IAEA
Atoms for Peace

Nuclear Safety Review 2013

GC(57)/INF/3

Nuclear Safety Review 2013

IAEA/NSR/2013

Printed in the IAEA in Austria
July 2013

Foreword

The *Nuclear Safety Review 2013* contains an analytical overview of the dominant trends, issues and challenges worldwide in 2012 and the IAEA's efforts to strengthen the global nuclear safety framework in relation to those trends. The report also has an appendix describing developments in the area of the IAEA's safety standards during 2012.

A draft version of the Nuclear Safety Review 2013 was submitted to the March 2013 session of the Board of Governors in document GOV/2013/4. The final version of the *Nuclear Safety Review 2013* was prepared in light of the discussions held during the Board of Governors and also of the comments received.

Table of Contents

Executive Summary

The *Nuclear Safety Review 2013* focuses on the dominant nuclear safety trends, issues and challenges in 2012. The Executive Overview provides crosscutting and worldwide nuclear safety information along with a summary of the major sections covered in this report. Sections A–E of this report cover improving radiation, transport and waste safety; strengthening safety in nuclear installations; improving regulatory infrastructure and effectiveness; enhancing emergency preparedness and response (EPR); and civil liability for nuclear damage. The Appendix provides details on the activities of the Commission on Safety Standards (CSS), and activities relevant to the IAEA Safety Standards.

The world nuclear community has made noteworthy progress in strengthening nuclear safety in 2012, as promoted by the IAEA Action Plan on Nuclear Safety (hereinafter referred to as "the Action Plan").[1] For example, an overwhelming majority of Member States with operating nuclear power plants (NPPs) have undertaken and essentially completed comprehensive safety reassessments ('stress tests') with the aim of evaluating the design and safety aspects of plant robustness to protect against extreme events, including: defence in depth, safety margins, cliff edge effects, multiple failures, and the prolonged loss of support systems. As a result, many have introduced additional safety measures including mitigation of station blackout. Moreover, the IAEA's peer review services and safety standards have been reviewed and strengthened where needed. Capacity building programmes have been built or improved, and EPR programmes have also been reviewed and improved. Furthermore, in 2012, the IAEA continued to share lessons learned from the Fukushima Daiichi accident with the nuclear community including through three international experts' meetings (IEMs) on reactor and spent fuel safety[2], communication in the event of a nuclear or radiological emergency[3], and protection against extreme earthquakes and tsunamis.[4]

As of the end of 2012, safety performance indicator data[5] on 437 power reactors and over 15 000 reactor-years of commercial operation, showed that the operational safety level remained high. Figure A-1 shows the total number of unplanned reactor shutdowns ('scrams'), including both automatic and manual scrams, which occurred per 7000 hours of critical power reactor operation. These data are

---

[1] The IAEA Action Plan on Nuclear Safety was approved by the Board of Governors on 13 September 2011, and endorsed by the General Conference during its 55th regular session on 22 September 2011. This document is available at http://www.iaea.org/newscenter/focus/actionplan/reports/actionplanns130911.pdf. Details on the progress of the implementation of the Action Plan will be provided in a GOV/INF document in the first quarter of 2013.

[2] The report on the International Experts' Meeting on Reactor and Spent Fuel Safety in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, held 19-22 March 2012, is available at http://www.iaea.org/newscenter/focus/actionplan/reports/spentfuelsafety2012.pdf.

[3] The report on the International Experts' Meeting on Enhancing Transparency and Communication Effectiveness in the Event of a Nuclear or Radiological Emergency, held 18-20 June 2012, is available at http://www.iaea.org/newscenter/focus/actionplan/reports/enhancetransparency2012.pdf.

[4] The report on the International Experts' Meeting on Protection against Extreme Earthquakes and Tsunamis in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, held 4 - 7 September 2012, is available at http://www.iaea.org/newscenter/focus/actionplan/reports/protection2012.pdf.

[5] Data derived from the Agency's Power Reactor Information System (PRIS) database and from the World Association of Nuclear Operators Nuclear (WANO). PRIS data is available at http://www.iaea.org/pris/About.aspx and WANO data is available at http://www.wano.info/wp-content/uploads/2012/11/2011-WANO-PI-Trifold.pdf.

helpful in monitoring performance in reducing the number of unplanned total reactor shutdowns and are commonly used to gauge improvement levels in plant safety. As shown in Figure A-1, steady improvements have been achieved in recent years although there is room for further improvement.

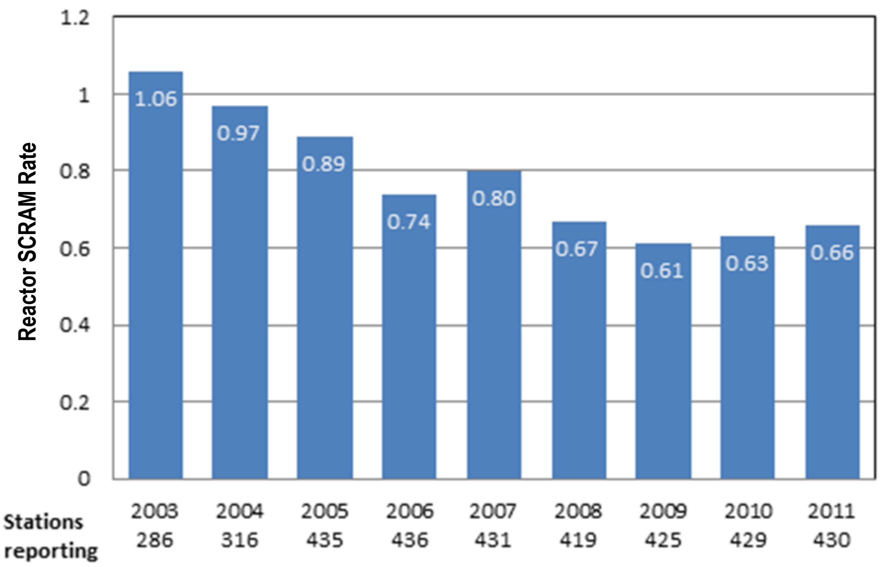

FIG. A-1. Total number of unplanned reactor shutdowns ('scrams'), including both automatic and manual scrams, which occurred per 7000 hours of critical power reactor operation.

Of these 437 power reactors in operation, 162 power reactors have been in operation for more than 30 years, and 22 have been in operation for more than 40 years. As previously covered in the *Nuclear Safety Review 2012*, long term operation (LTO) and ageing power reactors is an on-going challenge for regulators, operators and utilities.[6] The international nuclear community continues to examine nuclear plant life management issues regarding continuous safety improvements and economic life decisions of power reactors as they age. Additionally, there are growing expectations that existing nuclear reactors should meet enhanced safety objectives, closer to those of recent reactor design; the Fukushima Daiichi accident has shown the importance of applying new safety knowledge to existing power reactors throughout their lifetimes.

Many Member States have already taken action to address ageing reactors. For example, the US Nuclear Regulatory Commission (NRC), the Swiss Federal Nuclear Safety Inspectorate (ENSI) and the Canadian Nuclear Safety Commission (CNSC) have published guidelines and ageing lessons learned to ensure that safety and performance remain within acceptable limits throughout the life cycle of the NPP.[7]

The IAEA has also taken action with regard to managing long term aging through its International Generic Ageing Lessons Learned (IGALL) programme launched in September 2010. The IGALL

---

[6] *Nuclear Safety Review for 2012* is available at http://www.iaea.org/About/Policy/GC/GC56/GC56InfDocuments/English/gc56inf-2_en.pdf.

[7] *Generic Aging Lessons Learned (GALL) Report*, United States Nuclear Regulatory Agency, USA, 2010. Available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1801/r2/sr1801r2.pdf; ENSI-B01 Alterungsüberwachung, Richtlinie für die schweizerischen Kernanlagen, ENSI, Bern, Switzerland, August 2011. Available at: http://static.ensi.ch/1312470613/b01_d.pdf; and RD-334: Aging Management for Nuclear Power Plants, CNSC, Ottawa, Canada, June 2011. Available at: http://nuclearsafety.gc.ca/eng/lawsregs/regulatorydocuments/published/html/rd334/index.cfm.

programme has collected best practices and knowledge worldwide on verified ageing management programmes for safety related structures, systems and components. This information will be compiled into a practical guide for implementing, maintaining and improving ageing management programmes and will also be provided via a web-based database. These tools will be made available to Member States during the second half of 2013.

As of the end of 2012, data derived from the IAEA's Research Reactor Database (RRDB) indicated there were 247 operational research reactors and 165 reactors in various forms of shutdown, i.e. 15 have indicated plans to restart operations, and the remaining 150 reactors were either in extended shutdown or in preparation for final decommissioning.[8] In many cases, robust utilization programmes were not part of the decision making process for determining whether a new research reactor should be built or should continue to operate in the longer term.[9] This raises safety concerns related to, inter alia, the maintenance and to the adequacy of safety documents, radiological protection programmes, emergency planning, decommissioning planning, training and qualification of personnel. The feedback from the IAEA's activities during 2012 highlighted the need to decide the future of these reactors on the basis of a systemic feasibility study and to ensure the availability of the staff necessary to maintain both the knowledge and the safety of these reactors.

In 2012, the Commission on Safety Standards (CSS) conducted a review of the IAEA Safety Requirements in light of lessons learned so far from the Fukushima Daiichi accident. The CSS confirmed the adequacy of the current Safety Requirements. The review revealed no significant areas of weakness, and just a small set of amendments were proposed to strengthen the requirements and facilitate their implementation.

In March 2012, the Nuclear Security Guidance Committee (NSGC) was established, with the objective of contributing to greater transparency, consensus, quality, coherence and consistency of both technical and policy content by engaging more Member States in the development of publications on nuclear security.

Following the revision by the CSS of the Strategies and Processes for the Establishment of IAEA Safety Standards (SPESS) to assist in the task of addressing interfaces between the IAEA Safety Standards Series publications and the Nuclear Security Series publications, an interface group with balanced membership from the Safety Standards Committees and from NSGC initiated the process to review proposed publications that have safety-security interfaces in the two publications Series.

In August 2012, during the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety (CNS), more than 600 attendees from 64 Contracting Parties participated in discussions on topics ranging from severe accident management and recovery, reactor design, emergency preparedness and response and post-accident management, regulatory oversight and independence and international cooperation. In addition, the Contracting Parties decided to establish an "effectiveness and transparency working group", open to all Contracting Parties, with the task of reporting to the next review meeting on a list of actions to strengthen the CNS and on

---

[8] Research reactor data derived from the IAEA Research Reactor database: http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx.

[9] "…Underutilized research reactors may struggle to justify and secure adequate funding to be properly maintained… A research reactor constructed without a thorough utilization analysis could be faced with reduced utilization and funding cuts." *The Role of Research Reactors in Introducing Nuclear Power*, available at: http://www.iaea.org/About/Policy/GC/GC56/GC56InfDocuments/English/gc56inf-3-att5_en.pdf.

proposals to amend, where necessary, the Convention.[10] The Organizational Meeting for the Sixth Review Meeting was also held in August 2012.

In December 2012, the Fukushima Ministerial Conference on Nuclear Safety was organized by the Government of Japan, in co-sponsorship with the IAEA, and took place in Fukushima Prefecture, Japan[11]. The principal objective of the Conference was to contribute to strengthening nuclear safety worldwide by providing yet another opportunity to share with the international community, at the ministerial and expert levels, further knowledge and lessons learned from the Fukushima Daiichi accident and to further enhance transparency, including the implementation of the Action Plan. The Conference provided yet another opportunity for the international community to reconfirm the importance of nuclear safety and to maintain and enhance the momentum towards strengthening nuclear safety worldwide. The Conference was attended by over 700 delegates from 117 countries and 13 international organizations. Forty-six of these delegates attended at the level of minister or equivalent high rank, or as a head of organization. The Conference consisted of a plenary session, at which the statements by heads of delegations were delivered, and three working sessions, with the participation of internationally recognized experts as keynote speakers and panellists. At plenary, the Statement was issued by the Co-Presidents of the Conference, who, in doing so, endeavoured to reflect the substance and thrust of the views expressed by the Member States. The working sessions covered the following major topics:

- Working Session 1 on: “Lessons Learned from the Accident at TEPCO’s Fukushima Nuclear Power Stations” provided an opportunity of an overview of lessons learned from the Fukushima accident, measures to mitigate consequences and prevent an accident, as well as safety of the operation of nuclear installations and protection of NPPs against severe natural disasters;
- Working Session 2 on: “Strengthening Nuclear Safety, Including Emergency Preparedness and Response, in the Light of the Accident at TEPCO’s Fukushima Nuclear Power Stations” discussed ways to further strengthen nuclear safety, including emergency preparedness and response, in the light of the Fukushima accident, and the IAEA Safety Standards; and
- Working Session 3 on: “Protection of People and the Environment from Ionizing Radiation” provided an opportunity to discuss radiation protection, public communication on radioactivity, remediation related activities, and tasks related to research and development for off-site activities.

Preparatory work has begun on a comprehensive IAEA report on the Fukushima Daiichi accident, to be finalised in 2014. This report will be based on the available facts and information on the Fukushima Daiichi accident, including the IAEA’s assessment, and will consist of scientific and technical sections addressing, inter alia, nuclear safety, radiation exposure and radiation protection.

With regard to international knowledge networking, the IAEA continued to work closely with its Member States and multiple partners to strengthen the regional nuclear safety networks (Africa, Asia, Europe, Latin America and Middle East).[12] For example, in April 2012, the Global Nuclear Safety and Security Network (GNSSN) Steering Committee, comprising 15 Members States and the five regional networks, met for the first time to discuss and collaborate on a capacity building guidance document

---

[10] The Final Summary Report of the 2nd Extraordinary Meeting of the Contracting Parties to the Convention of Nuclear Safety is available at http://www.iaea.org/Publications/Documents/Conventions/cns-summaryreport310812.pdf.

[11] Information on the Fukushima Ministerial Conference on Nuclear Safety will be provided in an Agency information document at a later date.

[12] The five regional networks in attendance included: the Forum of Nuclear Regulatory Bodies in Africa (FNRBA), the Asian Nuclear Safety Network (ANSN), the European TSO Network, the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO), the Arab Network of Nuclear Regulators (ANNuR).

and self-assessment methodology. All stakeholders were encouraged to apply the new capacity building guidance in their respective countries. The Asian Nuclear Safety Network (ANSN) also agreed to adopt the new guidance and assist Member States in ANSN countries in applying it. Additionally, in July 2012, Ibero-American Forum of Radiological and Nuclear Regulatory Agencies, or FORO, celebrated its 15-year milestone in Cuba, where they were joined by twelve other countries from the Ibero-American region, as well as the Pan American Health Organization and the IAEA. An updated FORO Website is under development and is set to enable cooperation with other countries in the region.[13]

In reviewing developments in radiation protection, waste and transport safety during 2012, the IAEA noted the following trends, issues and challenges regarding:

- The increasing complexity of radiotherapy procedures making analysis of lessons learned from incidents and sharing of corrective actions throughout the medical community a key-issue.
- The challenges associated with occupational exposure, owing to: the expansion of the nuclear industry and wider application of radiation technologies, especially in medicine and industry; health surveillance of emergency workers exposed to high dose rates; re-adjustment of occupational dose limits for workers subject to eye lens exposure; monitoring workers exposed to radon as well as monitoring a mobile global nuclear workforce.
- The potential for accidents involving the transboundary movement of radiation sources inadvertently incorporated into scrap metal; especially as some such accidents have had serious consequences. In January 2012, the draft *Code of Conduct on the Transboundary Movement of Radioactive Material Inadvertently Incorporated into Scrap Metal and Semi-Finished Products of the Metal Recycling Industries*, prepared in 2011, was further developed by representatives from 28 Member States. In April 2012, this draft was formally sent to all Member States for comments; to further discuss the draft, a third open-ended meeting of technical and legal experts will be convened in February 2013.
- The need for both financial and human resources to address Member States' requirements in establishing and maintaining a national radiation safety regulatory infrastructure, compliant with the IAEA's safety standards and adequate for the level of risks posed by the actual use of radiation sources in the countries concerned. Additionally, the regulatory framework guidance as it relates to the security of radioactive sources is currently broad and will also need to be further developed.
- Variations in the application of transport regulations in Member States have resulted in shipping difficulties and delays as reported through the IAEA's denial of shipment process. The IAEA and Member States continue to support the work of the International Steering Committee on Denials of Shipment of Radioactive Material according to its action plan on denials, which is scheduled for completion before mid-2013.
- The current lack of available disposal facilities in countries for all types of radioactive waste. Although noticeable progress on the geological disposal of such waste has been made by some countries, the absence of such disposal facilities means that additional storage capacity is needed for radioactive waste and spent fuel.

In the area of nuclear installation safety during 2012, this report explores some important trends, issues and challenges, in the following key areas:

---

[13] The current FORO website is available in Spanish at: www.foroiberam.org.

- In the area of defence in depth, an important issue concerns the effective implementation and the effects of errors of commission on plant safety, i.e. erroneous actions either not anticipated or differently foreseen in design, operating or maintenance procedures rather than actual omissions of required features and actions. To mitigate errors of commission, regulatory authorities and operating organizations are, among other recommendations, encouraged to foster a questioning culture, whereby designers, operators, workers and regulators challenge assumptions and consider potential adverse consequences of planned actions.

- The need to rebuild safety culture by NPP stakeholders, operators, regulators, relevant institutions, and government advisory bodies was noted in a report by Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo electric Power Company.[14] The IAEA also observed through its review of mission and meeting outputs that regulators and operators often lacked a systematic, long-term and committed approach to continuously improving safety culture.

- Managing and preparing for beyond design basis accidents poses challenges to NPP operators, especially where interactions between individuals, technology and the organization occur. Through reviewing outputs of missions and meetings, the IAEA has observed that the personnel of nuclear installations often do not reflect upon the possibility of such accidents, and therefore also do not take appropriate measures to prepare for them.

- After the Fukushima Daiichi accident, the IAEA has noted a marginal increase in Member States' requests for specific hazard assessment reviews as part of the Site and External Events Design (SEED) review service bundle; this increase is likely to grow as countries with more developed NPPs start using the SEED review. However, newcomer countries have not necessarily availed themselves of the SEED review services.

