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MEASURES TO STRENGTHEN INTERNATIONAL CO-OPERATION IN MATTERS RELATING TO NUCLEAR SAFETY AND RADIOLOGICAL PROTECTION

(c) Implementation of resolution GC(XXXVI)/RES/584: Programme for education and training in radiological protection and nuclear safety

1. Last year, in resolution GC(XXXVI)/RES/584, the General Conference, taking "positive note of the proposal for education and training in radiological protection and nuclear safety contained in document GC(XXXVI)/1016", requested the Director General to prepare a report for the Board of Governors and for subsequent consideration by the General Conference on "a possible programme of activities on education and training in radiological protection and nuclear safety" based on that proposal.

2. The attached report, prepared in response to that request, was considered in June by the Board of Governors, which authorized the Director General to transmit it to the General Conference.

PROGRAMME FOR EDUCATION AND TRAINING IN RADIOLOGICAL PROTECTION AND NUCLEAR SAFETY

INTRODUCTION

1. Last year, in resolution GC(XXXVI)/RES/584, the General Conference, taking "positive note of the proposal for education and training in radiological protection and nuclear safety contained in document GC(XXXVI)/1016", requested the Director General to prepare a report for the Board of Governors and for subsequent consideration by the General Conference on "a possible programme of activities on education and training in radiological protection and nuclear safety" based on that proposal. The present report has been prepared in response to that request.

EDUCATIONAL COURSES

2. In resolution GC(XXXVI)/RES/584, the General Conference stressed the importance of the "educational courses" referred to in document GC(XXXVI)/1016 and urged the Secretariat "to maintain the current efforts in this area and to arrange for such courses to be held in appropriate official languages of the Agency".

The Standard Syllabus

3. In February 1993 a group of consultants prepared a draft Standard Syllabus for Post-Graduate Educational Courses in Radiation Protection (see Annex 1). The Secretariat intends to publish the Standard Syllabus in Arabic, Chinese, English, French, Russian and Spanish.

4. Educational courses based on the Standard Syllabus will be organized by the Agency. They will be designed to meet the educational and initial training requirements of junior staff of graduate level or the equivalent holding or earmarked for positions in radiation protection, including health physics. It is expected that the target audience will include young professionals needing to acquire a sound basis in radiation protection and a knowledge of some related nuclear safety fundamentals in order to become - in the course of time - trainers in their home countries. It is expected that the duration of the courses will be about one academic semester.

5. It is hoped that the Standard Syllabus will facilitate the integration of post-graduate educational courses in radiation protection into the curricula of educational institutions in Member States and, as education and training in radiation protection and nuclear safety remain primarily a national responsibility, Member States will be invited to encourage leading educational institutions to include such courses in their curricula when that is justified by national needs, so that the courses may be offered on a regular basis using already available expertise and trained manpower.

6. It is intended that the Standard Syllabus should permit the conversion of course programmes into self-contained modules corresponding to different degrees of utilization of radiation and nuclear technologies in Member States (see paras 15 and 19 of GC(XXXVI)/1016) and the design of programmes for specialized training courses tailored to the needs of individual Member States.

Interregional and Regional Approach

7. Within the framework of its overall effort to encourage general education in radiation protection and nuclear safety, the Agency has since 1981 been co-operating with the Argentine Atomic Energy Commission and the Argentine Ministry of Public Health in the organization of an annual eight-month interregional post-graduate course given in Spanish at the University of Buenos Aires; also, in 1985 the Agency co-operated with the Government of India in sponsoring an interregional post-graduate course for English-speaking participants at the Bhabha Atomic Research Centre, Bombay.

8. In response to resolution GC(XXXVI)/RES/584, and given the importance of radiation protection for virtually every Agency technical co-operation project, the Secretariat plans to continue supporting the courses held in Spanish and to promote the holding of post-graduate courses in English, French and Russian, with due regard to cost-effectiveness.

9. Thus, in addition to the established Interregional Post-Graduate Educational Course in Radiation Protection and Nuclear Safety, to be held in Spanish, two pilot Interregional Post-Graduate Educational Courses in Radiation Protection, one to be held in English and one in French, are planned for 1994. The duration of these pilot courses has been set, by way of exception, at about half an academic semester. It is intended that, besides serving an educational purpose, the pilot courses, which will be based on a syllabus derived from the Standard Syllabus, should provide experience to be used in converting the Standard Syllabus into a course programme with detailed time allotments for lectures, practical work, problem-solving sessions, technical visits and examinations. The cost of these two additional courses, which will be met from technical co-operation funds, is estimated at US $480 000. Also the Secretariat plans to organize a Post-Graduate Educational Course in Radiation Protection and Nuclear Safety in Russian within the framework of the UNDP/IAEA initiative aimed at strengthening radiation protection and nuclear safety infrastructures in countries of the former Soviet Union (see document GOV/INF/694).

