Radiation safety: New international standards

The forthcoming International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources are the product of unprecedented co-operation

by Abel J. González

By the end of the 1980s, a vast amount of new information had accumulated to prompt a new look at the standards governing protection against exposures to ionizing radiation and the safety of radiation sources.

First and foremost, a re-evaluation of the radioepidemiological findings from Hiroshima and Nagasaki suggested that exposure to low-level radiation was riskier than previously estimated.

Other developments — notably the nuclear accidents at Three Mile Island in 1979 and at Chernobyl in 1986 with its unprecedented transboundary contamination — had a great effect on the public perception of the potential danger from radiation exposure. Accidents with radiation sources used in medicine and industry also have attracted widespread public attention: Cuidad Juárez (Mexico), Mohamadia (Morocco), Goiânia (Brazil), San Salvador (El Salvador), and Zaragoza (Spain) are names that appeared in the news after people were injured in radiation accidents. Furthermore, the decade saw the rediscovery of natural radiation as a cause of concern for health: some dwellings were found to have surprisingly high levels of radon in air; natural radiation exposures of some non-radiation-related workers were discovered to be at levels much higher than the occupational limits specified in recognized standards.

Following these developments, the International Commission on Radiological Protection (ICRP) in 1990 revised its standing recommendations. The concerned organizations of the United Nations family and other multinational agencies promptly followed by triggering a review of their own standards.

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This article highlights an important result of this work for the international harmonization of radiation safety: specifically, it presents an overview of the forthcoming *International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources* — the so-called BSS. They have been jointly developed by six organizations — the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Labour Organization (ILO), the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (NEA/OECD), the Pan American Health Organization (PAHO), and the World Health Organization (WHO).

The framework for harmonization

In 1991, within the framework of the Inter-agency Committee on Radiation Safety, the six organizations created a Joint Secretariat under the co-ordination of the IAEA. The action capped decades of continuing efforts and marked an unprecedented international co-operation that has involved hundreds of experts from the Member States of the sponsoring organizations for establishing the BSS. These international standards supersede any previous ones in the field of radiation safety, in particular those developed under the auspices of the IAEA. *(See box, next page.)*

Radiation effects. From the time of early studies on X-rays and radioactive minerals it was recognized that exposure to high levels of radiation can harm exposed tissues of the human body. These radiation effects can be clinically diagnosed in the exposed individual; they are called *deterministic effects* because, given a radiation dose, they are determined to occur. Posteriorly, long-term studies of populations ex-

A number of bodies have supported the work to harmonize international radiation safety standards which draw upon information derived from extensive research and development by scientific and engineering organizations at national and international levels. For its part, the IAEA has the statutory authorization "to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health...". In discharging this function, the IAEA Board of Governors first approved Agency health and safety measures in March 1960. The Board approved the first version of the IAEA's *Basic Safety Standards for Radiation Protection* in June 1962 and a revised version in September 1965. A third revision was published by the IAEA as the 1982 Edition of *Safety Series No. 9;* this edition was jointly sponsored by the IAEA, the ILO, the OECD/NEA, and the WHO.*

The Inter-Agency Committee on Radiation Safety (IACRS). A number of years ago, the IAEA promoted the formation of IACRS as a mechanism for consultation and collaboration in radiation safety matters with competent organs of the United Nations and with the specialized agencies. The Committee aims *inter alia* to encourage the co-ordination of policies and consistency in radiation safety principles and standards. Members are the FAO, ILO, NEA/OECD, PAHO, UNSCEAR, WHO, Commission of the European Communities (CEC) and the IAEA. A number of organizations — the ICRP, the International Commission on Radiation Units and Measurements (ICRU), the International Electrotechnical Commission (IEC), the International Radiation Protection Association (IRPA) and the International Standards Organization (ISO) — have observer status.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). In developing the BSS, UNSCEAR provided the scientific information on which the standards are based. The Committee — which was established by the UN General Assembly in 1955 and today includes representatives from 21 countries — compiles, assesses, and disseminates information on the health effects of radiation and on the levels of radiation exposure from different sources.

