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Radiation Therapy

1990-2001



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SCIENCE AND

INTERNATIONAL ATOMIC ENERGY AGENCY

P U B L I C A T I O N S

2001

Radiation Therapy

1990–2001



**DIVISION OF CONFERENCE AND
DOCUMENT SERVICES**

This catalogue lists all sales publications of the International Atomic Energy Agency dealing with Radiation Therapy, and issued during the period 1 January 1990 – 30 April 2001. Most publications are issued in English, though some are also available in other languages. This is noted as A for Arabic, C for Chinese, E for English, F for French, R for Russian and S for Spanish before the relevant ISBN number.

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RADIATION THERAPY

ACCIDENTAL OVEREXPOSURE OF RADIOTHERAPY PATIENTS IN SAN JOSE, COSTA RICA

This report summarizes the assessment made of an accidental over-exposure of radiotherapy patients that occurred at the San Juan de Dios Hospital in San José, Costa Rica, in August and September 1996. The assessment was carried out by an Expert Team convened by the IAEA in July 1997 at the request of the Government of Costa Rica. The findings of the Expert Team's assessment are presented in two parts: (1) an evaluation of the doses to patients by analysing the treatment records and physical measurements; and (2) a medical examination of patients, together with the autopsy findings for those who died. Thirty cross-sectional images are reproduced that show the dose reconstructions made for some of the patients. The purpose of the report is to foster information exchange with a view to preventing similar accidents in the future.

Contents: Preface; Executive Summary; 1. Overview of radiotherapy and radiation protection; Part I. Background; 2. History of the accident; 3. Expert Assessment organized by the IAEA; Part II. Findings of the Expert Team; 4. Assessment of the dosimetry and the status of the equipment and the facility; 5. Medical effects of radiation exposure of the patients; Part III. Conclusions and recommendations; 6. Conclusions and recommendations; Appendix I: Results of the dosimetric findings and the status of the equipment and the facility; Appendix II: Data on patients; Annex: Records on the participation of the San Juan de Dios Hospital in the IAEA/WHO TLD postal dose quality audit; Addendum: Reconstruction of the doses to normal tissue for patients with marked adverse effects.

STI/PUB/1027 (176 pp., 45 figures; 1998)

E ISBN 92-0-102098-8

S ISBN 92-0-302799-8

Price: 600 Austrian schillings (€43.60)

AN ELECTRON ACCELERATOR ACCIDENT IN HANOI, VIET NAM

On 17 November 1992 a radiological accident occurred at an electron accelerator facility in Hanoi, Viet Nam. An individual entered the irradiation room without the operators' knowledge and

unwittingly exposed his hands to the X ray beam. His hands were seriously injured and one hand had to be amputated. The report details the circumstances of the accident, its medical consequences and the governmental response.

Contents: 1. Introduction: 1.1. Background to the IAEA post-accident review; 2. Regulatory control in Viet Nam; 3. The irradiation facility: 3.1. Facility origins and layout; 3.2. Accelerator design and operation; 3.3. Safety systems and procedures; 4. The accident and the response: 4.1. The accident; 4.2. The response; 5. Medical management: 5.1. Before hospitalization; 5.2. In hospital in Hanoi; 5.3. Specialized treatment in Paris; 6. Assessment of the dose to the patient: 6.1. Post-accident measurements at the facility; 6.2. Materials exposed in the accident; 7. Lessons learned: 7.1. Conclusions; 7.2. Recommendations to organizations operating irradiation facilities; 7.3. General recommendations to regulatory authorities; 7.4. Recommendation to medical authorities; 7.5. Recommendations to equipment suppliers; Annex.

STI/PUB/1008 (36 pp., 15 figures; 1996)

E ISBN 92-0-100496-6

Price: 200 Austrian schillings (€14.53)

**ASSESSMENT OF DOSES TO THE
PUBLIC FROM INGESTED RADIONUCLIDES
Safety Reports Series No. 14**

This Safety Report provides practical information as a basis for radiation protection of the public in the event of accidental releases of radionuclides to the environment, transfer from environmental media into foodstuffs and ingestion by members of the public. It offers the scientific basis for the values of committed effective doses per unit intake of radionuclides via ingestion and their application, providing the information necessary to assess the radiological implications, in terms of doses to population groups, of the measured concentrations of radionuclides in foodstuffs independent of the source of exposure.

Contents: 1. Introduction; 2. Entry of radionuclides into the food chain; 3. Food consumption and dose assessment; 4. Dose coefficients for ingested radionuclides; 5. Dose assessment from measurements on individuals; Annex I. Food consumption in different countries; Annex II. Committed equivalent tissue doses per unit activity ingested by adults; Annex III. Activity in total body, thyroid and excreta after acute and chronic intake by ingestion of selected radionuclides.

STI/PUB/1067 (87 pp., 13 figures; 1999)

ISBN 92-0-100899-6

Price: 320 Austrian schillings (€23.26)

**CALIBRATION OF RADIATION PROTECTION
MONITORING INSTRUMENTS**
Safety Reports Series No. 16

→NEW

This Safety Report provides guidance on the establishment and operation of calibration facilities for radiation monitoring instruments. It reflects the current internationally accepted principles and recommended practices in calibration procedures, taking account of the major changes and developments that have occurred over the past decade.

Contents: 1. Introduction; 2. Terminology, quantities and units; 3. Fundamentals of calibration; 4. Calibration of photon measuring instruments; 5. Calibration of beta measuring instruments; 6. Calibration of neutron measuring instruments; 7. Calibration of surface contamination monitoring instruments; 8. Measurement uncertainties; Appendix I: An example of determining the overall uncertainties for the calibration of an instrument; Appendix II: An example of determining the calibration factor, N_1 , of an ambient dose equivalent rate meter — Calibration with reference instrument without monitor (calibration method 1); Appendix III: An example of determining the calibration factor of a photon measuring instrument by means of a monitor (calibration method 2).