10. It is foreseen that the educational courses to be organized by the Agency on the basis of the Standard Syllabus will ultimately be given as either interregional or regional courses, on the lines of the following tentative scheme:

Geographical level (language)	1995	1996	1997	1998
Interregional (Spanish)		x		
Interregional (English)	x		x	
Interregional (French)				x
Regional (Spanish)	x		x	x
Regional (English)				
Regional (French)		Africa x		

This means the holding of two courses a year instead of one, the cost of each additional course being estimated at US $400 000 - to be met from technical co-operation funds.

11. To implement this tentative programme, the Secretariat will be seeking educational institutions willing and able to host post-graduate educational courses tailored to the Standard Syllabus. Preference will be given to leading institutions with demonstrated experience in the subject area and having the faculty staff and the technical and logistic facilities necessary for the provision of such courses on a regular basis without the charging of tuition fees for Agency-sponsored participants.

SPECIALIZED TRAINING COURSES/WORKSHOPS

12. A forecast of the interregional and regional specialized training courses in radiation protection and nuclear safety to be held during the period 1994-98 is given in Annex 2. The proposals for the courses in question were endorsed by the Advisory Committee on Training in Nuclear Power and Nuclear Safety at its most recent meeting (5-7 May 1993). The subjects to be covered by the courses are among those mentioned in paragraphs 23 and 24 of document GC(XXXVI)/1016. The regional courses do not include courses to be held within the framework of RCA, ARCAL and AFRA. The number of interregional training courses will decrease by one-three a year compared with the forecast for 1992-96 given in document GOV/INF/629; the estimated cost reduction will be US $135-405 000 a year. The number of additional regional training courses compared with the forecast for 1992-96 will be one-four a year in each region, the estimated cost per course being US $85 000.

13. As in the past, a number of national training courses and workshops will be supported within the framework of ongoing and new technical co-operation projects, along the lines indicated in paragraphs 26 and 27 of document GC(XXXVI)/1016. No forecast can be made of such Agency-supported training events as their numbers depend on the project requests submitted by Member States. In planning them, however, the Secretariat will take account of the findings of Agency advisory missions, including RAPAT, OSART and ASSET missions.

OTHER MECHANISMS

Fellowships

14. Fellowships will continue to be used primarily as a means of providing on-the-job training in radiation protection and nuclear safety to individuals from developing Member States. The Secretariat will continue to encourage Member States to nominate candidates who, after their fellowship training, can themselves contribute to national manpower development programmes.

Scientific Visits

15. Greater emphasis than in the past will be placed on arranging scientific visits for decision-makers and managers who may become involved in strengthening the radiation protection and nuclear safety infrastructures in their countries.

Seminars

16. As indicated in paragraph 30 of document GC(XXXVI)/1016, seminars for promoting education and training in radiation protection and nuclear safety will be organized on a regional basis (with one seminar a year), as follows:

Year	Region
1995	Asia & the Pacific
1996	Europe & the Middle East
1997	Africa
1998	Latin America

The cost per seminar is estimated at US $50 000. It is expected that the seminars will be financed from the budget of the Division of Nuclear Safety, with some cost-sharing with the Department of Technical Co-operation.

17. The seminars will be designed to familiarize decision-makers and managers in Member States with the means available for enhancing the infrastructures under their supervision, including the education and training opportunities available within the region. The seminars will also serve the objectives of upgrading educational and training capabilities and encouraging co-operation among the educational and training centres in the region.

Educational and training material

18. The Secretariat will continue to publish training manuals. The manual on the Safe Transport of Radioactive Material is currently being translated into Spanish, and the Spanish version is due to be published in 1994. A draft manual on the Safe Use and Regulation of Radiation Sources has been prepared and is expected to be published in 1995. The publication of training manuals will be financed from the budget of the Division of Nuclear Safety

19. Educational material developed for and during the pilot Interregional Post-Graduate Educational Courses referred to in paragraph 9 above will be made available to Member States for use in their own educational programmes.

20. The Agency's safety-related publications (standards, guides, radiation safety manuals, etc.) will continue to be used extensively - together with viewgraphs, slides and video films - at educational courses and specialized training events.

FINANCIAL IMPLICATIONS

21. On the basis of the cost figures given in paragraphs 9, 10, 12 and 16 and of the forecast in Annex 2, it is estimated that the overall costs of activities resulting from implementation of the programme, which could be met from technical co-operation funds, will be as follows:

	1994	1995	1996	1997	1998
US $	995 000	690 000	560 000	690 000	690 000

For the years 1995-98, an amount of US$ 50 000 a year should be added to cover the costs of the seminars.

