International Atomic Energy Agency
BOARD OF GOVERNORS

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# NUCLEAR SAFETY REVIEW FOR THE YEAR 2000

1. The attached draft Nuclear Safety Review for the Year 2000, which — like previous reviews — reports on worldwide efforts to strengthen nuclear and radiation safety, including radioactive waste safety, has the same format as that of the Nuclear Safety Review for the Year 1999 (GOV/2000/5).

2. Part 1 describes those events in 2000 that have, or may have, significance for nuclear, radiation and waste safety worldwide. It includes developments such as new initiatives in international co-operation, events of safety significance and events that may be indicative of trends in safety.

3. Part II describes some of the Agency's efforts to strengthen international co-operation in nuclear, radiation and waste safety during 2000. It covers legally binding international agreements, non-binding safety standards, and provisions for the application of safety standards. This is done in a very brief manner, because these issues are addressed in more detail in the Agency's Annual Report for 2000.

4. Part III presents a brief look ahead to some issues that are likely to be prominent in the coming year(s). The topics covered were selected by the Secretariat on the basis of trends observed in recent years, account being taken of planned or expected future developments.

5. The final version of the Nuclear Safety Review for the Year 2000 will be prepared in the light of the discussion in the Board, and published as soon as possible thereafter. It will also be supplemented by more detailed and updated information on the Agency's safety related activities, and this extended version will be presented to the forty-fifth session of the General Conference.

6. Any pertinent information from Member States on events, issues or trends not already addressed in parts I and III of the draft will be included in the extended document presented to the General Conference if the Board's discussion indicates a need.

## RECOMMENDED ACTION BY THE BOARD

7. It is recommended that the Board takes note of the draft Safety Review for the Year 2000 and identifies any necessary changes or additions.

GOV/2001/2
Attachment

# *Draft*
# *Nuclear Safety Review for the Year 2000*

## CONTENTS

# DRAFT NUCLEAR SAFETY REVIEW FOR THE YEAR 2000

## PART 1: SAFETY RELATED EVENTS AND ISSUES WORLDWIDE

This section aims to identify those events or developments during 2000 that:

(a) were of particular importance in their own right; and/or

(b) provided lessons that may be more generally applicable; and/or

(c) have potential long term consequences or could be indicative of developing trends that might be of longer term importance.

It is not intended to provide a comprehensive account of all events during the past year. It should be noted in particular that some events reported for reasons of the type indicated in (b) and (c) might not have been considered significant in their own right.

### Intergovernmental agreements

There are currently three binding international conventions related to safety: the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Nuclear Safety. In addition, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was adopted in 1997 and has not yet entered into force.

The Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency entered into force in October 1986 and February 1987 respectively. Luxembourg and Iran adhered to both Conventions during 2000 and Lithuania adhered to the Assistance Convention, bringing the total numbers of Contracting Parties to 86 and 82 respectively.

The Assistance Convention has been invoked on numerous occasions including, during 2000, in Thailand (see below). However, the Early Notification Convention — which applies in the event of an accident "from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international transboundary release that could be of radiological safety significance for another State" — has been formally invoked only once, by Turkey in 1999 in relation to a missing source (see the Nuclear Safety Review for the Year 1999). There have, however, been some recent events that were outside the scope of the Convention, but in relation to which the international demand for authoritative information was such that national authorities and international organizations had to perform many of the functions that would have been required of them by the Convention.

Under a new emergency response framework developed by the IAEA in consultation with other relevant international organizations and Member States, States are encouraged to report to the Agency any events likely to be of international concern (those with actual, potential or perceived radiological significance for other States), even when notification is not required under the terms of the Early Notification Convention. Such reports would be classed as 'warning messages' and, although the Convention would not be formally invoked, the international organizations would, as appropriate, perform similar functions to those set out in the Convention with regard to collecting information from the accident State and disseminating it to other States. 'Warning messages' should indicate the nature of the event (radiological accident, missing source, satellite re-entry or elevated radiation levels) and its severity (alert, site emergency or general emergency).[1] In the event of a 'transboundary emergency' the Convention would be formally invoked as before. The IAEA accordingly issued a new edition of the Emergency Notification and Assistance Technical Operations Manual and — jointly with the Food and Agriculture Organization of the United Nations, OECD/NEA, the United Nations Office for the Co-ordination of Humanitarian Affairs, the World Health Organization and the World Meteorological Organization — a Joint Radiation Emergency Management Plan of the International Organizations. A protected web site was also established for use by official contact points under the Early Notification and Assistance Conventions to share emergency-related information.

The new framework officially came into operation on 1 December 2000. A meeting of Member States' official contact points will be held in June 2001 to review experiences with the new framework and to advise the Agency on how to proceed.

The Convention on Nuclear Safety entered into force on 24 October 1996. Euratom adhered to the Convention during 2000, bringing the total number of Parties to 53 (52 States plus Euratom). Of the 31 States having a nuclear installation (as defined in the Convention) that has achieved criticality in a reactor core, all but India and Kazakhstan are Parties to the Convention.

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management is not yet in force. Finland, Latvia, Switzerland, the Netherlands, France, Poland, Bulgaria, Greece, Ukraine and Argentina adhered to the Convention during 2000, bringing the number of Contracting States to 23, 16 of which have operational nuclear power plants. The Convention will enter into force on the ninetieth day after the deposit of the twenty-fifth instrument of ratification, acceptance or approval, including the instruments of 15 States each having an operational nuclear power plant.

A draft Code of Conduct on the Safety and Security of Radioactive Sources was developed in two meetings of technical and legal experts held in Vienna in March and July 2000. The objective of the Code of Conduct is "to achieve and maintain a high level of safety and security of radioactive sources through the development, harmonization and enforcement of national policies, laws and regulations, and through the fostering of international co-

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[1] The relevant definitions and procedures are set out in detail in the Emergency Notification and Assistance Technical Operations Manual.

operation." The Code particularly addresses "the establishment of an adequate system of regulatory control from the production of radioactive sources to their final disposal, and a system for the restoration of such control if it has been lost." The text was submitted to the IAEA's Board of Governors and General Conference in September 2000. The General Conference, in resolution GC(44)/RES/11, welcomed the successful preparation of the Code of Conduct, and invited Member States of the Agency "to take note of the Code of Conduct" and "to consider, as appropriate, means of ensuring its wide application".

**Co-operation between national regulatory bodies**

Several forums exist in which regulators can exchange information and experience with their counterparts in other countries. The different groupings are based on various criteria, including:

- regional or linguistic considerations, e.g. the Western European Nuclear Regulators' Association and the Forum of Ibero-American Regulators;
- common reactor type, e.g. Senior Regulators from Countries Operating CANDU Type Nuclear Power Plants and the Co-operation Forum for WWER Regulators; and
- size of nuclear power programme, e.g. the International Nuclear Regulators' Association and the Network of Regulators of Countries with Small Nuclear Programmes.

All of these forums met during 2000 to discuss issues of common interest: the following text covers some selected activities of the groups.

The Co-operation Forum for WWER Regulators held its annual meeting in October 2000 in Odessa, Ukraine.[2] In addition to reports on developments at the national level, the meeting heard presentations by expert working groups on spent fuel storage, ageing management for equipment and structures, accident management and joint inspection practices. The work of the group on joint inspection practices was considered to be particularly useful, and some specific areas of inspection were identified for greater attention in the future. A new group was also established to develop a policy paper on strengthening the independence and technical competence of regulatory bodies.

The Senior Regulators from Countries Operating CANDU Type Nuclear Power Plants held their annual meeting in September 2000, with representatives from Argentina, Canada, India, the Republic of Korea, Pakistan and Romania. As well as exchanging information on national developments, the participants discussed a range of issues of common interest. These included generic safety issues for pressurized heavy water reactors, compliance and enforcement, safety indicators, periodic safety review, use of probabilistic safety assessment,

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2 The members of the group are Armenia, Bulgaria, the Czech Republic, Finland, Hungary, the Russian Federation, Slovakia and Ukraine. Germany and the IAEA participate as observers.

technical specifications and operating policies and principles, validation and verification of computer codes, configuration management and feedback from operational events.

The Western European Nuclear Regulators' Association (WENRA) is made up of the heads of the nuclear regulatory bodies in the western European countries that have nuclear power plants (Belgium, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom). In October 2000, WENRA issued a report expressing a collective opinion[3] on nuclear safety in those countries of central and eastern Europe that are candidates for membership of the European Union (EU) and that have nuclear power plants, namely Bulgaria, the Czech Republic, Hungary, Lithuania, Romania Slovakia, and Slovenia. This report updated and expanded upon a report on this topic issued by WENRA in March 1999. As in the earlier report, WENRA focused for each country on the status of the regulatory regime and regulatory body and the safety status of each of the nuclear power plants. For each candidate country, a comparison was made with the current western European practices and, where appropriate, discrepancies and deficiencies were identified. WENRA, however, has not made a detailed safety assessment of the different nuclear power plants. The full text of the report can be found at www.asn.gouv.fr/data/information/wenraRpt02.pdf. The following paragraphs summarize some of WENRA's conclusions.

In the Czech Republic, Hungary and Slovakia, the regulatory regimes and regulatory bodies were considered to be comparable with western European practice. Progress has been and is being made in the other countries, and specific recommendations were provided in each case, the most common problem being insufficient human and financial resources for the regulatory body.

Some of the nuclear power plants (Paks in Hungary, Mochovce in Slovakia and Kr ko in Slovenia) were considered to have achieved safety levels comparable with those of western European reactors of similar vintage, and most of the others have programmes in place that should achieve such a level of safety, but a few exceptions to this general conclusion were identified[4].

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3 The Swiss member of WENRA did not take part in preparing the report. Switzerland is not a member of the European Union.