- Severe accident management programmes facilitate management of beyond design basis accidents. In 2011, the IAEA introduced severe accident management as a stand-alone review area within the Operational Safety Review Team (OSART) peer review service. In the IAEA's review of findings from recent OSART missions, severe accident management guidelines (SAMGs) were non-existent, or not fully trained, or not scoped sufficiently in some NPPs. In addition, not all Member States have requested OSART missions in line with the Nuclear Safety Action Plan, which limits the potential for achieving an adequate and consistent level of preparedness to manage severe accidents at NPPs.

This report further explores trends, issues and challenges in strengthening Member States' nuclear and radiation safety through improvements to regulatory infrastructure and its effectiveness, covering: analysis of results from a review of 44 IRRS missions conducted from 2006 to 2012; identification of regulatory challenges faced by Member States embarking on NPPs and research reactors; and review of issues and constraints faced by Member States in establishing or strengthening their national regulatory infrastructure for radiation safety. Further, it is foreseen that the expected increases in demand for IRRS missions in the coming years could go unmet owing to the lack of available IAEA and Member State human resources.

In 2012, interest in emergency preparedness and response at both the national and international levels remained high. The IAEA implemented eight EPREV missions in 2012, the highest number since the programme began in 1999. Various improvements have also been made to EPREV, including extending the duration of EPREV missions, increasing the review time of a State's emergency

---

[14] *Final Report: Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo electric Power Company*, July 2012. This report is available at: http://icanps.go.jp/eng/final-report.html.

preparedness, set forth in the IAEA Safety Standards.[15] At the international level, the IAEA established the Emergency Preparedness and Response Expert Group (EPREG) to provide advice to the IAEA on actions needed to implement its EPR strategies and to ensure continuous and coordinated enhancement of the EPR programme.

The International Expert Group on Nuclear Liability (INLEX) continued to work towards achieving a global nuclear liability regime, as described in the Action Plan, through various IAEA meetings, workshops and IAEA/INLEX missions to Member States. Additionally, INLEX, as requested in the Action Plan, further discussed and finalized its recommendations to facilitate the achievement of a global nuclear liability regime.[16]

[15] *Preparedness and Response for a Nuclear or Radiological Emergency* (IAEA Safety Standards Series No. GS-R-2), 2002, IAEA—is the benchmark used to set up and maintain effective EPR systems. This publication is available at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1133_scr.pdf.

[16] *Recommendations on how to facilitate achievement of a global nuclear liability regime, as requested by the IAEA Action Plan on Nuclear Safety*, IAEA, 2012. This document is available at http://ola.iaea.org/OLA/documents/ActionPlan.pdf.

Analytical Overview

A. Improving Radiation, Transport and Waste Safety

A.1 Radiation Protection of Patients, Workers and the Public

Trends and Issues

1. The delivery of radiation to the patient, especially in radiation therapy, is becoming increasingly complex. Establishing the appropriateness of a given procedure remains a cornerstone of patient radiation protection. As part of radiation management, any incidents that have affected, or could have affected, the correct radiation dose delivered must be analysed and the lessons learned and corrective actions shared throughout the medical community.

2. The availability of information on previous radiological procedures has always been a part of the justification process when considering additional radiological procedures because it helps to provide the medical context. However, the availability of this information has never been as good as it should be. Fortunately this is likely to change as electronic, digital, software and hardware technologies combine to make reports of previous procedures more easily and widely available. Such software-based platforms will also facilitate the use of appropriateness criteria or referral guidelines as part of the process for requesting an imaging examination.

3. According to the 2008 report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) due to the expansion of the nuclear industry and the wider application of radiation and nuclear technologies, the number of occupationally exposed workers has increased in recent years, especially as a result of the use of radiation in medicine and industry.[17] Despite this increase, the average individual effective dose in different practices has not risen, owing to good radiation protection practices in many places.

4. The Fukushima Daiichi accident highlighted that the approaches, measures and actions for radiation protection workers in emergency situations still need to be improved worldwide. For example, better monitoring programmes, in particular for those workers receiving higher doses and those subject to internal exposures, are necessary to help reduce uncertainties in assessing exposures. Health surveillance for emergency workers exposed to high dose rates also needs further consideration.

5. With the reduction of the occupational dose limit for the lens of the eye following the *Statement on Tissue Reactions*[18] of the International Commission on Radiological Protection (ICRP), the monitoring and control of exposure of the lens of the eye has become an important aspect of occupational radiation protection. For occupational exposure in medicine, there is considerable information available on the range of doses received, as well as on the effectiveness of tools for

---

[17] *Sources and Effects of Ionizing Radiation.* United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), New York, 2008; Volume 1 and Volume 2 are available at: http://www.unscear.org/unscear/en/publications/2008_1.html and http://www.unscear.org/unscear/en/publications/2008_2.html

[18] *Statement on Tissue Reactions*, ICRP, 2011. This document is available at http://www.icrp.org/docs/ICRP%20Statement%20on%20Tissue%20Reactions.pdf.

reducing exposure to the lens of the eye. In the case of industrial applications of radiation, including in the nuclear industry, identification of those groups of workers potentially receiving high doses to the lens of the eye requires further work.

6. The globalization of professionals with special skills in nuclear and radiation technology has brought added challenges. These workers offer their services internationally and are therefore exposed to radiation at several different facilities and, in many cases, different States. There is a need to improve the regulatory control and oversight of the exposure of itinerant workers in terms of the allocation of responsibility and radiation protection issues. Solving this issue will require considerable cooperation among Member States in order to achieve an expanded, synchronized, international approach to regulations, codes of practice and other appropriate means to establish a unified occupational radiological protection system and radiation dose monitoring and recording system. Meetings were held in 2012 at the IAEA to discuss the establishment of a radiation passbook as a means of individual dose record-keeping; this passbook would be owned and controlled by the worker, but updated by the employer's dosimetry staff. Currently, some Member States use some form of passbook.

7. Despite reprocessing activities in a number of States, the nuclear industry continues to depend on the supply of fresh uranium made available through mining and milling activities. Recently, the ICRP has increased the dose coefficient for radon, which may have implications on radiation protection in the mining industry in general.[19]

Activities

8. The IAEA organized three regional workshops in 2012 to facilitate implementation of the revised International Basic Safety Standards (BSS)[20] in Member States. These workshops were hosted by the Governments of Costa Rica (for the Latin America region)[21], Malaysia (for the Asia and the Pacific region)[22] and Ukraine (for the Europe region).[23] The fourth workshop, for the Africa region, will take place in South Africa in early 2013. Representatives of regulatory bodies and other national authorities from 42 Member States attended these workshops, which primarily focused on new categorization of requirements, and on new or strengthened requirements as compared with the previous edition of the BSS. These workshops provided a valuable opportunity for Member States to discuss the implementation issues and valuable feedback was provided to the Secretariat on topics that require the development of detailed radiation protection guidance.

9. The IAEA held an International Conference on Radiation Protection in Medicine: Setting the Scene for the Next Decade in Germany, in December 2012[24], with the specific purpose of identifying and addressing issues arising in radiation protection in medicine. The conference was co-sponsored by the World Health Organization (WHO) and attended by participants from 77 Member States and 16

---

[19] *Statement on Radon*, ICRP, 2009. This document is available at http://www.icrp.org/docs/ICRP_Statement_on_Radon(November_2009).pdf.

[20] *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards* — Interim Edition, IAEA Safety Standards Series No. GSR Part 3 (Interim), IAEA, 2012. This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/p1531interim_web.pdf.

[21] Details are available at http://www-ns.iaea.org/standards/costa-rica-bss-2ndworkshop2012.asp

[22] Details are available at http://ww.ns.iaea.org/standards/malysia-bss-workshop2012.asp?s=11&1=88

[23] Details are available at: http://www-ns.iaea.org/standards/bss-reg-wshop-kiev2012.asp?s=11&l=88

[24] Details on this conference are available at http://www-pub.iaea.org/iaeameetings/41578/International-Conference-on-Radiation-Protection-in-Medicine-Setting -the-Scene-for-the-Next-Decade.

international organizations. One important outcome from the conference was the identification of responsibilities of stakeholders regarding radiation protection in medicine for the next decade.

10. In December 2012, Safety in Radiation Oncology (SAFRON), a safety reporting system developed by the IAEA to help Member States enhance knowledge that may result in better prevention of accidental exposure in radiation therapy, was made available to the worldwide radiation therapy community, through the Radiation Protection of Patients (PROP) website.[25]

11. The IAEA published *Radiation Protection and NORM Residue Management in the Titanium Dioxide and Related Industries* (Safety Report Series No. 76) in August 2012.[26] This publication is a compilation of detailed information on the processes and materials involved in the titanium dioxide and related industries, and on the radiological considerations that need to be taken into account by the regulatory body when determining the nature and extent of radiation protection measures.

12. At a Technical Meeting on the New Dose Limits for the Lens of the Eye — Implications and Implementation, held in Vienna in October 2012, presentations were made on the scientific background and justification for the reduction in the dose limit, as well as on challenges facing the fields of medicine and industry (including the nuclear industry).[27] Issues on the implementation of the new dose limits were discussed. Based on the discussions in the meeting the IAEA Technical Document (TECDOC) will be developed in 2013.

13. Several regional meetings on occupational radiation protection were held in 2012. Issues related to radiation protection in relation to naturally occurring radioactive material (NORM), and the radiation protection of workers in emergency situations were discussed, regionally specific needs were identified and experience was exchanged. In addition to these meetings, a meeting of the Regional European and Central Asian ALARA[28] Network Steering Committee was held in February 2012 in Vienna, and a meeting of the Regional ALARA Network for Latin America was held in April 2012 in Vienna.

14. The Occupational Radiation Protection Networks (ORPNET) website is being further developed to provide more comprehensive information.[29] This website provides information on the latest developments and events, provides material on occupational radiation protection to Member States, and will be updated routinely.

Future Challenges

15. Sufficient resources need to be provided to ensure full implementation of the requirements of the revised International BSS in each Member State to ensure the adequate protection of workers, patients, the public and the environment in line with accepted international norms.

16. Particular attention needs to be given to the application of a graded approach, which is now a key component of radiation protection as it is covered in the IAEA's safety standards. The philosophy behind the use of the graded approach is straightforward since not all practices represent the same degree of risk and the application of regulatory requirements needs to be commensurate with the

---

[25] The RPOP website can be accessed via this link: http://rpop.iaea.org.

[26] This publication is available at http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1568_web.pdf.

[27] More details are available at http://www-ns.iaea.org/standards/bss-tm-lens-of-eye-dose-limits2012.asp?s=11.

[28] ALARA stands for 'As Low as Reasonably Achievable'

[29] The ORPNET website can be accessed via this link: http://www-ns.iaea.org/tech-areas/communication-networks/norp/default.asp.

radiation risks associated with the exposure situation. The use of the graded approach represents an effective use of the often limited resources of the regulatory body in that greater attention and resources are focused on those practices that represent the highest risks. It is implicit that operators, registrants and licensees should also apply the graded approach to those activities for which they are authorized.

17. While regulatory bodies often focus their attention on those practices that involve the use of radiation sources in medicine and industry, the revised BSS also apply to sources of natural radiation for which, in many cases, the magnitude of exposure is greater. More attention needs to be given to the regulatory control of industries where exposure due to NORM may result in unacceptably high radiation doses to workers and the public. More resources also need to be assigned to assessing public exposure due to radon in buildings and, where necessary, to taking appropriate action to reduce exposures.

18. The medical community needs to ensure that radiation protection measures for patients keep pace with the continual developments in the technology and techniques in medical uses of radiation. The biggest challenges for ensuring the wider availability of a patient's previous exposure history and for incorporating appropriateness criteria[30] into systems for requesting imaging examinations are issues of standardization, compatibility and connectivity. Improvement of cooperation is needed between the hospitals and clinics on one side, and the manufacturers and vendors of the various components in the system on the other side.

19. As many nuclear reactors come to the end of their operating life, decommissioning activities are expected to increase significantly and raise additional challenges, such as the control of internal exposure for workers in these areas. During the process of decommissioning, in addition to the risk from radiation, workers may be subject to other industrial risks, such as chemical, mechanical and toxic hazards. A harmonized coherent approach needs to be introduced to address these risks and to ensure the safety of the workers.

20. Radiation protection in NORM industries (e.g., oil and gas) needs to be strengthened in terms of identifying the activities that give rise to radiation exposure and identifying adequate regulatory approaches, inter alia, to control exposure due to radon.

21. Radiation protection of itinerant workers requires further attention to address issues and challenges as they were identified during stress tests. As an example, after the Fukushima Daiichi accident, the activities related to stress tests have significantly increased; and workers involved in the tests changed their workplaces more frequently.

A.2 Strengthening Control over Radiation Sources

Trends and Issues

22. The management of disused sealed radioactive sources has recently been recognized as one of the remaining weaknesses in the control of sources during their life cycle. It is well recognized that the safety of radioactive sources can be ensured only by a commitment to and the application of continuous control at every stage of their life cycle, especially when they reach the end of their useful life. However, only a few States have disposal arrangements for radioactive sources, and many States do not have appropriate long term management strategies and practical arrangements.

---

[30] 'Appropriateness criteria' are the rationale used by a physician when deciding whether or not a particular imaging study is justified, taking into account risk and benefit, for answering the clinical question about a patient who exhibits a specific set of conditions.

23. A lack of appropriate control of sources in the past continues to be a contributing factor to accidents with radioactive material being found in scrap metal or in the metal recycling industry. The IAEA, through its various reporting mechanisms, receives several reports per year of such accidents. Some have serious consequences, but in most cases, the impact on human health is low. However, each accident is a radiation safety concern and reveals that control over radioactive sources is not optimal.

24. While there is considerable regulatory infrastructure guidance available from the IAEA related to radiation safety and protection, the guidance related to the regulatory framework for the security of radioactive sources needs to be developed further. This development should be consistent with current safety guidelines and should provide information to States on how to improve their overall regulatory framework to include security provisions.[31]

Activities

25. The Code of Conduct on the Safety and Security of Radioactive Sources continues to receive strong interest and support. As of December 2012, 115 States had explicitly stated their commitment to using the Code as guidance in the development and harmonization of their policies, laws and regulations. The revised Guidance on the Import and Export of Radioactive Sources, approved by the Board of Governors and endorsed by the General Conference in September 2011, was published in May 2012. As of December of 2012, 79 States had explicitly expressed their intention to act in accordance with the Guidance. Moreover, as of December 2012, 119 States have designated a point of contact for facilitating the import/export of sources in accordance with the Code and the Guidance. Efforts should continue to ensure the full and harmonized implementation of the provisions of the Code and the Guidance.

26. As part of the series of annual meetings organized to share experience in implementing the provisions of the Code, the Technical Meeting on the Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources with Regard to Long Term Strategies for the Management of Disused Sealed Radioactive Sources was held in Vienna, in February–March 2012.[32] The meeting was attended by 148 experts from 62 Member States and relevant organizations. States exchanged their views and experience on the end-of-life management of radioactive sources once they become disused, with a special focus on sustainable and comprehensive long term management strategies, including the return of disused sources to the supplier and repatriation to the country of origin; dedicated storage facilities and disposal capabilities for disused sources; comprehensive strategies for the end-of-life management of disused sources; and national strategies for regaining control over orphan sources (including disused sources).

27. The IAEA, with the assistance of Member States, also provided support for the conditioning and possible removal of disused sources from users' premises for safe and secure storage or shipment to another country.

---

[31] As part of its Guidance Development plan, the Agency is developing a guidance document to address in detail how the regulatory authority should discharge its functions and responsibilities with respect to the regulatory requirements for the security of radioactive sources; this publication is intended to focus specifically on authorization, inspection, and enforcement. It will incorporate examples of best practices and is expected to include a sample checklist of inspection measures for security (comparable to that for safety in TECDOC-1113). In addition, the Agency has developed Model Regulations for the Security of Radioactive Sources as unofficial working material, intended to provide information on how to create new, to review or to revise technical regulations for the security of radioactive material and associated facilities at every stage during their lifecycle.

[32] This report is available at www-ns.iaea.org/downloads/rw/code-conduct/info-exchange/chair-report-tm-march2012.pdf.

28. As recommended by an Open-ended Meeting of Technical and Legal Experts for Sharing Information on States' Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and its Supplementary Guidance on the Import and Export of Radioactive Sources held in Vienna, in May 2010, two regional workshops were organized to foster information exchange on the implementation of the Code and the Guidance in Latin America (Chile, November 2011) and in Africa (Burkina Faso, January 2012). The workshop in Latin America was held in Spanish and attended by 20 Member States. The workshop in Africa was held in French and attended by 17 Member States. These workshops provided opportunities for neighbouring States to discuss issues related to the safety and security of radioactive sources and to identify progress made and challenges to be solved at the regional level, such as the conclusion of agreements between neighbouring States to strengthen the control of radioactive source transfers. The fact that each workshop was held in the most widely shared language of the region in question was strongly appreciated.

29. Progress has been made in the development of a Code of Conduct on the Transboundary Movement of Radioactive Material Inadvertently Incorporated into Scrap Metal and Semi-Finished Products of the Metal Recycling Industries. In January 2012, at the second open-ended meeting, 41 representatives from 28 Member States, including technical and legal experts, further developed the draft Code of Conduct which was prepared at the first meeting held in July 2011. The draft document was formally sent to all Member States in April 2012. This Code of Conduct aims at harmonizing the approach to be adopted by States if they discover the presence of radioactive material that may inadvertently be present in a consignment, and how such radioactive material should be managed and handled safely, so that it can be brought under regulatory control. A dedicated website[33] has been created to increase awareness of this issue and of the work currently being carried out. The draft Code of Conduct will supplement *Control of Orphan Sources and Other Radioactive Material in the Metal Recycling and Production Industries* (Safety Standards Series No. SSG-17),[34] which provides recommendations, principally within a national context, on the protection of workers, members of the public and the environment in relation to the control of radioactive material inadvertently present in scrap metal.

30. A side event was co-organized by the IAEA and Finland on this topic during the 56th session of the General Conference, and attended by more than 60 delegates. A brief overview was given with regard to contaminated products in the metal recycling industry, and the IAEA presented the draft Code of Conduct and the future plans for its completion and promotion.