CONCLUDING REMARKS

22. The Secretariat will continue to assist Member States in the fields of radiation protection and nuclear safety through the means that the Agency has traditionally used, taking into account the results of assistance provided in the past and information obtained through Agency advisory missions. At the same time, additional emphasis will be placed on encouraging countries to establish manpower development programmes in the light of priorities identified with the help of Agency missions and the outcome of seminars.

23. In implementing the educational and training programme outlined in this document, the Secretariat will continue to take into account the identified needs and priorities of Member States. Provided that there is a clear commitment (with allocation of the necessary resources) by national authorities, which is essential if the Agency's assistance is to achieve its stated objectives, the Agency will continue to co-operate with national authorities in formulating manpower development programmes necessary for establishing and strengthening radiation protection and nuclear safety infrastructures, under the supervision of the national competent authority, which - as indicated in paragraph 5 above - should have the primary responsibility for education and training.

24. The outlined programme will be reviewed every two years by means of the available mechanisms. For example, at its biennial meetings the Advisory Committee on Training in Nuclear Power and Safety will advise on any necessary adjustments to the programme of training courses.

25. The General Conference is invited to consider the programme for education and training in radiation protection and nuclear safety outlined in this document.

STANDARD SYLLABUS OF POST-GRADUATE EDUCATIONAL COURSES IN RADIATION PROTECTION

Introduction

The Post-graduate Course is intended to meet the educational and initial training requirements of junior staff of graduate level or equivalent involved, or designated to take up positions in radiation protection, including health physics. It is expected that the target audience will include young professionals needing to acquire a sound basis in radiation protection with some related fundamentals of nuclear safety in order to become trainers in their home countries/institutions.

The following Syllabus is designed as a guide to the subjects and topics which should be included in such an educational course. The Syllabus contains twelve parts covering a wide, multidisciplinary field of fundamental background knowledge in radiation protection.

The suggested duration of the Course is one academic semester (18 weeks) including practical work, visits to relevant facilities/institutions as well as lectures, discussions and study sessions on topics in specific modules. Practical demonstrations, exercises, work/problem solving sessions and/or technical visits listed in each part of the Syllabus are illustrative of the type of practical work that is intended to be included in the Course.

It is suggested that an examination session be held following each major Course module, pertinent to the corresponding part of the Syllabus.

S Y L L A B U S

PART I

REVIEW OF FUNDAMENTALS

1. Basic Physics, Mathematics and Biology used in Radiation Protection.

1.1 Nuclear physics

1.1.1 Atomic structure

1.1.1.1 Constituents of nucleus

Neutrons and protons
Number of protons defines element
Atomic mass, isotopes of elements

Electrons

Responsible for chemistry
Ionization

1.1.1.2 Radioactivity

Stable and unstable nuclei
Modes of disintegration - alpha, beta, gamma
Law of radioactive decay, half-life, decay constant
Activity, units
Decay chains including natural sources
Radionuclides and table of radionuclides

1.1.2 Nuclear reactions

Example of reactions
Induced radioactivity
Fission and fusion (energy considerations)
Cross section

1.1.3 Electromagnetic and corpuscular radiation

Review of alpha, beta, gamma radiations
Accelerated particles
Neutrons
Characteristic X-rays, bremsstrahlung and X-ray production
Positron, electron capture, auger electrons, internal conversion
Energies and spectra

1.1.4 Practicals

Demonstration of radioactive decay
Demonstration of penetrating properties of different radiations

1.2. Basic mathematics

1.2.1 Elementary calculus

Differentiation/integration
Application to decay equations

1.2.2 Statistics

Probability theory
Random variables
Distributions - different types
Mean, mode, median
Standard deviation
Standard error
Confidence levels, regression, correlation
Practical application to counting
Statistical exercises

1.3. Basic biology

1.3.1. Overview

Basic characteristics of life
Biologically important elements

1.3.2 Structure of cell

Constituents
Types and functions
Chromosomes
DNA and RNA
Mitosis and meiosis
Cancer induction and development
Elementary genetics

1.3.3 Human biology

Digestive system
Haematopoietic system
Thyroid function
Bone physiology
Respiratory system
Reproductive system
Lymphatic system
Skin
Introduction to toxicity
Uptake of organs

2. Radiation Sources

2.1 Natural radionuclides

Uranium, thorium, potassium-40
Reiterate decay chain
Important radionuclides in uranium-238 and thorium-232 decay chains (radium and radon isotopes) and emissions

