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No.20

# Training in Radiation Protection and the Safe Use of Radiation Sources

International Atomic Energy Agency, Vienna, 2001

# TRAINING IN RADIATION PROTECTION AND THE SAFE USE OF RADIATION SOURCES

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# TRAINING IN RADIATION PROTECTION AND THE SAFE USE OF RADIATION SOURCES

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# FOREWORD

The need for education and training in the various disciplines of radiation protection has long been recognized by the IAEA, the International Labour Organization (ILO), the United Nations Educational, Scientific and Cultural Organization, the World Health Organization and the Pan American Health Organization (PAHO). This need has been partially met through the many training courses undertaken by these organizations, either individually or in collaboration. The IAEA has assisted developing Member States in the training of specialists in radiation protection and safety through its organized educational and specialized training courses, workshops, seminars, fellowships and scientific visits. Training is an important means of promoting safety culture and enhancing the level of competence of personnel involved in radiation protection activities, and has acquired a place in the IAEA's programme accordingly. For example, the IAEA Post-graduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources is regularly offered in countries around the world, and has been provided in Arabic, English, French, Spanish and Russian.

The training provided by the IAEA is primarily aimed at regulators, professionals working in radiation protection and those responsible for the development of training programmes in their own countries. The importance of adequate and appropriate training for all those working with ionizing radiation has been highlighted by the results of the IAEA's investigations of radiological accidents. A significant contributory factor in a number of the accidents has been a lack of adequate training, which gave rise to errors with serious consequences.

This report provides assistance in organizing training and complying with the requirements on training of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS). The previous version of this report, Technical Reports Series No. 280: Training Courses on Radiation Protection, was published in 1988. This revision takes account of the many developments in radiation protection and the safe use of radiation sources and in training methods of recent years. As well as the requirements on training established by the BSS, it also relates to the Safety Guide on Building Competence in Radiation Protection and the Safe Use of Radiation Sources.

The IAEA is grateful to the experts from various Member States and to the ILO and PAHO, who took part in the development and review of this publication. P. Wieland of the Department of Nuclear Safety was the responsible IAEA officer. Information provided by the Department of Technical Co-operation was used in preparing this report.

*EDITORIAL NOTE*

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# 1. INTRODUCTION

## 1.1. BACKGROUND

The IAEA published in 1996 the revised International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [1] as internationally harmonized and up to date radiation protection standards. The BSS require that a safety culture ensures that “the responsibilities of each individual, including those at senior management levels, for protection and safety be clearly identified and each individual be suitably trained and qualified” (Ref. [1], para. 2.28).

Also, “The government should ensure that an adequate legislative framework is established which requires appropriate training for all personnel engaged in activities relating to nuclear, radiation, radioactive waste and transport safety. The legislation should assign responsibilities for the provision of training” (Ref. [2], para. 2.1). In order to comply with regulatory requirements and with the principles of radiation protection, adequate training in radiation protection and the safe use of radiation sources is needed for any person who is occupationally exposed to ionizing radiation or who may be exposed in the course of his or her work. This training has to be relevant to the specific practice, and may vary from a one day radiation protection awareness course for the operator of a simple level gauge to an extensive comprehensive course for a qualified expert.

The IAEA, in co-operation with other organizations, offers the Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources in several languages. This course aims to meet the initial training needs of professionals of graduate level, or equivalent, who need to acquire a sound basis in radiation protection and the safe use of radiation sources. It is based on a standard syllabus, the structure of which can be found in Annex I. Other specialized courses on radiation safety are provided regularly for more experienced professionals needing to acquire a deeper knowledge of specific modules of the standard syllabus. The IAEA encourages, on a longer term basis, the establishment of self-sustained national or regional training centres.

There are many training courses on radiation protection and the safe use of radiation sources provided around the world. The Internet is a valuable source of up to date information, including training courses, training material and sample questions and answers. A survey of university level education programmes in radiation protection in several countries is given in Ref. [3].

The IAEA Safety Guide on Building Competence in Radiation Protection and the Safe Use of Radiation Sources [2] gives guidance on the responsibilities for building competence, categories of persons to be trained, the educational level, training and work experience needed for each category, the process of qualification and authorization of persons, and a national strategy for building competence in radiation protection and the safe use of radiation sources. The Safety Guide and this associated Safety Report will be of particular interest to those responsible for the development and provision of training programmes.

## 1.2. OBJECTIVE

This Safety Report provides advice on the development and implementation of training in protection and safety for a range of users and applications. It is written primarily for trainers and training providers and covers, among other things, the various methods of providing training and the developmental and organizational aspects associated with training activities. It is intended to assist trainers and training providers by giving information on and examples of training methods and materials that have proven to be effective in use with appropriate target audiences. It supersedes the IAEA Technical Reports Series No. 280: Training Courses on Radiation Protection [4], which was published in 1988.

## 1.3. SCOPE

This Safety Report addresses the development and provision of training in protection and safety to persons in a range of categories involved in work with ionizing radiation. The methods of training covered are classroom based training, distance learning and on the job training.

While this report is not intended for the design of educational courses or public awareness programmes, some of its content may be useful in those areas. References [5–8] provide information for school and public awareness programmes.

The development of training in specific technical aspects of nuclear installations,[1] such as siting, design, construction, operation and maintenance, is not considered in this report. Detailed guidance and information on training in these areas are given in other IAEA publications [9–11]. While this report focuses on training in protection and safety, it also provides useful information for the development and provision of training programmes in other areas.

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[1] A nuclear installation is a nuclear fuel fabrication plant, nuclear reactor (including subcritical and critical assemblies), research reactor, nuclear power plant, spent fuel storage facility, enrichment plant or reprocessing facility.

### 1.4. STRUCTURE

Section 2 addresses the minimum training needs for the different categories of persons identified in Ref. [2]. Section 3 considers various ways in which competence can be gained, maintained and developed, while Section 4 describes classroom based training, distance learning and methods of on the job training. Section 5 outlines a systematic approach to training and provides a logical sequence that could be followed in the design, development and implementation of training, and includes a section on evaluation methods that can be used to provide information for feedback to the design process. Additional practical information, including an example of a training course and the design and development of on the job training and basic steps for the establishment of a training centre, is given in the annexes.

## 2. CATEGORIES OF PERSONS TO BE TRAINED

In the development of training courses it is important to bear in mind that some of the participants may lack the basic knowledge necessary for assimilating technical training fully. Training is still needed, however, and in determining the content and depth of the training the trainer needs to concentrate on those points of practical and direct relevance to the radiation application in question. Establishing a basic level of competence is a matter of high priority for all personnel.