31. Several practical training courses on searching for orphan sources have been conducted under various national and regional technical cooperation projects. These courses provide guidance and hands-on training on establishing a national strategy to regain control over orphan sources and on performing physical searches at identified sites.

Future Challenges

32. The main challenges in the future with regard to strengthening control over radiation sources include managing disused sources in the long term; identifying and addressing the impact of new technologies on safety; maintaining a high level of awareness and support among policy makers; and coordinating and optimizing the many national and international efforts in this area.

---

[33] This website is available at www-ns.iaea.org/tech-areas/radiation-safety/orphan-sources-scrap-metal.asp?s=3&l=22.

[34] This publication is available at www.pub.iaea.org/MTCD/Publications/PDF/Pub1509_web.pdf.

33. All these challenges will be addressed at the IAEA's International Conference on the Safety and Security of Radioactive Sources: Maintaining the Continuous Global Control of Sources Throughout their Life Cycle to be held in October 2013 in Abu Dhabi, United Arab Emirates.

34. Another major challenge in this area is to reach international consensus on the Code of Conduct on the Transboundary Movement of Radioactive Material Inadvertently Incorporated into Scrap Metal and Semi-Finished Products of the Metal Recycling Industries. The third open-ended meeting of technical and legal experts scheduled for February 2013 is expected to finalize the Code for endorsement. The subsequent challenge will be the promotion and implementation of the Code worldwide in order to reduce the number of occurrences of radioactive material that inadvertently ends up in metal products.

35. The regulatory frameworks for the safety and security of radioactive sources are closely linked and in some cases the expectations are identical (such as inventory requirements). With the necessary development of the regulatory infrastructure for security, the challenge will be to ensure that there is an agreed overall regulatory framework, with safety or security provisions added as appropriate (for example, both safety and security require a licensing, inspection and enforcement capability, but there are aspects under each that are unique to either safety or security).

A.3 Strengthening the Safe Transport of Radioactive Material

Trends and Issues

36. While the United Nations Decade of Action for Road Safety 2011–2020 is primarily focused on road crashes (over 1 million people die per year, and the total associated losses exceed $500 billion), one component is the transport of dangerous goods. This initiative introduces a new UN body (WHO) to the subject area, and demonstrates a growing international focus on transport safety, including the transport of radioactive material.

37. Member States continue to support the implementation of the IAEA's Transport Regulations. These have been incorporated into several international instruments for all dangerous goods, including into the International Convention for the Safety of Life at Sea, which had 162 Contracting States/Parties (covering over 99% of the world's shipping by tonnage) as of 2012, and the Convention on International Civil Aviation, which had 190 Contracting States as of 2012.

38. The regular review, and possible revision, of the Regulations for the Safe Transport of Radioactive Material continued to be supported by the 2012 General Conference and the 2012 Transport Safety Standards Committee (TRANSSC and to a group of UN agencies and international NGO s) meetings. In recent years, the IAEA transport regulations have been made available in the IAEA's six official languages.

39. Industry has asked for improved stability in the regulation of transport and continued to report through the IAEA's denial of shipment process that variations in application of the transport regulation resulted in shipment difficulties. The 2012 meeting of the International Steering Committee on Denials of Shipment (ISCDoS) reviewed information in the denials and delays database and noted that there are reports of 168 denials and 14 delays for maritime shipments, and four denials and 47 delays for air shipments – all due to the shipment of radioactive material. In addition to those events reported in the database, the 2012 ISCDoS meeting was also notified of a further 400 delays in air shipments from a single consignor.

Activities

40. The 2012 ISCDoS meeting reviewed the reporting mechanism for denials and agreed on a new two-stage approach: the first stage will be to identify new issues as they arise; and a second stage will deal with anonymous input of numbers of denials related to these issues in order to assess the main problems. This revised method is intended to take into account industry concerns regarding the confidentiality of information. The meeting also updated the action plan on denials to identify the remaining key items, all of which are scheduled for completion before mid-2013. In addition, the meeting put together a plan for ending the work of the ISCDoS and handing over management of the remaining work to TRANSSC and to an inter-agency group of UN bodies and international NGOs.[35]

41. A technical meeting was held in 2012 in response to requests from Member State to review the output from the *International Conference on the Safe and Secure Transport of Radioactive Material* held in October, 2011. The outcome of this technical meeting resulted in a proposed list of actions, which were supported through resolution at the General Conference in 2012.[36] While the actions listed focused mainly on existing work in transport safety, security, liability and emergency response, it also encouraged additional work to be carried out in several other areas. For example, one area of significant interest related to communication between States regarding the shipment of radioactive material.

42. An implementing guide for the security of nuclear material during transport has been developed in connection with the publication of *Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5)*[37] and the corresponding update of the transport security provisions. The changes in the transport security provisions for nuclear material ensure that they correspond better with current practices and also include new provisions to take into account potential radiological consequences of nuclear material. The recommended threshold values and security provisions for radioactive material during transport have been communicated to the UN Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals and included in the 2011 edition of the UN Model Regulations on the Transport of Dangerous Goods (the 'Orange Book'), and will start to be implemented in national regulations in 2013.

43. At its meeting in 2012, the ISCDoS agreed to complete its work by the 57th regular session of the General Conference in September 2013. It also agreed that TRANSSC and an inter-agency group of UN bodies and international NGOs would manage work in this area after 2013, while additional support to transport regulators would be provided by networks of regional coordinators, who would also be responsible for reporting to TRANSSC. In addition, the ISCDoS produced a consolidated action plan focusing on essential activities expected to be completed in the second half of 2013. Once the number of denials has been reduced, the next challenge will be to ensure that this is sustained, taking into consideration the possible introduction of additional control mechanisms.

---

[35] International Civil Aviation Organization (ICAO); International Maritime Organization (IMO); United Nations Economic Commission for Europe (UNECE); World Health Organization (WHO); Airport Council International (ACI); Global Express Association (GEA); International Association of Ports and Harbours (IAPH); International Air Transport Association (IATA); International Cargo Handlers and Carriers Association (ICHCA); International Chamber OF Shipping (ICS); International Federation of Airline Pilot Associations (IFALPA).

[36] This relates to operative paragraph 43 of resolution GC(56)/RES/9. This is available at: http://www.iaea.org/About/Policy/GC/GC56/GC56Resolutions/English/gc56res-9_en.pdf.

[37] This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1481_web.pdf.

Future Challenges

44. UN bodies have responsibilities for regulations and international NGO's for standards and practices for all modes of transport of all dangerous goods, of which radioactive material is a subset Each of these groups have separate communications and training networks already established; but no single entity provides for all of the necessary information. When brought together, their individual networks can then work in a collaborative way to complement and extend the core expertise of their stakeholders. However, establishing this type of collaboration is difficult in the current economic climate, as these groups cannot always fund their staff to participate in activities that are solely focused on radioactive material transport.

A.4 Strengthening the Safety of Waste Management, Decommissioning and Remediation

A.4.1 Safety of Waste Management and Decommissioning

Trends and Issues

45. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management as well as the IAEA's safety standards support the establishment of comprehensive national policies and strategies for radioactive waste and spent fuel management. Some progress has been made in several Member States through IAEA support; however, many countries have not yet established such comprehensive policies and strategies.

46. No country currently has disposal facilities available for all types of radioactive waste. In particular, no solution has been implemented for the disposal of high level radioactive waste and spent fuel. The absence of such disposal facilities leads to longer periods of storage of radioactive waste and spent fuel, which is a safety concern.

47. Spent nuclear fuel needs to be safely managed following its removal from reactor cores. Reactor pool capacities are generally designed on the assumption that the fuel is removed after a certain time for reprocessing, disposal or other disposition options. As the result of delays in decisions on spent fuel disposition, the volume of spent fuel discharged from reactors which needs to be stored is growing and, in an increasing number of cases, exceeding the spent fuel pool capacities. Therefore, additional storage capacity is needed. Options for additional storage include wet storage in some form of storage pool or dry storage in a facility or storage casks built for this purpose.

48. The use of the dual purpose cask designed for both transport and storage is an attractive option because of its flexibility and economic efficiency. However, to make further progress with the use of dual purpose casks Member States need guidance on integrating the safety cases for storage and transport.

49. Noticeable progress on the geological disposal of high level radioactive waste and spent fuel has been made by some countries with established research and development programmes. For example, license applications have been submitted in Finland and Sweden and will soon be submitted in France. However in many other countries the geological disposal of high level radioactive waste and spent fuel remains a topic of concern.

50. Immediate dismantling continues to be the preferred strategy for decommissioning (the dismantling operation can, however, last 20 or 30 years). Even where a deferred dismantling strategy was initially chosen there are instances where the decommissioning strategy was subsequently changed to an immediate dismantling strategy (e.g. in France and Italy). Progress continues to be made

in the development of specialized tools for decommissioning that facilitate remote operations for the characterization, dismantling and demolition work. More sophisticated tools for decommissioning are now being applied routinely; for example, 3D visualization and simulation technologies are employed for both characterization and detailed planning, including safety assessment. A lack of disposal routes for radioactive waste has often been cited as an impediment for decommissioning; in many Member States this impediment is being removed as long term storage of decommissioning waste has gained acceptance as an option. Industrial reuse of former nuclear sites — instead of a 'green field' end state — is becoming more prevalent, especially for large and complex nuclear facilities.

51. Some of the problems faced by Member States in this area include a lack of regulations in countries with small programmes, inadequate funding arrangements, and inadequate training for decommissioning safety assessment and for post-accident decommissioning (strategy, planning and implementation). Furthermore, some Member States have difficulties with the management of decommissioning projects, including the management of uncertainties and technical interdependencies.

Activities

52. The Joint International Working Group on Guidance for an Integrated Transport and Storage Safety Case for Dual Purpose Casks for Spent Nuclear Fuel was established in 2011. As there are separate regulations that need to be complied with for both transport and storage for the dual purpose cask, the working group was established to provide guidance to Member States for integrating the safety cases for storage and transport. In April 2012, participants from 15 Member States attended a meeting led by the working group to discuss the issues and guidance for the use of dual purpose (transport and storage) casks for spent nuclear fuel. A report on guidance is currently being drafted and is expected to be completed by the second half of 2013. The report will then be presented to WASSC and TRANSSC for consideration in future revisions of IAEA Safety Standards.

53. In 2012, a new project was established to continue the work of the International Project on Demonstrating the Safety of Geological Disposal (GEOSAF). Whereas the first part of the GEOSAF project addressed long term safety, this second phase aims to draft guidance and recommendations on the development and review of an integrated safety case for operational and long term safety.

54. In September 2012, the International Project on Human Intrusion in the Context of Disposal of Radioactive Waste (HIDRA) was launched during a meeting at which participants from 21 Member States representing regulators, operators and technical support organizations attended. The project addresses the approach to future human actions and human intrusion in the safety case and safety assessment of radioactive waste disposal facilities, including both geological and near surface disposal facilities. The expected outcome will be guidance on how to address human actions in the safety case and safety assessment of radioactive waste disposal in the future, and how to use those assessments to optimize siting, design and waste acceptance criteria within the context of a safety case.

55. A draft of the revised Safety Requirements for decommissioning was approved by all Safety Standards Committees and sent to Member States for comment.[38] Member States' experience with decommissioning after a nuclear accident is being assembled and will be discussed at International Experts' Meeting on Decommissioning and Remediation after a Nuclear Accident to be held from 28 January to 1 February 2103 in Vienna. The International Project on the Use of Safety Assessment in Planning and Implementation of Decommissioning of Facilities using Radioactive Material, which

[38] Draft publication *Decommissioning of Facilities* available at http://www-ns.iaea.org/downloads/standards/drafts/ds450.pdf

addressed the application of safety assessments for decommissioning, was completed in 2012. The project's summary report is currently being finalized for publication. The new International Project on Decommissioning Risk Management (DRiMa) was launched in December 2012 in response to needs expressed by Member States.

Future Challenges

56. The IAEA has an essential role to play in supporting and assisting Member States to meet challenges related to the development and implementation of comprehensive radioactive waste and spent fuel management strategies. One such challenge is the implementation of geological disposal for high level radioactive waste and spent fuel. The demonstration of the safety of such projects as well as the development, construction, operation and closure of geological disposal facilities is a long process.

57. In this regard, enlargement of the scope of the Working Group on Guidance for an Integrated Transport and Storage Safety Case for the Dual Purpose Casks for Spent Nuclear Fuel is being considered to include safety case for disposal of radioactive waste and spent fuel.

58. Another challenge is the planning and implementation of decommissioning in countries with limited resources and without an extensive nuclear infrastructure, such as a regulatory infrastructure, a waste management infrastructure, and specialized services for decommissioning. With ageing facilities and workforces, training in decommissioning and the exchange of knowledge is crucial in countries that have fewer resources to draw upon. Implementation of decommissioning plans after nuclear accidents presents a daunting technical challenge and this will probably continue to be the case in the years ahead. Efficient arrangements for the characterization and clearance of large amounts of materials with very low levels of radioactivity are frequently a 'bottleneck' for the implementation of decommissioning.

A.4.2 Remediation and Protection of the Environment

Trends and Issues

59. The Fukushima Daiichi accident has underlined the need for reliable, robust and flexible tools to enable timely assessments of exposures to the public as a result of major unplanned releases of radionuclides to the environment. Assessment models are also required for providing reliable estimations of the exposures to people living on sites contaminated by, for example, nuclear accidents, inappropriate past practices, or the mining and processing of uranium and other ores. In conjunction with radiological site characterizations, dose assessments are needed to support decisions on the necessity of remediation and to identify effective and feasible actions that are accepted by the local population and which can be implemented at reasonable cost to reduce undue exposures to the public and to prove whether the end states of remediation comply with regulatory standards.

60. The revised BSS explicitly require the consideration of radiological impacts to the environment when setting up national legal and regulatory frameworks and infrastructures for radiation protection. This includes recent recommendations made by the ICRP and addresses an international trend of increasing awareness of the vulnerability of the environment. The general aim of radiation protection of the environment is to protect populations, communities and ecosystems rather than individuals.

61. With renewed interest in uranium production in recent years, there is heightened awareness of past practices that may have affected the environment and human health. Poor past practices have created a legacy of former uranium production sites in all parts of the world. A wide range of expertise, knowledge and capabilities to regulate and mitigate risks posed by these types of site has

since evolved. In recent years, various international and national organizations have taken steps to begin to address the risks posed by former uranium production sites.

Activities

62. The IAEA's Modelling and Data for Radiological Impact Assessments (MODARIA) programme provides support to Member States to maintain and improve their assessment capabilities. In November 2012, MODARIA was launched at a meeting attended by participants from more than 40 Member States. Ten working groups were established focusing on different aspects of exposure assessment for people in planned, existing and emergency exposure situations. MODARIA also covers the assessment of radiological impacts on flora and fauna from radionuclides released to the environment. The compilation of globally applicable datasets for application in assessment models is a priority. The MODARIA programme is scheduled to run for four years.

63. The revision of *Regulatory Control of Radioactive Discharges to the Environment* (Safety Standards Series No. WS-G-2.3)[39] is in progress. The revised standard will be fully integrated with *Fundamental Safety Principles* (Safety Standards Series No. SF-1) and will provide guidance on how to apply the revised BSS with regard to the control of radioactive discharges to the environment that may cause public exposure and have a radiological impact on the environment during planned exposure situations.

64. Guidance on the assessment of the radiological impact on the environment arising from authorized discharges to terrestrial or aquatic environments will be provided in a new Safety Guide that is being developed.[40] The preparation of a radiological environmental impact analysis is a key component for demonstrating radiological protection of the environment. For this purpose, a graded approach is proposed in order to ensure that the efforts dedicated to safety are commensurate with the radiation risks. These standards are designed to clearly identify protection of the environment as an issue to be assessed, while leaving some flexibility as to how to incorporate the results into appropriate decision making processes.

65. The *London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter* prohibits the disposal of radioactive wastes and other radioactive matter at sea.[41] However, both natural radionuclides as well as radionuclides from anthropogenic sources, such as fallout from atmospheric nuclear weapons testing, are present in all materials. Thus, the Contracting Parties to the London Convention asked the IAEA to derive levels of activity concentrations for material that might be disposed of at sea providing a de minimis radiological impact, which have been used for the London Convention since 2003. At the request of the Contracting Parties to the London Convention, the IAEA reviewed and updated these de minimis activity levels, taking into account the requirement in the BSS on the protection of the environment. These new levels will be considered for endorsement by the contracting parties to the London Convention in 2013.

66. The International Working Forum on Regulatory Supervision of Legacy Sites (RSLS) provides a platform for regulators and operators to exchange ideas and experience in the area of regulation and remediation of legacy sites. The goal of RSLS is to create a network of regulators and operators whose

---

[39] The document preparation profile (DPP) for this revised Safety Guide is available at http://www-ns.iaea.org/downloads/standards/dpp/dpp442.pdf.

[40] The DPP for this new Safety Guide is available at http://www-ns.iaea.org/downloads/standards/dpp/dpp427.pdf.

[41] The text of the Convention is available at http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx.

performance can be enhanced through workshops, scientific visits and shared experiences. Under RSLS and in co-sponsorship with the US Nuclear Regulatory Commission and US Department of Energy, the IAEA held an International Workshop on Management and Regulatory Oversight of Uranium Legacy Sites: Perspectives from Regulators and Operators, in Colorado, USA, in August 2012. This workshop was preceded by scientific visits to sites in the region where there are activities pertaining to remediation and post-closure care of uranium legacy sites, as well as to a site where there are uranium milling operations.

67. In response to various General Conference resolutions[42], the IAEA is working with interested Member States and relevant international organizations, to provide a forum for technical coordination for multilateral initiatives to remediate uranium production sites, notably in Central Asia. The draft terms of reference for a Coordination Group for Uranium Production Legacy Sites (CGULS), which were prepared at a meeting held in Vienna in June 2012, were sent for consideration and concurrence of relevant Member States.