STI/PUB/1074 (153 pp., 37 figures; 2000)

ISBN 92-0-100100-2

Price: 510 Austrian schillings (€37.06)

DIAGNOSIS AND TREATMENT OF RADIATION INJURIES
Safety Reports Series No. 2

The main purpose of this report is to assist physicians involved in the early medical handling of radiation victims to apply prompt diagnostic measures and emergency treatment. Special emphasis is given to localized radiation injuries, which are the most frequently occurring direct health effects observed from ionizing radiation. The lessons learned from the accidents at Chernobyl (Ukraine, 1986), Goiânia (Brazil, 1987), San Salvador (El Salvador, 1989), Soreq (Israel, 1990) and Nesvizh (Belarus, 1991) on the early medical handling of radiation injuries have been incorporated into this report.

Contents: 1. Introduction; 2. Types of accidental exposure and their medical management; 3. External exposure; 4. Contamination with radionuclides; 5. Combined radiation injuries; 6. Consulting system; 7. Record keeping; References; Annex I: Accidental exposure form samples; Annex II: Diagnosis and treatment of persons exposed to caesium-137: The Goiânia experience.

STI/PUB/1040 (59 pp.; 1998)

ISBN 92-0-100498-2

Price: 280 Austrian schillings (€20.35)

**DIRECT METHODS FOR MEASURING
RADIONUCLIDES IN THE HUMAN BODY:
A Safety Practice
Safety Serles No. 114**

This Safety Practice provides information on the establishment and operation of facilities for the measurement of body activity by direct methods, both in general application and in a range of specific situations. Emphasis is placed on measurements of body radioactivity made in programmes of internal dosimetry for occupationally exposed persons, or in investigations following incidents. Assessments of larger groups following general contamination of the environment are also addressed.

Contents: 1. Introduction; 2. Conditions for using direct methods for measuring radionuclides in the human body; 3. Techniques of investigation; 4. Analysis of data from measurements; 5. Practical details; References; Annex I. Indices of statistical significance and sensitivity; Annex II. Use of semiconductor detector in the investigation of internal contamination with complex mixtures of radionuclides; Annex III. Investigation of whole body ^{137}Cs with mobile equipment; Annex IV. Investigation of internal contamination with ^{60}Co ; Annex V. Estimation of whole body ^{137}Cs with a scanning array of NaI(Tl) detectors installed for assessment of fission and activation products; Annex VI. Assessment of ^{125}I and ^{131}I in the thyroid; Annex VII. Investigation of internal contamination with ^{241}Am ; Annex VIII. Assessment of uranium in the lungs.

STI/PUB/993 (110 pp., 44 figures; 1996)
ISBN 92-0-100896-1
Price: 400 Austrian schillings (€29.07)

**EFFECTS OF IONIZING RADIATION ON PLANTS
AND ANIMALS AT LEVELS IMPLIED BY CURRENT
RADIATION PROTECTION STANDARDS
Technical Reports Serles No. 332**

Releases of waste gases and liquids into the environment from facilities using radioactive materials are controlled so that people living in the vicinity are adequately protected from exposure to ionizing radiations. It is implicitly assumed that protecting humans will also protect the environment in which they live. Although this assumption has never been formally defended, neither has it been seriously challenged. This report examines the validity of the assumption for the case of radioactive releases to the terrestrial and freshwater environments and also for solid waste disposal underground.

Contents: 1. Introduction; 2. Summary of the available information on the effects of ionizing radiation on populations;

3. Estimated dose to plants and animals under current radiation protection standards; 4. Summary and conclusions; References.

STI/DOC/10/332 (74 pp., 2 figures; 1992)

ISBN 92-0-100992-5

Price: 280 Austrian schillings (€20.35)

**EXTENSION OF THE PRINCIPLES OF
RADIATION PROTECTION TO SOURCES
OF POTENTIAL EXPOSURE
Safety Series No. 104**

The principles of radiation protection recommended by the International Commission on Radiological Protection for the normal operation of a radiation source constitute a dose limitation system that has three components: namely, the justification of a practice, the optimization of radiation protection and the limitation of individual doses. This report describes how the application of these principles may be extended to unexpected or accidental situations by changing from the dose based system of radiation protection to a unified approach within a probabilistic framework.

Contents: Summary; 1. Introduction; 2. Basic principles; 3. Concepts and quantities; 4. Measures of societal risk; 5. Justification; 6. Optimization of potential exposures; 7. Limitation of individual risk; 8. Conclusions.

STI/PUB/834 (30 pp.; 1990)

ISBN 92-0-123590-9

Price: 160 Austrian schillings (€11.63)

**HEALTH SURVEILLANCE OF PERSONS
OCCUPATIONALLY EXPOSED TO IONIZING RADIATION:
GUIDANCE FOR OCCUPATIONAL PHYSICIANS
Safety Reports Series No. 5**

This Safety Report specifies features of work under radiation conditions, the general rules of radiological protection for occupational exposure and the organization of the medical surveillance of workers occupationally exposed to radiation. It supersedes IAEA Safety Series No. 83, Radiation Protection in Occupational Health: Manual for Occupational Physicians (1987).

Contents: 1. Introduction; 2. Modes of exposure; 3. Protection against occupational exposure; 4. Application of radiological protection principles; 5. Health surveillance and medical records;


6. Medical management of accidentally exposed workers; References; Annex: Health effects of ionizing radiation; Glossary.

STI/PUB/1056 (37 pp., 1 figure; 1998)

ISBN 92-0-103898-4

Price: 200 Austrian schillings (€14.53)

**INDIRECT METHODS FOR ASSESSING
INTAKES OF RADIONUCLIDES
CAUSING OCCUPATIONAL EXPOSURE
Safety Reports Series No. 18**

 **NEW**

This Safety Report provides assistance in the setting up and operation of an indirect monitoring programme for workers. As such it complements Safety Series No. 114, Direct Methods for Measuring Radionuclides in the Human Body (1996). It gives technical advice on the collection and analysis of biological and physical samples used to estimate intakes of radionuclides. The analytical methods described may also be applied to the monitoring of patients following medical treatment or of members of the public following a release of radionuclides to the environment.