The BSS [1] require national authorities to foster and maintain a safety culture. To this end all persons associated with radiation work have to be suitably trained and qualified so that they understand their responsibilities and perform their duties safely. Reference [2] identifies the following categories of persons for training: qualified experts, radiation protection officers, workers, including personnel working directly with sources of radiation and those persons with a low potential for exposure, qualified operators, health professionals, employers, registrants and licensees, staff of regulatory authorities and emergency response personnel.

The content and level of training for each of these categories are based on such factors as the potential for radiation exposure associated with the work, the level of supervision provided, the complexity of work to be performed and the degree of previous training of the individuals. Table I provides suggestions on the content and level of training for different categories of persons in different practices. The content of training refers to the modules of the standard syllabus for a Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources presented in Annex I [12].

TABLE I. CONTENT AND LEVEL OF TRAINING FOR CATEGORIES OF PERSONS ENGAGED IN DIFFERENT PRACTICES[a]

| | Parts and modules of the standard syllabus[b] to be covered for each category of job | | | | |
|---|---|---|---|---|---|
| | Qualified expert | Radiation protection officer | Worker occupationally exposed | Qualified operator | Regulator |
| Level of training[c] | Tertiary level | Secondary level | Basic level | Secondary level | Secondary or tertiary level |
| Personal attributes[d] | 1, 2, 3 | 1, 2, 3, 4, 5 | 1, 3, 4 | 1, 2 (for supervisors), 3, 4 | 1, 2, 3, 4 (for inspectors), 5 |
| Modules for industrial radiography | I–VI; VII.1–10; IX–XI | I–VI; VII.1–6; IX–XI | I–V; VII.1–6; IX.1–3; X.1, 2, 5, 7 | I–V; VII.1–6; IX.1–3; X.1, 2, 5, 7 | I–VI; VII.1–10; IX–XI |
| Modules for irradiators and accelerators | I–VI; VII.1–10; IX–XI | I–VI; VII.1–5, 7; IX–XI | I–V; VII.1–5, 7; IX.1–3; X.1, 2, 5, 7 | I–V; VII.1–5, 7; IX.1–3; X.1, 2, 5, 7 | I–VI; VII.1–10; IX–XI |
| Modules for gauging techniques | I–VI; VII.1–10; IX–XI | I–VI; VII.1–5, 8; IX–XI | I–V; VII.1–5, 8; IX.1–3; X.1, 2, 5, 7 | I–V; VII.1–5, 8; IX.1–3; X.1, 2, 5, 7 | I–VI; VII.1–10; IX–XI |
| Modules for tracer techniques | I–VI; VII.1–10; IX–XI | I–VI; VII.1–5, 9; IX–XI | I–V; VII.1–5, 9; IX; X.1, 2, 5, 7 | I–V; VII.1–5, 9; IX; X.1, 2, 5, 7 | I–VI; VII.1–10; IX–XI |
| Modules for mining and milling | I–VI; VII.1–10; IX–XI | I–VI; VII.1–5, 16; IX–XI | I–V; VII.1–5, 16; IX; X.1, 2, 5, 7 | I–V; VII.1–5, 16; IX; X.1, 2, 5, 7 | I–VI; VII.1–10; IX–XI |
| Modules for nuclear installations | I–VI; VII.1–10; IX–XI | I–VI; VII.1–5, 15; IX–XI | I–V; VII.1–5, 15; IX; X.1, 2, 6, 7 | I–V; VII.1–5, 15; IX; X.1, 2, 6, 7 | I–VI; VII.1–10; IX–XI |
| Modules for diagnostic radiology | I–VI; VII.1–5, 12–14; VIII; XI | I–VI; VII.1–5, 12; VIII; XI | I–V; VII.1–5; 12 VIII | I–V; VII.1–5; 12 VIII | I–VI; VII.1–5, 12–14; VIII; XI |
| Modules for nuclear medicine | I–VI; VII.1–5, 12–14; VIII; IX–XI | I–VI; VII.1–5, 13; VIII; IX–XI | I–V; VII.1–5, 13; VIII; IX.1–4; X.1, 2, 5, 7 | I–V; VII.1–5, 13; VIII; IX.1–4; X.1, 2, 5, 7 | I–VI; VII.1–5, 12–14;VIII; IX–XI |
| Modules for radiotherapy | I–VI; VII.1–5, 12–14; VIII; IX–XI | I–VI; VII.1–5, 14; VIII; IX–XI | I–V; VII.1–5, 14; VIII; IX.1–3; X.1, 2, 5, 7 | I–V; VII.1–5, 14; VIII; IX.1–3; X.1, 2, 5, 7 | I–VI; VII.1–5, 12–14; VIII; IX–XI |

[a] The list of practices is not intended to be comprehensive. The training content of other practices not listed here can be inferred from those listed, for example if the practice involves unsealed sources, if there is potential for public exposure or if the practice generates radioactive waste.

[b] Refer to Annex I for details of the parts and modules of the standard syllabus.

[c] Suggested level for which the training should be provided in consideration of the educational background of the participant: (a) basic level, corresponding to 6–10 years of schooling; (b) secondary level, corresponding to 10–12 years of schooling; (c) tertiary level, corresponding to education up to and including a university degree or diploma.

[d] Personal attributes to be stimulated during training: 1, communication skills; 2, leadership skills; 3, analytical skills; 4, human–machine interface skills; 5, multitask management skills. Responsibility, team work, self-control and reliability are essential attributes for any category of job.

## 2.1. QUALIFIED EXPERTS

Training for qualified experts should provide the broad knowledge of protection and safety as suggested in Table I. This level of knowledge may be obtained by formal education, specific training and work experience. Additionally, qualified experts need to have a thorough knowledge of specific topics related to their field of expertise and also need to keep abreast of developments in their field. Qualified experts need to have highly developed personal attributes, including communication, analytical and leadership skills, since they provide training and give advice to a wide range of personnel, such as workers, managers, health professionals or staff of government authorities.

## 2.2. RADIATION PROTECTION OFFICERS

Training for radiation protection officers will vary considerably depending on the radiation application, but all training should contain a certain amount of common core information on protection and safety. The depth to which each topic is covered should depend on the specific practice in which the person is being trained, and should also take into account the magnitude of the potential hazards associated with the application (see Table I). Radiation protection officers need to have specific personal attributes, such as communication skills, leadership and analytical skills, human–machine interface skills and multitask management skills, which can be stimulated during training through practical exercises.

## 2.3. WORKERS

Workers who are occupationally exposed to ionizing radiation under normal working conditions need more extensive and deeper training than those who have a low potential for exposure as a result of occasional activities in areas where exposure may occur. Training will vary from a few hours' radiation awareness training in the case of a worker who works in the vicinity of a simple level gauge to training of one week or more for workers at an irradiation facility.