International Commission on Radiological Protection (ICRP). Radiation safety standards are based on the recommendations of the ICRP, a non-governmental scientific organization founded in 1928. Its most recent recommendations were issued in 1990 (Publication 60, *Annals of the ICRP*, Vol. 21, No.1-3)) and form the basis of the BSS.

International Commission on Radiation Units and Measurements (ICRU). The quantities and units used in the BSS are primarily those recommended by the ICRU, a sister organization of the ICRP.*(See box, next page.)*

The International Nuclear Safety Advisory Group (INSAG). This advisory body of nuclear safety experts serves as a forum for the exchange of information and for the provision of advice to the IAEA on safety issues of international significance. In 1988, it issued through the IAEA the *Basic Safety Principles for Nuclear Power Plants* (Safety Series No. 75-INSAG-3). Many of these principles are relevant to the safety of other radiation sources and installations and have been used in the BSS.

* For a description of these previous international standards see the author's article in the *IAEA Bulletin*; Vol. 25, No. 3; (September 1983).

International harmonization in radiation safety

posed to radiation, especially of the survivors of the atomic bombing of Hiroshima and Nagasaki, have demonstrated that exposure to radiation also has a potential for the delayed induction of malignancies and possibly of hereditary effects. These radiation effects cannot be related to any particular individual exposed but can be inferred from epidemiological studies of large populations; they are called *stochastic effects* because of their aleatory statistical nature. *(See box, next page.)*

Human activities and radiation exposure: practices and interventions. Many beneficial human activities involve the exposure of people to radiation from both natural and man-made sources. These activities, which are planned in advance, may be expected to increase the background exposure that people already receive: they are termed *practices.*

On the other hand, there are radiation exposures incurred *de facto* by people. The activities which are intended to reduce these exposures are termed *interventions.*

Because of the radiation effects on health, practices and interventions need to be subject to certain standards of radiation safety to protect those persons adventitiously exposed.The BSS are intended to harmonize internationally the basic requirements for protecting people against undue radiation exposure in practices and interventions. *(See box, page 5.)*

Radiation health effects

Exposure to radiation can cause detrimental health effects. At large acute doses, radiation effects — such as nausea, reddening of the skin and, in severe cases, acute syndromes — are clinically expressed in exposed individuals within a short period of time after exposure. Large chronic dose rates also cause clinically detectable deleterious effects. These effects are called **deterministic** because they are certain to occur if the dose exceeds a certain threshold level.

At low doses as well, radiation exposure can plausibly induce severe health effects, such as malignancies, which are statistically detectable in a population, but cannot be unequivocally associated with an exposed individual. Hereditary effects due to radiation exposure have been statistically detected in mammals and are presumed to occur in humans as well. All these statistically detectable effects are called **stochastic** effects because of their aleatory nature.These effects are expressed after a latency period, presumably over the entire range of doses without a threshold level. In addition, there is a possibility of health effects in children exposed to radiation *in utero* during certain periods of pregnancy, including a greater likelihood of leukaemia and severe mental retardation.

Deterministic effects are the result of a process of cell killing due to radiation exposure, which, if extensive enough, can impair the function of the exposed tissue. The severity of a particular deterministic effect is higher as doses increase above the threshold which varies depending on the type of effects. The lower thresholds are a few sieverts for acute exposures and a few hundred millisieverts per year for chronic exposures. The likelihood of incurring the deterministic effect, therefore, is nil at lower doses and approaches certainty at threshold doses.

Stochastic effects may develop if an irradiated cell is modified rather than killed. Modified cells may, after a prolonged delay, develop into a cancer. The body's repair and defense mechanisms make this a very improbable outcome as doses become small; nevertheless, there is no evidence of a threshold dose below which cancer cannot result. The probability of occurrence of cancer is higher for higher doses, but the severity of any cancer that may result from irradiation is independent of the dose. If a stem cell whose function is to transmit genetic information is damaged owing to radiation exposure, it is conceivable that hereditary effects of various types may develop in the descendants of the exposed person.The likelihood of stochastic effects is presumed to be proportional to the dose received without dose threshold. The likelihood of severe radiation-induced stochastic effects during a lifetime is currently estimated to be around 5% per sievert of radiation dose for the general population.