Contents: 1. Introduction; 2. Selection of samples and methods of analysis; 3. Biological samples; 4. Physical samples; 5. Techniques of analysis; 6. Activity calculation and statistical considerations; 7. Quality assurance; 8. Records and reports; Annex I. Measurement of gamma emitting radionuclides in biological samples; Annex II. Analysis for beta emitting radionuclides in urine by liquid scintillation counting; Annex III. Analysis for strontium isotopes in urine; Annex IV. Analysis for ^{226}Ra , ^{228}Ra and ^{210}Pb in biological samples; Annex V. Analysis for uranium in urine by fluorimetry; Annex VI. Analysis for thorium in samples; Annex VII. Analysis for plutonium, americium and curium in urine and faecal samples by alpha spectrometry; Annex VIII. Analysis for tritium and ^{14}C by combustion techniques; Annex IX. Determination of creatinine in urine samples; Glossary.

STI/PUB/1090 (99 pp., 3 figures; 2000)

ISBN 92-0-100600-4

Price: 360 Austrian schillings (€26.16)

**INTERVENTION CRITERIA IN A NUCLEAR
OR RADIATION EMERGENCY
Safety Series No. 109**

This Safety Guide represents an international consensus and understanding on principles for intervention and numerical values for generic intervention levels. It became clear during the Chernobyl Project that there was a need for clarification of the international guidance on intervention and, moreover, for a simple set of inter-

nally consistent intervention levels having some generic application internationally. The recommendations in this publication are the basis for the standards and numerical guidance related to intervention that are contained in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (jointly sponsored by FAO, IAEA, ILO, OECD/NEA, PAHO and WHO).

Contents: 1. Introduction; Part I: Background and principles; Part II: Application to members of the public; Part III: Application to workers; Annex I: Technical analysis to assist in the selection of generic intervention levels; Annex II: Application of generic intervention levels; Annex III: Risk perspectives.

STI/PUB/900 (117 pp., 16 figures; 1994)

E ISBN 92-0-103094-0

F ISBN 92-0-201699-2

R ISBN 92-0-401698-1

S ISBN 92-0-303396-3

Price: 400 Austrian schillings (€29.07)

**LESSONS LEARNED FROM ACCIDENTAL
EXPOSURES IN RADIOTHERAPY**
Safety Reports Series No. 17

→ **NEW**

This Safety Report is a review of a large number of events that may serve as a checklist against which to test the vulnerability of a facility to potential accidents, and to provide a basis for improving safety in the use of radiation in medical applications. Furthermore, it is intended to encourage the development of a questioning and learning attitude, the adoption of measures for the prevention of accidents, and the preparation for mitigation of the consequences of accidents, if they occur.

Contents: 1. Introduction; 2. Review of accidents; 3. Classification of accidents; 4. Lessons learned and measures for prevention of accidents; Appendix: Appendix II of the BSS — Medical exposure: Optimization of protection for medical exposures.

Chinese, French and Spanish editions planned.

STI/PUB/1084 (93 pp., 1 figure; 2000)

ISBN 92-0-100200-9

Price: 340 Austrian schillings (€24.71)

**LESSONS LEARNED FROM ACCIDENTS IN
INDUSTRIAL IRRADIATION FACILITIES**

The purpose of this publication is to present the results of a review of accidents in industrial radiography which have either been

reported to regulatory authorities or to professional associations, or been published in scientific journals. Use of ionizing radiation in medicine, industry and research for technical development continues to increase throughout the world. Although this industry has a good safety record, there is a potential for accidents with serious consequences to human health because of the high dose rates produced by these sources. Five fatal accidents occurred between 1975 and 1994. Such accidents have prompted the present review, carried out by a team of manufacturers, regulatory authorities and operating organizations. Having closely looked at the circumstances of each accident, the apparent deficiencies in design, safety and regulatory systems, and personnel performance, the team made a number of recommendations. The findings of extensive research pertaining to the lessons that can be learned from irradiation accidents are presented.

Contents: 1. Introduction; 2. Brief description of accidents; 3. Major causes of accidents and lessons learned; 4. Prevention and remedial actions; Annex: Accidents with fatal consequences and with severe radiation injuries; References.

STI/PUB/1015 (52 pp., 10 figures: 1996)

E ISBN 92-0-102696-X

R ISBN 92-0-403597-8

S ISBN 92-0-303497-8

Price: 240 Austrian schillings (€17.44)

LESSONS LEARNED FROM ACCIDENTS IN INDUSTRIAL RADIOGRAPHY

Safety Reports Series No. 7

This Safety Report contains the findings of extensive research in terms of the lessons that can be learned from accidents which have occurred in industrial radiography, both in developed and developing countries. The review was carried out by a team of regulatory authorities, manufacturers and safety advisers. The objectives were to draw lessons from the initiating events of the accidents, the contributing factors and the consequences, and to identify several measures that, if implemented, would improve safety performance in industrial radiography.

Contents: 1. Introduction; 2. Primary causes of reported accidents; 3. Lessons learned; 4. Prevention and remedial actions; Annex I: Radiation protection training programme for radiographers; Annex II: Considerations for the safety operating procedures; Annex III: Emergency plan; References; Glossary.

STI/PUB/1058 (57 pp.: 1998)

ISBN 92-0-103098-3

Price: 280 Austrian schillings (€20.35)

**ONE DECADE AFTER CHERNOBYL —
Summing Up the Consequences
of the Accident
Proceedings Series**

Proceedings of an international conference, jointly sponsored by the European Commission, IAEA and WHO, and held in cooperation with UNDHA, UNESCO, UNEP, UNSCEAR, FAO and OECD/NEA, Vienna, 8–12 April 1996. Two major objectives were to reach agreement on established scientific facts and to clarify their interpretation in order to promote comprehension of the consequences of the Chernobyl accident and to help dispel misapprehensions. Background papers were prepared by teams of scientists from around the world who collaborated to ascertain and present the current state of knowledge on the health and environmental consequences of the accident. Nuclear safety aspects and the accident's social and economic impact were also considered, as well as the conclusions drawn at related conferences and in other national and international projects. The conference was attended by more than 800 experts in the field of radiation protection and nuclear safety, including medical, environmental and engineering specialists. The conference did much to achieve a broad consensus on the accident's consequences and to consolidate a common understanding of their nature and magnitude. In particular, the results of the conference will assist those countries most affected by the consequences in developing well informed and balanced policies for their alleviation. The proceedings contain a summary of the conference results and the texts of oral presentations and discussions, while an IAEA technical document (TECDOC) contains material from 181 poster presentations as well as the List of Participants.