As stated in the Ref. [2] (para. 3.37):

> "Training of workers in protection and safety should be a well established part of the overall programme on radiation protection. The training should be tailored to the particular radiation application and the type of work performed and should be designed so that the worker develops the necessary skills to work safely. The training programme should ensure that all workers receive adequate

> and up to date information on the health risks associated with their occupational exposure, whether routine exposure, potential exposure or exposure in an emergency, and on the significance of actions to be taken for protection and safety. It should also include local rules, safety and warning systems, and emergency procedures. Each training topic should be covered to the appropriate depth for the specific radiation application and the potential hazards associated with it [see Table I]. Workers should also be made aware of the presence of other hazardous agents in the workplace which may affect the safety of sources, such as inflammable items or corrosive agents. Female workers who are likely to enter controlled or supervised areas should be provided with appropriate information on the potential risks to an embryo or foetus due to exposure to radiation. They should also be made aware of the importance of notifying their employer as soon as pregnancy is suspected. Training should always include on the job training."

The necessary personal attributes of workers depend on the tasks undertaken, but may include communication, human–machine interface and analytical skills, which can be stimulated in training through practical exercises.

Workers who do not directly work with ionizing radiation, but nevertheless work in the vicinity of radiation sources (including, for example, cleaning and maintenance staff), have to be trained in and informed of the potential hazards associated with radiation sources and the basic protection and safety procedures, especially the recognition of warning signs and signals. Other workers, who may not be occupationally exposed but whose work may have an impact on the level of exposure of other workers or members of the public (e.g. designers, engineers and planners), have to be trained in the potential hazards associated with the results of their work and the means to prevent exposure.

Those visiting a nuclear facility briefly for short term projects or spending extended time periods on assignment to a facility may need basic training in radiation protection and the safe use of radiation sources in relation to the facility. Students who are engaged in course work or research projects in which radioactive materials and radiation producing devices are used are included in this category, and may need specific radiation safety training associated with their academic studies. Visitors to nuclear facilities are often escorted and, if such escorts are provided, specific training for the visitor may be minimal.

## 2.4. QUALIFIED OPERATORS

Training of qualified operators will vary considerably depending on the application and potential hazard. It should include radiation protection and safety tailored to the particular application and be designed so that the operator develops the necessary skills to work safely (see Table I). Minimum training would cover the safe use of radiation sources in the specific practice, local rules and procedures, including safety and warning systems, and emergency procedures. Many of the topics specified in the training for RPOs will also be appropriate for operators. Communication, analytical and human–machine interface skills are necessary to perform the work effectively and safely and can be stimulated during training. Leadership skills may be necessary in supervisory functions.

## 2.5. HEALTH PROFESSIONALS

The appropriate level of formal training for health professionals could, for example, be that shown in Table I corresponding to the practice and type of job, emphasizing the biological effects of ionizing radiation, together with specialized training in their field of work. Health professionals need to be acquainted with up to date information on the diagnosis and treatment of radiation injuries (see, for example, Ref. [13]), and have well developed communication, leadership, analytical and human–machine interface skills as part of their professional training. Further training in radiation protection and safety would enhance these skills. The duration and depth of the specialized training depends on the level of responsibility and the complexity of the job of the health professional.

## 2.6. MANAGERS

Reference [2] describes managers as “employers, registrants and licensees”. The term ‘managers’ is used in this report to describe those people responsible at all levels, including senior management, for overseeing the use of ionizing radiation sources. Training could include the basic principles of radiation protection, responsibilities relating to radiation risk management, the relevant legislation and regulations governing radiation protection, the concept and principles of safety culture and the principal elements of a radiation protection programme for occupational, medical and public exposure, as appropriate. Personnel in management positions will usually already have acquired communication, leadership and analytical skills, and skills in multitask management.

Managers have an important responsibility to ensure that all workers, including contractors and subcontractors, receive adequate training in radiation protection and safety.

## 2.7. STAFF OF REGULATORY BODIES

The level and depth of training for staff of regulatory bodies will vary considerably according to the duties performed and the potential radiological hazards of the radiation sources in the regulated facilities. Personnel involved in the assessment of safety and inspections at regulated facilities should have undergone extensive training; however, inspectors of industrial gauging systems, for example, may need only basic training in radiation protection. A thorough knowledge of the legislation and regulatory framework of the country is needed in addition to training in the safe use of radiation sources. The regulator should be familiar with the relevant international standards and practices in other countries. Radiation monitoring and inspection techniques are an important component of training for inspectors. Table I shows the suggested content of the training. The personal attributes of staff of regulatory bodies that can be stimulated during training include communication skills, leadership and analytical skills, human–machine interface skills (for inspectors) and multitask management skills.

## 2.8. EMERGENCY RESPONSE PERSONNEL

Emergency response personnel, such as fire fighters, civil defence personnel, police and paramedics, are usually not employees of a facility in which radioactive materials or radiation producing devices are used. They are not exposed to radiation on a regular basis, and thus they are not normally included in the occupational radiation protection programme of the facility. In such cases, training should be carefully designed to ensure that the participants have a clear understanding of the specific hazards and risks associated with nuclear or radiological emergencies and of how they are to respond to emergencies in specific installations. Furthermore, since such emergencies are infrequent, a regular schedule of training and simulation exercises is necessary to ensure that competence is maintained.

The level of training that should be provided may vary substantially: fire brigade and police personnel may have a basic level of education, while emergency response team co-ordinators at a nuclear installation would usually have a tertiary level of education. In general, training may include parts I to V, VII, IX and X of the standards syllabus (Annex I) to an appropriate depth. The personal attributes of the personnel of emergency response teams that can be stimulated during training include communication skills, leadership (for those at the management level) and analytical skills, multitask management skills and the ability to work under intense stress.

# 3. DEVELOPMENT OF COMPETENCE THROUGH TRAINING

Competence is acquired, developed and maintained through a programme of regular training. Several terms, such as initial training, basic training, refresher training and periodic training, are used to describe the types of training which make up a total programme. In this report:

— ‘Basic training’ is used to describe training in scientific and technical topics that provides the foundation for more specific training in protection and safety,
— ‘Initial training’ is used to describe the initial training for a specific practice,
— ‘Refresher training’ is used to describe the type of training provided at regular intervals to ensure that competence is maintained.

The term ‘periodic training’ usually has the same meaning as refresher training, but is not used in this report.

## 3.1. ACQUIRING COMPETENCE

Initial training is to be provided to personnel before they commence work in an area where they may be exposed to ionizing radiation; however, they may already have received basic training in scientific or technical disciplines. They will need additional training if they are to enter an area where different hazards may arise or different skills are needed, if working conditions or procedures change, or even if a specific task or new equipment or technology is introduced. An example is the introduction of new radiation generating equipment (e.g. an industrial irradiator, or a computerized tomography or interventional radiology X ray system). Specific training should be provided to operators before the equipment is used and should preferably be part of the commissioning process for the new equipment. Full and clear equipment operation manuals and instructions should be made available in the local language to facilitate the training process.