4 With regard to the RBMK reactors at Ignalina in Lithuania, WENRA concluded that "most of the generic safety concerns with RBMK reactors have been satisfactorily addressed", but reaffirmed their opinion from the earlier report that "compared with Western European light water reactors of the same vintage, there remain weaknesses in the design of the confinement" and hence that "regarding mitigation of accidents, a safety level comparable to light water reactors of the same vintage in operation in Western Europe will not be reached". For units 1–4 of the Kozloduy nuclear power plant in Bulgaria and units 1 and 2 of the Bohunice nuclear power plant in Slovakia (all of which are WWER-440/230 reactors), WENRA expressed its concern "about the ability of the confinement system to cope with the failure of the large primary circuit pipework." In the case of Bohunice, they concluded that: "If a solution can be found to this issue, the plant should reach a safety level comparable to that of Western European reactors of the same vintage." For the Kozloduy reactors, however, WENRA's conclusion was that: "Even if a solution could be found to this issue, significant time and effort would be required to achieve the necessary improvements to bring them up to equivalent Western European reactor standards." In the case of Cernavoda in Romania, which has a CANDU reactor, a direct comparison with western European reactors

**Activities of international advisory bodies**

A number of international expert bodies issue authoritative findings and recommendations on safety related topics. The advice provided by these bodies — inter alia — is an important input into the development of the Agency's safety standards and many national safety regulations. In particular:

- the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), a Committee of the General Assembly, which provides information and recommendations on sources and effects of ionizing radiation;
- the International Commission on Radiological Protection (ICRP);
- the International Commission on Radiation Units and Measurements (ICRU); and
- the International Nuclear Safety Advisory Group (INSAG), which advises the IAEA's Director General on nuclear safety issues.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

The UNSCEAR 2000 Report on sources and effects of atomic radiation was presented to the 55th Session of the United Nations General Assembly. This was the latest comprehensive review by UNSCEAR of the whole subject, superseding the 1993 report. The report had ten detailed technical annexes, containing reviews and assessments on: exposures from natural radiation sources; exposures to the public from man-made sources of radiation; medical radiation exposures; occupational radiation exposures; DNA repair and mutagenesis; biological effects at low radiation doses; combined effects of radiation and other agents; radiation-associated cancer risks; and exposures and effects of the Chernobyl accident.

The report included, inter alia, re-evaluations of two important parameters in radiation protection: the average risk of fatal cancer associated with exposure to a unit dose of radiation and the global average dose received by individuals from various sources of radiation. For a population of all ages, the Committee estimated that the average lifetime risk of dying from radiation-induced cancer if exposed to an acute effective dose of 1 Sv, is 9% for males and 13% for females. These figures are similar to previous estimates. The global average radiation doses were also found to be similar to previous assessments: about 2.8 mSv/a in total, comprising 2.4 mSv/a from natural sources, 0.4 mSv/a from diagnostic medical examinations, 0.007 mSv/a from fallout (from atmospheric weapons testing and the Chernobyl accident), and 0.0002 mSv/a from nuclear power production.

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was not possible, because there are no western European nuclear power plants that are sufficiently similar to offer a benchmark. On the basis of information from the Romanian operators and regulators, and some information from the Canadian regulatory body, WENRA's "main concern" was "the financial situation of the plant: under the current situation, the plant management may have serious difficulties in ensuring and maintaining an adequate level of safety."

The report placed particular emphasis on an evaluation of the consequences of the Chernobyl accident. UNSCEAR's scientific assessments indicated that there have so far been about 1800 cases of thyroid cancer in children who were exposed at the time of the accident, primarily as a result of ingesting (and, to a lesser extent, of inhaling) radioactive iodine. The Committee found no scientific evidence of increases to date in the incidence of any other health effects that could be related to radiation exposure. Although the most highly exposed individuals have an increased risk of suffering radiation-associated effects in the future, the Committee concluded that the great majority of the population are not likely to experience serious health consequences attributable to radiation from the Chernobyl accident.

During discussion of a draft resolution on the report in the General Assembly's Fourth Committee, some States expressed reservations about the methodology and conclusions of the Annex relating to the Chernobyl accident, stressing the need for further studies and for more account to be taken of the results of studies by scientists working in those areas. In resolution A/RES/55/121, the General Assembly took note with appreciation of UNSCEAR's report.

International Commission on Radiological Protection (ICRP)

Three ICRP Publications were issued in 2000.

Publication 81 set out the Commission's recommendations on the radiological protection of members of the public following the disposal of solid long lived radioactive wastes. The report was intended to supplement, update and clarify the recommendations made in Publication 46 in 1986, taking into account the general recommendations in Publication 60 (1991) and the general policy for disposal of all types of radioactive waste as described in Publication 77 (1999). The report emphasized that the primary basis for evaluating the radiological acceptability of a waste disposal system is the constrained optimization of protection, noting that optimization in this context is likely to be an essentially qualitative process.

Publication 82 addressed the radiological protection of the public in situations of prolonged exposure. In the report, the Commission recommended generic reference levels for intervention in such situations, and considered some specific issues that have been of concern, including:

- natural radiation sources that may cause high doses;
- rehabilitation of sites affected by radioactive residues from past practices;
- withdrawal of countermeasures and return to 'normality' following an accident; and
- global trade in commodities that contain radioactive substances.

Publication 84 addressed the basic issues of pregnancy and medical exposure. The recommendations related primarily to the protection of the foetus from any harmful effects of prenatal exposure, both in cases where a pregnant patient may be exposed to radiation for

diagnostic or therapeutic purposes, and in cases where female workers who are (or may be) pregnant are exposed to radiation in the course of their work.

International Commission on Radiation Units and Measurements (ICRU)

ICRU Publication 63, published in 2000, provides Nuclear Data for Neutron and Proton Radiotherapy and for Radiation Protection, a comprehensive tabulation of nuclear cross-sections and kerma coefficients relevant for medical, industrial, research, and protection applications. The report is accompanied by a CD-ROM containing a more extensive compilation of data in a user friendly format.

International Nuclear Safety Advisory Group (INSAG)

The fifth term of INSAG started in 2000, with a new membership appointed by the IAEA's Director General and a new Chairman, Mr. A. Baer. Approximately one-third of the members from the 1996–1999 term were reappointed. The Group has begun drafting reports covering a wide range of topics in nuclear, radiation and waste safety. Particular areas of current interest include:

- practical issues in achieving higher safety culture;
- safety aspects in the management of change in organizations;
- the independence of regulatory bodies in taking regulatory decisions;
- maintaining knowledge, training and research and development infrastructure;
- design authority;
- the safety of high temperature gas-cooled reactors; and
- international coherence of nuclear safety standards.

**Activities of other organizations**

World Association of Nuclear Operators (WANO)

WANO conducted 28 peer reviews at nuclear power plants during 2000, making a total of 138 since the programme began in 1992. WANO has a policy of keeping the content of its peer review reports confidential: during the year it proved necessary to take action to maintain this policy in the face of challenges from parties seeking access to reports on plants in Canada and Mexico.

A central operating experience team — based in WANO's Paris Centre, with representatives of all four WANO regions — has been established to enhance the service to members in this important field. An on-line database of all events reported to WANO has been produced, and three Significant Event Reports were issued during 2000 relating to events that could provide lessons relevant to many plants around the world. A database of "Just in

Time" reports has also been established, through which plant staff can check for relevant external experience immediately prior to undertaking specific operational activities.

WANO is putting more emphasis on Technical Support Missions, which focus on providing assistance in selected areas. The topics arise from the findings of Peer Reviews or through the ongoing dialogue with members as to their specific needs in the fields of safety and reliability. More than 40 such missions were undertaken during the year.

The workshop/seminar/training course programme has developed both in scope and in numbers. A new initiative has been the Senior Executive Seminar on "Nuclear Power in the 21st Century – Meeting the Challenge", established by WANO's Paris Centre, which takes place over three days and focuses on the challenges presented in addressing safety, cost and public acceptance. External speakers from outside the nuclear industry are used to bring additional perspectives. Two such seminars were held during 2000.

Nearly all WANO performance indicators continue to show a clear trend of improvement in plant and safety performance. Some changes to the performance indicators have been agreed: in addition to minor changes, indicators relating to thermal performance and radioactive waste will be deleted from 2001.

Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD/NEA)

The Forum on Stakeholder Confidence set up by the Radioactive Waste Management Committee held its first workshop in August 2000. This workshop brought together government-nominated participants as well as a considerable number of stakeholders, including academics, sociologists, representatives of independent review groups and elected political representatives. The workshop addressed a variety of topics, ranging from evolving participatory democracy, stakeholder identity and trust in institutional framework, to the role of open dialogue in all aspects of radioactive waste management and disposal.

In response to a request from Sweden, the NEA organized an international peer review on an important milestone of the Swedish programme on geological disposal.

The Committee on Nuclear Regulatory Activities organized a workshop entitled "Investing in Trust: Nuclear Regulators and the Public" in Paris in November 2000. The workshop, which was attended by some 80 participants including top regulators from member countries, provided an opportunity for an exchange of information and views on how national nuclear regulatory organizations can improve their interface with the public in a spirit of greater trust, confidence and accountability.

Continuing its efforts to stimulate international co-operation in safety research, a new NEA joint project has been established in the area of severe accidents. This is a follow up to the RASPLAV project, which concluded in November 2000 with a seminar in Munich,

Germany. The new project is named MASCA and is based at the Kurchatov Institute's facilities in the Russian Federation, with 17 countries participating.

The Committee on Radiation Protection and Public Health's report on Radiological Impacts of Spent Nuclear Fuel Management Options was forwarded to the OSPAR Commission[5] in May 2000. At the Commission's Meeting in Copenhagen in June, OSPAR acknowledged the value of the NEA study for the implementation of OSPAR's 1998 Sintra Strategy with Regard to Radioactive Substances.

International Radiation Protection Association (IRPA)

The Tenth International Congress of IRPA was held in Hiroshima, Japan, in May 2000, and was attended by over 1000 participants representing 58 countries. The programme included 24 technical sessions that addressed a complete range of radiation protection issues from dosimetry to waste management, from environmental monitoring to work management, from non-ionizing radiation to genetic risk. Three topical plenary sessions were also held, on radiation health effects at low dose and dose rates, on decision making about chronic radiation exposure of the public, and on challenges in radiation protection in the 21st century.