Contents: Summary of the conference results; Opening session; Briefing seminar; Updating sessions; Keynote presentations. Technical symposium; Topical session 1: Clinically observed effects; Topical session 2: Thyroid effects; Topical session 3: Long term health effects; Topical session 4: Other health related effects; Psychological consequences, stress, anxiety; Topical session 5: Consequences for the environment; Topical session 6: Social, economic, institutional and political impact; Topical session 7: Nuclear safety remedial measures; Topical session 8: The consequences in perspective: Prognosis for the future; Concluding session of the technical symposium; Panel discussion; Closing session.

STI/PUB/1001 (555 pp., 42 figures; 1996)
ISBN 92-0-103796-1
Price: 1600 Austrian schillings (€116.28)

**OPERATIONAL RADIATION PROTECTION:
A GUIDE TO OPTIMIZATION
Safety Series No. 101**

The purpose of this publication is to provide practical guidance on the application of the dose limitation system contained in the Basic Safety Standards for Radiation Protection, Safety Series No. 9, to operational situations both in large nuclear installations and in much smaller facilities, with special reference to the principles of optimization. It supersedes Safety Series No. 13.

Contents: 1. Introduction; 2. Dose limitation system; 3. Optimization and its practical application to operational radiation protection; 4. Major elements of an effective operational radiation protection programme; Annex I: Review of selected parts of the Basic Safety Standards with special reference to operational radiation protection; Annex II: Optimization of radiation protection; Annex III: Techniques for the systematic appraisal of operational radiation protection programmes.

STI/PUB/806 (55 pp., 8 figures; 1990)

ISBN 92-0-123090-7

Price: 240 Austrian schillings (€17.44)

**PLANNING THE MEDICAL RESPONSE
TO RADIOLOGICAL ACCIDENTS
Safety Reports Series No. 4**

This Safety Report was jointly sponsored by the IAEA and WHO. It outlines the roles and tasks of health authorities and hospital administrators in emergency preparedness for radiological accidents and provides information relevant to the integration of medical preparedness into emergency plans.

Contents: 1. Introduction; 2. Classification of possible radiological accidents; 3. Basic medical response to radiological accidents; Annex I: Major radiation accidents (1945–1997) in nuclear industry, non-nuclear industry, research and medicine involving workers as well as members of the public; Annex II: List of international consulting centres; Annex III: Plan of an ideal reception centre for radiation casualties.

STI/PUB/1055 (31 pp.; 1998)

ISBN 92-0-102598-X

Price: 200 Austrian schillings (€14.53)

**RADIATION AND SOCIETY:
COMPREHENDING RADIATION RISK
Proceedings Series**

Proceedings of an international conference, Paris, 24–28 October 1994. Upon a request by the IAEA, the Swedish Risk Academy commissioned a set of background papers on issues relating to the comprehension of radiation risk to serve as a scientific input for the conference. The papers cover topics of importance for risk assessment and for comprehending and communicating on radiation risk.

Contents: (Vol. 1) 1. Introduction; 2. Comprehending radiation risk; 3. The concept of probability; 4. Risk perception; 5. Interpreting epidemiological results; 6. Problems in radiation risk assessment; 7. Cause structure of global mortality; 8. Radiation levels; 9. Problems in risk comparisons; 10. Risk communication; 11. Risk and ethics. (Vol. 2) Background papers prepared for the conference by IPSN; Poster presentations: Assessment of radiation exposure levels; Assessment of radiation health effects; Impact of radiation on the environment; Perception of radiation risk; Managing radiation risk; The nuclear weapons legacy; Cancer and leukaemia clusters; Radon in homes; Radioactive waste disposal and the environment; Chernobyl health effects. (Vol. 3) Conference summary; Opening addresses; Technical sessions; Case study sessions; Special lecture, closing addresses; Media forums, media and policy makers forum, decision makers session.

STI/PUB/959 (Vol. 1: 196 pp., 7 figures; 1994; Vol. 2: 455 pp., 84 figures; 1996; Vol. 3: 249 pp., 13 figures; 1997)

1: ISBN 92-0-102194-1

2: ISBN 92-0-103096-7

3: ISBN 92-0-101197-0

Price: Vol. 1: 640 Austrian schillings (€46.51)

Vol. 2: 1360 Austrian schillings (€98.84)

Vol. 3: 760 Austrian schillings (€55.23)

SAFETY STANDARDS SERIES

The IAEA Safety Standards Series comprises publications of a regulatory nature covering nuclear safety, radiation protection, radioactive waste management, the transport of radioactive materials, the safety of nuclear fuel cycle facilities and quality assurance. These publications are issued under the terms of Article III of the Agency's Statute, which authorizes the Agency to establish standards of safety for protection against ionizing radiation. The Safety Standards Series supersedes the Safety Series, in which over 200 publications were issued. Safety Standards Series publications are categorized into:

- Safety Fundamentals (F; blue lettering), stating basic objectives, concepts and principles of safety and protection;
- Safety Requirements (R; red lettering), establishing the requirements that must be fulfilled to ensure safety for particular activities or applications; and
- Safety Guides (G; green lettering), recommending actions, conditions or procedures for complying with these safety requirements.

For numbering purposes, the Safety Standards Series is subdivided into the areas of nuclear safety (NS), radiation safety (RS), transport safety (TS) and waste safety (WS), and also general safety (GS; that is, of relevance in two or more of the four areas).