When a new technique is implemented (e.g. the production of a new radioisotope in a radioisotope production plant, or the introduction of a new process such as intravascular brachytherapy), additional training of personnel is also needed. The training may be provided in an institution or organization with experience in the technique.

## 3.2. EXTENDING COMPETENCE

Competence in specific areas may be extended by taking part in additional specialized training. Such training may be provided at all levels in order to extend levels of competence. Advanced training programmes provide a method of extending competence, as do other means such as workshops and exchange of information at seminars and scientific conferences.

## 3.3. MAINTAINING COMPETENCE

Principles of radiation protection are adapted as knowledge of the mechanisms of radiation injury is advanced. The publications of the International Commission on Radiological Protection (ICRP) and other organizations give information on the effects of radiation exposure. Regular developments are made in equipment and work techniques which lead to improved work procedures. It is important that all workers refresh and update their knowledge and skills through a programme of refresher training. Programmes of refresher training are designed to stimulate the interest of the participants and could include the following topics:

— A review of knowledge of radiation protection and safety;
— Information on changes to policies and procedures for radiation safety;
— Changes to equipment, instrumentation or processes;
— Results of internal audits or inspections;
— New or revised regulations;
— Feedback from operational experience and good practices;
— Lessons learned from incidents, accidents or operational failures;
— Topical subjects or events.

It is desirable that the training be as interactive as possible. One method of refreshing initial training and increasing competence in specific topics is that of leading from practical experience back to theory. An example of this method is to ask a question, such as ‘Why do we shield against beta radiation with aluminium rather than lead?’, in order to stimulate interest and discussion.

The frequency of refresher training may be determined by national regulations. It is also dependent on the type of work undertaken (and other methods used to keep workers informed); for example in some countries industrial radiographers receive refresher training every six months, whereas workers involved in transporting radioactive materials may receive refresher training less frequently, for example every five years. However, changes in regulations or notifications of safety issues need to be provided as written instructions as soon as they become available. The information may be followed up by inclusion in the refresher training.

## 4. TRAINING METHODS

Training in radiation protection and safety can be provided by various methods, including classroom based training, distance learning and on the job training, while an individual course may be presented either in a classroom or by distance learning. Training of a particular group need not be restricted to one training method alone; in fact training for most categories of persons will involve a combination of methods. The choice of training methods will be determined by factors such as geographical location of the participants, possibility of release from the workplace, and cost and availability of equipment and materials. In order to ensure a high quality of training, however, all training, regardless of the method of provision, will be subject to the recommendations given by the relevant national authority.

### 4.1. CLASSROOM BASED TRAINING

Classroom based training is still the most frequently used means of training provision, and is probably the most effective means of providing comprehensive instruction. It facilitates direct communication and discussion between the trainer and the participants and enables the trainer to modify a range of factors, such as the depth of the instruction and the speed of delivery, depending on the capabilities and progress of the participants. A classroom based course should consist of a series of lectures on specific topics from a syllabus, interspersed with practical exercises, group discussions and case studies designed to reinforce the lecture content. However, providing such courses is relatively expensive in terms of the resources needed, the efforts of the trainers and in the time and subsistence costs for the participants.

### 4.2. DISTANCE LEARNING

Distance learning is a means of training which may be an effective alternative to classroom based training. It can be provided for all categories of participants and is particularly appropriate for those who live far from training centres or have insufficient time or funds to attend classroom based training. It may also be an effective use of training resources where only small numbers of people need training.

Distance learning media cover a range of information technologies, including paper based correspondence courses, videotapes, video teleconferencing and Internet based classes. The function of the supervisor in distance learning will vary depending upon the medium used. Training through correspondence, videotaped instructions and most Internet based classes provide for little or no supervisor–participant interaction. Video teleconferencing, on the other hand, lets participants and supervisors interact almost at a classroom level. The availability of cameras and microphones facilitates the access of users of personal computers to Internet based distance learning.

A typical distance learning package will consist of a modular set of course notes, study guides and associated exercises based on specific topics from a syllabus. Participants complete the package in their place of work or at home. The training should include the completion of assessment tasks (e.g. written examinations, research assignments and problem solving exercises) which are then forwarded to a supervisor or tutor for marking and return. All distance learning in radiation protection should include a residential programme designed to reinforce the course material and to provide practical work and technical visits. The residential programme may be relatively brief, but should provide sufficient time for the participants to acquire the necessary skills, to learn problem solving methods or to gain practical experience. The role of the supervisor is important to the success of distance learning, and frequent interactions between the participants and the supervisor may be necessary.

Distance learning makes effective use of resources and permits the participants to study at their own pace. However, the success of the training depends on the self-motivation of the student to complete the work with a minimum of direct supervision.

Distance learning modules typically involve the use of printed course notes and study guides; however, the increasing availability of information technology permits the use of more sophisticated learning tools. Training organizations in several countries have developed distance learning packages that make use of video modules that are either sent out to participants or downlinked from broadcast transmissions. The video modules simulate the lectures in a classroom based course and are reinforced by periodic attendance at laboratory sessions. The disadvantage of video modules is that the participant does not have the opportunity to interact with the presenter during the presentation. The use of tools such as video conferencing may be considered if the equipment is available, as it allows useful interaction between participants and supervisors.

With the increased availability of personal computers, many workers now have access to a computer in the workplace. This has stimulated the development of computer based training packages consisting of interactive training modules with question and answer sections. Packages are available on CD-ROM or the Internet, and include several provided by the IAEA (see http://www.iaea.org/ns/rasanet/training/index.htm). The selection of a computer based training package will depend on the learning objectives planned for the training; advice to assist in their selection may be available from national authorities.

Computer based training modules can incorporate photographs, diagrams, simulations and video sequences. The information can be accessed and searched easily, and links can be provided to a glossary of terms. Printed learning materials and study guides are, however, needed to support the computer based training. This type of training is a form of distance learning and has similar advantages; it can be used wherever a suitable computer is available, thus obviating the need for absence from the workplace, and the participants can work at their own pace.

### 4.3. ON THE JOB TRAINING

Classroom based training or distance learning is unlikely to cover all the practical radiation protection and safety aspects and skills associated with specific work tasks; hence on the job training is a critical component of an overall training programme. In this form of training the participant works in his or her normal place of work or other suitable training site under the direct supervision of an experienced mentor.

The duration of on the job training can vary considerably, but it is important that the training be provided in a systematic manner to ensure that the benefits are maximized. A training plan based on identified practical competences and including a list of topics to be covered and tasks to be carried out may be prepared.