There was extensive discussion on the future direction of international radiation protection principles, stimulated by a paper by the Chairman of ICRP, Prof. Roger Clarke. The paper included a number of ideas for updating and simplifying the System of Radiological Protection currently recommended by ICRP. In addition to individual comments, presentations were made on behalf of several national and regional IRPA member societies, giving consolidated responses to Prof. Clarke's suggestions. The initiative to consult the radiological protection community on the fundamental issues at an early stage was universally welcomed, and there was support for yet broader consultation, to include other interest groups and the public. There was considerable discussion about the merits of the various ideas put forward, several of which received support. However, there was also a significant body of opinion favouring caution, arguing that the fundamentals of the current system were widely accepted and, in the main, being applied successfully, and that a degree of stability in ICRP's basic recommendations, along with further development of advice on applying them to 'problem' situations, might be preferable to more radical change.

EURATOM "Article 31 Group"

Pursuant to Article 31 of the EURATOM Treaty, the European Commission (EC) establishes directives on radiation protection that are binding on member countries of the European Union (EU). A Group of Experts — the "Article 31 Group" — is designated to advise the EC on appropriate standards to be embodied in these directives.

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5 The "OSPAR Convention" is the Convention for the Protection of the Marine Environment of the North-East Atlantic 1992, which replaced the Oslo and Paris Conventions. The OSPAR Commission is made up of representatives of each of the Contracting Parties.

In 2000, the EC published the Group's recommendations on general clearance levels[6]: activity concentrations below which materials from within controlled practices can be recycled, reused or disposed of freely (i.e. without any restrictions related to radiation protection). The radionuclide-specific clearance levels were derived on the basis that the maximum individual dose to any member of the public from the unrestricted use or disposal of materials at the clearance level should not exceed 10 μSv/a. These recommendations have the status of guidelines, and their application by national authorities is not obligatory.

A Working Group on the control of radiation sources was established, with a view to issuing a Directive on the issue. The results of the IAEA's Action Plan on the Safety of Radiation Sources and the Security of Radioactive Materials are being taken into account in the Group's deliberations.

**Safety of nuclear installations**

The following is a selection of events related to the safety of nuclear installations during 2000, which had some safety significance or received particular attention.

The previous Nuclear Safety Review included a report on the temporary unavailability of some components of the residual heat removal system at the Blayais nuclear power plant, France, as a result of flooding during severe storms in late December 1999. In February 2000, the French nuclear safety regulatory body DSIN specified conditions for the restart of the two units affected, which included increasing the height of the dyke and implementing measures to prevent water spread. These units were restarted in May 2000. DSIN also ordered a systematic review of flood prevention measures at all nuclear power plants located close to the sea or rivers. In September 2000 the Blayais nuclear power plants hosted an international expert meeting to review the IAEA's Safety Guides on floods and on extreme meteorological events, taking into account the feedback experience of this event.

In October 1999, British Nuclear Fuels plc (BNFL) dismissed three workers at its MOX Demonstration Facility (MDF) for falsifying quality control data relating to the dimensions of MOX fuel pellets. It emerged in February 2000 that some quality control data had also been falsified for fuel from BNFL loaded into the Unterweser nuclear power plant in Germany in 1997. BNFL stated that the falsified data were used only to replace genuine data that had been lost, and that had shown the fuel to be satisfactory. Also in February, a report was issued giving the results of an investigation by the UK's Nuclear Installations Inspectorate (NII). They "concluded that data had indeed been falsified but that this would not affect the safety performance of the fuel", and made 15 specific recommendations that BNFL were required to address before the MDF could restart. In December 2000, the NII announced that it had accepted BNFL's responses to all 15 recommendations.

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6 EUROPEAN COMMISSION, Practical Use of the Concepts of Clearance and Exemption — Part I: Guidance on General Clearance Levels for Practices: Recommendations of the Group of Experts established under the terms of Article 31of the Euratom Treaty, Radiation Protection 122, Luxembourg (2000).

In January 2000, the United Kingdom's nuclear safety regulator, the Health and Safety Executive (HSE), published a report of a safety audit on two subsidiaries of British Energy, which are the licensees for eight nuclear power plants in the UK. British Energy was created as a holding company in 1996 when these nuclear power plants were transferred into the private sector, and the subsidiary companies underwent considerable reorganization and downsizing during and after privatization. The aim of the audit was "to confirm that downsizing had not reduced the Licensees' capability to discharge their responsibilities and to deliver acceptable safety performance." Although a number of good practices were observed, a central finding of the audit was that "in some key safety areas ... staff levels are at, and in a limited number of areas, below that required to sustain the work load and discharge the requirements of Licensees."

In mid-February 2000, a steam generator tube failed at the Indian Point-2 nuclear power plant in the USA. The plant was shut down manually and cooled by the other steam generators and the residual heat removal system. A subsequent inspection by the Nuclear Regulatory Commission concluded that deficiencies in the in-service inspection of the steam generators in 1997 had allowed flawed tubes to remain in service.

In March 2000, the Ukrainian Government announced that unit 3 of the Chernobyl nuclear power plant, the last unit still in operation[7], would be shut down permanently by the end of 2000: the closure date was subsequently fixed as 15 December. On 27 November, the reactor was shut down following a drop in the frequency of the off-site power supply. On 6 December, the plant was again shut down by the emergency protection system when a leak of steam was detected. The plant was briefly restarted at low power, and was finally shut down on 15 December.

The Chernobyl Shelter Implementation Programme (SIP) was set up in 1997 to plan and implement the stabilization of the shelter protecting the remains of unit 4 of the Chernobyl nuclear power plant. At a donors' conference in Berlin, Germany, in July 2000, more than US$300 million was pledged towards the cost of the SIP, bringing the total pledged to $715 million, about 93% of the estimated total cost of the project. The European Bank for Reconstruction and Development (EBRD), which administers the funding of the SIP, announced after the conference that the programme could now proceed from its 'investigative' phase to 'implementation'. Decisions were expected soon on a conceptual design of the new confinement and on a strategy for managing the fuel debris inside the shelter.

In May 2000, the Lithuanian parliament passed legislation to close unit 1 of the Ignalina nuclear power plant by 2005. In June, a donors' conference was organized in Vilnius at which a total of about US$200 million was pledged towards the cost of decommissioning the reactor.

In June 2000, the Mexican Federal Electricity Commission (CFE) announced that an independent expert group was to be established, with observers from the Mexican parliament and Greenpeace Mexico, to study the management of safety at the Laguna Verde nuclear

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7 Unit 4 was destroyed in the 1986 accident, unit 2 was shut down in 1991 and unit 1 was shut down in 1996.

power plant. This followed domestic controversy over a leaked report about the findings of a 1999 WANO peer review.

During a refuelling outage in late August 2000, an on-site gamma radiation detector in front of unit 3 of the Kozloduy nuclear power plant in Bulgaria detected dose rates of up to 11 μSv/h (around 70 times the normal background rate). The cause of the radiation increase was found to have been a drop in the water level in the reactor internals storage shaft (a shaft in the reactor hall used for temporary storage of reactor internals during refuelling), due to a leak in the drain valve and deficiencies in procedures for handling such a leak. No radiation increase was detected by off-site monitoring systems, and the incident was rated at Level 1 on the International Nuclear Event Scale (INES).

In his speech to the United Nations Millennium Summit in September 2000, the President of the Russian Federation called for the development of a proliferation-resistant and inherently safe fuel cycle for civil nuclear power. The aim would be to phase out the use of enriched uranium and plutonium from use in nuclear power generation. The innovative reactors designed for such a fuel cycle could also be used to transmute existing weapons grade materials, with benefits for both non-proliferation and radioactive waste management. The IAEA's General Conference invited "all interested Member States to combine their efforts under the aegis of the Agency in considering the issues of the nuclear fuel cycle, in particular by examining innovative and proliferation-resistant nuclear technology". The Agency initiated an International Project on Innovative Nuclear Reactors and Fuel Cycles, to include consideration of technology, safeguards, economic and safety issues. A meeting of senior officials from Member States was held in November 2000 with the goal of specifying the conditions of the Project and finalizing the Terms of Reference.

The Temelin-1 nuclear power plant in the Czech Republic achieved criticality on 11 October 2000. The plant is a WWER-1000/320 reactor with substantial design modifications, the most important of which — in relation to the core design and instrumentation and control systems — were supplied by a western vendor. The startup was surrounded by considerable debate, particularly between the Czech Republic and Austria, about the safety and environmental impact of the plant. Although the Czech State Office of Nuclear Safety confirmed that all national regulatory requirements had been met, the Austrian Government called for an environmental impact assessment, of the type required for major new industrial developments in the European Union, to be performed before the plant was put into operation. In December 2000, the Austrian and Czech Governments signed an agreement to the effect that a joint team of experts would review the safety of the plant, that the process of putting the plant into operation would continue in the mean time, but that the plant would not start commercial power operation until the experts had reported their findings.

During a special inspection in November 2000, cracks were found in a weld in the primary circuit of the Biblis-A nuclear power plant in Germany. Subsequent investigation indicated that these cracks had been detected by ultrasound testing of the weld in 1992, but that the results of the testing were misinterpreted and the cracks were not repaired at that time. The operators undertook to repair the weld before restarting the reactor. An investigation was

ordered relating to the corresponding welds at other similar plants in Germany, but the scope of the investigation will be limited to a review of the relevant documentation.

**Safety regulation**

In April 2000, the United States Nuclear Regulatory Commission began implementing a revised reactor oversight process at all of the nuclear power plants it licences. This followed a six-month pilot programme in 1999, applying the new process at nine reactor sites, and the incorporation into the process of lessons learned from the pilot programme. The revised process was designed to be more risk-informed, objective, predictable, understandable, and focused on areas of greatest safety significance. To measure plant performance, the oversight process focuses on seven 'cornerstones' which support the safety of plant operations: initiating events; mitigating systems; barrier integrity; emergency preparedness; occupational radiation safety; public radiation safety; and physical protection. Plants that do not meet specified objectives related to the 'safety cornerstones', as measured by objective performance indicators and inspection findings, will receive increased inspection, focusing on areas of declining performance. In addition, the process features three 'cross-cutting' elements, which affect each of the cornerstones: human performance; management attention to safety and workers' ability to raise safety issues; and finding and fixing problems.