Future Challenges

68. Work on remediation needs to focus on providing Member States with practical guidance in the form of Safety Standards and supporting activities to identify situation-specific strategies for the remediation of contaminated urban and rural areas. Supporting documents need to cover a wide range of contamination situations and environmental conditions to appropriately address local circumstances, and the importance of analysis and assessment of exposures must be emphasized for the selection of optimized remedial actions. In addition, appropriate monitoring strategies need to be developed to provide input for the radiological characterization of contaminated areas and for validating the success of remedial actions.

69. Furthermore, an integrated and strategic approach to the remediation of legacy uranium production sites is needed to ensure the safety of former uranium production sites in Central Asia. This will be dependent upon a well-coordinated, integrated and collaborative effort by various national, regional and international organizations involved with remediation in the region, and sustained resources will be required over long periods to reduce or eliminate the risks posed by these sites. To address safety issues related to legacy site around the world, there is a need to enhance and improve the regulatory framework, expertise and capabilities in many Member States.

---

[42] This relates to operative paragraph 64 of resolution GC(56)/RES/9, operative paragraph 66 of resolution GC(55)/RES/9, operative paragraph 54 of resolution GC(54)/RES/7 and operative paragraph 65 of resolution GC(53)/RES/10.

B. Strengthening Safety in Nuclear Installations

B.1. Defence in Depth

Trends and Issues

70. The Fukushima Daiichi accident has led the international nuclear safety community to re-evaluate the implementation of defence in depth (DID) measures at nuclear facilities. DID is regarded as the foundation of nuclear safety and is one of the primary means for preventing and mitigating the consequences of nuclear accidents.

71. For nuclear installations, DID helps to produce a strong design by relying on successive, multiple layers of prevention and control through multiple engineering barriers and operational/procedural levels. These multiple layers are designed to ensure the protection of people and the environment by effectively containing radioactive material, and mitigating the effect of an unlikely event of a failure of one or more of the engineered barriers. While the concept of DID has been rigorously implemented in nuclear installations, recent events such as the Fukushima Daiichi accident have highlighted that low-likelihood, high-consequence events can lead to multiple failures and radiological releases that might affect existing DID measures.

72. In *Defence in Depth in Nuclear Safety* (IAEA publication INSAG-10), the International Nuclear Safety Group (INSAG) states that "human errors bear a potential for jeopardizing defence in depth … With regard to the potential degradation of defence in depth, one major concern is errors of commission: erroneous actions either not anticipated or differently foreseen in operating or maintenance procedures rather than omissions of required steps. Examples are selecting wrong controls, issuing wrong commands or information, changing sequences of tasks, and performing tasks too early or too late. Such errors can occur as a result of errors in decision making by the operators; misinterpreted or vague procedures; misleading instrumentation; misunderstandings; or simply errors by an operator."[43] Not discussed in this passage, but equally important are errors of commission in design. Reference to design in this context refers not only to the initial design of the nuclear facility, but also to the design of such things as plant operating procedures and modifications. These errors can trigger common cause failures, as was learned from the Fukushima Daiichi accident and other NPP events that occurred this year.

73. Another lesson learned is the need to develop a 'questioning attitude', and reinforcing this questioning culture in all areas of the nuclear community (regulators, operators and governmental organizations).[44] A questioning attitude asks "why" and "what if" type questions to identify concerns, challenge assumptions, investigate anomalies, and consider potential adverse consequences of planned

---

[43] *Defence in Depth in Nuclear Safety* INSAG 10, IAEA, 1996, which is available at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1013e_web.pdf.

[44] The following excerpt is taken from *Requisite Environment for Effective Implementation of Integrated Safety Management (ISM) Systems*, US Department of Energy, June 2005. The report is available at http://www.hss.energy.gov/deprep/2005/MS05G05.PDF.

"Attributes of a questioning attitude (include): Workers recognize the possibility of mistakes and discuss worst-case scenarios. Contingencies are developed to deal with these possibilities. Anomalies are recognized, thoroughly investigated, promptly mitigated, and periodically analysed in the aggregate. Personnel do not proceed in the face of uncertainty. Workers identify conditions or behaviours that have the potential to degrade operating or design margins. Such circumstances are promptly identified and resolved. Employees understand that complex technologies can fail in unpredicted ways. They are aware that latent problems can exist, and they make conservative decisions considering this potential. Group-think is avoided through diversity of thought and intellectual curiosity. Opposing views are encouraged and considered."

actions that might degrade operating, design or DID margins. The ability to ask good questions leads to discussions on relevant issues such as what is wrong at the margins; why do the margins exist; are the margins correct in the current context; what should be done when operators are close to a margin or on the wrong side of the limits. Having these discussions in advance creates sensitivity to the margins and a knowledgeable workforce. One of the lessons from recent events indicates that the safety culture should be such that workers are encouraged and reinforced in applying this questioning attitude.

74. This attitude is shaped by an understanding that accidents often result from a series of decisions and actions that reflect flaws in shared assumptions, values and beliefs. A questioning attitude encourages employees to be watchful for conditions or activities that might have an undesirable effect on plant safety and this questioning culture should be encouraged by regulatory authorities and operating organizations.

75. The ability to ask good questions ultimately leads to modifications in plant equipment or procedures which enhance DID at a given facility. Since the Fukushima Daiichi accident, the international nuclear safety community has worked diligently to strengthen this questioning attitude. For example, the question as to how an NPP will withstand a range of external events or whether the NPP design, equipment or procedures need to be augmented to address those external events were just two of the questions asked and analysed during the NPP stress tests conducted worldwide in 2011 and 2012.

Activities

76. Another example of DID-driven efforts focused on improving the quality and effectiveness of safety-focused training. In particular, the IAEA has provided seminars on the Guidelines for Systematic Assessment of Regulatory Competence Needs (SARCoN) for 18 countries and on the Safety Assessment Education and Training (SAET) Programme for five Member States. During 2012, the IAEA began adjusting some of these training programmes to focus more on how to ask good questions and these efforts will continue in 2013.

77. Peer reviews, both on a national and international level, are an effective tool for examining the effectiveness of the implementation of DID principles. Following the Fukushima Daiichi accident, the IAEA modified the scope of both its OSART and Integrated Regulatory Review Service (IRRS) missions to focus more on the implementation of DID principles. During 2012, the IAEA conducted eight OSART missions and four IRRS missions to Member States that included this new focus.

78. In September 2012, DID was also the focus of a side event held at the 56th session of the General Conference. This event provided a forum to discuss means of effectively implementing DID principles and it helped to identify challenges to improve DID provisions for external hazards and issues and recommendations to guide future IAEA activities.

79. The fifth *International Conference on Topical Issues in Nuclear Installation Safety: Defence in Depth – Advances and Challenges for Nuclear Installation Safety* will be held in Vienna, from 21 – 24 October 2013. This conference continues the work done in this area so far and will focus on the concept of DID and its implementation in nuclear installations. It is important for the international nuclear community to exchange ideas and information on how the application of the concept of DID is evolving, and the challenges that are being encountered as national and international actions unfold.

Future Challenges

80. Given the importance of the DID principle, it is expected that new approaches will continue to be developed to strengthen its implementation. As with any fundamental principle, any changes made need to be studied in a holistic manner to ensure that the implementation of them achieves the desired impact.

81. While international collaboration on the implementation of DID principles is ongoing, maintaining the current level of focus is seen as a challenge because the implementation of ideas such as 'asking good questions' and the use of peer review services are resource-intensive activities. However, since the knowledge of best practices derived from others' experience and an internally questioning culture allows for improved implementation of change, Member States are urged to encourage a safety focused questioning environment.

82. Evaluations of the effectiveness of the implementation of DID need to take a holistic look at any changes made to a facility in the name of improving DID to ensure that they do not lead to any unintended consequences. For example, additional off-site equipment that may be proposed to increase the diversity in the means to ensure safety functions may be sitting idle for most plants that are implementing this measure. Requirements should be put in place to guard against complacency and to make sure that this equipment is properly maintained and that provisions are in place to ensure that it is available any time it may be needed.

83. The current proposed measures to improve the implementation of DID mainly apply to operating reactors (e.g. additional on-site or off-site emergency equipment). These measures may or may not be needed for new reactor designs with enhanced safety features. However, innovative features in new reactors that are claimed to enhance DID should be based on proven technologies either through practical application or adequate development and testing programmes.

84. Finally, there is still a need to ensure the independence of decision making by the regulatory authorities.

B.2 Safety Culture

Trends and Issues

85. Inadequate safety culture and the impact of managerial and human factors on safety were, in part, causes of the Chernobyl accident. In *The Chernobyl Accident: Updating of INSAG-1*, INSAG described safety culture as the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.[45]

86. The Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo Electric Power Company noted shortcomings in the safety culture in Japan and pointed to the need to rebuild the safety culture of practically every stakeholder in nuclear power generation in the country, including nuclear operators, regulators, relevant institutions, and government advisory bodies.[46] The

[45] *The Chernobyl Accident: Updating of INSAG-1*, A Report by the International Nuclear Safety Advisory Group, Safety Series No. 75-INSAG-7, 1992. This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub913e_web.pdf.

[46] *Final Report: Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo electric Power Company*, July 2012. This report is available at: http://icanps.go.jp/eng/final-report.html http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/report/index.html

international, regional and national accident reports and meetings have further stressed that the lessons learned on safety culture from the Fukushima Daiichi accident should be applied on a general, worldwide basis and that it would be beneficial for all nuclear operating organizations to examine their own practices and behaviour in light of this event and use case studies or other approaches to heighten awareness of safety culture principles and attributes.[47]

87. The reactions to the Fukushima Daiichi accident show an evolving global and national maturity in understanding the importance of a strong safety culture at nuclear installations. As addressed at the IAEA Ministerial Conference on Nuclear Safety held in Vienna in June 2011 and in the resulting Action Plan, the systematic, long term commitment needs to be reinforced to continuously improve safety culture. Additionally, at the Fukushima Ministerial Conference on Nuclear Safety held Fukushima Prefecture in Japan in December 2012, experts stressed that establishment of a robust and enduring safety culture is crucial. Other aspects of promoting a vibrant safety culture were also noted, in particular: recognizing the significant efforts that are needed to embed the attributes of a strong safety culture, such as open reporting and learning, in a prevailing, more established culture.[48]

88. However, despite the increased awareness of the significance of a strong safety culture as well as the ongoing reinforcement of safety culture by the IAEA through meetings and OSART missions, the IAEA has observed, based upon support missions and technical meetings, that regulators and licensees often lack a systematic, long-term and committed approach to continuously improving safety culture and that nuclear organizations tend to take an inadequate, ad hoc approach to safety culture in their nuclear operations.

89. A common misconception has been that passive information campaigns and strong leadership can change safety culture behaviours instead of actually addressing the basic assumptions and understanding about reality shared by the workers. Therefore, improvement activities have often ended up addressing only visible behaviours of people, and leaving out major underlying psychological and sociocultural drivers. As a result, changes in safety culture have been insufficient and unsustainable.

Activities

90. During the past few years, the IAEA has been working continuously to strengthen and improve safety culture. A number of publications had previously been issued in order to bridge the gap between what a strong safety culture comprises and how to practically strengthen safety culture.[49] *Safety Culture in Pre-operational Phases of Nuclear Power Plant Projects* (Safety Reports Series No. 74)

---

[47] *Lessons Learned from the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station*, INPO 11-005 Addendum, August 2012. The report is available at http://www.nei.org/resourcesandstats/documentlibrary/safetyandsecurity/reports/lessons-learned-from-the-nuclear-accident-at-the-fukushima-daiichi-nuclear-power-station. See also *Report of the External Advisory Committee Examining the Response of the Canadian Nuclear Safety Commission to the 2011 Japanese Nuclear Event*, Canadian Nuclear Safety Commission, 12 April 2012; *Forging a New Nuclear Safety Construct*, ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events, June 2012. Additionally, the Second Extraordinary Meeting of the Contracting Parties to the Convention of Nuclear Safety in Vienna, 27–31 August 2012, and the IAEA Ministerial Conference on Nuclear Safety, 20-24 June 2011, reinforced the importance of maintaining a strong safety culture.

[48] Chairpersons' summaries from the Fukushima Ministerial Conference on Nuclear Safety are available at http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2012/20120216/20120216_CSummaries.pdf.

[49] See, among others, the following Agency publications: *The Management System for Facilities and Activities* (Safety Standards Series No. GS-R-3); *Application of the Management System for Facilities and Activities* (Safety Standards Series No. GS-G-3.1); and *The Management System for Nuclear Installations* (Safety Standards Series No. GS-G-3.5), available at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1252_web.pdf; http://www-pub.iaea.org/MTCD/publications/PDF/Pub1253_web.pdf; http://www-pub.iaea.org/MTCD/publications/PDF/Pub1392_web.pdf.

was published in 2012.[50] In 2013, the IAEA will publish two Safety Reports on safety culture assessment and on continuous improvement for safety culture: a TECDOC on regulatory oversight of safety culture, and guidelines for independent safety culture assessment within the framework of OSART.

91. As publications only provide partial guidance and support, the IAEA is conducting a range of other activities to further enhance nuclear safety culture in Member States. An IAEA training course on how to perform safety culture self-assessments has been developed and has already been delivered to the nuclear waste facility in Belgium. In the first quarter of 2013, this self-assessment training course will be adapted for use by regulatory bodies; the first training course will be conducted with the Pakistan Nuclear Regulatory Authority in the second quarter of 2013. The IAEA is planning to conduct training workshops for senior managers of regulators and operators on the topic of safety culture and leadership in 2013.

92. Periodic, independent safety culture assessments are also of key importance to maintain a strong DID that is resilient and able to prevent severe accidents. The IAEA offers an independent safety culture assessment module as an optional review service to Member States integrated into OSART. So far, two missions have been conducted — one in Brazil in 2010 at Angra 2 and one in South Africa in 2012 at Koeberg — and one is planned for France in 2014.

93. The IAEA has also developed a safety culture perception questionnaire, which encompasses the various characteristics and attributes of a strong safety culture. This questionnaire can be used by Member States in conjunction with other assessment methods, such as interviews, focus groups, observations and document reviews. The IAEA has also recently provided tailored support in the area of safety culture to Belgium, Bulgaria and Sweden.

94. Finally, a three-year project was initiated in March 2011 aimed at enhancing the nuclear power licensee safety culture in Latin America. Using a peer exchange approach, 81 participants from Argentina, Brazil and Mexico have been involved in visiting 14 NPPs in eight different countries: Argentina, Belgium, Brazil, Canada, Mexico, Spain, United Kingdom and United States. To sustain experience, information and connections established during this project, the Latin America Safety Culture Network (LASCN) is under development. It is a collaboration platform sponsored by the IAEA to serve as a regional forum for connecting Latin America Nuclear operators' staff with the aim of knowledge sharing and learning, sharing good practices and collaborating to find solutions to challenging problems.

Future Challenges

95. Developing and maintaining a strong safety culture is a continuous process, requiring a systematic, sustainable, long term commitment to continuously improve safety culture in all organizations working with nuclear technology. This requires safety culture specialists with competencies to assess managerial and human factors and to drive continuous improvement efforts to ensure the high levels of safety performance required in nuclear facilities. While Member States have committed to and acknowledged the importance of improving safety culture, many of them lack the necessary skilled human resources. One of the key future challenges for the nuclear energy community, therefore, is to ensure that Member States acquire competent experts with the necessary

---

[50] *Safety Culture in Pre-operational Phases of Nuclear Power Plant Projects*, Safety Reports Series No. 74, 2012. The report is available at: http://www-pub.iaea.org/books/IAEABooks/8792/Safety-Culture-in-Pre-operational-Phases-of-Nuclear-Power-Plant-Projects.

educational background in behavioural and social sciences and a specialization in nuclear technology and operation, human and organizational factors, and safety culture assessment.

96. As was once again highlighted by the Fukushima Daiichi accident and other recent NPP events, cultural factors as well as cross-cutting human and organizational factors have a strong impact and influence on all activities within the whole organization. Furthermore, external factors such as national culture, as well as societal, site specific and local factors have as well an impact on nuclear safety and accident management. Both the internal and external factors need to be addressed and considered to lower risk of conflict and overlapping interests which can jeopardize safety. The key challenge for Member States in this regard is to recognize that all organizations have strengths and weaknesses, and that cultural, human and organizational factors — the attributes of which differ from site to site or country to country — must be proactively identified and addressed in order to strengthen nuclear safety in general and accident management in particular.

B.3 Managing the Unexpected

Trends and Issues

97. The unexpected sometimes occurs quite dramatically as was seen with the Fukushima Daiichi accident, which resulted from the combined forces of an earthquake and tsunami. Or, the unexpected could occur in even more subtle ways, emerging from the underlying interactions between individuals, technology and the organization which, for example, contributed to a station blackout at the Kori 1 reactor in the Republic of Korea in 2012. These recent events and others in the not too distant past point to the fact that nuclear installations need to be better prepared for managing unexpected events.[51]

98. As discussed in detail in Section B.5 of this report, the IAEA's OSART missions have highlighted a need to improve beyond design basis accident management and preparedness with particular regard to the interactions between individuals, technology and the organization. Furthermore, the IAEA has observed that the personnel of nuclear installations often do not reflect upon the possibility of such accidents, and therefore also do not take appropriate measures to prepare for them.

99. Historically, nuclear regulators have not required nuclear operators to include multi-reactor accidents at a single site or multi-site accidents in their design basis. However, as one of the lessons learned from the Fukushima Daiichi accident, regulators are now taking a further look at regulating a wider range of possible events to improve nuclear safety worldwide.