The participant's progress and achievements may be recorded on a checklist of topics and tasks. The supervisor's role is an important one, and includes ensuring that the participant receives comprehensive training and is not being used as an extra pair of hands. A staged approach to on the job training should ensure that the participants progress from observing the task being performed by others to assisting in and finally carrying out the task themselves. On completion of the training, the supervisor and participant should prepare a comprehensive report describing the participant's progress, the areas of competence gained and any further training needs.

## 5. A SYSTEMATIC APPROACH TO TRAINING

A systematic approach to training provides a logical progression from the analysis of competences to the design, development and implementation of training to achieve these competences, and subsequent evaluation of the training for feedback to the design stage. This section provides information to trainers, training providers and training organizers on the design, development, implementation and evaluation of training, on the assumption that an analysis of the competences needed has been completed [2].

Training in radiation protection and the safe use of radiation sources may be delivered by a range of training providers, including colleges, universities, training consultants and training departments within organizations. Countries may consider establishing training facilities in the form of training centres; Annex II provides information to assist this process.

Annexes III and IV contain examples of, respectively, the classroom based and on the job components of the design and development of training for industrial radiographers.

## 5.1. DESIGN OF THE TRAINING

The successful provision of classroom based training, workshops, seminars, on the job training and distance learning demands careful attention to the design of the training in order to ensure that the appropriate information is provided to the participants and that the training fulfils their expectations. Training design should commence after the identification of the target group by an analysis of training needs, and should include the following:

— The aims of the training,
— The learning objectives,
— The training syllabus.

Feedback from previous courses provides information for consideration at all stages in the design process.

### 5.1.1. Aims of the training

The aims of the training are determined by considering the needs of all interested parties, including the requirements set by the regulatory body. These needs are usually assessed after the regulatory body and the users of radiation sources have identified the availability of trained personnel and the numbers of individuals needed in the various job categories [2].

A statement of the aims of the training should include:

— Identification of the body of knowledge to be included in the training;

— Specification of the regulations, guides or other requirements relating to the topics covered;
— Delineation of the work practices, equipment usage and procedures for which the training is to be provided.

Although the aims may be couched in general terms, they have, nonetheless, to be specific for each particular application.

### 5.1.2. Learning objectives

Once the aims of the training have been decided upon, the learning objectives can be determined. These objectives are the knowledge and skills that the participants are expected to have attained and mastered upon completion of the training to meet the responsibilities concerning radiation safety in their job descriptions; achievement of the objectives shows that the training aims have been met. The objectives are considered performance goals for the participants. Typical objectives have measurable outcomes that can be determined through some type of testing or assessment procedure. Consequently, a normal list of objectives will appear as a series of statements that describe the competences that the student will be able to demonstrate upon successful completion of the training. For example, the objectives might appear as: ‘Upon completion of the training, the participant will be able:

— To recognize radiation risks in the workplace;
— To identify warning signals and signs;
— To operate and/or use correctly radiation monitoring equipment and/or individual radiation protection devices;
— To measure correctly levels of dose rate or contamination;
— To distinguish between practices and interventions, and between workers’ and licensee’s responsibilities;
— To interpret the results of measurements;
— To put on and remove safely protective clothing and respiratory devices;
— To inspect the safety of a given facility;
— To decontaminate different surfaces;
— To respond correctly and promptly to alarm signals and emergencies;
— To determine and/or calculate radiation doses and shielding.’

Note that in most cases the learning objectives are characterized as action verbs or phrases that can be assessed.

### 5.1.3. Syllabus

The syllabus provides an outline of the content of the training for the guidance of the trainers or supervisors. It should be drawn up to reflect the aims and objectives of the training and contain sufficient information and detail to enable the trainers or supervisors to appreciate the content and depth of the training activity. The content of the syllabus may be divided into modules, and the approximate time for each module may also be given. The format and style of syllabuses may vary considerably, and some may incorporate additional information such as reference materials and guidance on the duration of the training.

## 5.2. DEVELOPMENT OF TRAINING

The development of training is based on the initial design and involves preparation of the following items:

— A training schedule,
— Lesson plans,
— Training materials,
— Practical training sessions,
— Assessment procedures.

### 5.2.1. Training schedule

Training schedules should be prepared based on the syllabus. It is advisable to structure the schedule so as to maintain the interest of the participants for the duration of the training and to build on previous knowledge and experience.

In classroom based training, the lecture content should be restricted to a maximum of six hours and there should be several short breaks during the day. The scheduling of practical exercises, video presentations and interactive group sessions at regular intervals throughout the course will break the lecture blocks into manageable units and helps to reinforce the subject matter of the formal lectures. It is suggested that the practical classes account for 40 to 50% of the duration of the course. The training co-ordinator should ensure that sufficient time is included in the schedule to permit participants to complete group exercises and experiments or to participate in technical visits. The interest and attention of the participants can be sustained by the following methods:

— Involving participants in the learning process;
— Asking questions and waiting for answers, with encouragement if necessary;

— Relating the content to the experience of the students;
— Encouraging co-operation and interaction among the class.

Additional ideas and methods for motivating students may include technical visits and discussions with specialists in the subject matter of the training.

For on the job training it is important to prepare a training schedule that takes into account the availability of equipment and the operation of the facility. The schedule needs to be flexible enough to take advantage of opportunities to train in conjunction with infrequent or non-routine activities (for example radiation protection during maintenance of accelerators, replacement of sources in radiotherapy or decontamination work). The schedule should be designed to encourage learning that progresses from simple to more complex tasks on the basis of the results of monitoring the progress of the participant.

### 5.2.2. Lesson plans

While the syllabus will give a broad overview of the content of the training and an indication of the approximate amount of time to be spent on each subject, further guidance needs to be given to the trainers or supervisors to ensure that the learning objectives are achieved. This guidance, sometimes called a lesson plan, typically includes the following information:

— Specific content and key points that are to be emphasized;
— Order of learning so that new material will, in most cases, build on material presented previously;
— Details of the key points to be included in the assessment of the course, and when this should take place;
— Suggested training tools, such as demonstrations and practical work;
— A list of available resources (e.g. videotapes, computer simulations, reference material, technical equipment, local rules and procedures).

Plans of this nature help to ensure that the material is covered in appropriate detail and that the content of the training activity remains the same regardless of who gives the training. Plans are considered to be essential where an assessment of competence is held on completion of the training. Without such a plan the trainer may not always cover all of the material that is being tested in the assessment.

For on the job training the same approach can be used, but the emphasis should be on the practical nature of the training.