On 11 January 2000, the Law on the Licensing of Activities in the Field of Nuclear Energy entered into force in Ukraine. The main aims of this Law are the legal regulation of relations during all activities subject to licensing in the field of nuclear energy and the establishment of a legal regime governing the licensing of activities in the field of nuclear energy.

On 31 May 2000, the Nuclear Safety and Control Act entered into force in Canada. This replaced the Atomic Energy Control Act, which dated back to 1946.

The fatal accident at a fuel processing facility in Tokaimura in September 1999 prompted the Japanese authorities to introduce a number of changes to the legislation and regulations governing the safety of nuclear activities and to the regulatory structure. A new Law on Special Nuclear Disaster Countermeasures and a partially revised Nuclear Reactor Regulation Law were approved in late 1999 and came into effect during 2000. The new Law aimed to strengthen collaboration between local and national authorities in their immediate response to accidents, to strengthen the government's emergency response capabilities, and to clarify the responsibilities of operating organizations. The revisions to the existing Law aimed to strengthen the inspection and enforcement system for fuel cycle facilities, the training of staff and feedback mechanisms for staff to raise safety issues. The Nuclear Safety Commission was also expanded and moved from the Science and Technology Agency to the Prime Minister's Office.

**Safety of radiation sources and security of radioactive materials**

In late January 2000 in the Samut Prakan area of Bangkok, Thailand, one of three radiotherapy machine heads was removed from an area in which they were being stored. Four individuals partially dismantled the head, unaware that it contained a cobalt-60 source of about 15.7 TBq. On 1 February, the pieces were taken to a scrapyard, where workers cut open a lead cylinder that had been in the head. As a result, the source came out of the cylinder, leading to the scrapyard workers being exposed to a very high radiation field. A total of ten people were hospitalized with symptoms of acute radiation exposure, three of whom died within weeks of the accident.

At about midday on 18 February 2000, the Office of Atomic Energy for Peace (OAEP) of Thailand was informed by a doctor that he had patients who demonstrated symptoms of exposure to a high dose of radiation. That evening, the source was traced to the scrapyard. A dose rate of 1 mSv/h was measured at the entrance to the scrapyard, and rates of the order of Sv/h were measured close to the source. The following day, the exact location of the source was determined and the source was recovered. The maximum individual dose recorded among the emergency workers was reported as 32 mSv.

At the subsequent request of the Thai Government, under the terms of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the IAEA sent a medical and radiation safety expert team to Bangkok to provide advice and share its expertise with the Thai authorities.

In late April or early May 2000, an iridium-192 source was lost by an industrial radiographer inspecting welds in a gas pipeline at the village of Meet Halfa near Cairo, Egypt. In early May, a local farmer found the source and took it home, without realizing what it was: at the time, the activity would have been about 1 TBq. During May, he and six members of his family all began to display deterministic health effects, but the cause was not recognized. By mid-June, both the farmer and his 9-year-old son had died from acute radiation effects. When, in late June, the cause of the effects was identified as radiation exposure, the Chemical Administration of the Ministry of Defence and the Egyptian Atomic Energy Authority located the source in the farmer's house and recovered it. The father and the son who died were both estimated to have received doses of greater than 5 Gy: the doses to each of the other five members of the family were estimated to have been between 3 and 4 Gy. About 200 associates of the family were estimated, from analysis of blood samples, to have received radiation doses of up to 150 mSv, and the workers involved in recovering received doses of 15–100 mSv.

Previous Nuclear Safety Reviews have reported on events involving radiation sources abandoned in Georgia after the breakup of the Soviet Union. In May–June 2000, an aerial radiological survey of a large area of Georgia was organized by the IAEA under the framework of its Technical Co-operation Programme, using a detection system provided by the Commissariat à l'énergie atomique (CEA) of France. A total area of about 1200 $km^2$ was surveyed, focusing on highly populated areas and on locations of abandoned military bases. As a result of the survey, a caesium-137 source was located in the city of Poti, western Georgia: this source was subsequently recovered. Three other areas with slightly elevated

radiation levels were identified: these areas will be investigated further by the Georgian authorities. A final report containing detailed information on the survey was provided to the Government of Georgia.

On 9 November 2000, radiation was detected during a routine check of a worker entering Tricastin nuclear power plant in France. The source was found not to be connected with the plant, but rather to be the metal bracelet of the worker's wristwatch, which was found to contain several kBq of cobalt-60. The dose rate was measured to be 30–40 μSv/h, which could theoretically lead to an annual dose to the skin of up to 300 mSv. Watches of the model concerned were discovered to have been on sale in a chain of French supermarkets since 26 October, and about 4500 were believed to have been sold. Subsequent measurements indicated that about 50% of watches of this model had cobalt-60 in the bracelets. The Office for Protection against Ionizing Radiation (OPRI) stopped the sale of the watches and urged members of the public who had already bought them to return them to the supermarket. The French authorities submitted a warning message to the IAEA, who then communicated the message to all Member States. The watches were found to have been assembled in China, using components from various suppliers, made with steel from various origins in China. The Chinese authorities initiated their own enquiries into the source of the contaminated steel.

Also in November 2000, in Ulsan, Republic of Korea, an iridium-192 source of approximately 20 Ci (740 GBq) became stuck in its guide tube during non-destructive examination work. Two technicians began to cut the guide tube in order to retrieve the source, but accidentally cut into the source capsule itself. The immediate area was contaminated with dispersed material from the source, and one of the technicians received a significant external dose: he was treated in hospital but was not in serious condition. The area was sealed off and the contamination and damaged source removed.

In September 2000, the IAEA's Member States endorsed the use of a system for the categorization of radiation sources developed under the Agency's Action Plan on the Safety of Radiation Sources and the Security of Radioactive Materials. The system divides sources into three categories:

- higher risk (industrial radiography sources, teletherapy sources, irradiators);
- medium risk (brachytherapy sources, well logging sources and some fixed industrial gauges); and
- lower risk (fixed industrial gauges with lower activity sources).

This general categorization provides an indication of the priority that a regulatory authority should assign to the control of such sources.

An International Conference of National Regulatory Authorities with competence in the Safety of Radiation Sources and the Security of Radioactive Materials was hosted by the Government of Argentina in Buenos Aires in December 2000. The Conference was organized as part of the Action Plan on the Safety of Radiation Sources and the Security of Radioactive Materials established by the IAEA following a review of the conclusions of a major International Conference, held in Dijon in 1998.

The Buenos Aires Conference achieved its objective of facilitating a broad exchange of views and experience among the participants on the administrative, technical and managerial aspects of ensuring the regulatory control of radiation sources and radioactive materials by national authorities. Moreover, there were very important findings from the Conference; these may have an important impact on the Action Plan. A document summarizing the major findings of the Buenos Aires Conference is being submitted to the IAEA Board of Governors.

**Management of radioactive waste**

An International Conference on the Safety of Radioactive Waste Management took place in Córdoba, Spain, from 13 to 17 March 2000, organized by the IAEA in co-operation with the European Commission, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development and the World Health Organization, and hosted by the Government of Spain. More than 300 senior officials and scientists from 55 Member States and six international organizations participated in the Córdoba Conference. The programme included seven topical sessions, covering: the siting of radioactive waste management facilities; legislative and general safety aspects; the predisposal management of radioactive waste; near surface disposal; geological disposal; the management of disused radioactive sources; and the transboundary movement of radioactive waste.

The observations, conclusions and recommendations of the Córdoba Conference were presented to the IAEA's General Conference in September 2000. In resolution GC(44)/RES/12, the General Conference, inter alia, invited all Member States to "take the decisions necessary for the implementation of a national radioactive waste management policy, bearing in mind, inter alia, the Summary Observations, Conclusions and Recommendations of the Córdoba Conference" and requested the Secretariat to prepare a report on the implications for future work on the safety of radioactive waste management.

Management of solid radioactive waste

In June 1999, the Swiss Federal Department of the Environment, Transport, Energy and Communication set up an independent expert group to compare different concepts for long term, safe isolation of radioactive waste and to make recommendations for future actions. The report of the expert group was published in February 2000. The group concluded that a concept of "monitored long-term geological storage" could satisfy both technical safety requirements and social demands for reversibility. They envisaged, in addition to the main waste emplacement facility, construction of a separate "test facility" and "pilot facility". The test facility would be constructed first to investigate the suitability of the selected disposal site. The main facility would be designed to hold most of the waste to be disposed of, and the pilot facility would hold a small but representative fraction of the waste. The pilot facility would be monitored and controlled for as long as is considered necessary, during which time the waste in the main facility would be kept in a retrievable form. If no reason arose to retrieve the waste, the main facility could eventually be closed to complete geological disposal. The group recommended that, based on currently available information, a site at Wellenberg

appeared to be potentially suitable for the monitored geological storage concept, and proposed that steps should be taken towards constructing an exploratory drift at the site.

In May 1999 the company responsible for spent fuel management in Finland, Posiva, requested a "decision in principle" to permit the construction of a spent fuel repository at their preferred site, Olkiluoto. In January 2000 the regulatory body STUK gave its preliminary safety assessment, which was supported by an international review. It concluded that nothing in the assessments gave reason to believe that the safety requirements would not be fulfilled with the disposal concept proposed by Posiva, and therefore the preconditions for the decision in principle were fulfilled from the point of view of nuclear and radiation safety. Also in January 2000, the municipality of Eurajoki, in which Olkiluoto is situated, made a decision formally supporting the selection of Olkiluoto as the repository site. The Finnish Government announced in December 2000 its intention to allow the project to go ahead: this "decision in principle" will need to be endorsed by the parliament.