Activities

100. The IAEA has initiated activities both to inform the nuclear power community of the need to prepare for managing the unexpected and to make use of the large amount of research and experience developed in order to create resilient high-risk organizations that are actively managing for the unexpected. A meeting on managing the unexpected from the perspective of the interaction between individuals, technology and the organization was held in Vienna in June 2012. The meeting was organized within the framework of the Action Plan. Nuclear safety experts and scientists took part in

---

[51] See *2012 Fukushima Anniversary Q&A*, WANO, 2012, available at http://wano.forepoint.biz/wp-content/uploads/2012/03/March2012_Q-A-document-for-Fukushima.pdf; *Lessons Learned from the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station*, INPO 11-005 Addendum, August 2012, available at http://www.nei.org/resourcesandstats/documentlibrary/safetyandsecurity/reports/lessons-learned-from-the-nuclear-accident-at-the-fukushima-daiichi-nuclear-power-station); and *Forging a New Nuclear Safety Construct*, ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events, June 2012, available at http://files.asme.org/asmeorg/Publications/32419.pdf.

this meeting, and discussed how to reinforce the capacity of nuclear power installations to manage unexpected events. The meeting concluded that to create organizations that are better prepared to manage the unexpected, operators of nuclear installations need to first recognize that total control and predictability is unrealistic in a dynamic world. Only once this has been accepted can organizations start to prepare properly for managing unexpected events. It was further emphasized that when preparing to deal with accidents, one must be aware of the fact that these are not solely caused by measurable failures and malfunctions. Rather, they may emerge from non-linear, dynamic, unexpected, and multi-dimensional interactions within and among the individual, technical and organizational factors comprising a nuclear organization. It was therefore concluded that the focus should be on optimizing everyday operational safety at NPPs.

101. In 2013, a consultancy meeting will take place to work on a methodology for Member States on developing high reliability organizations that are prepared to manage unexpected events.

102. Furthermore, 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 will take place in May 2013 within the framework of the Action Plan.

Future Challenges

103. The application of the IAEA's severe accident management guidelines is an important measure to build resilience within NPPs. Nevertheless, an additional challenge is to educate and provide practical methods to build resilience through an individual–technology–organization approach that can make DID more tangible, because frequently root causes of severe accidents include intangible interactions among individuals, technology and the organizations.

B.4 Site Assessment and Design related to External Hazards

Trends and Issues

104. Member States planning to build NPPs, must select suitable sites that will support the construction and safe operation of NPPs. Member States utilize varying arrangements with vendor countries for their design, construction and operation of NPPs, but the selection and licensing of these sites remain the responsibility of the Member State. The Member State licenses the site based on the technical evaluation of the site safety assessment, including site specific hazards. Member States therefore have an interest in the development of technical capacity to support their activities related to site selection and evaluation.

105. Over the past ten years, more than 120 missions have been conducted to provide training and review work undertaken in Member States related to site safety aspects. In 2012 alone, ten such review missions were undertaken in nine countries and 13 training workshops were held. The missions to some newcomer Member States identified that there was a serious lack of planning with respect to their needs, including which competencies to build and which to contract out as well as the sequence in which to request IAEA assistance that would best suit their national needs. It was found that Member States not committed to building NPPs in the short term primarily requested capacity building assistance for site selection and site assessment since these activities are developed in parallel to competency development. Also, some Member States with no short term plant construction plans have conducted early site surveys (an action that precedes site selection and site assessment) but did not request a SEED review service. Therefore, these Member State did not benefit from an international expert team review of their early site survey work.

106. The Fukushima Daiichi accident highlighted the paramount importance of site safety for the safety objectives of nuclear facilities. In this respect, Member States have endorsed the Action Plan to

increase the use of peer review services associated with site safety aspects and safety margin assessments against extreme hazards. Requests for specific hazard assessment reviews as part of the SEED review service bundle have increased by a small percentage; however, this increase is likely to grow in the future as countries with more developed nuclear power programmes start using the SEED review service for design review and installation safety assessment against extreme hazards for existing and new NPPs.

Activities

107. A new module on environmental impact assessment was developed to support Member States' increased demand for capacity building assistance. This module, which is part of the SEED review service, comprises a series of customized capacity building and review services. It completes the SEED service package, which contains the following individual modules: capacity building; site selection process review; integrated site evaluation review; site hazard evaluation review (for each specific external hazard); safety review of structures, systems and components against external and internal hazards; and environmental impact assessment review. In 2012, SEED review services were carried out in Hungary, Japan, Kazakhstan, Lebanon, Nigeria, Romania, South Africa, Turkey and Vietnam.

108. To further optimize resource sharing and learning from mutual experience the IAEA is encouraging Member States using the same reactor vendors to attend common capacity building workshops provided by the IAEA.

109. Tailored capacity building services in the area of site regulation development and the development of scopes of work for contracted work to assure compliance with the IAEA's safety guidance have been established, and were implemented in Indonesia and Malaysia. The IAEA has conducted missions to assist Member States in the planning and deployment of SEED missions for capacity building and subsequent reviews of their ongoing work related to site and nuclear installations safety with respect to external hazards. As a result, some embarking countries have provided the IAEA with a sequenced list of SEED services needed in the near future to help them meet their national objectives. Similar follow-up mission requests are expected from more embarking countries.

110. *Site Evaluation for Nuclear Installations* (Safety Standards Series No. NS-R-3) is currently being revised to include the lessons learned from the Fukushima Daiichi accident.[52] This publication will be updated to provide, inter alia, requirements for multi-unit sites and considerations for periodic confirmation or reassessment of the site specific hazards.

111. In response to the Action Plan, the IAEA has developed a new methodology for assessing NPP vulnerabilities against extreme hazards, which was used in January 2012 during a mission to Japan for reviewing the stress test for the Ohi NPP. As a result of this mission, many recommendations were provided to the Nuclear and Industrial Safety Agency of Japan, such as: to ensure that the definition of the safety margin capacity with appropriate confidence level is specified and communicated to the licensee for use in the comprehensive safety assessment; and to confirm the effectiveness of safety improvements by conducting seismic and tsunami probabilistic safety assessments (PSAs) using methodologies consistent with the IAEA's safety standards and international practice.

---

[52] *Site Evaluation for Nuclear Installations*, Safety Standard Series No. NS-R-3, 2003. This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1177_web.pdf.

Future Challenges

112. When developing their national nuclear energy programmes, many Member States do not engage the IAEA at the early stages of planning for their site and installation safety activities, and do not make use of the IAEA's SEED services and peer reviews. This is especially the case in the areas of building capacity; reviewing site and installation safety against external hazards; and using the IAEA's assessment methodology to review site-specific extreme hazards and associated safety margins.

B.5 Managing Severe Accidents

Trends and Issues

113. Severe accident management programmes extend existing design, technical, operational and EPR measures in order to facilitate the management of accidents that occur beyond the scope of a reactor's design basis. In establishing a severe accident management programme, it should be ensured that workers involved in managing an accident have the training, knowledge of procedures and resources that are necessary in order to:

- Prevent the escalation of a reactor accident so that the reactor core does not suffer severe damage;
- Mitigate the effects of an accident when the reactor core is severely damaged;
- Prevent or mitigate the effects of accidental exposures of workers and the public to radioactive materials, as well as of accidental releases thereof into the environment; and
- Bring the reactor into a controlled, stable and safe state as quickly as possible.

114. The IAEA introduced severe accident management as a stand-alone review area within the OSART peer review service in 2011. Since then, severe accident management was evaluated during eight OSART missions with the following findings:

- At one NPP, severe accident management guidelines (SAMGs) were not available. Implementation of a severe accident management programme is scheduled for 2014. At this NPP, the plant specific analyses for severe accident management actions (e.g. determining the time available for implementation of mitigation actions, assessing environmental conditions and radiation levels in working places for plant staff) were not sufficient for their validation and training.
- At another NPP, although the SAMGs were available in the control room and in the technical support centre, validation and training had not been performed so the SAMGs could not be effectively used. At this NPP, the plant specific inputs for mitigation of accident management actions in the SAMGs were not sufficient for validation of the SAMGs.
- At some NPPs, the scope of the severe accident management programme was not sufficiently broad to cover accidents occurring during shutdown status, such as accidents when the plant is configured with the reactor head open and accidents stemming from spent fuel pools. Furthermore, some programmes did not address the occurrence of accidents at several units simultaneously.

115. At some NPPs where the scope of the severe accident management programme was sufficient, the following areas for improvement were identified:

- The instructions in the SAMGs, the information on priorities and on rules of usage, and the assessment of the potential negative impacts of certain strategies were not always provided in detail;

- The severe accident management programme was not yet fully implemented and the plan for further development was incomplete;
- The use of the containment venting system under all expected plant conditions and the link to the use of the containment spray system were not clearly described in the SAMGs;
- The plan for severe accident mitigation did not sufficiently address all the challenges to the containment based on the station-specific features;
- There was no hydrogen management strategy once the available passive autocatalytic hydrogen recombiners are no longer functional;
- Insights from the Level 2 probabilistic safety assessment[53], such as manual containment isolation in the event of a station blackout prior to core damage, had not been addressed.

116. During these OSART missions, good practices were identified at some NPPs in the area of severe accident management such as:

- The SAMGs had been expanded to cover accidents during shutdown conditions and to accidents involving the spent fuel pool;
- A project had been established for safety reassessment of external events with a focus on self-assessment of the SAMGs as a response to the Fukushima Daiichi accident;
- The station had planned and implemented backup cooling connections in response to the Fukushima Daiichi accident and the operation crews routinely carried out exercises to execute preventive accident management measures with these backups;
- Capabilities were in place for severe accident analysis, PSA and the development of severe accident management guidelines;
- The plant had an expert system for the evaluation of source term based on accident type and status of barriers against fission product releases

Activities

117. A meeting will be organized in 2013 to analyse the combined results of eight OSART severe accident management review missions which were organized during 2012. This analysis will also address the methodology, guidelines and additional supporting documentation for the severe accident management reviews. New guidelines for severe accident management reviews will be published in 2013.

118. In response to the Action Plan's call to review and strengthen the IAEA's safety standards and to improve their implementation, detailed reviews were initiated of *Severe Accident Management Programmes for Nuclear Power Plants* (Safety Standards Series No. NS-G-2.15) and *Guidelines for the review of accident management programmes at nuclear power plants* (Services Series No. 9) to examine them in relation to the lessons learned from the Fukushima Daiichi accident. Safety Standards Series No. NS-G-2.15 will be revised together with other Safety Guides as part of the activities under the Action Plan. The new guidelines are expected to be published in 2014.

---

[53] Level 2 PSA identifies ways in which associated releases of radioactive material from fuel can result in releases to the environment. This analysis provides additional insights into the relative importance of accident prevention and mitigation measures and the physical barriers to the release of radioactive material to the environment (e.g. a containment building).

119. The WANO Post-Fukushima Commission has completed its work to determine lessons from the accident. The Governing Board of WANO has approved the Commission's recommendations, including the expansion of the scope of WANO's activities to include emergency preparedness, severe accident management and on site fuel storage; the addition of selected elements of design safety fundamentals to the scope of WANO's activities; and the implementation of an integrated WANO emergency response plan.

120. The European Nuclear Safety Regulators Group (ENSREG) has carried out peer reviews of the stress tests implemented in the 15 EU countries with NPPs as well as in Switzerland and Ukraine. The peer reviews concluded that all countries had taken significant steps to improve the safety of their plants, with varying degrees of practical implementation. The peer reviews showed that in spite of differences in the national approaches and degree of implementation, there was overall consistency across Europe in the identification of strong features, weaknesses and possible ways of increasing plant robustness in light of the preliminary lessons learned from the Fukushima Daiichi accident. In addition, it was shown that significant measures to increase the robustness of plants had already been decided or considered. Such measures included the provision of additional mobile equipment (e.g. portable diesel-generators, batteries, pumps, compressors) to prevent or mitigate severe accidents; the installation of more robust fixed equipment; the improvement of severe accident management; and appropriate staff training measures.

121. Reviews of stress tests have also been implemented at international levels. In August 2012, during the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety, the IAEA organized a side event where presenters from the Canada Nuclear Safety Commission (CNSC), ENSREG, the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO), the International Nuclear Regulators Association (INRA), the Western European Nuclear Regulators Association (WENRA), the Forum of the State Nuclear Safety Authorities of the Countries Operating WWER Type Reactors (WWER Regulators' Forum) presented stress test results and a variety of measures taken to increase plant safety margins against extreme natural hazards and defence in depth.

Future Challenges

122. The findings from OSART missions indicate that the capability to manage severe accidents at NPPs has become more comprehensive. However, the level of implementation varies among NPPs and more needs to be done to share relevant information among NPP operators and to achieve a consistent level of preparedness to manage severe accidents.

123. Currently, only a limited number of NPPs have undergone an international review of their severe accident management programmes and made the review results publicly available on their websites. Although the Action Plan called on all Member States with NPPs to voluntarily host at least one OSART mission during the coming three years, with the initial focus on older NPPs, requests for this review service do not appear to have increased. This is limiting the potential for achieving an adequate and consistent level of preparedness to manage severe accidents at NPPs.

124. Nevertheless, some countries which plan to develop or improve their severe accident management programmes and/or SAMGs have requested the IAEA to provide education and training under the Review of Accident Management Programmes service during 2013.

C. Improving Regulatory Infrastructure and Effectiveness

C.1 Existing Nuclear Power Programmes

Trends and Issues

125. The IRRS is designed to assist Member States in improving the effectiveness of their national nuclear and radiation safety regulatory framework. The IRRS peer review is conducted by comparing the host country's regulatory framework with the requirements set forth in *Governmental, Legal and Regulatory Framework for Safety* (Safety Standards Series No. GSR Part 1) and other applicable safety standards requirements.[54] Regulatory lessons learned from the Fukushima Daiichi accident were elaborated in the Action Plan, which requested each Member State with NPPs to voluntarily host, on a regular basis, an IRRS mission to assess its national regulatory framework. In addition, a follow-up mission is to be conducted within three years of the main IRRS mission. Regulatory lessons learned were further discussed during the Fukushima Ministerial Conference on Nuclear Safety held in December 2012.

126. From 2006 to the end of 2012, the IAEA conducted 44 IRRS missions worldwide. Of these missions, 31 were conducted in Member States with nuclear installations. The data on the chart in Figure C-1 suggest that the number of initial and follow-up missions will eventually stabilize at about eight per year.

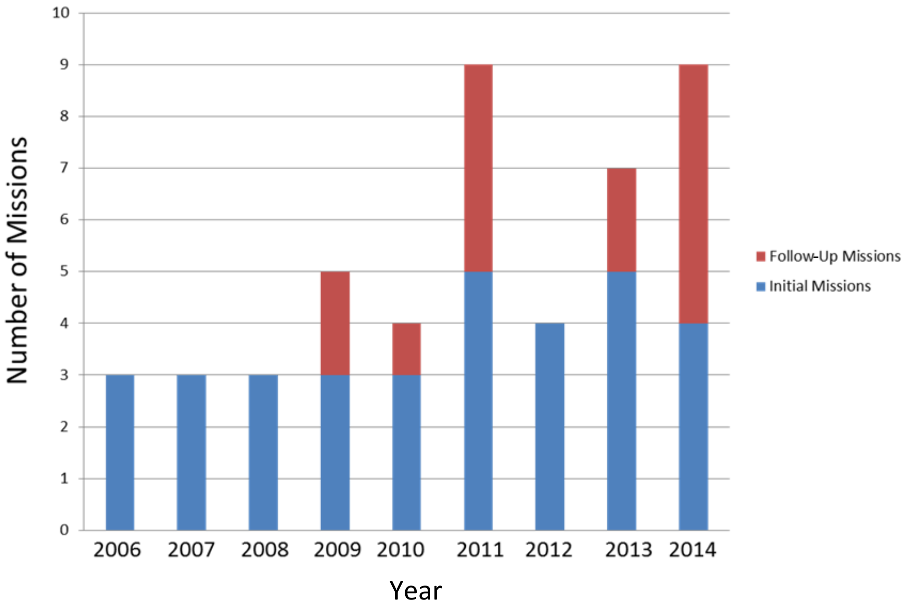

FIG. C-1: Number of IRRS missions carried out and projected in countries with nuclear installations.

127. The Action Plan requires the IAEA to strengthen existing peer reviews by incorporating lessons learned and by ensuring that these reviews appropriately address regulatory effectiveness among other key challenges. During IRRS peer reviews, the review team notes when a relevant aspect of an IAEA safety standard is not fully met (called a 'recommendation'), and when there is an opportunity for further improvement in the regulatory practice ('suggestion'). It also highlights 'good practices' — with the Member State's consent—to be shared with nuclear regulators worldwide. As reported in

[54] *Governmental, Legal and Regulatory Framework for Safety*, Safety Standards Series No. GSR Part 1, 2010. This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1465_web.pdf.

Nuclear Safety Review for 2012, the IAEA reviewed and analysed the IRRS mission results noting how often regulators did not meet various requirements stipulated in Safety Standards Series No. GSR Part 1[55], which has a total of 36 requirements.[56] According to further analysis conducted in 2012, Requirement 24, “demonstration of safety for the authorization of facilities and activities”, was the requirement that was most often referred to in the IRRS mission recommendations and suggestions. Requirements 32, 2, 18 and 25 (“regulations and guides”, “establishment of a framework for safety”, “staffing and competence of the regulatory body” and “review and assessment of information relevant to safety” respectively) complete the top five requirements referred to in the IRRS mission in their respective order of frequency as shown in Figure C-2.

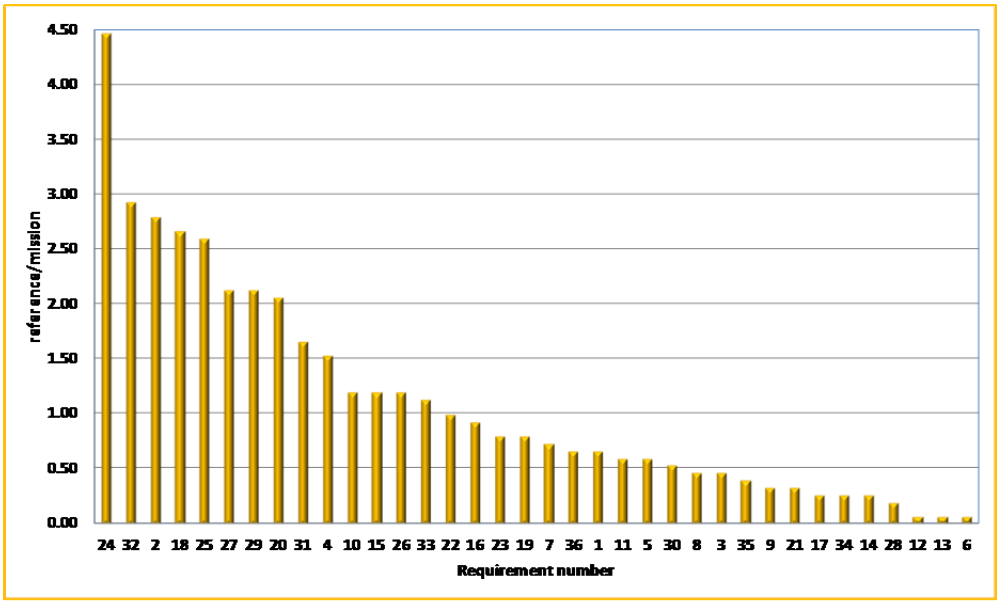

FIG. C-2: Average number of references to requirements in Safety Standards Series No. GSR Part 1 made in IRRS missions.