2.1.1 Practical work

Demonstration of radon emanations

2.2 Nuclear reactors

Review of fission and fission products
Neutrons, multiplication factor, criticality
Moderation
Types of reactors
Nuclear fuel cycle

2.3. Other sources of artificial radionuclides

Accelerators

2.4 Neutron generators

Generators based on alpha-n or gamma-n reactions; applications

2.5 X-ray production

Principles
Spectra
Filtration
Quality

2.6 Cosmic radiation

Variation with altitude and latitude

2.7 Applications of radionuclides

Medical
Industrial
Agricultural
Research and teaching

3. Interaction of Radiation with Matter

3.1 Charged particle radiation

3.1.1. Heavy particles (alpha, proton,nuclei)

Energy transfer mechanism, ionization, scattering, nuclear interaction
Range-energy relationship

3.1.1.1 Practical work

Demonstration of alpha particle range

3.1.2 Beta particles

Mechanisms of energy transfer
Range-energy relationships
Bremsstrahlung
Cherenkov radiation

3.1.2.1 Practical work

Demonstration of bremsstrahlung effect
Determination of maximum energy of beta radiation by absorption

3.2. Uncharged radiation

3.2.1 X and gamma-rays

Photoelectric effect
Compton scattering
Pair production
Secondary photon production
Attenuation
Effect of Z on absorbing medium
Build-up correction

3.2.1.1. Practical work

Attenuation as a function of thickness and Z

3.2.2. Neutrons

Interaction, scattering, absorption
Energy categories
Neutron activation
Moderation
Shielding

3.2.2.1 Practical work

Demonstration of alpha-n reaction
Examples of shielding for different material (cross-section for capture)

PART II

QUANTITIES AND MEASUREMENTS

4. Theory of Radiation Detection and Measurement

4.1 Detection by ionization in gases

Ionization chambers with current measurements
Condensor chambers
Pressure ionization chamber
Extrapolation chambers

4.2 Pulse counting detectors

Proportional counters
GM tubes - quenching
Pulse counting scalers and ratemeters
Discriminators
Pulse height analysis - coincidence and anticoincidence

4.3 Detection by excitation

Scintillation counters
Solid and liquid-counting and pulse height analysis
Pulse shape analysis

4.4 Semiconductor detectors

4.5 Photographic emulsions

4.6 Track detectors

4.7 Neutron detectors by (n,alpha) or (n,proton) reactions or by activation

4.8 Measurement techniques, efficiency, background, geometry - statistics

4.9 Practical work

Determination of counting rate vs. voltage curve in GM tube
Determination of background
Measurement of beta emitters and determination of total efficiency

Analysis of self-absorption and backscattering
Use of a low-background GM system for low-activity beta-emitting sources
Figure of merit of the counting system
Calibration of a gamma scintillation spectrometer in energy and in activity
Complex-spectrum analysis using resolving computer codes - the same using semiconductor detector
Calibration of proportional internal counter for alpha spectrometry (energy and activity)
Calibration of Zn S(Ag) scintillation counter for alpha activity measurements
Calibration of energy-dependent and energy-independent photographic emulsion measurement systems
Measurements with track-etching systems
Measurements of low activity of tritium and carbon-14 by liquid scintillation
Neutron counting and spectrometry using helium-3 detector (or equivalent)

5. Dosimetric Quantities and Units

Energy and particle fluence and fluence rate
Flux and flux density
Collision stopping power
Bragg-Gray cavity principle
Absorbed dose and absorbed dose rate and their units
Kerma
Exposure
Specification of radiation fields in receptor-free conditions
Exposure to external radiation sources - calculation of doses from beta and gamma sources
Electronic equilibrium
Attenuation of primary radiation and build-up of secondary radiation
Absorption and scattering in air and in the body
Influence of geometry
Point sources, plane sources and volume sources

6. Dosimetric Measurements

Calibration of dose meters as an essential step in specifying what the meter measures
Integrating personnel dose meters (TLD, film, condensor chambers etc.) calibrated for personal dose (superficial and deep)
Dose rate meters for receptor-free conditions calibrated for "ambient" and "directional" quantities
Concepts of extended and aligned fields
Use of various radiation detectors for dosimetric purposes
The problem of energy dependence or independence, linearity, sensitivity, overload, recovery, pulsed fields, mixed fields
Relative merits of different types of instruments

7. Practical Work

Calculation of depth doses in the body in the case of a unidirectional exposure to cobalt-60 gamma rays
Comparison with measurements using a phantom and TLDs calibrated for "personal" dose
Calculation of the "surface" dose from a surface beta source and comparison with measurements using an extrapolation chamber

PART III

BIOLOGICAL EFFECTS OF IONIZING RADIATION

8. Cellular Effects, Including Molecular Mechanisms

8.1 Basic radiation chemistry

Excitation, ionization, breakage of chemical bonds
Production of free radicals
Interaction with DNA