In November 2000, SKB, the company responsible for managing nuclear fuel and radioactive waste in Sweden identified three sites — Oskarshamn, in south-east Sweden, and Östhammar and Tierp, two neighbouring municipalities about 120 km north of Stockholm — that it wants to investigate as possible locations for a geological repository for spent fuel. The three sites, all in granite formations, were selected from a list of six candidate sites. SKB aims to identify one preferred site by about 2007. A government decision on whether site investigations can proceed is expected in 2001.

Radioactive discharges to the environment

At the annual meeting of the OSPAR Commission in June 2000, twelve of the Contracting Parties to the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention)[8] adopted a decision requiring the urgent review of current authorizations for discharges and releases of radioactive substances from nuclear reprocessing plants, with a view to implementing the non-reprocessing option for spent nuclear fuel management at appropriate facilities, and taking preventive measures against pollution from accidents. France and the United Kingdom, the only two Parties to the Convention that have such plants, abstained from voting and therefore, under the rules of the Convention, are not bound by the decision.

Management of residual radioactive waste

In March 2000, the Australian Department of Industry, Science and Resources (DISR) announced the completion of work to clean up the main sites used for nuclear weapon tests at Maralinga, South Australia. The major part of the work was the rehabilitation of areas contaminated with plutonium as a result of safety trials (non-nuclear explosions to simulate accidents involving nuclear weapons) between 1955 and 1963. More than 300 000 $m^3$ of

[8] Belgium, Denmark, Finland, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and Switzerland. Luxembourg subsequently indicated its support for the decision.

contaminated soil and debris was removed and buried in trenches 10–15 m deep, covered by 5 m of clean soil. Pits containing contaminated materials from previous cleanup operations were treated either by in situ vitrification of the contents or by exhuming and reburying the materials. The basic cleanup criterion used was that full-time occupation of any given area should in no case lead to an individual receiving doses greater than 5 mSv/a, but realistic assessments suggest that, in practice, the highest individual doses are likely to be much closer to 1 mSv/a. The only proposed restriction on use of the site relates to an area of about 120 $km^2$ that could not be cleaned up to the same standard without causing unacceptable environmental damage. This area is safe for transitory uses, such as travelling through or hunting in the area, but it is not suitable for full-time occupation. In October 2000, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) issued a licence authorizing the DISR to 'operate' the site as a 'controlled facility'. In order for the site to be returned to its traditional owners the Maralinga Tjarutja people, the DISR will need to apply to ARPANSA for a further licence to decommission the facility.

An International Conference on the Radiation Legacy of the 20$^{th}$ Century: Environmental Restoration was held in Moscow in November 2000. The conference was hosted by the Ministry of the Russian Federation for Atomic Energy, in co-operation with the IAEA, the European Commission and the Russian Academy of Sciences, and was attended by about 200 participants from 16 countries and six international organizations. In some respects, the conference was complementary to the International Symposium on Restoration of Environments with Radioactive Residues held in Arlington, USA, in 1999 (see the Nuclear Safety Review for the Year 1999), with greater emphasis being placed on restoration projects in Europe and the countries in the territory of the former Soviet Union. The Conference agreed on a set of conclusions and recommendations. One conclusion in common with the Arlington Symposium was that most restoration projects appeared to be working on the basis of radiation protection criteria applied to practices rather than, as recommended by ICRP and the IAEA, intervention criteria. Other conclusions of the Moscow Conference emphasized the importance of prioritizing restoration work, especially when the available resources are limited, and of fully re-establishing normal social and economic conditions in areas that have been restored.

The Agency completed a study of radiological conditions at sites in Algeria that were used for testing nuclear weapons. The report on the study has been submitted to the Algerian Government.

The United Nations 2000 General Assembly adopted resolution A/RES/55/44 on international co-operation and co-ordination for the human and ecological rehabilitation and economic development of the Semipalatinsk region of Kazakhstan. By the terms of that text, it stressed the need for extra efforts in solving problems with regard to the region and its population. The Assembly invited the Secretary-General to pursue a consultative process, with the participation of interested States and relevant United Nations agencies, on modalities for mobilizing the necessary support to seek solutions to the problems and needs of the Semipalatinsk region.

In November 2000, a preliminary mission organized by the United Nations Environment Programme (UNEP) visited several sites in Kosovo, Yugoslavia, where ammunition containing depleted uranium had been used during air attacks by NATO in 1999. This was a follow-up to a "desk assessment" conducted in 1999 by the UNEP/UNCHS[9] Balkans Task Force, and used additional information provided by NATO in 2000 about locations at which such ammunition was used. The mission participants, who included two experts from the IAEA, made measurements of external dose rates and took samples of soil, water, vegetation and milk. A report of the results from the mission will be used in planning a comprehensive mission in the Spring of 2001.

**Transport of radioactive materials**

The Nuclear Safety Review for the Year 1998 reported on the suspension of rail transport of spent nuclear fuel between Germany, Switzerland and France. France and Switzerland resumed shipments in 1998 and 1999 respectively. The resumption of transports within Germany was approved in January 2000, and approval was given by the Federal Agency for Radiological Protection (BfS) in September 2000 for shipments from Germany to France to resume. However, in October 2000, the French Government confirmed that it would not accept any further shipments of spent fuel from Germany until Germany accepted the return of vitrified high level waste from the reprocessing by Cogéma at its La Hague plant of German spent fuel from past shipments.

Shipments by sea of spent fuel and vitrified high level waste between Japan and France and the United Kingdom, pursuant to long term reprocessing agreements, continued to take place. Some coastal States close to the routes taken by the ships continued to express concern about the shipments. In December 2000, the Governments of Argentina, Brazil, Chile and Uruguay issued a joint statement reiterating their concern in relation to shipments of radioactive waste by the Cape Horn route, particularly with regard to potential harmful effects on the human populations along the coasts and the vulnerability of Antarctic and sub-Antarctic ecosystems. The statement expressed support for continued efforts within the framework of the competent international organizations aimed at strengthening standards for the safety of transport of radioactive materials.

**Miscellaneous**

Following an incident in 1998 in which a caesium-137 source was inadvertently melted in a steel smelter in Spain (as reported in the Nuclear Safety Review for the Year 1998), the Spanish authorities and steel industry signed a protocol establishing a "vigilance and control" system. Under the agreement, all scrap dealers and steel smelting facilities undertook to install radiation detectors and to train their staff in relevant aspects of radiation protection. The total cost of detection equipment for the whole country was estimated to be about one-third the cost of the decontamination measures taken after the 1998 incident.

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[9] United Nations Centre for Human Settlements (Habitat).

Contact Expert Group

The Contact Expert Group (CEG) for International Radioactive Waste Projects in the Russian Federation was established in 1995 to promote international co-operative efforts aimed at resolving radioactive waste management issues. Meetings of the CEG were held in Helsinki, Finland, in May 2000, and in Cherbourg, France in October 2000. The main topics at the meetings included:

- the Strategy Working Group's updated reports on strategy for radioactive waste and spent fuel management in the Russian Federation;
- a plan of measures for provision of environmental safety in the decommissioning of nuclear submarines and nuclear-powered ships, radwaste and spent nuclear fuel interim storage facilities (on-shore and floating) and remediation of radiation hazardous sites;
- a list of the most urgent projects requiring international support; and
- the formation of 'project-focused' working groups of the CEG to concentrate on specific high priority projects.

## PART 2: AGENCY ACTIVITIES IN NUCLEAR, RADIATION AND RADIOACTIVE WASTE SAFETY

The Agency's activities can be addressed in the context of the three main elements of the global safety culture:

(a) Legally binding international instruments, such as safety related conventions;
(b) Internationally accepted safety standards; and
(c) Application of those safety standards.

Only a very brief summary of some of the main activities in relation to the issues raised in Parts 1 and 3 (and not already covered in those parts) is given here; the Agency's safety related work in its various programmes is described in detail in the IAEA Annual Report, in the report submitted annually by the Secretariat to the IAEA General Conference, and on the Agency's WorldAtom web site at www.iaea.org.

### Conventions

The major safety related agreements currently in force are the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Nuclear Safety. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management has been opened for signature, but has not yet entered into force. Up-to-date lists of the Parties and Signatories to these Conventions can be found on the Agency's WorldAtom web site at www.iaea.org/worldatom/Documents/Legal/.

One part of the Agency's work in relation to these Conventions is administrative, typically including a secretariat role and, in the person of the Director General, the function of depositary. Important developments during 2000 are outlined in Part 1. The Agency also has specific, more active roles in relation to the Notification and Assistance Conventions when incidents occur; examples of such activities are indicated in the relevant sections of Part 1.

### Safety standards

Nine safety standards were published during 2000:

- in the general safety area, Safety Requirements on legal and governmental infrastructure for safety;
- in nuclear safety, Safety Requirements for the design and the operation of nuclear power plants and Safety Guides on fire safety in operations, software for computer based systems important to safety and operational limits and conditions;

- in radioactive waste safety, Safety Requirements on predisposal management of waste (including decommissioning), and a Safety Guide on the regulatory control of discharges to the environment;
- in transport safety, the 1996 Edition of the Regulations for the Safe Transport of Radioactive Material (in English) was reissued following some minor editorial changes.

A further eight Safety Guides were endorsed by the Commission on Safety Standards for publication, and another 65 new and revised safety standards are currently in preparation. The current status of all safety standards can be found on the Agency's WorldAtom web site at www.iaea.org/ns/CoordiNet/safetypubs/sftypub.htm.

A glossary aimed at harmonizing the terminology and definitions used in the various safety standards was completed in 2000. Although this is intended primarily as working material for the drafters and reviewers of safety standards, it is freely available, for informational purposes only, in hard copy or through the Agency's WorldAtom web site, at www.iaea.org/ns/CoordiNet/safetypubs/iaeaglossary/glossaryhomepage.htm.

The IAEA's safety standards on quality assurance (QA) are mostly used, directly or indirectly, to establish requirements at the utility–regulator interface. The industrial QA standards in the ISO 9000 series are progressively being used at the utility–supplier interface. A technical document, developed in collaboration with FORATOM, was published in 2000, providing an explanation of the technical differences between the IAEA and ISO standards. The comparison will be repeated in the coming years when new ISO standards are published.