RADIATION SAFETY

RADIATION PROTECTION AND THE SAFETY OF RADIATION SOURCES: A Safety Fundamental Safety Series No. 120

Jointly sponsored by FAO, IAEA, ILO, OECD/NEA, PAHO and WHO

This title was published as a Safety Fundamentals publication in the IAEA Safety Series and serves now as the Safety Fundamentals publication on Radiation Safety for the IAEA Safety Standards Series.

This Safety Fundamentals publication provides a coherent set of objectives and principles for protection against ionizing radiation

and for ensuring safety in the use of radiation sources. The protection objective and the safety objective, together with the eleven principles that have to be applied to achieve them, represent an international consensus. They provide the basis for the requirements in IAEA Safety Standards for the control of occupational, public and medical exposures and for the safety of sources. The Safety Fundamentals also provide an insight into the general system of protection and safety for those at senior levels in government and regulatory bodies and those responsible for making decisions relating to the uses of radiation in medicine, industry, agriculture, research and other areas.

Contents: 1. Introduction; 2. Biological effects of irradiation; 3. Objectives of protection and safety; 4. Principles for practices; 5. Principles for intervention; 6. Implementation principles; 7. Infrastructure for protection and safety; Definitions.

STI/PUB/1000 (24 pp.; 1996)

ISBN 92-0-105295-2

Price: 160 Austrian schillings (€11.63)

**INTERNATIONAL BASIC SAFETY STANDARDS
FOR PROTECTION AGAINST IONIZING
RADIATION AND FOR THE SAFETY
OF RADIATION SOURCES: A Safety Standard
Safety Series No. 115**

Jointly sponsored by FAO, IAEA, ILO, OECD/NEA, PAHO and WHO

This title was published as a Safety Standards publication in the IAEA Safety Series and serves now as the Safety Requirements publication on Radiation Safety for the IAEA Safety Standards Series.

These Standards are based on the latest assessments of the biological effects of irradiation made by the United Nations Scientific Committee on the Effects of Atomic Radiation, and on the recommendations of the International Commission on Radiological Protection and the International Nuclear Safety Advisory Group. The Standards represent an international consensus on qualitative and quantitative requirements for protection and safety for: planned practices such as nuclear power generation and the use of radiation and radioactive materials in medicine and industry; intervention in existing situations such as chronic exposure to natural sources of radiation or exposure following an accident; control of radiation sources, including notification and authorization, and criteria for exemption. Consensus guidance is also given on: occupational radiation protection; protection of patients in radiography, fluoroscopy, computer tomography, mammography and nuclear medicine; protection of members of the public from exposure to radioactive

materials released to the environment; prevention of incidents giving rise to potential exposures; and intervention in a radiological emergency.

Contents: Preamble: Principles and fundamental objectives; Principal requirements: 1. General requirements; 2. Requirements for practices; 3. Requirements for intervention. Appendices: Detailed requirements: Occupational exposure; Medical exposure; Public exposure; Potential exposure: Safety of sources; Emergency exposure situations; Chronic exposure situations; Schedules: Exemptions; Dose limits; Guidance levels of dose, dose rate and activity for medical exposure; Dose levels at which intervention is expected to be undertaken under any circumstances; Guidelines for intervention levels and action levels in emergency exposure situations; Guidelines for action levels in chronic exposure situations; Glossary; Index.

STI/PUB/996 (353 pp.; 1996)

A ISBN 92-0-104195-7

C ISBN 92-0-505196-9

E ISBN 92-0-104295-7

F ISBN 92-0-204497-X

R ISBN 92-0-401598-7

S ISBN 92-0-300397-5

Price: 1080 Austrian schillings (€78.49)

THE BASIC SAFETY STANDARDS ON DISKETTE

Safety Series No. 115

This Windows based software program contains the text and data from the English printed version of Safety Series No. 115. The user of the program should be generally familiar with the organization and content of the Standards. The program enables the user to search for and retrieve any topic directly through the 'Contents' tree, with access based on keyword searches, a subject index or cross-referencing. The definitions of the main concepts can be found in the 'Glossary' list. Text may be printed directly, or used in the development of other documents through the normal 'copy and paste' Windows feature. The software requires an IBM compatible Personal Computer with an 80386 processor or better, more than 4 MB internal memory, at least 4 MB free memory on hard disk and Windows 3.11 or Windows '95.

Contents: Preamble: Principles and fundamental objectives; Principal requirements: 1. General requirements; 2. Requirements for practices; 3. Requirements for intervention. Appendices: Detailed requirements: Occupational exposure; Medical exposure; Public exposure; Potential exposure: Safety of sources; Emergency exposure situations; Chronic exposure situations; Schedules: Exemptions; Dose limits; Guidance levels of dose, dose rate and

activity for medical exposure; Dose levels at which intervention is expected to be undertaken under any circumstances; Guidelines for intervention levels and action levels in emergency exposure situations; Guidelines for action levels in chronic exposure situations. Glossary; Index.

STI/DAT/2 (1997)

ISBN 92-0-100997-6

Price: single user: 300 Austrian schillings (€21.80)

multiuser: 600 Austrian schillings (€43.60)

**OCCUPATIONAL RADIATION PROTECTION: Safety Guide
Safety Standards Series No. RS-G-1.1**

The present Safety Guide provides general guidance on the establishment of an effective radiation protection programme for occupational exposure, appropriate for the sources of radiation likely to be encountered in a range of industries, medical institutions, educational and research establishments and nuclear fuel cycle facilities. The report further provides the necessary guidance to meet the requirements as laid down in Safety Series No. 115, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (1996).

Contents: 1. Introduction; 2. Framework for occupational radiation protection; 3. Dose limitation; 4. Optimization of radiation protection for practices; 5. Radiation protection programmes; 6. Intervention in emergencies; 7. Health surveillance.

Arabic, Chinese, French, Russian and Spanish editions planned.

STI/PUB/1081 (73 pp., 2 figures; 1999)

ISBN 92-0-102299-9

Price: 200 Austrian schillings (€14.53)

**ASSESSMENT OF OCCUPATIONAL EXPOSURE
DUE TO INTAKES OF RADIONUCLIDES: Safety Guide
Safety Standards Series No. RS-G-1.2**

The present Safety Guide addresses the assessment of exposure due to intakes of radionuclides in the workplace and reflects the major changes which have occurred in international practice in internal dose assessment over the past decade. The report further provides the necessary guidance to meet the requirements as laid down in Safety Series No. 115, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (1996).