8.2. Cellular radiobiology

Point mutations, chromosome breaks, mitotic disfunction, cell death
Consequences of cell death
Consequences of cell damage, DNA repair
Cell sensitivity
Chromosome aberrations as biological indicators

9. Deterministic Effects

General dose-response curve, threshold, severity
Skin: erythema, ulceration, effect of radiation quality
Effect of whole-body radiation: gastrointestinal tract, central nervous system
Haematopoietic system
Other organs: thyroid, lungs, eyes, gonads
Threshold doses
Effect of fractionation and dose rate
Case histories (accidental exposures)

10. Stochastic Somatic Effects

Sources of data: A-bomb survivors, dial painters, medical exposures, miners, animal data
Dose-response relationship
Absolute and relative risk models
Dose and dose rate effectiveness factors
ICRP risk factors, fatal and non-fatal cancers

11. Hereditary Effects (Stochastic)

Natural mutations
Review of production of gametes and damage to chromosomes
Gene mutations
Sources of data: man and animals
Concept of doubling dose
UNSCEAR and ICRP 60 approaches
ICRP risk assumptions - subsequent generations and severity

12. Effects on the Embryo and Fetus

Sensitivity at different stages of development
Brain development and retardation
Cancer induction

13. Epidemiological Studies and Issues

Statistical requirements
Current studies; prospects and pitfalls (including publication by Gardner)

14. Concept of Radiation Detriment

Need for an aggregated measure of harm; w_T , dose limits, value of collective dose
Approach adopted by ICRP

15. Practical Work

Determination of a survival curve for cells (yeast)
Measurement of DNA repair by labelled compound
Exercise using epidemiological data

PART IV
EXTERNAL DOSE ASSESSMENT

16. Operational Quantities

16.1 The practical ICRP 60 quantities

The average dose in an organ or tissue
The equivalent dose in an organ or tissue
The unit of equivalent dose (J/kg with the special name Sievert)
Radiation weighting factors for radiation type and energy range

16.2 The formalistic system of quantities

Absorbed dose at a point
The quality factor in terms of unrestricted linear energy transfer in water
The dose equivalent
Interrelation of both systems

16.3 The effective dose

Assessments of effective dose in various external exposure conditions - practical approximations

17. Individual Monitoring

Practical systems based on materials presented in part II.4., type and frequency of monitoring
Calibration and quality assurance
Influence of the working environment (heat, humidity, etc.)
Recording levels
Problems regarding values applied to whole body, extremities and skin
Interpretation of records using different quantity definitions
Decisions regarding tissues exposures determined by personal monitor

18. Area Monitoring

18.1 Monitoring of the workplace - purpose, nature, frequency

Monitoring for work planning purposes
Monitoring to detect changes in the working environment
Practical monitoring systems for receptor free radiation fields, for surface contamination leading to skin exposures
(Surface contamination as a source of resuspension and air contamination monitoring will be dealt with in part V.20)

18.2 Fixed and portable monitors

19. Practical Work

Comparison of predicted personnel doses based on area monitoring and the results of individual monitoring in complex gamma fields

PART V

INTERNAL DOSE ASSESSMENT

20. Modes of Intake

Inhalation, ingestion and absorption through skin or wounds
Influence of specific activity and physico-chemical state: precipitation in tissues, complexation, polymerization, etc.
Special case of tritiated water and vapour: intake through skin of splashed water and of vapour and respiratory intake

21. Metabolic Behaviour

Quantitative aspects of intake
Uptake into blood and transport to various organs
Deposition in organs
Compartment modelling
Relationships between compartments as one basis for specifying monitoring procedures
Retention and elimination
Exponential compartments, biological half-life and effective half-life
Non-exponential retention

22. Metabolic Models Used by ICRP

Evolution of the models, gut model and lung model
Uptake, distribution and deposition model
Body model of ICRP 30 (standard man)
Age-dependent models

23. Calculation of Effective Dose

Dosimetric models of ICRP 30 and 61
Calculation of the organ contribution to the effective dose
Committed effective dose per unit intake in the standard adult and as a function of age
ALI (annual limit on intake)
Special case of radon and daughters

24. Monitoring for Internal Contamination

Personal air monitors
Relationships between area air monitoring and personal air monitoring readings
Surface monitoring and resuspension

Track monitors for exposure to radon or daughters
Nose excreta monitoring
Bioassay, urine monitoring; interpretation based on the basic metabolic models
Normalization of samples (e.g. with respect to creatinine)
Fecal analysis for suspected special contaminations
In-vivo monitoring: whole body, thyroid
Lung monitoring and spectrometry
Shielded rooms and procedures to reduce background as appropriate
Thyroid and lung monitoring