**Providing for the application of safety standards**

Application of safety standards at the request of Member States is a statutory function of the Agency, and includes:

- Providing direct safety related assistance to Member States;
- Fostering the exchange of safety related information;
- Encouraging education and training;
- Rendering a wide range of safety review services; and
- Co-ordinating and supporting safety related research and development.

Many of these activities are supported through the technical co-operation (TC) programme.

Safety related assistance

In addition to the IAEA's Regular Budget, there are two major sources of direct safety related assistance from the Agency to Member States: the technical co-operation (TC) programme and extrabudgetary programmes.

By far the larger of the two is the safety related TC programme, through which the Agency supported 110 projects during 2000 in the various areas of nuclear, radiation and waste safety through the TC programme, amounting to about US$16 million.

A substantial activity in recent years has been the Model Project on upgrading radiation and waste safety infrastructure in more than 50 Member States, where the Agency is providing technical support and assisting in the implementation of Action Plans in the participating States. In order to quantify the progress achieved so far under the Model Project, peer review teams are visiting participating States to evaluate the adequacy of the legal and regulatory framework, the empowerment of the regulatory authority to enforce legislation and regulations, the system of notification, authorization and control of radiation sources, existing financial and human resources, and the number of adequately trained personnel. Seventeen such peer reviews were conducted during 2000.

Another major area of work is nuclear safety assistance to countries in central and eastern Europe and the former Soviet Union. Three TC projects in particular provide training courses, workshops, safety review missions and expert advice on key safety issues to countries in the region operating nuclear power plants with WWER and RBMK reactors. The three projects cover:

- support for safety assessment of nuclear power plants, aimed at strengthening the capabilities of operating and technical support organizations;
- capability for assessment of operational safety of nuclear power plants, aimed at assisting operating organizations in reviewing their own operational safety performance; and
- nuclear safety regulatory infrastructure, aimed at strengthening nuclear safety regulatory bodies.

An extrabudgetary project on accident analysis for the Kursk-1 nuclear power plant in the Russian Federation (an RBMK-1000 unit) was initiated in 1998. The first phase of the project was completed in 2000. The analysis methodology using both western and Russian computer codes was validated through a detailed assessment of the models used. The results will help plants in achieving independent accident analysis capabilities, and are applicable to any first generation RBMK power reactor. The second phase of the project will be the development of a training programme.

The Extrabudgetary Programme on the Safety of Nuclear Installations in South East Asia, Pacific and Far East Countries continued to provide assistance to China, Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. The Programme places particular emphasis on enhancing the technical capabilities of regulatory bodies and technical support organizations and the safety of nuclear power plants and research reactors. Activities during 2000 included an International Regulatory Review Team (IRRT) mission to China, and assistance to Indonesia, Malaysia and Viet Nam in addressing recommendations from earlier IRRT missions. Other assistance to China was provided in reviewing the Safety Assessment Report for Tianwan nuclear power plant and initiating a periodic safety review of Qinshan-1.

Information exchange

The Agency fosters the exchange of safety related information through conferences and seminars, a wide range of publications and electronic media.

Three major safety related conferences during 2000 were mentioned in Part 1:

- the International Conference on the Safety of Radioactive Waste Management was organized by the IAEA in co-operation with the European Commission, the OECD/Nuclear Energy Agency and the World Health Organization, and hosted by the Government of Spain in Córdoba;
- the International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials was organized by the IAEA and hosted by the Government of Argentina in Buenos Aires; and
- the International Conference on Radiation Legacy of the 20th Century: Environmental Restoration was organized by the Ministry of the Russian Federation for Atomic Energy in co-operation with the IAEA.

The International Symposium on the Uranium Production Cycle and the Environment, organized by the IAEA in co-operation with the Nuclear Energy Institute and the Uranium Institute included sessions on the safety, environmental and waste management aspects of uranium production.

A common feature of some recent events involving 'orphan' sources has been that symptoms of acute radiation exposure have been, at least initially, misdiagnosed by physicians, leading to delays in response and unnecessary exposure. In an effort to raise awareness and knowledge, the IAEA and WHO jointly issued a leaflet, aimed at physicians — primarily general practitioners and hospital emergency departments — on how to recognize and initially respond to an accidental radiation injury. The Agency also issued a technical document of practical procedures for assessment and response to radiological emergencies.

A Safety Report was published summarizing lessons learned from accidents in radiotherapy. Reports were also issued on recent accidents in Turkey, Peru and Georgia, highlighting the course of the accidents and lessons to be learnt.

At the request of the 1999 General Conference, the Secretariat conducted a survey among Member States on the national implementation of the Agency's Transport Regulations. A questionnaire was sent to all Member States and responses were received from 72 Member States, including all 30 of those with operating nuclear power plants. Of those States responding, 60 indicated that their national systems for regulating domestic and international transport of radioactive material were based on the IAEA's Regulations.

Education and training

Safety related training courses, workshops and seminars are supported by the Agency, mostly under the TC programme, but also through the EBPs and regular budget activities (in addition, a number of TC projects are dedicated to establishing/strengthening infrastructure for plant personnel training).

More than 60 training courses and workshops on safety related topics were organized under the TC programme. In addition, almost 350 fellowships and scientific visits were awarded.

Regional Post-Graduate Educational Training Courses were held on radiation protection in South Africa (in English) and on radiation protection and nuclear safety in Argentina (in Spanish). The second regional Basic Professional Training Course in Nuclear Safety was held in Brazil (in Spanish).

A standard training course for response to radiological emergencies was piloted through the European regional TC programme.

The 1996 Edition of the Agency's Transport Regulations will be put into force by all of the international modal organizations during 2001. During 2000, 84 people from 37 countries were trained at three regional transport safety training courses organized under the Agency's TC programme. Training materials, reflecting the 1996 Edition and the lessons learned from the course during 2000, will be completed in 2001.

The General Conference adopted a resolution GC(44)/RES/13, urging the Secretariat to intensify post-graduate educational course activities and to develop, in a systematic way, syllabuses and training material for particular target groups and specific uses of radiation sources and radioactive materials. This work is aimed at encouraging the harmonization of training in radiation protection and source safety and the application of the International Basic Safety Standards.

Safety related services

The Agency renders a range of safety review services to its Member States on request. During 2000, the Agency conducted:

- three full scope OSART[10] missions, one reduced scope OSART and four OSART follow-ups;
- five IPSART[11] missions and one follow-up;
- two design safety reviews, one seismic safety review and three follow-up missions, one site safety review preparatory mission and one

[10] Operational Safety Review Team.
[11] International Probabilistic Safety Assessments Review Team.

follow-up, and one preparatory visit for a review of instrumentation and control systems

- two INSARR[12] missions and eight expert missions to research reactors under IAEA Project and Supply Agreements;
- three full scope IRRT[13] missions, one reduced scope IRRT and one preparatory meeting;
- one RSRI[14] mission and six peer reviews of the effectiveness of national regulatory infrastructure for radiation safety in Asia;

The ASSET[15] service previously offered by the Agency has been replaced by a more broader scope service — PROSPER[16] — on the use of operating experience to improve operational safety performance. A pilot mission was conducted in 2000, along with seven seminars in five Member States to introduce the new service.

A new safety and technical advisory service on radioactive waste management was launched in 2000. The objective of this service is to assist Member States, on request, in the application of the Agency standards and ensure that all waste is managed in a safe manner, and in a way which protects both individuals and the environment.

The Agency also offers a service — TranSAS[17] — to appraise national implementation of the IAEA Transport Regulations. Two requests for such an appraisal were received during 2000, and one pre-mission visit was made. It is hoped that both requests can be met in 2001.

Research and development

14 Co-ordinated Research Projects (CRPs) on safety related topics were active during 2000: four in nuclear safety, six in radiation safety and four in radioactive waste safety. Four CRPs came to an end during the year, on methodologies for incident analysis, limitations of radioepidemiological assessments for stochastic radiation effects, comparison of the potential impacts of wastes from different electricity generation technologies and safety assessment methodologies for near surface radioactive waste disposal facilities. Two new CRPs were started, on methods and procedures to apply PSA techniques to large radiation sources, and on safety indicators (such as concentrations or fluxes of radionuclides) in the assessment of radioactive waste disposal. A CRP on reliability data for research reactor PSAs has been approved and will start in 2001.

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12 Integrated Safety of Research Reactors.
13 International Regulatory Review Team.
14 Radiation Safety Regulatory Infrastructure.
15 Assessment of Safety Significant Events Team.
16 Peer Review of Operational Safety Performance Experience.
17 Transport Safety Appraisal Service.

## PART 3: LOOKING AHEAD

This section provides a brief discussion of some forthcoming events, and of some safety related issues that are likely to be prominent in the coming years. (The order in which items appear is not intended to imply their relative importance.)

### Topical issues in nuclear safety

An International Conference on Topical Issues in Nuclear Safety, which will be held in Vienna on 3–6 September 2001, will address the following topics. The objective of the conference is to foster the exchange of information on topical issues in nuclear safety, with the aim of consolidating international consensus.

Risk informed regulatory decision making

A prerequisite for an expanded use of risk insights in both improved safety and a reduction in unnecessary regulatory requirements is the availability of a high quality 'living PSA'. Issues to be addressed include: the advantages and disadvantages of risk-informed decision making, and whether it will improve regulatory effectiveness; the value and limitations of PSA in underpinning risk-informed decision making; consistency between risk-informed decision making, defence in depth and good engineering practice; the criteria to be used in risk-informed decision making; and the treatment of uncertainties.