Quantities and units in radiation safety

Although most of the requirements of the BSS are qualitative by nature, they also establish quantitative limitations and guidance levels. The quantities and units used in the BSS are based on the ICRP and ICRU recommendations.

The main physical quantities on which the BSS are based are: the **activity** or rate of emission of radiation from a radionuclide and; the **absorbed dose** or energy absorbed by a unit mass of a substance from the radiation to which it is exposed.

The **unit of activity** is the reciprocal second (number of emissions per second) which is named **becquerel (Bq)**. The **unit of absorbed dose** is the joule per kilogram, called the **gray (Gy)**.

The **absorbed dose** is the basic physical dosimetric quantity of the BSS but it is not entirely satisfactory for radiation protection purposes because effectiveness in damaging human tissue differs for different types of ionizing radiation. Consequently, the absorbed dose in tissues is multiplied by a weighting factor to take account of the effectiveness of the given type of radiation in inducing health effects.

The **equivalent dose** is the quantity resulting from weighting the absorbed dose with the effectiveness of the radiation type. But the likelihood of injurious effects due to a given equivalent dose differs for different organs and tissues. Consequently, the equivalent dose to each organ and tissue is multiplied by a tissue weighting factor to take account of the organ radiosensitivity.

The **effective dose** is the quantity resulting from the sum total of the equivalent doses weighted by the radiosensitivity of organs and tissues for all exposed organs and tissues in an individual.The **unit of equivalent dose and effective dose** is the same as the unit of absorbed dose, namely joule per kilogram, but the name used for the unit is **sievert (Sv).**

When radionuclides are taken into the body, the resulting dose is received throughout the period of time such radionuclides remain in the body.

The **committed dose** is the total dose delivered during the period of time the radionuclides remain in the body, and is calculated as the time integral of the rate of receipt of the dose. Any relevant dose restriction is applied to the committed dose from the intake. The **unit of committed dose** is the **sievert.**

The total impact of the radiation exposure delivered by a given practice or source depends on the number of individuals exposed and on the dose they receive.

The **collective dose**, defined as the summation of the products of the mean dose in the various groups of exposed people and the number of individuals in the group, is therefore used to characterize the radiation impact of a practice or source.The **unit of collective dose** is the **man-sievert**.

For operational purposes, the BSS use the **ambient dose equivalent** and the **personal dose equivalent.**These are quantities defined by the ICRU to facilitate measurement and monitoring while conforming with the radiation protection basic quantities.

Objective of the BSS

The declared aim of the BSS is to prevent the occurrence of deterministic effects of radiation and to restrict the likelihood of occurrence of stochastic effects.

For any justified *practice*, the objective is achieved by requirements for protecting the exposed individuals and for ensuring the safety of the source of exposure. Thus,

- the risk to any exposed individual is restricted, regardless of where or when the individual would commit the exposure, by keeping individual doses below specific dose limits; and
- any source of exposure is kept safe by, *inter alia*, a) constraining both the doses expected to be delivered by it with certainty and also the probability of delivering radiation doses due to (potential) exposures that may but are not certain to occur; b) keeping the delivered doses, the probabilities of incurring doses, and the number of exposed individuals as low as reasonably achievable under the prevailing circumstances; and c) applying to the source a number of administrative, technical, and managerial requirements intended to ensure its safety.

For any justified *interventions*, the objective is achieved by:

- keeping, under any foreseeable circumstance, the individual doses lower than the threshold levels for deterministic effects; and
- keeping all doses expected to be averted by the intervention as low as reasonably achievable under the prevailing circumstances.

Practices and interventions

Planned human activities that add radiation exposure to that which people normally receive due to background radiation, or that increase the likelihood of incurring exposure, are termed *practices*. The human activities that seek to reduce the existing radiation exposure, or the existing likelihood of incurring exposure, are termed *interventions*.

The BSS apply to both the commencement and the continuation of practices that involve or could involve radiation exposure, and also to existing, *de facto* situations in which exposure or its likelihood can be reduced or ruled out by means of some intervention. For a practice, provisions for radiation protection and safety can be made before its commencement, and the associated radiation exposures and their likelihood can be constrained from the outset. In the case of intervention, the circumstances giving rise to exposure or the likelihood of exposure already exist, and their reduction can only be achieved by means of remedial or protective actions.