25. Practical Work

Removing caesium-137 from contaminated rats using a gut scavenger (prussian blue)
Monitoring urine for soluble uranium contamination by fluorimetry of sodium-fluoride fused samples - preparation of calibration standards
Measurement of the potassium content of the body by whole-body counting of potassium-40

PART VI

GENERAL APPROACH TO RADIATION PROTECTION

26. The Role of International Organizations in Radiation Protection

International Commission on Radiological Protection (ICRP)
International Commission on Radiological Units and Measurements (ICRU)
International Atomic Energy Agency (IAEA)
United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)
International Labour Organisation
World Health Organization
Food and Agriculture Organization of the United Nations
Nuclear Energy Agency of OECD
Pan American Health Organization

27. Conceptual Framework

The basic framework (types of exposure, points of control)
The system of radiological protection for proposed and continuing practices
Review of quantities and units, including additional collective quantities
Justification of a practice
Optimization of protection

Individual dose limits
Dose and risk constraints
Potential exposures
The system of protection for intervention

PART VII

REGULATORY CONTROL

28. Enabling Legislation

Statutory base
Mandate of regulatory authorities

29. Regulatory System

Organization and staffing
Training and qualifications of staff
Regulations (performance or prescriptive)
Responsibilities of an operating organization (licensee)
Standards and guides
Adequate resources
Advisory committees and consultants
Notification, registration and/or licensing
Exemptions
Co-operation between employers (sharing safety information, individual monitoring records, etc.)
Safety assessment
Inspection
Enforcement
Relationship between regulator and regulated
Investigations
Feedback

30. Practical Work

Review a safety analysis report on a gamma irradiator
Prepare safety assessment and recommend licensing actions
Prepare conceptual regulatory framework for a country with a defined type and number of radiation sources
Prepare an evaluation of application for the use of tritium for the illumination of gun sights (take into account justification)
Plan an inspection visit to a hospital using radionuclides, Xrays and an accelerator for medical diagnosis and treatment

PART VIII

OCCUPATIONAL RADIATION PROTECTION

31. Organization and Management

Objectives of the radiation protection programme (compliance with dose limits, optimization, dose constraints)
Responsibility and commitment of management
Radiation protection organization
Pre-operational radiological evaluation
Responsibility of workers
Special administrative arrangements
Training
Classification of work places
Record keeping and reporting
Local rules and supervision
Investigations and feedback

32. Methods of Protection

32.1 Facility and equipment design safety features

Ventilation (including control of radon in mines)
Shielding
Interlocks
Remote handling equipment
Storage facilities
Fume hoods
Hot cells
Glove boxes
Physical barriers
Monitors
Warning signs
Quality assurance
Commissioning survey and regulatory review

32.2 Administrative and procedural controls

Policies and procedures
Training
Classification of work places
Record keeping and reporting
Local rules and supervision

Personal protective equipment
Protective clothing
Respiratory protection
Security of sources (e.g. leak testing)
Contamination control
Signs and tagging
Emergency procedures

33. Monitoring

Purposes of monitoring
Individual monitoring for external exposure
Interpretation of results
Monitoring for internal exposure
Relation between intakes, retained quantities and excreted quantities
Choice of instrumentation and methods
Air monitoring (including radon in mines)
Workplace monitoring

34. Natural Sources of Radiation

Occupational exposure to radon (mines and other workplaces)
Occupational exposure in work practices at high altitude
Occupational exposure from work with ores containing elevated levels of natural radioactivity

35. Potential Exposures

Safety culture of staff at all levels
Safety assessment of structures, systems, components and procedures related to protection and safety, including modifications of such items
Documentation of safety assessments
Investigations of accidents and abnormal exposures and follow-up with corrective action
Safety training of staff at all levels

36. Case Study - Gamma Irradiators

Irradiators - types, facility design and construction parameters - defence in depth
Safety assessment
Radiation safety programme for irradiators
Safety review of application for a license to construct and operate a gamma irradiator
Inspection of irradiator licensees
Review of irradiator accidents and unusual occurrences

37. Practical Work

Prepare an organizational chart and highlights of a radiation protection programme for a given installation
Prepare optimization report on shielding for a shipping container for cobalt-60 of a given activity
Calculate retained quantity of a radionuclide in the body from a given intake through inhalation
Visit to gamma irradiator/facility using radiation sources

PART IX

PUBLIC EXPOSURE FROM PRACTICES

38. Responsibilities and Organization

Competent authorities
Regulations
Source control
Inspection
Monitoring
Reporting
Adequate records
Emergency planning
Public information
Training