### 5.2.3. Training materials

For classroom based training the lecture notes should correspond to the topics in the syllabus, and the level of information in the notes needs to be consistent with the level of training provided. Where practicable, the notes could be illustrated with figures and diagrams to clarify the subject matter and to make them more visually attractive and readable. Providing written questions and model answers is a useful means of encouraging participants to check their level of understanding. The scripts for practical exercises and group work (case studies) need to be clear and concise, and model answers should be provided to the participants at the end of any group activity.

In preparing the visual aids, conciseness and clarity are important.

— The content should be limited to not more than one theme per transparency, slide or screen;
— No more than four different messages per transparency, slide or screen should be used;
— The sentences should be simple and short;
— Ambiguity should be avoided;
— Key words should be used;
— Figures, photographs or graphics should be incorporated to help convey ideas effectively.

Annex V gives further suggestions on the preparation and presentation of effective visual aids. Professionally produced visual aids, prepared by international organizations, such as the IAEA videos and the Pan American Health Organization (PAHO)/IAEA presentation on radiation protection in medical applications, are available; other materials are available from national organizations.

Trainers are encouraged to include, as handouts, copies of material used as transparencies, slides, diagrams or drawings, and the text of the presentation. Provision of these materials allows the participants to concentrate on the lecture content rather than on reproducing the information being presented, and it also serves as a backup in case slide projectors or overhead projectors fail to operate properly.

In distance learning, the technical content of the material will be similar to that provided in classroom based training. However, the material should be presented in such a way as to allow and encourage self-instruction.

For on the job training the material to be provided to the participants should include instructions, procedures, local rules, technical descriptions, books for reference and an on the job checklist.

### 5.2.4. Practical training sessions

Theoretical information should be reinforced by the effective use of demonstrations, laboratory exercises, case studies, simulations and technical visits. The careful scheduling of these events introduces variation into the course day and helps sustain the interest of the participants. These practical exercises may also be included in distance learning and on the job training. Examples of practical exercises can be found in Annex VI.

If radiation sources are to be used in exercises, care needs to be taken to ensure that the doses to participants are controlled and kept as low as reasonably achievable. Regulations may require that doses to participants be monitored and dose records kept. It is suggested that the participants receive written instructions on the procedures to be followed for radiation protection, and personal dosimeters should be provided when appropriate. In some cases it may be preferable to use simulated radiation sources. As an introduction to a laboratory exercise or simulation, a demonstration of the correct procedures and operations will assist in controlling doses by avoiding unnecessary exposure and will prevent any damage to equipment.

#### *5.2.4.1. Demonstrations*

Demonstrations involving the use of radiation sources and/or equipment can be performed by trainers to illustrate a concept, phenomenon or procedure. Suggested demonstrations are those on the correct and safe operation of equipment, handling of sources or the use of computer software before a laboratory exercise, and should be chosen to be of direct relevance to the participants' area of work. Examples of demonstrations can be found in Annex VI.

#### *5.2.4.2. Laboratory exercises*

Laboratory exercises that make use of radiation sources and/or equipment can be carried out by the participants themselves under the supervision of a trainer or other technical member of staff. Exercises are normally undertaken outside the lecturing environment, in a session reserved for the purpose. In order for the participants to gain the maximum benefit, it is important that they all obtain hands-on experience in the exercise. The groups for each exercise therefore need to be small, with generally no more than four students; this may necessitate the provision of a set of different exercises in a single session, around which small groups of participants can progress. Suitable exercises might cover practical techniques for dose rate and contamination monitoring, experiments to demonstrate the inverse square law and instrument calibration procedures. Other examples of laboratory exercises can be found in Annex VI. The learning objectives and procedures to be followed for each practical exercise should be provided in writing to the participants at the beginning of each exercise, and solutions and conclusions should be provided on its completion.

#### *5.2.4.3. Case studies*

Case studies are tabletop exercises that demand the participants to work through a specific scenario to analyse a situation and draw conclusions. The outline of the scenario may be presented to the participants in advance, and progress is made by asking the trainer appropriate questions and applying the information taught on the course. At the end of the exercise the participants should present and discuss their solutions and be provided with a model answer.

Case studies are an effective way of reinforcing the training material since the participants have to apply and use the knowledge and skills they have acquired in a simulated working environment. The case studies chosen should reflect the participants' areas of work and represent both normal and abnormal situations. Examples of case studies include the assessment of doses to workers in an incident, a review of the adequacy of safety and warning systems for a new item of equipment and the regulatory requirements associated with the use of radioactive sources in industry. The scenario sets the scene and provides sufficient information to enable the participants to determine what additional information, if any, is needed. This additional information may be obtained from the trainer, who may be 'role playing' other characters in the scenario, for example an equipment supplier or an exposed worker. The participants need to be given sufficient time to allow them to analyse the scenario and propose actions. A review session may be held at the end of the exercise, at which the various actions that were taken can be assessed. The model answer provided at the end of the study should provide a useful reference for the participants if a similar situation occurs in the workplace.

#### *5.2.4.4. Simulation exercises*

In simulation exercises, situations or scenarios representing the work environment or conditions are simulated. These exercises are similar to case studies but differ in that the participants actually take the actions. The type of scenario may range from preparing to enter a controlled area with potential contamination risks to emergency response exercises. Simulation exercises may also assist in the development of communication skills and teamwork, and in multitask management skills and analytical capability. The simulation exercise may be complex and careful preparation, including the clarification of learning objectives, is needed.

Simulation exercises should be implemented in three stages:

- — A pre-exercise briefing, to define and explain the roles of each of the participants;
- — A simulation exercise, with a suitable number of observers or referees;
- — A post-exercise debriefing, to analyse individual and team attitudes, application of knowledge, use of rules and procedures, and response to unexpected situations.

In addition to providing valuable training, simulation exercises may yield results that lead to improvements in work procedures.

#### *5.2.4.5. Technical visits*

Technical visits to facilities where ionizing radiation is used give the course participants a valuable opportunity to observe the practical application of requirements and procedures for radiation protection. The venue of the visit should be chosen to reflect the participants' interests, but examples include an industrial radiography company, diagnostic and radiotherapy units of a hospital, an irradiation facility or a nuclear power plant. The visit may be planned to complement and illustrate the topics covered in the training. Prior to the commencement of the course, the training manager and the host company should plan the visit to ensure that appropriate areas are visited and appropriate topics discussed. It is advisable to organize the visit in groups of a size that is suitable for the facility.

In order that the participants benefit fully from the visit, they may be given a checklist beforehand which identifies the different items to be observed. For example, during a visit to a radiotherapy department, an inspection checklist may be provided and the participants may be asked to act as inspectors and record their observations and comments.