Contents: 1. Introduction; 2. Dosimetric quantities; 3. Monitoring programmes; 4. Direct methods; 5. Indirect methods; 6. Biokinetic

models for internal dosimetry; 7. Interpretation of measurements; 8. Dose record keeping and reporting; 9. Quality assurance; Appendix I: Suggested criteria for individual monitoring; Appendix II: Detection limits for measurement methods; References; Annex I: Basic data.

Arabic, Chinese, French, Russian and Spanish editions planned.

STI/PUB/1077 (85 pp., 7 figures; 1999)

ISBN 92-0-101999-8

Price: 200 Austrian schillings (€14.53)

**ASSESSMENT OF OCCUPATIONAL EXPOSURE
DUE TO EXTERNAL SOURCES OF RADIATION:**

Safety Guide

Safety Standards Series No. RS-G-1.3

The present Safety Guide addresses the assessment of exposure to external sources of radiation in the workplace and the monitoring of workers and the workplace in such situations. It also reflects the major changes over the past decade in international practice in external dose assessment. It further provides the necessary guidance to meet the requirements as laid down in Safety Series No. 115, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (1996).

Contents: 1. Introduction; 2. Dosimetric quantities; 3. Monitoring programmes; 4. Dosimetric specifications; 5. Type testing; 6. Pre-use and periodic testing; 7. Performance testing; 8. Dose record keeping and reporting; 9. Quality assurance; Appendix: Monitoring for skin contamination and assessment of skin dose; References; Annex I: Summary of recommended radiation weighting factors and Q-L relationships; Annex II: Instrumentation for individual monitoring; Annex III: Instrumentation for workplace monitoring; Annex IV: Reference conditions and standard test conditions; Annex V: Data relevant to type testing of personal dosimeters and area monitors in terms of the operational quantities; Annex VI: Examples of IEC standards on radiation monitoring equipment.

Arabic, Chinese, French, Russian and Spanish editions planned.

STI/PUB/1076 (89 pp., 5 figures; 1999)

ISBN 92-0-101799-5

Price: 200 Austrian schillings (€14.53)

FORTHCOMING

**BUILDING COMPETENCE IN RADIATION
PROTECTION AND THE SAFE USE OF
RADIATION SOURCES**

Safety Standards Series No. RS-G-1.4

This forthcoming Safety Guide makes recommendations concerning the building of competence in protection and safety within a national radiation protection infrastructure and provides guidance for setting up the structure for a national strategy. It relates to the training and assessment of qualification of new personnel and the retraining of existing personnel in order to develop and maintain appropriate levels of competence. It provides the necessary guidance to meet the requirements as laid down in Safety Series No. 115, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (1996).

Contents: 1. Introduction; 2. Responsibilities for building competence in protection and safety; 3. Education, training and work experience; 4. A national strategy for building competence in protection and safety.

Foreseen publication date: June 2001

STI/PUB/1108 (approx. 37 pp., 1 figure; 2001)

ISBN 92-0-100701-9

Price not yet set.

**ORPGUIDE - SOFTWARE ON OCCUPATIONAL
RADIATION PROTECTION**

NEW

This CD-ROM provides guidance on Occupational Radiation Protection (ORP) and comprises the following IAEA publications: Safety Series No. 120, Radiation Protection and the Safety of Radiation Sources: A Safety Fundamental (1996); Safety Series No. 115, International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources: A Safety Standard (1996); Safety Standards Series No. RS-G-1.1: Occupational Radiation Protection: Safety Guide (1999); Safety Standards Series No. RS-G-1.2: Assessment of Occupational Exposure Due to Intakes of Radionuclides: Safety Guide (1999); and Safety Standards Series No. RS-G-1.3: Assessment of Occupational Exposure Due to External Sources of Radiation: Safety Guide (1999). These documents, jointly sponsored by the IAEA and ILO, provide the user with a comprehensive set of safety standards on occupational radiation protection. The three interrelated Safety Guides reflect the current internationally accepted principles and recommended practices in occupational radiation protection and provide guidance on meeting the requirements laid down in Safety Series No. 115. The Safety

Fundamentals publication, Safety Series No. 120, states basic objectives, concepts and principles of occupational radiation protection.

IAEA-ORPG-CD (2000)
ISBN 92-0-103100-9
Price: 900 Austrian schillings (€65.41)

Special set price:
ORPGUIDE together with hard copies of Safety Series Nos 115, 120 and
Safety Standards Series Nos RS-G-1.1., RS-G-1.2 and RS-G-1.3
IAEA-ORPG-SET (2000)
Price: 1500 Austrian schillings (€109.01)

THE CRITICALITY ACCIDENT IN SAROV

NEW

On 17 June 1997 a physicist working as a senior technician at the Nuclear Centre, Sarov, in the Russian Federation, was severely exposed as a result of a criticality accident with an assembly of highly enriched uranium. The exposure, which caused a high neutron radiation dose, led to death within three days despite prompt medical attention. This is the first report that the IAEA has published on a criticality accident. It is based on the information provided by the Russian authorities and addresses the circumstances leading to the accident as well as the medical management of the patient.

Contents: 1. Introduction; 2. Radiation protection and regulatory control in the Russian Federation; 3. The site of the accident; 4. Circumstances of the accident; 5. Response to the accident; 6. Dosimetric analysis; 7. Medical treatment of the patient; 8. Findings of the post mortem investigation (autopsy); 9. Findings and lessons to be learned.

Russian edition planned.

