Safety Culture after the Fukushima Accident
Y.-G. Kim
Korea Hydro & Nuclear Power Company (KHNP), REPUBLIC OF KOREA

Safety Culture Oversight — Finnish Experience
A.-M. Sunabacka-Starck
Radiation and Nuclear Safety Authority (STUK), FINLAND

Enhancement of Safety Culture in China: Vision and Guidelines
W. Lei
Ministry of Environmental Protection, CHINA

Overcoming the New Challenges in Safety after Fukushima
J.M. Diaz Francisco
Eletronuclear, BRAZIL

Role of Individual, Technology and Organizational (ITO) Factors in Managing a Nuclear Emergency
M. Iqbal
Pakistan Nuclear Regulatory Authority (PNRA), PAKISTAN

A Systemic Perspective to Improve the Human and Organizational Aspects of Nuclear Safety
F. Kraft
French Nuclear Safety Authority (ASN), FRANCE

Preparation of TSO Support for the Polish Nuclear Power Programme in the Area of Nuclear Safety and Public Information
T. Jackowski
National Centre for Nuclear Research (NCBJ), POLAND

Decision Making in an Uncertain World: Regulatory Challenges
J.-Y. Fiset
Canadian Nuclear Safety Commission (CNSC), CANADA

High Reliability Organization (HRO) Mindfulness: Ensuring Nuclear Safety
T. Anderson
Lancaster University, UNITED KINGDOM

Dimensions of Human Factors in Nuclear Power Safety
A.H. Akbar
Chashma nuclear power plant (CHASNUPP), PAKISTAN

Plenary Session V (Friday): What Have We Learned?

Nuclear Ecosystem and Safety Culture Self-Assessment at a Regulatory Body
N. Afghan
Institute of Business Administration Karachi, PAKISTAN

Strategic Vision and Implementation of Human and Organizational Factors in the Nuclear Industry
K. Dahlgren-Persson
Vattenfall, SWEDEN

Poster Sessions:

Making Claims for Operator Response — Do We Have the Tools?
J. Berman,
UNITED KINGDOM

Fukushima Daiichi Nuclear Accident Context Research in Depth
G. Petkov,
BULGARIA