The table presents the UNSCEAR summary of the relative radiological impact from some practices as well as from severe accidents that required intervention. The levels of radiation exposure are expressed as equivalent periods of exposures to natural sources.

Levels of radiation exposure

Exposure resulting from	Basis	Equivalent period of global exposure to average natural background
Nuclear weapons testing	All past tests	2.3 years
Apparatus and substances used in medicine	One year of practice at the current rate	90 days
Severe accidents	Accidents to date	20 days
Nuclear power generation (under normal operating conditions)	Total nuclear generation to date	10 days
	One year of practice at the current rate	1 day
Occupational activities	One year of occupational activities at the current rate	8 hours

Scope of the BSS

Exclusions. Any radiation exposure essentially unamenable to control through the BSS requirements is excluded from the BSS scope. Examples are the exposure caused by the naturally radioactive potassium, which is a normal constituent of the body, exposure to cosmic rays at ground level, and generally other naturally occurring exposures.

The BSS, moreover, only apply to:

- human beings (it is considered that standards of protection that are adequate for this purpose will also ensure that no other species is threatened as a population, even if individuals of the species might potentially be harmed); and
- ionizing radiation, namely gamma and X-rays and alpha, beta and other particles that can induce ionization; (the BSS do not apply to non-ionizing radiation, neither do they apply to the control of other non-radiological aspects of health and safety).

Apart from these exclusions, the BSS scope extends to any practices, including any radiation sources within those practices, provided they are not *exempted* from the BSS requirements, and to any interventions, including any related exposures.

Practices. The practices to which the BSS apply include:

- the use of radiation or radioactive substances for medical, industrial, agricultural, educational, training, and research purposes; and
- the generation of energy by nuclear power, comprising any activity in the nuclear fuel cycle which involves or could involve exposure to radiation or radioactive substances.

Sources. Within a practice, the BSS apply to any source of radiation being used in the practice, both natural sources and artificial sources, including:

The justification of practices and interventions

The justification of practices and interventions involves many factors, including social and political aspects, with radiological considerations usually playing a minor role. Some practical guidance on justification for practices and interventions provided by the BSS is summarized here.

Unjustified practices. The BSS provide guidance on unjustified practices. These practices include those that would result in an increase of the amount of radioactive substances in food, beverages, cosmetics, or other commodity or product intended for ingestion, inhalation or percutaneous intake by, or application to, a human being (except for medical purposes); and practices involving the frivolous use of radiation in commodities or products such as toys, personal jewelry, or adornments. Additionally, certain medical exposures are also deemed to be not justified: radiological examination for occupational, legal, or health insurance purposes; radiological examinations for theft detection purposes; exposure of population groups for purposes of mass screening; and the exposure of humans for medical research (unless it is in accordance with the provisions of the Helsinki Declaration, follows the guidelines for its application prepared by the Council for International Organizations of Medical Sciences (CIOMS) and WHO, and is subject to the advice of an Ethical Review Committee and to applicable national and local regulations).

Interventions. Intervention shall be justified if it is expected to achieve more good than harm, having regard to health, social and economic factors. The BSS establish that protective actions shall be nearly always justified if the doses in an intervention situation are expected to approach the values in the table below. However, actual intervention levels should be optimized and usually lead to much lower doses *(see table, page 10).*

Individual dose levels at which intervention shall be expected under any circumstances

Acute exposures

Organ or Tissue	Projected absorbed dose to the organ or tissue in less than 2 days (Gy)
Whole body	1
Lung	6
Skin	3
Thyroid	5
Lens of the eye	2
Gonads	3

Chronic exposures

Organ or Tissue	Annual equivalent dose rate (Sv/year)
Gonads	0.2
Lens of the eye	0.1
Bone marrow	0.4

- radioactive substances and devices that contain radioactive substances or produce radiation, such as consumer products, sealed sources, unsealed sources, and radiation generators; and
- installations and facilities which contain radioactive substances or devices which produce radiation, such as irradiation installations, mines and mills processing radioactive ores, installations processing radioactive substances, nuclear installations, and radioactive waste management facilities. (When an installation could release radioactive substances or emit radiation into the environment, it is as a whole considered as a source and the BSS apply to each individual source of radiation within the installation and to the installation as a whole.)