STI/PUB/1106 (46 pp., 15 figures; 2001)
ISBN 92-0-100101-0
Price: 210 Austrian schillings (€15.26)

THE RADIOLOGICAL ACCIDENT AT THE IRRADIATION FACILITY IN NESVIZH

On 26 October 1991, a fatal radiological accident occurred at an industrial sterilization facility in Nesvizh, Belarus. Following a jam

in the internal product transport system, the operator entered the irradiation chamber to clear the fault. In doing so, he bypassed a number of safety features, leaving the controls in a position such that exposure was imminent. It was estimated that he received a whole body dose of 11 Gy, with localized areas of up to 20 Gy. Despite intensive medical treatment, he died 113 days later. The significant feature of this case was related to the medical management. In its post-accident review, the IAEA also brought to light other circumstances of the accident. The present report documents the causes and consequences of the accident and defines the lessons learned with a view to assisting those people with responsibility for the safety of such facilities and those medical authorities who might be involved in the management of a radiation event.

Contents: 1. Introduction; 2. Irradiation facility; 3. Radiation accident; 4. Dose estimation; 5. Lessons learned; 6. Medical management; Annex I: Estimation of whole body dose from blood cell counts; Annex II: Results of cytogenetic analyses; Annex III: List of drugs, doses and administration dates.

STI/PUB/1010 (76 pp., 37 figures; 1996)

ISBN 92-0-101396-5

Price: 280 Austrian schillings (€20.35)

THE RADIOLOGICAL ACCIDENT IN GOIÂNIA

The Government and authorities in Brazil were faced with a tragic accident in Goiânia resulting from the misuse of a strongly radioactive medical teletherapy source not under radiation protection surveillance. The present report is divided into four parts: a chronology of destruction of the source, discovery of the accident and initial response; a description of the human consequences and the dosimetry and treatment of seriously exposed and contaminated persons; an account of the assessment of the environmental contamination and the remedial actions taken; and observations and recommendations. Appendices and annexes give an assessment of the effectiveness of international co-operation in the emergency response, and provide further information on: public communications; radiological survey equipment; guidelines for the discharge of patients; radiological protection; chemical decontamination; and the lessons learned.

Contents: Executive summary; Part I. The accident: 1. Introduction; 2. Background information; 3. Description of the accident; 4. Initial actions upon discovery of the accident; Part II. The human consequences: Dealing with the people affected; 5. Medical response; 6. Dosimetry; Part III. The environmental contamination: Assessment and remedial actions; 7. Introduction and account of actions taken; 8. Environmental assessments;

9. Decontamination; 10. Waste disposal; Part IV. Observations and recommendations; Appendices and annexes.

STI/PUB/815 (132 pp., 25 figures + 32 colour photographs; 1988)

E ISBN 92-0-129088-8

F ISBN 92-0-229089-X

R ISBN 92-0-429089-7

S ISBN 92-0-329089-3

Price: 430 Austrian schillings (€31.25)

THE RADIOLOGICAL ACCIDENT IN ISTANBUL



A serious radiological accident occurred in Istanbul, Turkey, in December 1998 and January 1999 when two packages used to transport ^{60}Co teletherapy sources were sold as scrap metal. The persons who purchased the two packages opened them and broke open the shielded containers, thereby unknowingly exposing themselves and several others to radiation from at least one unshielded ^{60}Co source. The persons who dismantled the containers suffered from acute radiation syndrome. Altogether, eighteen persons were admitted to hospital, ten of which exhibited clinical signs and symptoms of acute radiation exposure. The present report gives an account of the circumstances which led to the accident, the medical aspects and the lessons learned.

Contents: 1. Introduction; 2. Background information; 3. The accident; 4. Response to the accident; 5. Summary of medical aspects of the accident; 6. Summary of biological dosimetric analyses; 7. Findings, conclusions and lessons to be learned; Annex I: Chronology of events; Annex II: Medical data; Annex III: Biological dose estimation.

French, Russian and Spanish editions planned.

STI/PUB/1102 (75 pp., 12 figures; 2000)

ISBN 92-0-101400-7

Price: 290 Austrian schillings (€21.08)

THE RADIOLOGICAL ACCIDENT IN LILO



The radiological accident described in this report took place in Lilo, Georgia, when sealed radiation sources were abandoned by a previous owner at a site without following established regulatory safety procedures. As a consequence, 11 individuals at the site were exposed for a long period of time to high doses of radiation which resulted, inter alia, in severe radiation induced skin injuries. The present report, which is co-sponsored by the World Health Organization, provides information on the medical management of radiation induced skin injuries as well as a comprehensive report

on the circumstances and details of the accident and the lessons learned.

Contents: Executive summary; 1. Introduction; 2. Background information; 3. Chronology of the accident; 4. Recovery of sources; 5. Co-operation between the WHO and the IAEA; 6. IAEA mission; 7. Biological dosimetry; 8. Overview of the medical aspects; 9. Primary medical assessment of the patients by local physicians in Georgia; 10. Diagnosis and treatment in specialized hospitals in France and Germany; 11. Pathophysical considerations regarding the development of clinical signs and symptoms; 12. Treatment of four patients with recurrent skin ulcers in a specialized hospital in the Russian Federation; 13. Conclusions drawn from the medical management of the patients; 14. Recommendations on the follow-up of the patients; 15. Conclusions and lessons to be learned; Annex I: Status of the Georgian patients in August 1999; Annex II: WHO collaborating centres and liaison institutions within REMPAN.

STI/PUB/1097 (103 pp., 39 figures; 2000)

ISBN 92-0-101300-0

Price: 370 Austrian schillings (€26.89)

THE RADIOLOGICAL ACCIDENT IN SAN SALVADOR

On 5 February 1989, a radiological accident occurred at an industrial irradiation facility near San Salvador, El Salvador. Medical products are sterilized at the facility by irradiation by means of an intensely radioactive cobalt-60 source in a movable source rack. This source rack became stuck in the irradiation position. The operator bypassed the irradiator's degraded safety systems and entered the radiation room with two other workers to free the source rack manually. The three men were exposed to high radiation doses and developed the acute radiation syndrome. They received initial hospital treatment in San Salvador and subsequent, more specialized treatment in Mexico City. The legs and feet of two men were so seriously injured that amputation was required. The worker who had been most exposed died six and a half months after the accident from lung damage due to irradiation complicated by injury sustained during treatment. The report describes the accident and the response to it and presents lessons derived for operators and suppliers of irradiators, national authorities, medical staff and international organizations. Detailed information on dosimetric and medical aspects of the accident is presented in appendices and annexes.