128. Collectively, these results indicated that in some areas, the regulatory bodies were not fully meeting IAEA Safety Standards (Figure C-2). These results will be closely examined by the IAEA to gain an understanding of what actions might be needed to better assist Member State regulators. It should be noted that during follow-up missions, the IAEA re-examines issues identified in the initial IRRS mission to determine if the Member State has implemented the recommended actions. The final report of the review of IRRS mission results are expected to be published in the second half of 2013.

Activities

129. In 2011, the IAEA launched a project in cooperation with the European Commission aimed at strengthening national nuclear regulator capabilities so that regulatory responsibilities and functions can be carried out more effectively. This project concentrates on conducting regular IRRS missions to IAEA Member States in the region and increasing the effectiveness and efficiency of the IRRS

---

[55] *Governmental, Legal and Regulatory Framework for Safety*, Safety Standards Series No. GSR Part 1, 2010. This publication is available online at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1465_web.pdf.

[56] *Nuclear Safety Review for 2012*, document GC(56)/INF/2, July 2012, provided significant details and discussion on this issue. This document is available online at: http://www.iaea.org/About/Policy/GC/GC56/GC56InfDocuments/English/gc56inf-2_en.pdf.

missions. Under this project, a series of targeted consultancy meetings were held with the aim of enhancing the efficiency of IRRS missions using data and feedback from previous missions. Nine meetings were held with IRRS international experts to review the various thematic modules within the IRRS and to review the overall implementation of the IRRS. The output provided an improved template and guiding document for conducting the peer reviews and for writing mission reports. This template was tested during the last mission of 2012 (to Finland) and was found by the reviewers to be very efficient. Results from these meetings will be used to prepare an entirely new edition of the IRRS guidelines as well as in the development of training materials.

130. In January 2013, the IAEA will host a meeting to share lessons learned and experience gained from past IRRS missions. Team leaders and deputy team leaders of all past IRRS missions, as well as of missions to be conducted in the near future will attend to discuss the IRRS process and share their IRRS mission experience.

131. During 2012, IRRS missions were conducted in Finland, Greece, Slovakia and Sweden. The analysis and review of these missions to extract lessons learned will continue in 2013.

132. The IAEA's Self-Assessment of Regulatory Infrastructure for Safety (SARIS) methodology and tools were developed to support Member States' periodic self-evaluation of national regulatory infrastructure for nuclear and radiation safety based upon the IAEA's safety standards. Each State planning to host an IRRS mission has to complete a SARIS as a prerequisite. SARIS software has also been updated to make it more user-friendly.[57]

Future Challenges

133. The IAEA will have difficulty in finding the necessary resources to meet the expected increased demand for IRRS missions in the coming years. Between 10 and 20 international experts from Member States are called upon to participate in an IRRS mission and the coordination and participation in IRRS missions by IAEA staff are also quite resource-intensive. Furthermore, to cope with these increased demands, better cooperation and coordination among host countries, IRRS experts and the IAEA will be needed.

134. To better assist Member States, the IAEA needs to further analyse the IRRS missions to see which areas need improvement within the regulatory framework so as to have a better understanding of how best to assist regulators in exercising their regulatory authority.

C.2 States Embarking on Nuclear Power Programmes

Trends and Issues

135. In July 2012, the United Arab Emirates became the first newcomer country in 27 years to start the construction of an NPP, after it received a construction licence from the Federal Authority for Nuclear Regulation. Barakah Unit 1 is scheduled to go into operation in 2017 and three additional units are planned to be operational by 2020. During the past year Belarus, Turkey and Vietnam have taken significant steps towards their first NPP.

136. In 2012, the IAEA conducted numerous peer reviews, expert missions and training activities at the request of Member States embarking on nuclear power programmes. These missions and activities have identified many common weaknesses and challenges for the safe, secure and successful implementation of a nuclear power programme. Major issues included establishing a functioning,

---

[57] The information is available at http://www-ns.iaea.org/tech-areas/regulatory-infrastructure/sat-tool.asp?s=2&l=9

effective and independent regulatory framework and body; establishing a management system at the regulatory body; building the necessary regulatory human and technical competences and capabilities; developing safety regulations that will be used in bid specifications or during the licensing process; and establishing national arrangements for providing the necessary technical support. Given the short project schedules of some Member States for the introduction of nuclear power, these weaknesses may adversely impact the ability of those regulatory bodies to perform their regulatory functions e.g. the capacity to perform the review and assessment of construction licence applications.

Activities

137. The IAEA has continued to organize national and regional workshops and training sessions to introduce and provide guidance on the application of *Establishing the Safety Infrastructure for a Nuclear Power Programme* (Safety Standards Series No. SSG-16).[58] For example, two regional training courses based on Safety Standards Series No. SSG-16 were held for Member States in the Europe region. Additionally, various technical cooperation activities based on this safety standard, such as regulatory framework and capacity building, were conducted in Member States considering expanding or embarking on a nuclear power programme, including Bangladesh, Belarus, Egypt, Indonesia, Lithuania, Malaysia, Nigeria, Poland, the Philippines, Turkey and Vietnam.

138. The Integrated Review of Infrastructure for Safety (IRIS)[59] methodology and companion software is a self-assessment tool based on the 200 actions contained in Safety Standards Series No. SSG 16. It supports the progressive application of the IAEA safety standards in an effective manner when establishing the national safety infrastructure during phases 1, 2 and 3[60] of a nuclear power programme. A workshop providing training on the use of this methodology was held for ANNuR and the ANSN, and also at the national level for Egypt, the Philippines and Poland. The IRIS methodology was introduced and recommended to representatives of embarking countries at all relevant IAEA activities, such as workshops and expert missions. The IRIS methodology was further presented in the margins of the 56th session of the General Conference in September 2012 at a side event on establishing safety infrastructure for countries embarking on nuclear power and at a specific Technical Meeting held in December 2012. Poland has requested an IRRS mission for April 2013 that will include the IRIS module on establishing safety infrastructure within the scope of this mission.

139. Expert missions were conducted in several newcomer Member States to review existing legislation and regulation of the NPP licensing process to identify gaps or areas for improvement. Recommendations and guidance were provided to those countries on how to enhance the existing legislation and regulations accordingly. Expert missions were also conducted in Indonesia, Malaysia and Poland either to provide guidance on the establishment of a management system in the regulatory body, or to review the existing regulatory body management system to identify potential areas for improvement.

---

[58] The publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1507_Web.pdf.

[59] IRIS is embedded within the SARIS software available at http://www-ns.iaea.org/tech-areas/regulatory-infrastructure/sat-tool.asp?s=2&l=9.

[60] According to *Nuclear Safety Infrastructure for a National Nuclear Power Programme Supported by the IAEA Fundamental Safety Principles* (INSAG-22, 2008), which is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1350_web.pdf, and IAEA Safety Standards Series No. SSG-16:

- Phase 1 is safety infrastructure before deciding to launch a nuclear power programme;
- Phase 2 is safety infrastructure preparatory work for construction of a nuclear power plant after a policy decision has been taken; and
- Phase 3 is safety infrastructure during implementation of the first nuclear power plant.

140. The IAEA held two international workshops in France (June 2012) and in the USA (August 2012) on leadership and management of nuclear power, consistent with IAEA Safety Standards, in order to provide knowledge and awareness of the implications of a nuclear power programme and its relevant key aspects and issues.[61] Participants of the workshops included representatives from regulatory bodies and governmental project management organizations.

141. A technical meeting was conducted in Vienna in July 2012 on the development of a regulatory inspection programme for new reactor projects. A draft IAEA safety report on the development of a regulatory inspection programme in support of new NPP projects was reviewed during this technical meeting. The report addresses influencing factors, the approach to vendor inspection and procurement of long lead items, resources, staff training and qualification, and enforcement. The revised report, which is currently being prepared, will also include examples of practices in various Member States. This report will be available in the third quarter of 2013.

142. In June 2012, a high-level senior regulators meeting was held in Vietnam for the Vietnamese regulatory authority and other governmental bodies involved in the regulatory oversight of Vietnam's nuclear programme. The meeting was organized under the Regulatory Cooperation Forum (RCF) programme, with representatives from RCF members, OECD/NEA and IAEA participating. The main purpose of the meeting was to provide government officials with a review of the importance of an effective, independent and robust regulatory body for nuclear power.

143. A safety report on managing regulatory body competences has been drafted and is expected to be published in the second quarter of 2013. This safety report includes a specific annex devoted to managing regulatory competence in nuclear power plant newcomers.

144. A revised version of the Guidelines for Systematic Assessment of Regulatory Competence Needs in Nuclear Safety (SARCoN) guidelines was also produced in June 2012 and is available for use by Member States.[62]

Future Challenges

145. Globally, there are a limited number of experienced and knowledgeable experts and institutions in the area of nuclear safety and security that can provide direct or indirect assistance and guidance to newcomer Member States on the establishment of different elements of a national nuclear safety infrastructure. Finding host institutions/organizations for human resource development purposes, particularly for on-the-job training, is another major challenge.

146. Slow or inadequate implementation of human resource development programmes results in deficiencies in staffing and/or competence. Some newcomer Member States experience difficulty in finding staff with the appropriate background education to assign for further training programmes on subjects relevant to nuclear power programmes. Some Member States are developing their own education and training programmes, including the introduction of nuclear engineering programmes in technical universities. This process should be comprehensive and provide technical knowledge in relation to design, safety assessment and other elements of a nuclear safety infrastructure. As programmes continue to develop, it will be important to monitor and continue to assist Member States in building their competence, so that all the relevant stakeholders — especially the owner-operator and the regulatory body — will be able to safely operate and provide oversight of the NPPs. Furthermore, there needs to be a balance of training and retaining staff during the period of infrastructure

---

[61] *The Management Systems for Facilities and Activities, No. GS-R-3*. IAEA Safety Requirement. Vienna 2006 is available at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1252_web.pdf.

[62] This document is available at http://www-ns.iaea.org/downloads/ni/training/sarcon/SARCoN_Tool_V1.306.zip.

development. The governments of newcomer countries need to make national commitments to appropriate funding of the regulatory body and institutions involved in providing technical support so that they can build and maintain the competences necessary to implement a safe and secure nuclear programme.

147. Lastly, there is a lack of dissemination of relevant nuclear safety assessment knowledge to all relevant stakeholders, including owner-operators and technical support groups. The mechanisms by which nuclear safety information and knowledge is used, shared and managed still need to be further improved.

C.3 States Embarking on Research Reactor Programmes

Trends and Issues

148. More than 20 Member States are currently in different stages of new research reactor projects. The majority of these Member States are building their first research reactor in preparation for embarking on a nuclear power programme. These Member States have difficulties in developing the necessary safety, regulatory and technical infrastructures that are needed for such projects, primarily because the majority of them do not have qualified staff and adequate competences in most of the areas related to safety assessment, construction, commissioning, operation, safe utilization, and decommissioning, and do not have a clear national strategy for human resource development or for building the necessary competencies. However, a number of these Member States do have education and training programmes in nuclear safety at different levels of development and implementation. Weaknesses in the establishment of an effective regulatory body and in government support related to its establishment have also been identified during safety review missions.

Activities

149. In 2012, the IAEA published *Specific Considerations and Milestones for a Research Reactor Project* (Nuclear Energy Series No. NP-T-5.1), which provides practical guidance on the implementation of different phases and activities of a new research reactor project.[63] Another publication is expected to be issued in 2013 on the development of the technical requirements for the bidding process for a new research reactor project. In addition, Three Safety Guides were published in 2012 on *Safety in the Utilization and Modification of Research Reactors*[64], *Use of a Graded Approach in the Application of Safety Requirements for Research Reactors*[65], *and Safety Assessment for Research Reactors and Preparation of Safety Analysis Report.*[66] These publications will provide further guidance on establishing the safety and regulatory infrastructures needed for new research reactor projects.

150. In 2012, two meetings in Vienna, two national workshops in Jordan and Lebanon, two ARASIA (Cooperative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology) workshops, and four interregional training workshops in Vienna and in the United States of America, were held with the participation of Member States operating or building their first research reactors. These activities covered a wide range of safety and regulatory infrastructure elements, including regulatory supervision; siting; safety considerations in a new

---

[63] Specific Considerations and Milestones for a Research Reactor Project, Nuclear Energy Series No. NP-T-5.1, June 2012 is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1549_web.pdf.

[64] This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1559_web.pdf.

[65] This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1547_web.pdf.

[66] This publication is available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1508_web.pdf.

research reactor project; strategy for human resource development, training and qualification programmes for operators and regulatory body staff; preparation, review and assessment of safety documents; safety of experiments; human factors; and of the lessons learned from the Fukushima Daiichi accident on research reactor safety. In addition, two regional meetings in Africa and Europe were held on the application of the Code of Conduct on the Safety of Research Reactors with a focus on regulatory infrastructure, radiological safety, and emergency planning and preparedness. These activities will help to build national capacity by identifying and implementing improvements.

151. Safety review and expert mission services were conducted in Jordan, Lebanon and Tunisia on new research reactor projects. Safety review services were also carried out in the Democratic Republic of the Congo, Egypt, Ghana, Kazakhstan, Malaysia, Slovenia, Thailand and Uzbekistan, which will help to further develop the national regulatory and safety infrastructures for research reactors.

Future Challenges

152. The IAEA's activities have shown that important challenges that need to be overcome include the timely development of the safety and regulatory infrastructures for the implementation of different phases of research reactor projects. These cover the need to ensure the availability of qualified human resources to fulfil regulatory functions including, in particular, the establishment of regulatory requirements and the performance of review and assessment of safety documents. One lesson learned from the Fukushima Daiichi accident is that appropriate attention needs to be given to ensuring regulatory effectiveness for research reactors, especially for the evaluation of safety in extreme events and for the emergency response to such events in case of off-site consequences.

153. The IAEA fact-finding missions and workshops, conducted in Member States where research reactors are developed as a first step towards embarking on a nuclear power programme, highlighted the need to ensure effective coordination between the research reactor project and nuclear power development teams.

C.4 Improving the Regulatory Infrastructure for Radiation Safety

Trends and Issues

154. While some States are making good progress in establishing or strengthening their national regulatory infrastructure for radiation safety, more work is needed on ensuring the sustainability of the infrastructure. In addition, new Member States, which want to benefit from the wide range of peaceful uses of nuclear applications in a safe manner, often have no, or a very limited, regulatory framework to ensure the safety of people and the environment. One possible reason for this is the financial and economic constraints faced by many Member States; even some established national regulatory frameworks have faced challenges when governments have reduced their public expenditures.

155. For some Member States, after the essential initial steps for establishing a national regulatory infrastructure have been taken, there were delays and difficulties in implementing the infrastructure and establishing an effective regulatory body with adequate resources to discharge its functions. Governments have an essential role to play in the improvement of regulatory infrastructures, as well as in the implementation of a national safety policy and strategy, and they need to ensure that all individuals within the regulatory body, as well as other individuals with responsibilities for the safety of facilities and activities, have access to the necessary professional training for building and maintaining the appropriate competences. An increasing number of Member States are, therefore, relying on guidance and technical assistance from the IAEA to address these issues.

Activities

156. The IAEA has organized appraisal and advisory missions in States aimed at assessing and monitoring progress made towards strengthening their national regulatory infrastructure for radiation safety and the control of radiation sources. Missions took place in Bahrain, Burundi, Congo, Gambia, Mongolia, Rwanda, Seychelles, South Africa and Togo. Heads of regulatory bodies were provided with guidance on various aspects of their national regulatory infrastructure for radiation safety. A seminar on this same topic was organized in June 2012 in Jamaica for the Caribbean States.

157. Authorization and inspection of radiation sources are an essential prerequisite to an effective regulatory infrastructure. To further support Member State regulators, expert missions, fellowships and training courses were organized throughout the year under the technical cooperation programme and within the framework of various extrabudgetary projects.

158. Member States need to build and maintain competences in radiation protection to effectively develop and implement regulations. To this end, the IAEA developed a methodology for establishing a national strategy for education and training in radiation, transport and waste safety. Such a strategy, when implemented by a State, will contribute to strengthening radiation protection by developing national expertise in a sustainable and effective way. Regional workshops held in 2012 in Brazil, Botswana, Jordan, Lithuania, Morocco, Tajikistan and Thailand promoted this methodology. As a result of feedback from these workshops, the methodology was improved and revised guidance on its application was developed and is expected to be published in 2013.

159. Networking of radiation safety regulators was also facilitated by the establishment of a dedicated platform, the control of sources network, under the GNSSN.[67]

160. The web-based radiation safety information management system (RASIMS) was used by the IAEA and Member States to monitor the status and progress of States' efforts to strengthen their national regulatory radiation safety infrastructures. Participants from 31 Member States attended the inaugural international workshop for national RASIMS coordinators in 2012; and, over the year, a total of 122 Member States accessed RASIMS to update their radiation safety infrastructure profiles. The updated information provided baseline data for the development of new IAEA projects and aided the radiation safety clearance process prior to the procurement of radiation sources.

161. The regulatory authority information system (RAIS), which assists the regulatory bodies in Member States in maintaining their national register of sources and managing the information related to their regulatory functions, was upgraded and a new version, RAIS 3.2 Web[68], was released in February 2012. Expert missions and regional training courses were organized to promote its use and to facilitate the exchange of experience among users.

162. The self-assessment methodology (SARIS[69]) and tools used to assist Member States in reviewing their national regulatory infrastructure for the safe use of radioactive sources, as well as to support IRRS missions have been revised and upgraded based on feedback from Member States and on the latest versions of the relevant IAEA safety standards, including the revised BSS. Information about SARIS, can also be found in Section C.1.