Exemption and clearance. Practices, and sources within a practice, may be *exempted* from BSS requirements if they meet established exemption criteria. The exemption criteria ensure that the individual risks arising from an exempted source are negligible and that the collective radiological impact does not warrant regulatory concern. Moreover, an exempted source must be inherently safe.

The exemption criteria are also expressed in exemption levels, i.e. levels of [radio]activity or activity concentration in materials below which exemption is almost automatic.

Materials and objects from practices and sources already subject to BSS requirements may be released from these requirements subject to satisfying *clearance* levels which shall not exceed the specified exemption levels.

Interventions. The intervention situations to which the BSS apply include any *de facto* situation causing people's exposure which can justifiably be reduced by intervention measures.

These include:

- emergency situations such as those created by environmental contamination in the aftermath of an accident; and

● chronic situations such as exposure to natural sources of radiation (e.g. radon in dwellings) and to radioactive residues from previous events and activities (e.g. chronic environmental contamination from past activities).

Exposures. The BSS apply to any exposure due to:

● any relevant practice or source, including: normal exposures (i.e. exposures that are certain to occur); potential exposures (i.e. exposures that may or may not occur); occupational exposures (i.e. exposures of workers); medical exposures (i.e. mainly exposures of patients); or public exposures (i.e. the remaining type of exposures).

● any relevant intervention situation involving: emergency exposure, including exposures requiring prompt intervention and other temporary exposure due to situations in which an emergency plan or emergency procedures have been activated; and chronic exposure, including exposure to natural radiation sources, exposure due to radioactive residues from previous events, and exposure due to radioactive contamination from practices and sources which, for whatever reason, have not been under regulatory control.

Natural sources. According to the BSS, exposure to natural sources shall normally be considered as a chronic exposure situation and be subject to requirements for intervention. Exceptions to this are: activities involving natural sources that cause increased public exposure due to, for example, discharges of radioactive substances into the environment and certain occupational exposures to radon which shall be subject to the requirements for practices if the intervention cannot reduce such exposure below action levels given by the BSS.

Individual dose limitation

The dose limits established by the BSS are intended to ensure that no individual is committed to unacceptable risk due to radiation exposure.

Dose Limits for Occupational Exposure

● an effective dose of 20 mSv per year averaged over 5 consecutive years;
● an effective dose of 50 mSv in any single year;
● an equivalent dose for the lens of the eye of 150 mSv in a year; and
● an equivalent dose for the extremities (hands and feet) and for the skin of 500 mSv in a year.

(In special circumstances, workers undertaking intervention may be exposed to up to 100 mSv in a single year.)

Dose Limits for Members of the Public

● an effective dose of 1 mSv in a year;
● in special circumstances, an effective dose up to 5 mSv in a single year provided that: the average dose over 5 consecutive years does not exceed 1 mSv per year; and the dose for special circumstances is specifically authorized by the regulatory authority;
● an equivalent dose for the lens of the eye of 15 mSv in a year; and
● an equivalent dose for the skin of 50 mSv in a year.

Application of the Dose Limits

The dose limits apply to the sum of the relevant doses from external exposure in the specified period and the relevant committed doses from intakes in the same period (the period for calculating the committed dose shall normally be 50 years for adults and 70 years for intakes by children). Compliance with this requirement can be determined through compliance with the condition that the personal dose equivalent from penetrating radiation during the year plus the sum of committed doses due to the intake of radionuclides during the year are lower than the relevant limit.

Obligations

The BSS establish general obligations in relation to both practices and interventions. The obligations are that, unless the exposure is excluded from the BSS:

● no practice shall be adopted, introduced, conducted, discontinued, or ceased and no source within the practice shall, as applicable, be mined, milled, processed, designed, manufactured, constructed, assembled, acquired, imported, exported, sold, loaned, hired, received, sited, located, commissioned, possessed, used, operated, maintained, repaired, transferred, decommissioned, transported, stored or disposed of, except in accordance with the requirements of the BSS, unless the practice or source is exempted from the requirements of the BSS; and

● whenever justified, existing *de facto* exposures shall be reduced through intervention, by undertaking remedial or protective actions in accordance with the requirements of the BSS.