### 5.2.5. Assessment procedures

Assessment of the competence of participants should take place at the end of, and sometimes during, the training. Examinations, tests and evaluation of practical work should be used to determine whether the learning objectives have been met and the necessary level of competence has been achieved. Examinations may be written, oral or demonstrational (where a student shows that he or she can operate or use a piece of equipment or carry out a specific task), or a combination of these.

In designing an assessment process, the trainer should consider its purpose. Several purposes, not necessarily mutually exclusive, could be considered.

— Legal purposes: a written examination (or a written or electronic record of examination results) may serve as evidence that an individual has received the training prescribed by a regulatory body for a particular job or activity. Likewise, such a record may serve to demonstrate that the individual has not only received the necessary training but also reached the necessary level of competence, and is thus legally qualified to carry out the indicated task.
— Administrative purposes: the examination provides evidence that the requirements of the employer have been met.
— Technical purposes: aside from legal or administrative requirements, the trainer and the radiation safety staff need assurance that the individual is, in fact, qualified to conduct the work in question safely. The assessment is intended to demonstrate that the individual is capable of meeting the performance objectives identified in the training.

For typical training of the type described in this report, the assessment procedure is intended to fulfil one or more of the above purposes. It is often sufficient for a qualified trainer to set a pass mark and then to determine whether the participant has passed. The degree of difficulty of the assessment needs to be such that a properly selected participant who attends all the sessions and carries out all the assignments can readily pass. The intent is to identify those who are clearly capable and ready to apply radiation protection requirements and adopt safe work practices.

*5.2.5.1. Written assessments*

Written assessments may have a variety of test formats, including multiple choice questions, true–false questions, short answers, matching alternatives, problem solving, and discussion and/or essay questions. There are advantages and disadvantages to each of these, and often the method used is based on the trainer's preference and personal experience. Regardless of the question style, the questions should generally be designed to test understanding and application rather than just memory. There are many literature references on the topic of structuring examination questions which might serve as examples and for general guidance.

For on the job training it is suggested that the participants be asked to write a technical report, in addition to other forms of assessment, to ensure that the theoretical aspects of their training have been understood and learned.

*5.2.5.2. Oral assessments*

Oral assessments have to be used with great care. Normally participants are assessed one at a time and, unless the questions are identical for each participant, the issue of fairness and equality of treatment arises. Since oral examinations typically involve feedback from the questioner, participants may pick up clues to the correct response, which would not be the case in a written assessment format. Furthermore, such feedback is unlikely to be the same from participant to participant. The main role of an oral assessment is to evaluate how well the participant can communicate and explain concepts, and whether he or she can think clearly under pressure. Careful questioning can sometimes uncover mistaken ideas that might go unrecognized in a written assessment.

In cases where the participants are preparing to become trainers or teachers of radiation safety, oral assessments may help in identifying the individual's ability and effectiveness in teaching and presenting technical material. In such cases, an oral assessment may be a useful supplement to a written examination of the technical material.

#### *5.2.5.3. Assessment of practical work*

The main purposes of assessing practical work are:

- To determine the individual's ability to carry out a specific task or procedure that has been taught as part of an on the job training programme or as part of a practical exercise in classroom based training or distance learning;
- To ensure that the individual can carry out such a task or procedure alone (without help) or as a designated part of a team;
- To evaluate the level of skill with which the task or procedure is performed.

The method of conducting practical assessments normally consists of observing the participant, thus it is important that the trainer and/or supervisor use a specific checklist of skills that the participant is expected to demonstrate or actions that he or she should take.

#### *5.2.5.4. Administration of examinations*

Written examinations should be held in suitable facilities, large enough to permit participants to be seated far enough apart to prevent collusion. Calculators, writing materials and any permitted reference materials should be provided immediately before the commencement of the examination. Examinations may be either 'open book' or 'closed book'; that is, the participants may or may not be permitted to use reference materials during the examination. Provided that the examination paper has been correctly designed to test understanding and application rather than just memory, open book examinations are quite acceptable. The time limit on the examination paper should prevent the participants from using the reference materials for anything other than reference purposes.

One member of the technical staff should be appointed as the invigilator, whose duties include informing the participants of the duration of the examination, the availability or otherwise of reference materials and the consequences of collusion. The invigilator passes out the examination papers, starts the examination and remains in the room for its duration. At regular intervals the invigilator should inform the participants how much time is left, and on completion of the examination should tell them to stop writing and collect the examination papers.

#### *5.2.5.5. Recognition of achievements*

Successful completion of the training should be formally recognized by the issuance of a certificate to the individual, either by the recognized training centre or the examining body [2].

The certificate should contain information such as the name of the training centre or training provider, the title of the course or training, the topics covered, the date and number of training hours, the results of the examination or other form of assessment and the names of the lecturers. Usually the certificate will be signed by the course manager (see Section 5.3.1) and by a senior representative of the training centre or training provider.

## 5.3. IMPLEMENTATION OF TRAINING

Successful training demands good administration and planning. It is important to create an environment suitable for learning and to address any concerns of the participants. This section considers the infrastructure necessary and the organizational aspects of classroom based training, but some of the information is also relevant for distance learning.

### 5.3.1. Administration of training courses

The administration associated with a training course includes the initial publicizing of the course and the distribution of invitations and application forms to potential participants. Some form of screening and selection of participants may also be necessary; this subject is considered further in Section 5.3.3. These actions should be carried out several months in advance of the course to give institutions and organizations sufficient time to arrange to send appropriate participants. To assist institutions in the selection of participants, it is important that sufficient information on the content of training be provided. It is suggested that a description of the training course and a statement of the aims and objectives and the schedule be sent out with any publicity material or invitations.

Residential courses will necessitate booking suitable accommodation for the students. It is suggested that the accommodation includes sufficient space for study and be within a reasonable distance of the course venue. Transport arrangements warrant careful consideration; it is preferable to minimize the amount of travelling time involved. Suitable catering facilities will also be necessary.

If participants from other countries are attending, it may be necessary for administrative staff to assist with travel and visa arrangements, financial matters and general welfare.

For classroom based training, arrangements may be made for greeting and registering the participants on the opening day. If appropriate, name badges may be provided. A set of statements of the aims of the training, the learning objectives and the syllabus, and the schedule and relevant training materials, also need to be issued to the participants. Regular breaks for refreshments and meals should be incorporated into the schedule, and arrangements made to ensure that these are available at the designated times. Participants will need to have access to telephones, fax transmission and e-mail facilities, as appropriate.

It is important that one member of the training staff acts as a central contact for both participants and trainers, and is able to answer queries on all aspects of the training course. Experience has shown that this ‘course manager’, who should be one of the training staff or other technically qualified staff, plays a vital role in the course’s success. An effective course manager should be available if the participants wish to discuss training related matters, and will also be in a position to deal with any complaints and rectify any deficiencies. The course manager should also monitor the progress of the course to ensure that it follows the schedule. Some training centres may also wish to appoint co-ordinators for specific aspects of the training, for example for practical sessions. Good logistical support has always to be available for all aspects of the course.