Influence of external factors on safety

The trend in many countries towards deregulation of the electricity supply business is creating much greater competition between electricity producers, and the resulting market pressures are forcing NPPs to further maximize production while minimizing costs. Staff reductions, outsourcing, increased use of contractors, reduced cost of regulation and oversight, increased on-power maintenance and testing with reduced outage length and frequency are some of the operational changes resultant from such pressures. Decisions on the future of nuclear installations — including early closures — based on factors other than economic or factual environmental considerations are also becoming more common. Issues to be addressed by the conference include: the possible role of economic pressures in encouraging or discouraging improved nuclear safety in the long term; the safety implications of decisions on early closure of nuclear installations; and the role of the regulator in ensuring that safety margins are not eroded without unnecessarily hindering the competitiveness of nuclear power.

Indicators of operational safety performance in nuclear power plants

There is growing interest in the use of measurable 'indicators' to provide continuous monitoring of the safety performance of nuclear power plants, so that possible improvements can be identified and any deterioration in safety performance can be detected at an early stage, preferably before it begins to affect safety. Sets of such indicators need to be defined at the plant level in order to give plant management a complete picture of the safety performance of the plant. At a higher level still, a regulatory body also needs to define a set of indicators to monitor the safety performance of the plants in the country, and for use in communication with the public. Questions then arise as to whether the same or similar sets of indicators can be applied at the different levels. The question can then be extended to whether a comprehensive set of operational safety performance indicators could be agreed at an international level. The IAEA has developed a framework for operational safety performance indicators and identified operational safety attributes. The use of this framework at the international level will be discussed.

Safety of nuclear fuel cycle facilities

International nuclear safety standards have to date been focused on nuclear power plants and research reactors. Although some similar safety hazards may be posed at reactor and non-reactor fuel cycle facilities, there are some safety issues specific to the non-reactor fuel cycle facilities that must be given special consideration in their design and operation, such as criticality, chemical toxicity, fire and explosion hazards. The relative importance of such hazards varies from facility to facility depending on the processes employed and the age, throughput, inventory and material condition of the plant. The IAEA now has a programme of work to develop specific safety standards for non-reactor fuel cycle facilities.

Safety of research reactors

The safety of research reactors has been identified as an issue of concern in previous Nuclear Safety Reviews, and the Agency's programme in this area has been strengthened. In April 2000 the Chairman of the International Nuclear Safety Advisory Group (INSAG) wrote to the IAEA's Director General, expressing the group's continued concern that the magnitude and urgency of the problem did not appear to have been fully appreciated by States. INSAG identified three major safety issues: the increasing age of research reactors; the number of research reactors that are shut down but not decommissioned; and the absence of appropriate regulatory supervision of research reactors in some countries. As well as indicating a need for immediate action to address these specific issues, INSAG proposed adding a protocol on research reactors to the Convention on Nuclear Safety, and suggested that the IAEA begin developing such a protocol.

In September 2000, the IAEA's General Conference adopted a resolution GC(44)/RES/14 which, inter alia, called upon all Member States with research reactors to ensure that those reactors are subjected to strict safety and radiation protection arrangements,

requested the IAEA to continue to monitor closely research reactors subject to IAEA Project and Supply Agreements, and requested the Agency to continue exploring options to strengthen the international nuclear safety arrangements for civil research reactors.

Maintaining competence in nuclear safety

As a result of uncertainties about the future of nuclear power in many countries, and the consequent lack of interest in working in the nuclear field (including related fields such as radiation protection and radioactive waste management), there is a corresponding lack of interest in educating and training people for such work. For example, higher educational opportunities in nuclear engineering have been greatly reduced by the elimination of nuclear engineering departments in many universities and the closure of research facilities. Meanwhile, the existing work force is ageing and no renewal is taking place.

In view of this situation, and in response to resolution GC(44)/RES/13, the IAEA is strengthening its educational and training activities in the field of nuclear safety. Several new courses are being offered covering basic nuclear safety, design and operational safety, regulatory control and accident analysis. In 2000, several courses have been held at various centres in Brazil, Germany, Slovenia and USA, and work has been initiated to prepare educational modules for distance learning in nuclear safety, reactor physics and thermal hydraulics. The IAEA is also participating in an international task force organized by the OECD/NEA to propose further actions to address the problem.

**Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management**

The Joint Convention will enter into force on the ninetieth day after the receipt by the depositary of the twenty-fifth instrument of ratification, acceptance or approval, including the instruments of 15 States each having an operational nuclear power plant. As of 31 December 2000, 23 States, including 16 that have operating nuclear power plants, had deposited such instruments.

Pursuant to Article 29 of the Convention, a preparatory meeting of the Contracting Parties shall be held not later than six months after the date of entry into force. At the preparatory meeting, the Contracting Parties will, inter alia:

- determine the date for the first review meeting, to be held as soon as possible, but not later than 30 months after entry into force;
- prepare and adopt Rules of Procedure and Financial Rules;
- establish in particular, and in accordance with the Rules of Procedure, guidelines regarding the form and structure of the national reports to be submitted by Contracting Parties, the process for reviewing such reports and a date for the submission of such reports.

In doing this, it is expected that the Contracting Parties to the Joint Convention will benefit from the experience during the first 'review cycle' of the Convention on Nuclear Safety.

**Convention on Nuclear Safety**

The second Review Meeting of Contracting Parties to the Convention on Nuclear Safety will begin on 15 April 2002. Under the terms of the Convention, each State or organization that will be a Contracting Party on that date[18] shall submit a report on steps and measures taken to implement Convention obligations, for review by the other Contracting Parties, and shall attend the Review Meeting. An Organizational Meeting is scheduled to begin on 25 September 2001. The Organizational Meeting will, inter alia:

- elect a President and two Vice-Presidents for the Review Meeting;
- agree the composition of country groups for the Review Meeting;
- elect a co-ordinator for each country group; and
- select chairpersons and rapporteurs for the country groups, and assign them in such a way that no rapporteur or chairperson is assigned to the country group of which his or her country is a member.

The deadline for submission of National Reports is 15 October 2001 (except for States ratifying after that date). The Summary Report of the first Review Meeting in 1999 identified a number of topics on which Contracting Parties agreed to provide more information in their National Reports to the second Review Meeting. These include:

- the "de jure" and "de facto" independence of regulatory bodies, experience gained in implementing different regulatory strategies, actions taken to monitor safety management, implementation of quality assurance systems for regulatory activities and international co-operation between regulatory bodies;
- further and more detailed information on the status of safety improvement programmes (including whether the original workplan and schedule have been implemented and, if not, the reasons why this has not been possible), with demonstration of progress achieved by safety assessments of the improved installations;
- evaluation of the performance and efficiency of the confinement function at existing nuclear power plants, including evaluation of the original design basis, impact of ageing, modifications to the original design, and evaluation of its capability to cope with events beyond the design basis, including severe accidents;
- probabilistic safety assessments, periodic safety reviews and updating of safety analysis reports;
- additional data on trends in collective doses and effluent releases; and

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[18] In order to be a Contracting Party on 15 April 2002, a State or organization must have deposited an instrument of ratification, accession, acceptance or approval with the depositary by 15 January 2002.

- information on improvements to emergency preparedness and response plans from the results of national and international exercises.

**Radiological criteria for long-lived radionuclides in commodities**

In the aftermath of the Chernobyl accident, criteria were developed for allowable concentration of radionuclides in foods moving in international trade following accidental contamination. The FAO/WHO Codex Alimentarius Commission published guideline levels in 1989, and these were used as the basis for "generic action levels for foodstuffs" specified in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources published by the Agency in 1996. These criteria were aimed at protecting consumers in the short term from foods contaminated with higher levels of fission products, while allowing trade in foods with levels of contamination low enough as not to pose a significant risk.

More recently it has become clear that criteria are also needed for commodities produced in areas where there is chronic contamination with long-lived radionuclides. This includes food products, but also other commodities, such as wood. Experience has shown that such commodities originating in countries affected by the Chernobyl accident are automatically suspected of being 'contaminated', irrespective of whether they contain significant activity. In resolution GC(44)/RES/15 the IAEA's General Conference requested the Secretariat, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, to develop during the next two years radiological criteria for long-lived radionuclides in commodities, particularly foodstuffs and wood. A Technical Committee meeting on the issue is scheduled for February–March 2001.

**International safety standards**

As business becomes increasingly globalized, differences between national standards are becoming an issue in more and more areas. Radiological criteria for commodities are just one example of a situation in which the use of different safety standards in different countries can affect international trade. It is increasingly the case that nuclear facilities in one country may be owned, financed, designed, constructed and/or operated by organizations based in another country: in principle, the applicable safety standards are those of the country in which the facility is located, but this may be problematic if the standards differ significantly from those of, say, the country in which the facility is designed. For innovative reactor designs such as the Pebble Bed Modular Reactor being developed in South Africa, which is intended to be produced for export, consistency in safety standards could be a crucial issue. Hence, it is expected that States will identify those issues for which international harmonization of safety standards would be beneficial. With respect to those issues, the IAEA would be the natural focal point for establishing harmonized safety standards.

**Radiation protection in medicine**

The increasing international attention on radiation protection in medicine was noted in the Nuclear Safety Review for the Year 1999. The interest in the topics is further illustrated by the fact that ICRP has recently published reports on radiation doses to patients from radiopharmaceuticals and on pregnancy and medical exposure and has a report in preparation on avoidance of radiation injuries from interventional procedures.

An international conference on Radiological Protection of Patients in Diagnostic and Interventional Radiology, Nuclear Medicine and Radiotherapy, organized by the IAEA and co-sponsored by the European Commission, the Pan American Health Organization and the World Health Organization, will be hosted by the Government of Spain in Torremolinos (Málaga) from 26 to 30 March 2001. The objective of the Conference is to foster the exchange of information on issues related to the radiological protection of patients during medical applications of radiation and to formulate recommendations, as appropriate, regarding further international co-operation in this area.

**Research and development for safety**

A consequence of increased commercial pressures on nuclear power plant operators is a re-evaluation of research and development priorities. In seeking to reduce expenditure on research and development, there may be a temptation to favour projects with the potential to improve performance or efficiency over those with the potential to improve safety. Within the safety related research and development, there may also be a tendency to focus on issues of immediate concern (e.g. issues currently being pursued by regulators) rather than those of longer term importance. Although this is unlikely to affect safety in the short term, there is concern that it could lead to a gradual degradation in operators' ability to cope effectively with future safety challenges in the longer term.