Additionally, the BSS establish that any source containing radioactive substances shall be transported in accordance with the provisions of the IAEA *Regulations for the Safe Transport of Radioactive Material* (Safety Series No. 6, IAEA, Vienna (1990)) and with any applicable international convention.

Requirements

To enable fulfillment of the above obligations, the BSS establish the basic requirements for protection and safety.

The requirements have to be fulfilled in all activities involving radiation exposure with the

Guidance levels for diagnostic radiological procedures for a typical adult patient

Radiography

Examination	Entrance surface absorbed dose per radiograph (mGy)	
Lumbar spine	AP	10
	LAT	30
	LSJ	40
Abdomen, intravenous urography & cholecystography	AP	10
Pelvis	AP	10
Hip joint	AP	10
Chest	PA	0.4
	LAT	1.5
Thoracic spine	AP	7
	LAT	20
Dental	Periapical	7
Skull	AP	5
	PA	5
	LAT	3

PA= Posterior - anterior projection, LAT= Lateral projection, LSJ= Lumbo- sacral-joint projection; AP= Anterior - posterior projection

Computed tomography

Examination	Multiple scan average absorbed dose (mGy)
Head	50
Lumbar spine	35
Abdomen	25

Mammography

Average glandular dose per cranio-caudal projection
1 mGy (without grid) 3 mGy (with grid)

Fluoroscopy

Mode of operation	Entrance surface absorbed dose rate (mGy/min)
Normal	25
High level	100

force that is derived from the statutory provisions of the sponsoring organizations. They do not entail any obligation for States to bring their legislation into conformity with them, nor are they intended to replace the provisions of national laws or regulations, or the standards in force. Rather, they aim to serve as a practical guide for public authorities and services, employers and workers, specialized radiation protection bodies, and safety and health committees, laying down basic principles and indicating the different aspects that should be covered by an effective radiation protection programme.

Moreover, they are not intended to be applied as they stand in all countries and regions. Rather, they should be interpreted to take account of local situations, technical resources, and the scale of installations — factors which will determine the potential for application. As the BSS cover a broad range of practices and sources, many of the requirements have been drafted in general terms so that any given requirement may have to be fulfilled differently according to the type of practice, and source, or intervention, the nature of the operations, and the potential for exposures.

Requirements for practices. The BSS include requirements for administration, radiation protection, management, technological aspects and verification:

Administrative requirements. These include notification of intentions to carry out practices; registration or licensing of sources; responsibility of registrants and licensees; and exemption and decontrol (clearance) of sources.

Radiation protection requirements.These include justification of practices; dose limits for individuals; optimization for protection and safety; dose constraints for sources; and guidance levels for medical exposure. *(See boxes and tables, pages 5, 6, 7, and 8.)*

Management requirements. These include safety culture; quality assurance; human factors; and qualified experts. *(See box, page 9.)*

Technical requirements. These include security; defense in depth; and good engineering practice. *(See box, page 9.)*

Verification. This includes safety assessments; compliance; and records.

Requirements for intervention. The BSS establish administrative and radiation protection requirements for intervention as follows:

Administrative requirements. These include responsibilities of intervening organizations, registrants and licensees; and notification of situations requiring protective actions.

Radiation protection requirements. These include justification of intervention; and optimization of intervention and action levels. *(See box and tables, page 6 and 10.)*

The BSS are appended with detailed requirements for all types of exposure as follows:

For occupational exposures: Responsibilities of employers, registrants, licensees, workers; conditions of service (special compensatory arrangements, pregnant workers, alternative employment, conditions for young persons);

BSS technical requirements

The BSS establish technical requirements that address:

Security of sources. Sources are to be kept secure so as to prevent theft or damage and to prevent any unauthorized person from carrying out any of the actions specified in the obligations of the BSS, by ensuring that: ● control of a source not be relinquished without complying with all relevant requirements specified in the relevant registration or licence and without immediately communicating to the Regulatory Authority, and when applicable to the relevant sponsoring organization, information regarding any lost, stolen, or missing source; ● a source not be transferred unless the receiver possesses a valid authorization; and ● a periodic inventory of sources be conducted at a frequency appropriate to confirm that they are in their assigned locations and are secure.