Contents: 1. Introduction; 2. The background in El Salvador; 3. The irradiation facility; 4. The accident; 5. The response to the accident; 6. Factors contributory to the accident; 7. Generic lessons learned; Addendum; Photographs; Appendix I: Dosimetric analysis; Appendix II: Medical treatment; Annexes I and II: Patients A

and B: Nutritional reports by the Angeles del Pedregal hospital in Mexico City.

STI/PUB/847 (94 pp., 24 colour photographs, 20 figures; 1990)

E ISBN 92-0-129090-X

F ISBN 92-0-229090-3

R ISBN 92-0-400292-1

S out of print

Price: 340 Austrian schillings (€24.71)

THE RADIOLOGICAL ACCIDENT IN SOREQ

On 21 June 1990 a fatal radiological accident occurred at an industrial irradiation facility at Soreq, Israel. An operator entered the irradiation room by circumventing safety systems and was acutely exposed, with an estimated whole body dose of 10–20 Gy. The accident, like earlier accidents at similar irradiators, was the consequence of the contravention of operating procedures. An IAEA review team investigated the causes of the accident. This report presents its findings and recommendations and describes the clinical management of the patient, particularly of the haematological phase. The medical treatment included the use of emerging therapies with haematopoietic growth factor drugs which may rescue the overexposed patient, albeit in this case only temporarily. The report is intended for regulatory authorities responsible for the regulation and inspection of irradiators, operating organizations and physicians who may need to treat overexposed patients.

Contents: 1. Introduction; 2. The irradiation facility; 3. Regulatory control; 4. The accident; 5. Actions and lessons; 6. Overview of the medical aspects; 7. Medical management of the patient; 8. Findings of the post-mortem investigation; 9. Lessons to be learned.

STI/PUB/925 (78 pp., 14 figures + 32 illustrations; 1993)

ISBN 92-0-101693-X

Price: 300 Austrian schillings (€21.80)

THE RADIOLOGICAL ACCIDENT IN TAMMIKU

In October 1994 three members of the public entered the radioactive waste repository at Tammiku, Estonia, without authorization and removed a metal container enclosing a radiation source, which one of them placed in his pocket. This action resulted in the death of one person and injury to a number of others. The purpose of this report is to provide information to help to ensure that similar accidents can be avoided in the future.

Contents: 1. Introduction; 2. Radiation protection infrastructure in Estonia; 3. The accident; 4. Recovery of the source; 5. Subsequent

actions; 6. Dosimetry; 7. Medical aspects; 8. Generic lessons learned; Annex I: Physical dosimetry; Annex II: Biological dosimetry; Annex III: Medical findings.

Russian and Spanish editions planned.

STI/PUB/1053 (59 pp., 7 figures; 1998)

E ISBN 92-0-100698-5

Price: 280 Austrian schillings (€20.35)

THE RADIOLOGICAL ACCIDENT IN THE REPROCESSING PLANT AT TOMSK

On 6 April 1993 a major radiological accident occurred at a plutonium extraction facility at a location then known as Tomsk-7, Russian Federation. The accident blew the concrete cover off the reaction vessel and led to widespread contamination of the site and the surrounding area up to a distance of 28 km. The report describes the events leading up to the accident and the radiological consequences. It provides a detailed description of the decontamination and recovery operations and gives an analysis of their effectiveness.

Contents: Preamble; 1. Introduction; 2. Background information; 3. Fuel reprocessing at the radiochemical works; 4. The accident and its cause; 5. Radiological situation after the accident; 6. SCE site; 7. Surrounding area; 8. Recommendations.

Russian and Spanish editions planned.

STI/PUB/1060 (77 pp., 33 figures; 1998)

E ISBN 92-0-103798-8

Price: 320 Austrian Schillings (€23.26)

THE RADIOLOGICAL ACCIDENT IN YANANGO → **NEW**

In February 1999 a serious radiological accident occurred in Yanango, Peru, when a welder picked up a ^{192}Ir industrial radiography source and put it in his pocket for several hours. This action resulted in his receiving a high radiation dose that necessitated the amputation of one leg. His wife and children were also exposed, but to a much lesser extent. The purpose of this report is to provide an account of the circumstances of the accident and its medical aspects.

Contents: 1. Introduction; 2. Background information on the circumstances of the accident; 3. The accident; 4. The emergency response; 5. Medical treatment of the patient; 6. Dosimetric analysis; 7. Findings, conclusions and lessons to be learned.

French, Russian and Spanish editions planned.

STI/PUB/1101 (41 pp., 1 figure; 2000)

ISBN 92-0-101500-3

Price: 200 Austrian schillings (€14.53)

→ FORTHCOMING

**TRAINING IN RADIATION PROTECTION
AND THE SAFE USE OF RADIATION SOURCES
Safety Reports Series No. 20**

This report provides assistance in how to organize adequate and appropriate training for personnel working with ionizing radiation. It is primarily intended to be used by trainers and training providers, covering amongst others the various methods of training provision and giving advice on the development and organizational aspects associated with the management of training activities. It complies with the requirements laid down in Safety Series No. 115, International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (1996) and supersedes Technical Reports Series No. 280, Training Courses on Radiation Protection (1988).

Contents: 1. Introduction; 2. Categories of people to be trained; 3. Development of competence through training; 4. Training methods; 5. A systematic approach to training; Annex I. Standard syllabus of the post-graduate educational course in radiation protection and the safe use of radiation sources; Annex II. Establishment of a training centre; Annex III. Classroom based training in radiation protection for industrial radiographers; Annex IV. On the job training in radiation protection for industrial radiographers; Annex V. Visual aid materials; Annex VI. Practical exercises; Annex VII. Example of questionnaire for the evaluation of training by the participants.

Foreseen publication date: June 2001

STI/PUB/1107 (approx. 69 pp.; 2001)

ISBN 92-0-100601-2

Price not yet set.

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