A challenge for regulators may be to identify whether particular changes in research and development priorities are of concern for safety. The research and development needs of a mature technology are different from, and typically less than, those of a developing one. Some reduction in research and development might therefore be entirely defensible for operators with established reactor designs, particularly if the prospects for the development of new plants in the future are poor. Considerable regulatory judgement will therefore be needed to decide whether cuts in research and development are acceptable.

**Geological disposal of radioactive waste**

A significant gap in the current programme to update the Agency's safety standards has been standards for the geological disposal of high level and long lived radioactive waste, an area in which there appeared to be insufficient international consensus. Events in 2000 suggested that progress might now be possible: the results of the Córdoba Conference and a subsequent Scientific Forum during the IAEA's General Conference indicated that a new

consensus on some of the key issues was beginning to emerge; and the Agency's Waste Safety Standards Committee approved an outline for a Safety Requirements publication. The Committee also identified specific topics on which consensus still needs to be developed: a Specialists' Meeting has been scheduled for June 2001 to attempt to resolve these issues.

**Protection of the environment**

Radiation and waste safety principles have historically focused on protecting humans from the effects of radiation, on the assumption that providing adequate protection for humans would ensure adequate protection of other species. There is, however, a growing interest among Member States in the explicit protection of the environment in its own right. This interest has been reflected in various international forums. In 1999, following several years of work, the IAEA published a discussion document on the issues. The International Union of Radioecologists (IUR) has established a programme of work, and in May 2000 ICRP announced the establishment of a Task Group to develop international recommendations.

In August–September 2000, the IAEA hosted a Specialists' Meeting. Three Working Groups addressed: ethical dimensions and principles; endpoint specification; and quantities, units and compliance. The meeting participants were able to agree on the overall objectives of environmental protection, the meaning of harm in the context of environmental protection, and the basis for approaches for assessment and compliance. It was agreed that priority should be given to building on the IAEA's discussion document in a systematic manner to develop an international system of protection for the environment. The Agency was urged to facilitate further information exchange, to work towards developing a Safety Guide on protection of the environment, and to provide a focus for co-operation with organizations such as ICRP and IUR. A second Specialists' Meeting will be held in Vienna during the week of 26-30 November 2001.

**Transport of radioactive materials**

The IAEA's Regulations for the Safe Transport of Radioactive Material specify radiation-safety-based requirements that are largely independent of the mode of transport employed. Regulations for the safe carriage of hazardous materials by specific modes of transport (modal regulations) are established by a number of international organizations. These include the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) for air transport, the International Maritime Organization (IMO) for sea transport, and the Inland Transport Committee of the United Nations Economic Commission for Europe (UN/ECE) for transport by road, rail and inland waterways. The parts of these modal regulations relevant to radioactive material have been modified to be consistent with the 1996 Edition of the IAEA Transport Regulations, and these modified regulations will enter into force over the course of 2001.

Work is already under way, however, on the next edition of the IAEA Regulations, which are expected to be published in 2003. The schedule for this and future revisions of the

IAEA Regulations has been designed to be better synchronized with the revision cycles of the modal regulations. It is therefore expected that the requirements of the 2003 Edition of the IAEA Transport Regulations will be incorporated more quickly into the relevant modal regulations.

**Information on nuclear events**

At the request of INSAG, the IAEA has developed, with the agreement of OECD/NEA and WANO, a Nuclear Events Web-based System (NEWS) to help make the dissemination of information on events to participants in Member States quicker and easier. NEWS may be regarded as an extension of the INES reporting mechanism, making use of the Internet. INES national officers will be able to post event reports directly on the system, WANO and nuclear power plant operators will be able to post press releases and similar information and all participants will have read access to the information on the system and access to a discussion forum. The system is currently undergoing trial use, and is expected to be put into operation during 2001. The success of the system will ultimately depend upon the readiness of participants to disseminate information on events quickly.

**Chernobyl**

There will be many events during 2001 to mark the fifteenth anniversary of the Chernobyl accident, reflecting on — inter alia — the lessons learned, the health, environmental, social and economic consequences and the ongoing remediation work in affected areas. These events will include two international conferences in Ukraine:

- "Fifteen Years after the Chernobyl Accident — Lessons Learned", organized by Ukraine's Ministry of Emergencies and Affairs of Population Protection from the Consequences of Chernobyl Catastrophe and the European Centre of Technological Safety, to be held from 11 to 13 April 2001; and
- "Health Effects of the Chernobyl Accident: Results of 15 Years' Follow-up Studies", organized by the World Health Organization and "Physicians of Chernobyl" from 4 to 8 June 2001.

**Early shutdown of nuclear power plants**

Several European countries have plans to close nuclear power plants earlier than originally intended. The reasons for such decisions vary: some States of central and eastern Europe have taken decisions for early closure in the context of negotiations on future membership of the European Union (EU), and some western European governments have decided, as a matter of national energy policy, to phase out nuclear power. There are safety issues that stem from those decisions, and these must be addressed in the coming years. For example, operational safety must be maintained from the time of the closure decision through to shutdown and decommissioning. This requires specific programmes that compensate for

the organizational and technical changes that will occur during this period. A decision for early closure can also reduce incentives for making upgrades to improve the safety of these facilities for their remaining period of operation. It could also be perceived as undermining regulators who have licensed a plant if political shutdown decisions are presented as safety related.

**Decommissioning issues**

As will be apparent from several items in Part 1 of this Review, particular attention will need to be given in the coming years to the decommissioning of nuclear power plants, research reactors, and other fuel cycle facilities. The Agency already has projects to provide assistance to Member States in this area both directly, notably in relation to the BN-350 nuclear power plant in Kazakhstan, unit 1 of Ignalina, Lithuania, and units 1, 2 and 3 of Chernobyl, and also through training activities. The Agency will need to expand its activities in this area, to ensure that the requisite technical expertise can be made available to Member States, to foster the necessary exchange of scientific and technical information, and to establish appropriate safety standards and assist in their implementation.

**Nuclear power plant fuel behaviour under off-normal conditions**

Under economic pressure, utilities are implementing more demanding fuel utilization schemes including increased burnup, longer fuel residence time and higher thermal rates. Over the next decade, the trend of higher burnup levels is projected to continue. The main licensing challenges from increases in burnup are in the area of fuel performance under accident conditions. National and international programmes to address the impact of high burnup are under way. With regard to fuel behaviour in loss of coolant accident conditions, these programmes should answer questions about the applicability of current fuel related criteria or justify new criteria. The first results appear to confirm the current criteria. With regard to fuel behaviour in reactivity initiated accidents, these programmes should provide a database of fuel failure boundaries for uranium dioxide and mixed oxide fuels for different burnups and cladding conditions, and knowledge of mechanisms and models describing fuel behaviour under such accident conditions. Recent simulation tests conducted in France, Japan and the Russian Federation have created a good basis for fuel performance analysis for this type of accident and will be continued. However, it is still unclear how these results can be extrapolated to higher burnups: intensive modelling work is needed to investigate.

**Spent fuel storage**

Higher fuel burnup, higher enrichment of fresh fuel and the use of plutonium in mixed oxide fuel affect the characteristics of the spent fuel, giving rise to higher decay heat, higher dose emission and a flatter downward curve over time. This demands a longer storage period than is necessary for most of the existing spent fuel in many countries, which had lower burnup. The lack of final repositories also leads to longer, and uncertain, periods of spent fuel

storage. The lifetime of existing storage facilities will therefore need to be extended and new facilities for long-term storage will have to be built.

Operating experience indicates that spent fuel can be safely stored for long periods of time: some spent fuel has now been stored for over 30 years, and there is a scientific and technical consensus that the present technologies of spent fuel storage give adequate protection to the population and the environment. The possible storage duration for different fuel types is dictated by the corrosion resistance of the cladding material and the storage technology used. Under dry inert conditions, spent fuel can be safely stored for long periods of time, but the creep strain capability of the materials used needs to be clarified. Creep tests should be done under realistic conditions (irradiation, oxidation, hydrogen, local effects, etc.) to assess the straining capability and to assure safety. An international surveillance programme on spent fuel behaviour under dry storage conditions appears to be needed to verify the predicted behaviour and provide assurance that no unexpected phenomena occur. Additional research and development is needed to obtain information on the long-term performance of spent fuel and storage systems including cladding materials, organic shielding, seals/gaskets and concrete performance. Regulatory criteria for extended storage should also be harmonized internationally.

**Research reactor fuel cycle**

Two major international programmes are helping to address safety issues related to the research reactor fuel cycle.

A major component of one programme, reduced enrichment in research and test reactors, involves the development and qualification of new, high density, low enriched uranium (LEU) fuels based on uranium–molybdenum alloys. This has the twin goals of enabling further conversion of reactors from highly enriched uranium (HEU) to LEU and of developing a substitute for LEU silicide fuel that can be more easily disposed of after expiry of the United States Foreign Research Reactor Spent Fuel Acceptance Programme in 2006. The challenge is to complete by 2006 testing to demonstrate that the new fuels are safe to use in reactors around the world, i.e. to achieve international qualification of the fuels. The programme is on schedule to qualify U–Mo dispersion fuels with uranium densities of up to 6 g/cm$^3$ by the end of 2003 and 8–9 g/cm$^3$ by the end of 2005. The IAEA is supporting the programme and will play a co-ordinating role in international qualification of the fuels.

Meanwhile, the Foreign Research Reactor Spent Fuel Acceptance Programme is proceeding on schedule with several shipments of both MTR and TRIGA fuel in 2000. This programme is continuing to reduce safety concerns at some sites where the spent fuel is seriously corroded. Based on interest expressed by the States concerned, the feasibility of a similar programme to return research reactor fuel of Russian/Soviet origin for storage and disposition in the Russian Federation is being discussed through a tripartite initiative involving the IAEA, the Russian Federation and the USA.