Defense in depth. A multilayer system of protection and safety provisions commensurate with the radiation hazards involved is to be applied to sources, such that a failure at one layer is compensated for or corrected by subsequent layers, for the purposes of: ● preventing accidents that may cause exposure; ● mitigating the consequences of any such accident, if it does occur; and ● restoring sources to safe conditions after any such accident.

Good engineering practice. As applicable, the siting or location, design, construction, assembly, commissioning, operation, maintenance, and decommissioning of sources within practices is to be based on sound engineering which shall, as appropriate: ● reflect approved codes and standards and other appropriately documented instruments; ● be supported by reliable managerial and organizational features, with the aim of ensuring protection and safety throughout the life of the sources; ● include sufficient safety margins for the design and construction of the sources and for operations involving the sources, such as to assure reliable performance during normal operation, taking into account quality, redundancy, and inspectability, with emphasis on preventing accidents, mitigating their consequences, and restricting any future exposures; and ● take account of relevant developments in technical criteria, as well as the results of any relevant research on protection or safety and lessons from experience.

BSS management requirements

The BSS has established a number of management requirements to ensure radiation safety. They address:

Safety culture. A safety culture is to be established and maintained which encourages a questioning and learning attitude to protection and safety and to discourage complacency, by ensuring that: ● policies and procedures be established that identify the protection and safety of the public and workers as being of the highest priority; ● problems affecting protection and safety be promptly identified and corrected, commensurate with their importance; ● each individual's responsibilities including those at senior management levels for protection and safety be clearly identified and that each individual be suitably trained and qualified; ● clear lines of authority for protection and safety decisions be established; and ● organizational arrangements and lines of communications be established that result in an appropriate flow of protection and safety information at and between the various levels of the organization.

Quality assurance (QA). QA programmes are to be established that provide, as appropriate: ● adequate assurance that the specified requirements related to protection and safety are satisfied; and ● quality control mechanisms and procedures to review and assess the overall effectiveness of protection and safety measures.

Human factors. Provisions are to be made for reducing as far as practicable the contribution of human error to accidents and other events that could give rise to exposures, by ensuring that: ● all personnel on whom protection and safety depend be appropriately trained and qualified such that they understand their responsibilities and perform their duties with appropriate judgement according to defined procedures; ● sound ergonomic principles be followed as appropriate in designing equipment and operating procedures, so as to facilitate the safe operation or use of equipment, to minimize the possibility that operating errors will lead to accidents, and to reduce the possibility of misinterpreting indications of normal and abnormal conditions; ● appropriate equipment, safety systems, procedural requirements, and other necessary provisions be provided to reduce, as far as practicable, the possibility that human error will lead to inadvertent or unintentional exposure of any person; ● means be provided for detecting human errors and for correcting or compensating for them; and ● intervention in the event of failure of safety systems or of other protective measures be facilitated.

Qualified experts. Qualified experts are to be identified and made available for providing advice regarding the observance of the BSS. Registrants and licensees have to inform the Regulatory Authority of the arrangements made to provide the expertise necessary for observance of the BSS. This information shall include the scope of the functions of any qualified experts identified.

Guidelines for intervention levels in emergency exposure situations

Urgent protective actions

Action	Avertable dose
Sheltering	10 mSv for a period of no more than 2 days
Iodine prophylaxis	100 mGy (committed absorbed dose to the thyroid)
Evacuation	50 mSv for a period of no more than 1 week

Withdrawal and substitution of foodstuffs
(From the CODEX Alimentarius Commission guideline levels for radionuclides in food moving in international trade following accidental contamination)

Radionuclides	Foods destined for general consumption (kBq/kg)	Milk, infant foods, and drinking water (kBq/kg)
Caesium-134, Caesium-137, Ruthenium-103, Ruthenium-106, Strontium-89	1	1
Iodine-131		0.1
Strontium-90	0.1	
Americium-241, Plutonium-238, Plutonium-239	0.01	0.001

Long-term actions

Action	Avertable dose
Initiating temporary relocation	30 mSv in a month
Terminating temporary relocation	10 mSv in a month
Considering permanent resettlement	1 Sv in a lifetime

and requirements for classification of areas; local rules and supervision; personal protective equipment; co-operation between employers, registrants and licensees; individual monitoring and exposure assessment; monitoring of the workplace; health surveillance; records; and dose limitation in special circumstances.