39. Waste Management

39.1. General considerations

Terminology and classification of radioactive wastes
Principles of concentration and dilution
Technical options for treatment, conditioning and disposal

39.2 Control of radioactive effluents

Definition of dose constraints
Optimization of releases
Limits for releases

39.3 Solid waste disposal

Safety and protection aspects

40. Dose Assessment

Modes of exposure
Models for dispersion, transfer and dose assessment from releases of radioactive material

41. Monitoring

Objectives (surveillance and control of releases, refinement of models)
Effluent monitoring (technical options, comparison with the release limits)
Environmental monitoring (technical options, verification of results, dose assessment)

42. Physical Protection and Security of Sources

Security of source location
Registry and periodic physical inventory of sources
Control and disposal of spent sources

43. Consumer Products

Definition
Prior authorization
Justification
Optimization
Guidance for users
Labelling

44. Practical Work

Controls and checks; checking and management of waste
Exercise in setting release limits and in preparing a corresponding set of licensing criteria, including requirements for monitoring
Planning for environmental monitoring programme; sampling, analytical methods, etc.
Pre-operational study and assessment of critical pathways and assessment of relevant transfer parameters leading to dose
Visit to a waste treatment facility

PART X

INTERVENTION FOR PROTECTION OF THE PUBLIC

45. Chronic Exposure Situation

Definition (radon, radioactive residues from past practices)
Responsibilities of designated intervening organizations
Identification of the areas or buildings affected
Action levels
Remedial plans

46. Acute Exposure Situations

Emergency plans
Type of accident, classification, factors affecting the consequences
Responsibilities of designated intervening organizations
Assessment of accidental exposure
Protective actions and intervention
Recovery phase
Limitation of occupation exposure in emergencies
Emergency exercises
Public information

47. Practical Work

Training exercise on the response to a hypothetical accident involving a loss of a gamma radiography source
Training exercise on the response to a hypothetical accident involving environmental release of a substantial amount of radioactive material

PART XI
MEDICAL EXPOSURES

48. Scope and Responsibilities

Diagnostic and treatment purposes
Registrant and licensees
Medical practitioner, qualified expert

49. Training

Groups to be trained
Training programmes
Updating of programmes

50. Justification of Medical Exposures

Identification of alternative techniques
Evaluation of the detriment
Criteria for the justification of practices (difference between diagnostic and treatment practices)

51. Optimization of Protection for Medical Exposures

51.1 Operational considerations

Minimize patient exposure (difference between diagnostic and treatment practices)
Mobile equipment vs. fixed equipment
Exposure of women of reproductive capacity
Use of organ shielding

51.2 Constraints and reference levels for the patient

Reference levels for the patient specified by professional bodies on the basis of relevant surveys
Dose constraints (persons exposed for medical research purposes)
Ethical review committee for experiments
Dose restrictions (members of the patient's household)

51.3 Design considerations for equipment

Radiation safety aspects
International standard(s International ElectrotechnCommission, International Standards Organization
Basic technical characteristics
Regular review and maintenance

52. Calibration of sources

Traceability
Quantities used for calibration
Different criteria for calibration (radiotherapy equipment, sealed and unsealed sources)

53. Determination of a Dose to the Patient

Optimization of dose distribution
Determination by assessment
Determination by measurement
Comparison with reference levels

54. Quality Assurance for Medical Exposures

Comprehensive programme
Periodic control (physical and clinical parameters)
Periodic quality audit and review

55. Records for Diagnostic Radiology, Radiotherapy and Nuclear Medicine

Identification of the information to be recorded
Difference between diagnostic radiology, nuclear medicine and radiation therapy

56. Visits

Visit to a hospital: Departments of Radiology, Radiotherapy, Nuclear Medicine
Demonstration of relevant procedures
Identification of the information to be recorded
Difference between diagnostic radiology, nuclear medicine and radiation therapy

57. Practical Work

57.1 Diagnostic radiology

Procedure for dose reduction
Quality assurance: techniques, routine checks, maintenance rules

57.2 Radiotherapy

Procedures for dose reduction
Quality assurance

57.3 Nuclear medicine

Preparation of radiopharmaceuticals
Controls (quality assurance)
Measurement of activity
Incident management
Contamination monitoring

57.4 Visits

Visit to a hospital: Departments of Radiology, Radiotherapy, Nuclear Medicine

PART XII

NUCLEAR SAFETY AND RADIATION PROTECTION INTERFACE

58. Criticality Safety

Nuclear fission
Chain reaction
Fission products
Criticality - multiplication factor: Four Factor Formula
Criticality radiation hazards
Criticality safety measures