---

[67] Available at: http://gnssn.iaea.org/default.aspx

[68] This information is available at www-ns.iaea.org/tech-areas/regulatory-infrastructure/rais.asp?s=3&l=92.

[69] This information is available at www-ns.iaea.org/tech-areas/regulatory-infrastructure/sat-tool.asp.

Future Challenges

163. Continuous efforts and resources will be needed to address Member States' needs in establishing and maintaining a national radiation safety regulatory infrastructure, compliant with the IAEA's safety standards and adequate to the level of risks posed by the actual use of radiation sources in the countries. With priority being given to other aspects of safety at the international level, it might be difficult to mobilize resources at the required level both in the IAEA and in Member States. The IAEA will therefore need to ensure that radiation safety infrastructure, and in particular the regulatory framework, remains high on the international agenda.

D. Enhancing Emergency Preparedness and Response

D.1 Emergency Preparedness and Response (EPR) at the National Level

Trends and Issues

164. Authorities in States have the responsibility to decide upon and to take appropriate response actions to nuclear and radiological emergencies, and to ensure that resources are available for mitigating the consequences. Such emergencies can have serious consequences for life, health, the environment and society over wide geographical areas. Not all Member States have generic and operational criteria for response actions, which are harmonized with international standards.

165. The principal tasks of the responsible authorities both in the State where an emergency occurs and in any other potentially affected States are to protect life, health, property and the environment; and to provide timely, consistent and appropriate information regarding, inter alia, the event, its consequences and the actions taken. These tasks can be performed effectively only if emergency preparedness arrangements are in place to ensure a timely, managed, coordinated and effective response at the scene and at the local, regional, national and international levels. Establishment of these arrangements in line with *Preparedness and Response for a Nuclear or Radiological Emergency* (Safety Standard Series No. GS-R-2) continues to be of high importance for many Member States.[70]

166. The Fukushima Daiichi accident brought an increase in interest in EPR at the national level. This interest is reflected in the broader mandate of the IAEA with regard to response to nuclear and radiological emergencies introduced by the Action Plan[71], in the rise of requests to the IAEA for appraisal services to review national emergency preparedness and response programmes, in increased requests for EPR capacity building and in newly registered assistance capabilities in RANET.

167. Member States consider the Safety Standards Series No. GS-R-2 particularly useful and many of them have implemented or are compliant with most of its requirements.[72] Member States find this

---

[70] *Preparedness and Response for a Nuclear or Radiological Emergency*, Safety Standards Series No. GS-R-2, 2002. This publication is available at http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1133_scr.pdf.

[71] The Action Plan calls on the Secretariat to provide Member States, international organizations and the general public with timely, clear, factually correct, objective and easily understandable information during a nuclear emergency on its potential consequences, including analysis of available information and prognosis of possible scenarios based on evidence, scientific knowledge and the capabilities of Member States.

[72] As shown by EPREV missions and by a survey of Member States, as well as comments made during the Technical Meeting for Review of the Draft Safety Requirements in Emergency Preparedness and Response held in November 2012.

standard to be a good benchmark against which to test existing arrangements and to assist in setting up an appropriate national emergency preparedness and response system. However, they also have suggestions for improvements. Member States with advanced nuclear programmes highlighted the importance of the basic requirements aspect of Safety Standards Series No. GS-R-2. Some regulators would like more detailed requirements and others would prefer practical examples.[73] Safety Standards Series No. GS-R-2 is currently undergoing review and revision.

168. The EPREV review service provides an in-depth assessment of national EPR capabilities. The growing interest in this IAEA service is clearly indicated by the increasing number of requests: the IAEA implemented eight EPREV missions in 2012, the highest number since the programme began in 1999.

169. As a result of the Fukushima Daiichi accident, a number of Member States have increased their efforts in capacity building in EPR. The number of training events requested and implemented in the area of nuclear and radiological emergency preparedness and response increased (39 in 2012 funded through TC projects, the Regular Budget and extrabudgetary resources). In addition to first responders and medical response training, there were more requests for training in other specific topics, such as notification and reporting, requesting assistance, and public communication in an emergency.

170. While in the past, requests by Member States in the area of emergency preparedness and response focused more on the establishment of the infrastructure elements, such as the installation of radiation early warning systems, recent requests have focused on EPR capacity building. Over 30 expert missions were organized to support these requests in 2012. In addition, several Member States that did not participate in TC regional EPR projects in the previous programme cycles, requested to be considered for the 2012–2013 cycle (Angola, Bahrain, Burundi, Cambodia, Central African Republic, Honduras, Lesotho, Mozambique, Nepal and Oman). Furthermore, TC regional projects on EPR are also receiving support from organizations such as the EU.

171. Team members of EPREV and IRRS missions had the opportunity to observe national emergency exercises. In almost all cases, these exercises highlighted important lessons and the need for improvements. For example, these exercises emphasized the importance of training and exercising the plans and procedures that are otherwise very seldom used, and highlighted challenges in the area of public communications, such as shortcomings in the coordination of public communications among different authorities.

172. Some States do not communicate smaller scale radiation events to the IAEA. As a consequence, given the high media interest or the need to respond to questions from Member States, the IAEA may have to communicate with the State where an event occurred. There are no legal requirements for communicating such events to the IAEA. However, by informing the IAEA in a timely manner, the State would clearly demonstrate transparency both nationally and internationally.

173. In 2012, the IAEA conducted two ConvEx-1 exercises and two ConvEx-2 exercises.[74] In preparing these exercises it was noticed that Member States were not willing to act as an ‘accident State’ if the exercise scenario is based on a severe nuclear emergency. In addition, it was observed that

---

[73] All received suggestions and comments are being considered in the current revision of Safety Standards Series No. GS-R-2.

[74] The Agency conducts regular exercises within the framework of the Early Notification and Assistance Conventions named ConvEx exercises at three levels of complexity: at level 1 (ConvEx-1) only communication tests with emergency contact points are performed; at level 2 (ConvEx-2) emergency communications as well as different parts of emergency arrangements are tested; and at level 3 (ConvEx-3) the exercise aims to test full scale emergency arrangements and capabilities at national as well as international level.

Member States are not often willing to share their national exercise messages internationally. There has been persistently low participation by some emergency contact points in regular emergency communication exercises such as the ConvEx-1 and ConvEx-2 exercises. Since 2008, nearly 61% of all contact points have participated in fewer than half of all exercises. Severe communication problems (unsuccessful fax deliveries and no attempts to resolve the issue) exist with 17% of all emergency contact points.

174. The IAEA carried out an active outreach programme to encourage Member States to register with the Unified System for Information Exchange in Incidents and Emergencies (USIE), for example by setting up a helpdesk at various IAEA meetings and conferences and by addressing individual questions from official channels. The number of registered external users on USIE increased by 30% in 2012.

Activities

175. The following actions were taken to strengthen the IAEA's national EPR peer reviews:

- Lessons in EPR from the response to the Fukushima Daiichi accident, based on the available information, were identified and analysed; as a result of these analyses an updated self-assessment questionnaire was prepared, adding further questions to the original questionnaire to cover the Member States' preparedness regarding decision making, management systems, information management for logistical support, etc.;

- Highlights and lessons learned from EPREV missions were discussed with Member States at a workshop in June 2012. Threat assessment and categorization of radiation hazards were identified as high priority tasks that will need further attention in the coming years;

- A new confidentiality clause was added to the EPREV Terms of Reference to make EPREV reports available automatically to the public; the IAEA also requested Member States to allow previous EPREV reports to be made public; as a consequence most EPREV reports are now available on the Action Plan website;

- EPREV guidelines for Member States and EPREV team members are now available on request;

- The duration of an EPREV mission was increased from five to ten days to be able to review States' EPR arrangements and capabilities in more detail.

176. The revision of Safety Standards Series No. GS-R-2 following the adoption of the Action Plan has been intensive this year and is based on lessons identified in actual responses to radiation emergencies and in exercises since 2002 when the standard was first published.

177. The IAEA held three workshops on the Emergency Notification and Assistance Technical Operations Manual in Vienna (in June, October and November), one in Singapore and one in Kuwait (both in December) to raise contact points' awareness of information exchange arrangements and of international emergency communication channels.

Future Challenges

178. In view of Member States' increasing interest in EPR, the IAEA needs to be ready to implement more EPREV missions in the coming years. Effective and successful peer reviews are dependent on careful mission design, the recruitment of high quality experts and continuous improvements to the review process based on mission team experience and host feedback.

179. Further steps, such as continuing to encourage Member States to use the EPR self-assessment methodology and holding awareness workshops for decision makers, have to be taken to provide for the implementation of safety standards in the area of EPR at national level.

D.2 Emergency Preparedness and Response at the International Level

Trends and Issues

180. Interest in international EPR measures increased as a result of the Fukushima Daiichi accident. Member States agreed that revision of Safety Standards Series No. GS-R-2 should also elaborate on the requirements for EPR at the international level.

181. At the 22nd regular meeting of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), held in Paris in December 2012, the relevant international organizations[75] agreed to enhance international response arrangements in an emergency as well as in the post-emergency phase based on lessons identified in response to the Fukushima Daiichi accident.

182. At their meeting in April 2012, representatives of the competent authorities identified under the Early Notification and Assistance Conventions discussed the latest EPR arrangements, the response to the Fukushima Daiichi accident, international assistance and recent developments in the area of safety and security, and recommended a number of actions, such as to explore mechanisms to improve and strengthen both Conventions; to develop minimum compatibility requirements for EPR capabilities; to develop guidance on the management of contaminated commodities, cargoes, and shipments; to explore possible financing mechanisms for international assistance; and to instigate a review of legal and liability issues related to the provision of international assistance.

183. The Fukushima Daiichi accident and its aftermath highlighted the need to establish an international standardized data format for expediting the processing and evaluation of radiation monitoring data exchanged among States. In 2012, the IAEA continued with the development of the International Radiation Information Exchange (IRIX) standard[76] and the International Radiation Monitoring Information System (IRMIS) that will contribute to the efficient exchange of monitoring data in future emergencies. IRIX is at present available to Member States as Version 01 while it is planned that pilot use of IRMIS will start by the end of 2013.

184. Based on the lessons identified in response to the Fukushima Daiichi accident, Member States proposed to extend the scope of assistance capabilities within RANET with the additional functional area of “nuclear installation assessment and advice” that will cover guidance to Member State competent authorities on the on-site mitigatory actions.

185. In 2012, Canada, Norway and the United Kingdom registered some of their national assistance capabilities in RANET for the first time, while Australia and the United States of America increased their registered capabilities. Some Member States expressed concern over the legal and liability issues related to the provision of assistance under the Assistance Convention and recommended that the

---

[75] Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the EC, the European Police Office (EUROPOL), the FAO, IAEA, the International Civil Aviation Organization (ICAO), the International Criminal Police Organization (INTERPOL), the International Maritime Organization (IMO), the OECD/NEA, the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP), the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), the United Nations Office for Outer Space Affairs (OOSA), UNSCEAR, the WHO and the World Meteorological Organization (WMO).

[76] The relevant recommendations of the International Action Plan for Strengthening the International Preparedness and Response System for Nuclear and Radiological Emergencies (2004–2009) are being implemented in the development of the IRIX standard.

IAEA initiate a review of these issues in order to clarify them. To this end, the IAEA has developed a questionnaire and sent it out to Member States and the results will be available to Member States at the latest by the next meeting of the competent authorities identified under the Early Notification and Assistance Conventions in 2014.

Activities

186. Specific requirements for EPR at the international level (in particular on the emergency management system and on international assistance) were incorporated in the revised Safety Standards Series No. GS-R-2 with the agreement of the relevant international organizations as well as Member States.

187. Based on the lessons identified in response to the Fukushima Daiichi accident, the international organizations members of the IACRNE[77] revised the Joint Radiation Emergency Management Plan of International Organizations (Joint Plan), which is expected to be published in the first quarter of 2013. The revised Joint Plan will include the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), which became a new member of IACRNE in 2012.

188. The IAEA also continued to work with relevant international organizations on cooperative arrangements for information exchange and technical support in case of a radiation emergency.

189. EPREG was set up at the end of 2012 as a standing body of senior experts with high professional competence and demonstrated leadership in the field of preparedness for and response to radiation emergencies to provide advice to the IAEA on actions needed to ensure continuous and coordinated EPR enhancement and implementation strategies.

190. The IAEA continued to work on a revision of the 2010 edition of *IAEA Response and Assistance Network*[78] based on lessons identified in the past few years to include assessment and advice to competent authorities on the on-site response activities in emergencies at nuclear facilities.

Future Challenges

191. Enhancing the implementation of the Early Notification and Assistance Conventions and effectiveness of operational arrangements in international EPR will require willingness and effort on the part of Member States as well as on the part of relevant international organizations.

192. The full scale ConvEx-3 exercise that is being prepared for 2013, to be hosted by Morocco, will for the first time offer an opportunity to test whether Member States and relevant international organizations are prepared to respond effectively to a radiological emergency resulting from an explosion of a dirty bomb by testing their emergency plans and coordination between all relevant response organizations.

193. There is a clear need to develop guidelines that would help to harmonize response capabilities. The IAEA is, in cooperation with some Member States, developing minimum required compatibility guidelines for international assistance; however, these guidelines can improve harmonization of assistance capabilities only if Member States agree to comply with them.

---

[77] The Agency provides the secretariat for IACRNE.

[78] *IAEA Response and Assistance Network*, EPR-RANET (2010), 2010. This publication is available at http://www-pub.iaea.org/MTCD/Publications/PDF/ranet2010_web.pdf.

E. Civil Liability for Nuclear Damage

Trends and Issues

194. States continue to place emphasis on having effective civil liability mechanisms in place to insure against harm to human health and the environment, as well as economic loss caused by nuclear damage.

195. The Action Plan specifically calls on Member States to work towards establishing a global nuclear liability regime that addresses the concerns of all States that might be affected by a nuclear accident with a view to providing appropriate compensation for nuclear damage. Furthermore, the Action Plan calls on Member States to give due consideration to the possibility of joining the international nuclear liability instruments as a step toward achieving such a regime. The Action Plan also calls on the IAEA International Expert Group on Nuclear Liability (INLEX) to recommend actions to facilitate the achievement of such a global regime.

Activities

196. During 2012, joint IAEA/INLEX missions were dispatched to Vietnam (March 2012), Republic of Korea (April 2012), Jordan (May 2012), South Africa (July 2012), and Ukraine (July 2012). Preparations are under way to implement similar missions in 2013 and the Secretariat continues to conduct informal discussions with potentially interested Member States in this context. Joint IAEA/INLEX missions are aimed at raising awareness of the international nuclear liability regime and encouraging wider adherence to the relevant international legal instruments.

197. Presentations were made on civil liability for nuclear damage at the technical meeting/workshop on topical issues on infrastructure development: Managing the Development of a National Infrastructure for nuclear power plants (January 2012); at the 31st meeting of the Commission on Safety Standards (March 2012); at the fifth meeting of the International Nuclear Safety Advisory Group VIII (April 2012); at the sixth meeting of representatives of the competent authorities identified under the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (April 2012); and at a meeting of the Advisory Group on Nuclear Security (April 2012).

198. The IAEA also organized a workshop aimed at providing diplomats and experts from Member States with an introduction to the international legal regime of civil liability for nuclear damage. The workshop was held at the IAEA in May 2012, and was attended by diplomats and experts from 34 Member States and one international organization. Given the success of the workshop, it has been decided to organize it as an annual event.

199. At its 12th regular meeting held from May/June 2012, INLEX discussed and finalized its *Recommendations on how to facilitate achievement of a global nuclear liability regime,* as requested by the IAEA Action Plan on Nuclear Safety.[79]

Future Challenges

200. The main challenge for the future is the establishment of a global nuclear liability regime; in light of the comparatively low number of Contracting Parties to the existing nuclear liability conventions, in

---

[79] This document is available at http://ola.iaea.org/OLA/documents/ActionPlan.pdf.

particular those conventions embodying the modernized regime adopted under the auspices of the IAEA after the Chernobyl accident.

201. INLEX will continue to facilitate the establishment of a global nuclear liability regime, as also requested in resolution GC(56)/RES/9, which encouraged INLEX to continue to consider and identify specific actions to address gaps or to make enhancements in the scope and coverage of the international nuclear liability regime, as well as to carry out further outreach activities.

Appendix

The IAEA Safety Standards: Activities during 2012

A. Summary

1. The fifth term of the Commission on Safety Standards (CSS) began in 2012, with Dana Drábová as new Chairperson. At its meeting in March 2012, the former CSS Chairman, André-Claude Lacoste presented the fourth term report to the Director General in which he highlighted the main achievements, challenges and recommendations for the future.

2. At its first meeting in 2012, the CSS identified its priorities for the fifth term as follows:

- Finalization of the General Safety Requirements (including the review following the Fukushima Daiichi accident);
- Initiation of the revision of relevant Safety Requirements in order to finalize the remaining Specific Safety Requirements (including the review of existing Specific Safety Requirements following the Fukushima Daiichi accident);
- Enhancing the feedback process;
- Protection of the public against indoor exposure to natural sources of radiation
- Radiation Safety in Medical Uses of Ionizing Radiation ;
- Application of the justification principle;
- Harmonization of exemption and clearance criteria, as well as other radionuclide specific criteria;
- Addressing NORM related issues in a Safety Guide;
- Preparing a safety guide on Occupational radiation protection, including its application to rescuers;
- Knowledge management;
- Addressing regulatory oversight of human and organizational factors in a safety guide;
- The safety/security interface;
- Usefulness of standards for countries embarking on nuclear power programmes;
- The need for more detail in standards on probabilistic safety assessment and severe accident management.

A.1 Review of the IAEA Safety Standards in the Light of the Fukushima Daiichi Accident

3. The IAEA Action Plan on Nuclear Safety includes the following action on the IAEA's safety standards[80]:

"Review and strengthen IAEA Safety Standards and improve their implementation

- The Commission on Safety Standards and the IAEA Secretariat to review, and revise as necessary using the existing process in a more efficient manner, the relevant IAEA Safety Standards in a prioritized sequence.
- Member States to utilize as broadly and effectively as possible the IAEA Safety Standards in an open, timely and transparent manner. The IAEA Secretariat to continue providing support and assistance in the implementation of IAEA Safety Standards."