For medical exposure: Responsibilities; justification of medical exposures; optimization of protection for medical exposures; guidance levels; dose constraints; maximum activity in therapy patients discharged from hospitals; investigation of accidental medical exposures; records.

For public exposure: Responsibilities; control of visitors; sources of external irradiation; radioactive contamination in enclosed spaces; radioactive waste; discharge of radioactive substances into the environment; radiation and environmental monitoring; consumer products.

For potential exposure — safety of sources: Responsibilities; safety assessment; requirements for design; requirements for operations; quality assurance.

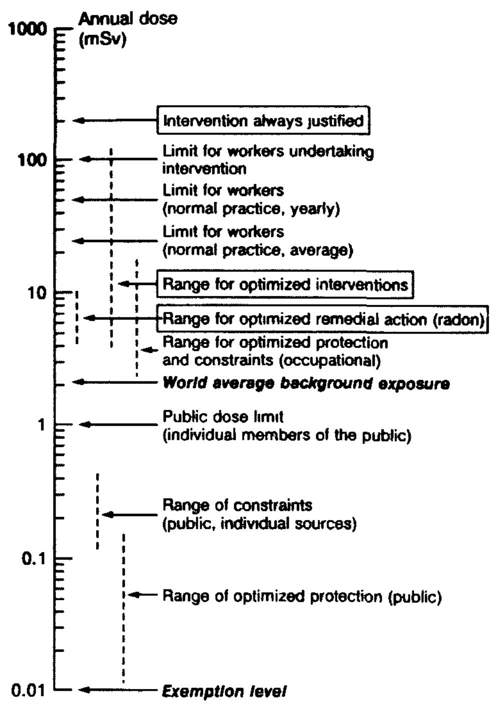
For emergency exposure situations: Responsibilities; emergency plans; intervention for emergency exposure situations; assessment and monitoring after accidents; cessation of intervention after an accident; protection of workers undertaking an intervention.

For chronic exposure situations: Responsibilities; remedial action plans; action levels for chronic exposure situations.

An international effort

The BSS establish a large number of interrelated requirements aimed at ensuring radiation protection and safety. *(See figure, next page.)* Although the majority of requirements are of a qualitative nature, the BSS also establish many quantitative requirements in terms of restrictions or guidance on the dose that may be incurred by people. The range of these doses is large, spreading over four orders of magnitude: from doses that are considered so minute as not to warrant

Implicit quantitative requirements and guidance for practices



The BSS encompass a large number of interrelated requirements which, in their entirety, provide adequate protection and safety. It is therefore impossible to paraphrase these requirements without losing their essence. The figure at right, however, attempts to provide a simplified visual description on how the BSS work for practices. The chart presumes compliance with the administrative requirements for registration or licensing.

regulatory concern, but rather exemption from the requirements, to doses that are so large as to make intervention almost mandatory. *(See figure.)*

The BSS mark the culmination of attempts that have continued over the past several decades towards the harmonization of radiation protection and safety standards internationally. Following this unprecedented international effort to draft and review the Standards, the BSS were endorsed at a meeting of a Technical Committee held at IAEA headquarters in Vienna in December 1993. It was attended by 127 experts from 52 countries and 11 organizations.

The IAEA's Board of Governors is expected to approve the BSS soon. Thereafter, the IAEA will issue the BSS in an interim publication (in English only). Once the Standards have been formally endorsed by the other sponsoring organizations, they will be issued in the IAEA Safety Series as a final publication in Arabic, Chinese, English, French, Russian and Spanish. ❐

How the BSS work for practices