59. Research Reactor Safety

Conceptual design
Fission product inventory
Safety in design
Safety in operation
Radiation protection considerations

60. Nuclear Power Reactor Safety

Conceptual design
Fission product inventory

61. Nature and Types of Reactor Accidents

Reactivity excursion, loss of cooling capacity

62. Basic Safety Principles for Nuclear Power Plants - Defense in Depth

Siting considerations
Physical barriers
Fuel matrix
Fuel cladding
Primary coolant system barrier
Confinement-containment
Multiple layers of protection
Conservative design, quality assurance, surveillance activities, human factors, safety culture
Control of operation; rapid response to abnormal operation or any indication of system failure
Engineered safety features and protective systems
Accident management to preserve containment

63. Accident Analysis Methodology

Deterministic approach
Probabilistic approach

64. Reactor Accidents - Case Studies

Windscale
TMI
Chernobyl

65. Transboundary Considerations

66. Off-Site Emergency Planning

67. Visit to a Research Reactor Facility

Radiation Protection

No.	*Title*	*1994*	*1995*	*1996*	*1997*	*1998*
RP-4	*Safe transport of radioactive material*			*x*		
RP-5	*Planning, organization and implementation of radiation protection at a national level*				*x*	
RP-6	*Management of radiological accidents involving radiation sources*		*x*			

REGIONAL TRAINING COURSES

AFRICA

A. Nuclear Safety and Radiation Protection

	Title	*1994*	*1995*	*1996*	*1997*	*1998*
1	*Operational safety of research reactors*				*x*	
2	*Radiation protection in medical practice: occupational protection of medical staff and protection of the patient in diagnostic radiology, radiotherapy and nuclear medicine*		*x Eng.*	*x French*		
3	*System of notification, registration, licensing and control of radiation sources and installations*	*x Eng.*	*x French*	*x Eng.*	*x French*	*x Eng.*
4	*Techniques for external and internal dose assessment (workshop)*			*x Eng.*		*x French*
5	*Calibration of radiation protection instruments (workshop, Seibersdorf)*	*x Eng.*			*x French*	
6	*Emergency planning and preparedness and international co-operation during radiological emergencies*		*x French*		*x Eng.*	

ASIA AND THE PACIFIC

B. Nuclear Safety and Radiation Protection

	Title	*1994*	*1995*	*1996*	*1997*	*1998*
1	*Operational safety of research reactors*		*x*			
2	*System of notification, registration, licensing and control of radiation sources and installations*	*x*		*x*		
3	*Radiation protection in medical practice: occupational protection of medical staff and protection of the patient in diagnostic radiology, radiotherapy and nuclear medicine*			*x*		
4	*Techniques for external and internal dose assessment (workshop)*	*x*		*x*		
5	*Measurements and dosimetry for radon and thoron (workshop)*	*x*				*x*
6	*Preparation of off-site emergency plans (workshop)*		*x*		*x*	

At its 16th meeting, the Advisory Committee on Training in Nuclear Power and Safety also recommended that the IAEA consider offering a Regional Training Course on "Safety and reliability improvements through optimized maintenance of NPPs". Possible host country - China.

MIDDLE EAST AND EUROPE

B. Nuclear Safety and Radiation Protection

	Title	*1994*	*1995*	*1996*	*1997*	*1998*
1	*Reliability-centred maintenance methods for NPPs*			*x*		*x*
2	*Operational safety assessment techniques*	*x Spain*				
3	*Operational safety of research reactors*	*x*				*x*
4	*Management of safety aspects of NPP ageing: components, systems, structures*		*x*		*x*	
5	*System of notification, registration, licensing and control of radiation sources and installations*				*x*	
6	*Safe transport of radioactive material*	*x Germany*	*x Joint IAEA/CEC*			*x Middle East*
7	*Technical solutions aimed at reduction of radiation exposure for different environments*			*x*		
8	*Radiation protection in medical practice: occupational protection of medical staff and protection of the patient in diagnostic radiology, radiotherapy and nuclear medicine*				*x*	
9	*Techniques for external and internal dose assessment*		*x*		*x*	

LATIN AMERICA

B. Nuclear Safety and Radiation Protection

	Title	*1994*	*1995*	*1996*	*1997*	*1998*
1	*Operational safety of research reactors*			*x*		
2	*Safe transport of radioactive material*	*x Arg.*				
3	*Radiation protection in medical practice: occupational protection of medical staff and protection of the patient in diagnostic radiology, radiotherapy and nuclear medicine*	*x Mexico*		*x*		*x*
4	*System of notification, registration, licensing and control of radiation sources and installations*		*x Mexico*		*x*	
5	*Techniques for external and internal dose assessment (workshop)*	*x*	*x*			