4. In December 2011 and in January 2012, the CSS held meetings to discuss the progress of the review of the IAEA's safety standards; these meetings also involved the Safety Standards Committees. At its meeting in October 2012, the CSS discussed further progress achieved on the review of Safety Requirements, with specific focus on the activities carried out to take into account additional reports from different sources, among others the results of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety. The intent is to complement this systematic analysis by incorporating any additional lessons identified from these reports.

5. The CSS concluded that the review had confirmed the adequacy of the current Safety Requirements so far. The review revealed no significant areas of weakness, and just a small set of amendments were proposed to strengthen the requirements and facilitate their implementation. The CSS believes that the IAEA's safety standards should be enhanced mainly through the well-established review and revision process that has been in use for some years.

6. Another source of information for strengthening the IAEA's safety standards was the safety reassessments ('stress tests') which Member States and their national regulatory bodies carried out after the Fukushima Daiichi accident. The CSS recognized the determination and readiness of Member States to carry out such detailed reassessments and the resulting important contribution to nuclear safety. In this context, the CSS members also underlined the importance of periodic safety reviews and recalled that there was already very good IAEA guidance available in this area.

7. As an important milestone, the CSS approved document outline DS462 for revision, through addenda, of five Safety Requirements, namely *Governmental, Legal and Regulatory Framework for Safety* (Safety Standards Series No. GSR Part 1), *Safety Assessment for Facilities and Activities* (GSR Part 4), *Site Evaluation for Nuclear Installations* (NS-R-3), *Safety of Nuclear Power Plants: Design* (SSR-2/1) and *Safety of Nuclear Power Plants: Commissioning and Operation* (SSR-2/2). These revisions will be prepared in parallel to the ongoing revision of *Preparedness and Response for a Nuclear or Radiological Emergency* (GS-R-2) and *The Management System for Facilities and Activities* (GS-R-3).

8. The CSS also discussed the approach for the corresponding review of the IAEA's Safety Guides. In this context, the CSS proposed that a prioritization process be put in place and a pilot study for a

---

[80] The IAEA Action Plan on Nuclear Safety was approved by the Board of Governors on 13 September 2011, and endorsed by the General Conference during its 55th regular session on 22 September 2011. This document is available online at http://www.iaea.org/newscenter/focus/actionplan/reports/actionplanns130911.pdf

few Safety Guides be initiated in order to test whether the methodology adopted for the Safety Requirements could be applied to or adapted for the review of the Safety Guides.

9. At the same time, CSS members highlighted that the basis for the review and revision of the IAEA's safety standards should not be limited to the lessons of the Fukushima Daiichi accident, but should also include experience from elsewhere and information gained from advances in research and development. The CSS also stressed the need for greater attention to be paid to the implementation of the IAEA's safety standards by Member States.

A.2 The IAEA's Safety Standards Series and the Nuclear Security Series

10. A joint task force of the Advisory Group on Nuclear Security and the CSS was established in 2009, "with the aim of exchanging views on issues relating to safety and security synergies and interfaces". It prepared a report summarizing its recommendations, which was provided to the Director General in November 2011. The report recommended a two-step process to establish a committee for the review and approval of draft safety and security publications. As an intermediate committee structure, it recommended the establishment of the Nuclear Security Guidance Committee (NSGC) with terms of reference consistent with the terms of reference of the four existing Safety Standards Committees and of an interface group to decide which of these Committees should be involved for the review and approval of each draft safety standard and draft nuclear security series publication. As a long term vision, the report recommended the establishment of a new safety and security standards commission supported by various committees with technical expertise in safety and security.

11. The NSGC was established in March 2012 and held its first meeting in June 2012. In September 2012, the interface group met for the first time and determined which of the five Committees should be involved in the review and approval process for all drafts currently in process.

A.3 Strategies and Processes for the Establishment of IAEA Safety Standards (SPESS)

12. The first version of SPESS was issued in 2010.[81] SPESS describes all policy and strategy papers established by the Secretariat and approved by the CSS and the process for the review and approval of all safety standards. SPESS was revised in 2012, essentially to reflect the above-mentioned process for addressing the interfaces between the IAEA's Safety Standards Series and Nuclear Security Series.

---

[81] The report can be downloaded at: http://www-ns.iaea.org/downloads/standards/spess.pdf.

B. Current IAEA Safety Standards

B.1 Safety Fundamentals

SF-1	Fundamental Safety Principles (2006), co-sponsorship: Euratom, FAO, ILO, IMO, OECD/NEA, PAHO, UNEP, WHO

B.2 General Safety Standards (Applicable to All Facilities and Activities)

GSR Part 1	Governmental, Legal and Regulatory Framework for Safety (2010)
GS-R-3	The Management System for Facilities and Activities (2006)
GSR Part 3	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — Interim Edition (2011)
GSR Part 4	Safety Assessment for Facilities and Activities (2009)
GSR Part 5	Predisposal Management of Radioactive Waste (2009)
WS-R-5	Decommissioning of Facilities Using Radioactive Material (2006)
GS-R-2	Preparedness and Response for a Nuclear or Radiological Emergency (2002), o-sponsorship: FAO, ILO, OCHA, OECD/NEA, PAHO, WHO
GS-G-2.1	Arrangements for Preparedness for a Nuclear or Radiological Emergency (2007), co-sponsorship: FAO, ILO, OCHA, PAHO, WHO
GS-G-3.1	Application of the Management System for Facilities and Activities (2006)
GS-G-3.2	The Management System for Technical Services in Radiation Safety (2008)
GS-G-3.3	The Management System for the Processing, Handling and Storage of Radioactive Waste (2008)
GSG-1	Classification of Radioactive Waste (2009)
RS-G-1.1	Occupational Radiation Protection (1999), co-sponsorship: ILO
RS-G-1.2	Assessment of Occupational Exposure Due to Intakes of Radionuclides (1999), co-sponsorship: ILO
RS-G-1.3	Assessment of Occupational Exposure Due to External Sources of Radiation (1999), co-sponsorship: ILO
RS-G-1.4	Building Competence in Radiation Protection and the Safe Use of Radiation Sources (2001), co-sponsorship: ILO, PAHO, WHO
RS-G-1.7	Application of the Concepts of Exclusion, Exemption and Clearance (2004)
RS-G-1.8	Environmental and Source Monitoring for Purposes of Radiation Protection (2005)
RS-G-1.9	Categorization of Radioactive Sources (2005)
WS-G-2.3	Regulatory Control of Radioactive Discharges to the Environment (2000) (under revision)
WS-G-2.5	Predisposal Management of Low and Intermediate Level Radioactive Waste (2003) (under revision)
WS-G-2.6	Predisposal Management of High Level Radioactive Waste (2003) (under revision)
WS-G-3.1	Remediation Process for Areas Affected by Past Activities and Accidents (2007)
WS-G-5.1	Release of Sites from Regulatory Control on Termination of Practices (2006)
WS-G-5.2	Safety Assessment for the Decommissioning of Facilities Using Radioactive Material (2008)
WS-G-6.1	Storage of Radioactive Waste (2006)
GSG-2	Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency (2011), co-sponsorship: FAO, ILO, PAHO, WHO

B.3 Specific Safety Standards (Applicable to Specified Facilities and Activities)

B.3.1 Nuclear Power Plants

SSR-2/1	Safety of Nuclear Power Plants: Design (2012)
SSR-2/2	Safety of Nuclear Power Plants: Commissioning and Operation (2011)
NS-R-3	Site Evaluation for Nuclear Installations (2003)
SSG-16	Establishing the Safety Infrastructure for a Nuclear Power Programme (2011)
GS-G-1.1	Organization and Staffing of the Regulatory Body for Nuclear Facilities (2002)
GS-G-1.2	Review and Assessment of Nuclear Facilities by the Regulatory Body (2002)
GS-G-1.3	Regulatory Inspection of Nuclear Facilities and Enforcement by the Regulatory Body (2002)
GS-G-1.4	Documentation for Use in Regulating Nuclear Facilities (2002)
GS-G-3.5	The Management System for Nuclear Installations (2009)
SSG-12	Licensing Process for Nuclear Installations (2010)
GS-G-4.1	Format and Content of the Safety Analysis Report for Nuclear Power Plants (2004)
NS-G-1.1	Software for Computer Based Systems Important to Safety in Nuclear Power Plants (2000) (under revision)
NS-G-1.3	Instrumentation and Control Systems Important to Safety in Nuclear Power Plants (2002) (under revision)
NS-G-1.4	Design of Fuel Handling and Storage Systems for Nuclear Power Plants (2003)
NS-G-1.5	External Events Excluding Earthquakes in the Design of Nuclear Power Plants (2003)
NS-G-1.6	Seismic Design and Qualification for Nuclear Power Plants (2003)
NS-G-1.7	Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants (2004)
NS-G-1.8	Design of Emergency Power Systems for Nuclear Power Plants (2004) (under revision)
NS-G-1.9	Design of the Reactor Coolant System and Associated Systems in Nuclear Power Plants (2004)
NS-G-1.10	Design of Reactor Containment Systems for Nuclear Power Plants (2004)
NS-G-1.11	Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants (2004)
NS-G-1.12	Design of the Reactor Core for Nuclear Power Plants (2005)
NS-G-1.13	Radiation Protection Aspects of Design for Nuclear Power Plants (2005)
NS-G-2.1	Fire Safety in the Operation of Nuclear Power Plants (2000)
NS-G-2.2	Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants (2000)
NS-G-2.3	Modifications to Nuclear Power Plants (2001)
NS-G-2.4	The Operating Organization for Nuclear Power Plants (2001)
NS-G-2.5	Core Management and Fuel Handling for Nuclear Power Plants (2002)
NS-G-2.6	Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants (2002)
NS-G-2.7	Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants (2002)
NS-G-2.8	Recruitment, Qualification and Training of Personnel for Nuclear Power Plants (2002)
NS-G-2.9	Commissioning for Nuclear Power Plants (2003) (under revision)
NS-G-2.10	Periodic Safety Review of Nuclear Power Plants (2003) (under revision)
NS-G-2.11	A System for the Feedback of Experience from Events in Nuclear Installations (2006)
NS-G-2.12	Ageing Management for Nuclear Power Plants (2009)
NS-G-2.13	Evaluation of Seismic Safety for Existing Nuclear Installations (2009)

NS-G-2.14	Conduct of Operations at Nuclear Power Plants (2008)
NS-G-2.15	Severe Accident Management Programmes for Nuclear Power Plants (2009)
SSG-13	Chemistry Programme for Water Cooled Nuclear Power Plants (2011)
NS-G-3.1	External Human Induced Events in Site Evaluation for Nuclear Power Plants (2002)
NS-G-3.2	Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants (2002) (under revision)
SSG-9	Seismic Hazards in Site Evaluation for Nuclear Installations (2010)
SSG-18	Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations (2011), co-sponsorship: WMO
SSG-21	Volcanic Hazards in Site Evaluation for Nuclear Installations (2012)
NS-G-3.6	Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants (2004)
SSG-2	Deterministic Safety Analysis for Nuclear Power Plants (2009)
SSG-3	Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants (2010)
SSG-4	Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants (2010)
WS-G-2.1	Decommissioning of Nuclear Power Plants and Research Reactors (1999) (under revision)
79	Design of Radioactive Waste Management Systems at Nuclear Power Plants (1986) (under revision)

B.3.2 Research Reactors

NS-R-3	Site Evaluation for Nuclear Installations (2003)
NS-R-4	Safety of Research Reactors (2005)
SSG-9	Seismic Hazards in Site Evaluation for Nuclear Installations (2010)
SSG-18	Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations (2011), co-sponsorship: WMO
SSG-21	Volcanic Hazards in Site Evaluation for Nuclear Installations (2012)
GS-G-1.1	Organization and Staffing of the Regulatory Body for Nuclear Facilities (2002)
GS-G-1.2	Review and Assessment of Nuclear Facilities by the Regulatory Body (2002)
GS-G-1.3	Regulatory Inspection of Nuclear Facilities and Enforcement by the Regulatory Body (2002)
GS-G-1.4	Documentation for Use in Regulating Nuclear Facilities (2002)
GS-G-3.5	The Management System for Nuclear Installations (2009)
SSG-12	Licensing Process for Nuclear Installations (2010)
NS-G-2.11	A System for the Feedback of Experience from Events in Nuclear Installations (2006)
NS-G-2.13	Evaluation of Seismic Safety for Existing Nuclear Installations (2009)
NS-G-4.1	Commissioning of Research Reactors (2006)
NS-G-4.2	Maintenance, Periodic Testing and Inspection of Research Reactors (2006)
NS-G-4.3	Core Management and Fuel Handling for Research Reactors (2008)
NS-G-4.4	Operational Limits and Conditions and Operating Procedures for Research Reactors (2008)
NS-G-4.5	The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors (2008)
NS-G-4.6	Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors (2008)
WS-G-2.1	Decommissioning of Nuclear Power Plants and Research Reactors (1999) (under revision)
SSG-10	Ageing Management for Research Reactors (2010)

SSG-22	Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors (2012)
SSG-24	Safety in the Utilization and Modification of Research Reactors (2012)
SSG-20	Safety Assessment for Research Reactors and Preparation of the Safety Analysis Report (2012)

B.3.3 Fuel Cycle Facilities

NS-R-3	Site Evaluation for Nuclear Installations (2003)
NS-R-5	Safety of Nuclear Fuel Cycle Facilities (2008) (under revision)
SSG-9	Seismic Hazards in Site Evaluation for Nuclear Installations (2010)
SSG-18	Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations (2011), co-sponsorship: WMO
SSG-21	Volcanic Hazards in Site Evaluation for Nuclear Installations (2012)
GS-G-1.1	Organization and Staffing of the Regulatory Body for Nuclear Facilities (2002)
GS-G-1.2	Review and Assessment of Nuclear Facilities by the Regulatory Body (2002)
GS-G-1.3	Regulatory Inspection of Nuclear Facilities and Enforcement by the Regulatory Body (2002)
GS-G-1.4	Documentation for Use in Regulating Nuclear Facilities (2002)
GS-G-3.5	The Management System for Nuclear Installations (2009)
SSG-12	Licensing Process for Nuclear Installations (2010)
NS-G-2.11	A System for the Feedback of Experience from Events in Nuclear Installations (2006)
NS-G-2.13	Evaluation of Seismic Safety for Existing Nuclear Installations (2009)
SSG-5	Safety of Conversion Facilities and Uranium Enrichment Facilities (2010)
SSG-6	Safety of Uranium Fuel Fabrication Facilities (2010)
SSG-7	Safety of Uranium and Plutonium Mixed Oxide Fuel Fabrication Facilities (2010)
WS-G-2.4	Decommissioning of Nuclear Fuel Cycle Facilities (2001) (under revision)
SSG-15	Storage of Spent Nuclear Fuel (2012)

B.3.4 Radioactive Waste Disposal Facilities

SSR-5	Disposal of Radioactive Waste (2011)
GS-G-1.1	Organization and Staffing of the Regulatory Body for Nuclear Facilities (2002)
GS-G-1.2	Review and Assessment of Nuclear Facilities by the Regulatory Body (2002)
GS-G-1.3	Regulatory Inspection of Nuclear Facilities and Enforcement by the Regulatory Body (2002)
GS-G-1.4	Documentation for Use in Regulating Nuclear Facilities (2002)
GS-G-3.4	The Management System for the Disposal of Radioactive Waste (2008)
SSG-1	Borehole Disposal Facilities for Radioactive Waste (2009)
SSG-23	The Safety Case and Safety Assessment for the Disposal of Radioactive Waste (2012)
111-G-3.1	Siting of Near Surface Disposal Facilities (1994) (under revision)
SSG-14	Geological Disposal Facilities for Radioactive Waste (2011)

B.3.5 Mining and Milling

RS-G-1.6	Occupational Radiation Protection in the Mining and Processing of Raw Materials (2004), co-sponsorship: ILO
WS-G-1.2	Management of Radioactive Waste from the Mining and Milling of Ores (2002) (under revision)

B.3.6 Applications of Radiation Sources

GSR Part 3	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — Interim Edition (2011)
GS-G-1.5	Regulatory Control of Radiation Sources (2004), co-sponsorship: FAO, ILO, PAHO, WHO
RS-G-1.4	Building Competence in Radiation Protection and the Safe Use of Radiation Sources (2001), co-sponsorship: ILO, PAHO, WHO
RS-G-1.5	Radiological Protection for Medical Exposure to Ionizing Radiation (2002), co-sponsorship: PAHO, WHO (under revision)
RS-G-1.9	Categorization of Radioactive Sources (2005)
RS-G-1.10	Safety of Radiation Generators and Sealed Radioactive Sources (2006), co-sponsorship: ILO, PAHO, WHO
WS-G-2.2	Decommissioning of Medical, Industrial and Research Facilities (1999) (under revision)
WS-G-2.7	Management of Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education (2005)
SSG-8	Radiation Safety of Gamma, Electron and X Ray Irradiation Facilities (2010)
SSG-11	Radiation Safety in Industrial Radiography (2011)
SSG-17	Control of Orphan Sources and Other Radioactive Material in the Metal Recycling and Production Industries (2012)
SSG-19	National Strategy for Regaining Control over Orphan Sources and Improving Control over Vulnerable Sources (2011)

B.3.7 Transport of Radioactive Material

SSR-6	Regulations for the Safe Transport of Radioactive Material: 2012 Edition (2012)
TS-G-1.1 (Rev. 1)	Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2008) (under revision)
TS-G-1.2 (ST-3)	Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material (2002)
TS-G-1.3	Radiation Protection Programmes for the Transport of Radioactive Material (2007)
TS-G-1.4	The Management System for the Safe Transport of Radioactive Material (2008)
TS-G-1.5	Compliance Assurance for the Safe Transport of Radioactive Material (2009)
TS-G-1.6	Schedules of Provisions of the IAEA Regulations for the Safe Transport of Radioactive Material (2005 Edition) (2010) (under revision: one addendum and one complete revision)