For residential courses longer than one week, the inclusion of activities that encourage participants to interact socially may be considered, such as dinners or cultural or recreational activities.

### 5.3.2. Training facilities

The availability of training facilities varies greatly from country to country. In some countries there are no adequate facilities and equipment available for the provision of a comprehensive range of classroom based training. It is suggested, therefore, that the more extensive courses of several weeks’ duration or more be held in conjunction with an educational and/or training institution such as a university, college or training institute. A suitable lecture room furnished in an appropriate manner (e.g. desks, tables, armchair desks) should accommodate all the participants without crowding. The lecture room equipment may include a slide projector, computer projecting system, overhead projector, video player and television monitor, projection screen, blackboard and/or whiteboard, and a flipchart.

When practicable, the participant to trainer ratio should be kept sufficiently low such that participants will be able to interact readily with the trainers. Although there is no strict limit on this ratio, practical experience suggests that facilities for a maximum of 30 participants would be appropriate. The ideal number of participants for a course is 20 or fewer. If larger numbers of individuals need training, multiple course sections may be provided, or the course could be repeated at a later date.

A resource room needs to be readily accessible to the participants (either near the lecture room or near the participants' living quarters) and should contain reference materials, books on radiation protection and related subjects, journals and audiovisual materials that can serve as study aids. Such an area may also provide a set of lecture notes, sample exams and sample problem sets, and, if possible, study tables or desks should be available. The course manager may also consider providing a photocopier. Where appropriate, the provision of a personal computer for access to the Internet and to electronic data and reference sources could also be helpful.

Several separate rooms are needed for practical and group exercises. For most courses these will not need to be elaborate, merely rooms where groups can be alone and have the opportunity to carry out simple practical exercises or group sessions. Some practical simulated work, such as the setting up of barriers for site radiography, the recovery of 'lost' radioactive sources or the mapping of radiation fields, needs more space and can beneficially be done in a suitable place away from the lecture building.

### 5.3.3. Materials and equipment

In addition to audiovisual equipment, the provision of equipment to illustrate the various topics covered by the trainer will contribute to the quality and successful outcome of the course. The following list specifies commonly available equipment that would be relevant for classroom demonstrations and practical exercises in most training courses in radiological protection (note that it is preferable to have more than one item of each type of equipment, the number depending on the number of participants):

- Ionization chamber type rate meters with integrating capabilities;
- Geiger–Müller type rate meters with audible outputs;
- Scintillation type rate meters with audible outputs;
- Contamination monitors with audible outputs and probes for detecting alpha and beta radiation;
- Several small calibration sources for demonstrating alpha, beta and gamma emissions in conjunction with the above equipment;
- A short lived isotope (e.g. from a $^{99}Tc^{m}$ generator used in nuclear medicine);

— Sets of absorbers (thin sheets of cardboard, Perspex, aluminium and lead);
— Sample film badges, thermoluminescent dosimetry badges and direct reading pocket dosimeters;
— Personal alarm monitors (electronic personal dosimeters);
— Dummy source capsules;
— Consumer products containing naturally occurring radioactive materials (e.g. gas lantern mantles, ceramic dinnerware or luminous clocks).

The items on this list are considered to be the minimum resources for basic lectures and demonstrations in nearly all training. Additional material or equipment may include, for example, protective clothing, respirators, remote handling equipment, gamma ray spectrometers, alpha spectrometry equipment, equipment for monitoring radon progeny or other specialized detectors. Participants would also benefit from access to equipment kits for emergency responses.

Trainers are advised to make sure, in advance, that equipment is operational and, where applicable, properly calibrated. It is prudent to maintain a supply of spare batteries for portable equipment and copies of the instruction manuals for the equipment. Trainers need to be familiar with the equipment being used so as to be able to change batteries or perform minor maintenance.

### 5.3.4. Selection of participants

In selecting participants for a particular training course the following factors are relevant:

— The educational level of the participant: the prerequisites for the course and whether or not the applicant has the educational background to understand the material should be considered.
— Previous training and experience: the applicant's past experience and training in the technical area of the course will be an important indicator of whether the course is needed and whether it is at the appropriate level for that person.
— Responsibilities relative to the training to be provided: whether or not the applicant will actually be engaged in the work for which the training is designed, will be supervising others who will be doing that type of work or is simply interested in the topic in a general way should be considered.
— Language: in selecting participants, consideration should be given to the level of ability of the applicant in reading, understanding and speaking the language in which the course is presented.

After considering these factors, the course manager will be able to assess the suitability of an individual applicant for a particular training course.

### 5.3.5. Selection of trainers and supervisors

The selection of individuals qualified to train or supervise is a critical aspect of successful training. The following are the principal criteria to be considered in selecting trainers or supervisors:

— Technical ability: the trainer should show evidence of being technically competent in the topic or subject matter being taught and have relevant practical experience.
— Teaching ability: the trainer should be an experienced instructor with good communicational skills and a demonstrated record of success in teaching and training. He or she should apply the appropriate focus as suggested in the lesson plan and determine the delivery style for a particular group of trainees.
— Language skills: the trainer should be fluent and understandable in the language in which the training is being offered.

The involvement of international trainers and trainers from other centres in the region has significant benefits for participants. The trainers' input to the learning process is enhanced by familiarity with the relevant IAEA publications.

In the case of classroom based training involving multiple trainers, the co-ordination of the lectures in a specific course is a fundamental consideration. This can be aided by providing the trainers with the training aims, learning objectives, lesson plans and training schedule. The use of a large number of trainers can confuse the participants and result in disjointed training. It is advisable, therefore, to restrict the number of trainers and to ensure that the trainers have a few days for presenting their material, which has the benefit of allowing the participants to interact with the trainers both formally and informally.

Trainers are responsible for ensuring that:

— Their lectures meet the aims of the training and the learning objectives and are tailored to the background of the participants;
— Up to date information is used;
— The presentation is consistent with the radiation safety regulations;
— The lecture notes and oral presentations are clear, objective and easily understandable.

There is also a need for competent technicians to be available to assist with practical work, the maintenance of equipment and setting up of laboratories.

## 5.4. EVALUATION OF TRAINING

The purpose of evaluation is to determine the effectiveness and impact of the training. Evaluation conducted at the end of a course provides input to the design of future training programmes, allowing modifications and improvements to be made. Evaluation may also take place during training, which allows modifications to be made to the course during its progress. This is particularly valuable for on the job training and ensures that the needs of the participants are met.

The evaluation process consists of the following stages:

— Assessment of the extent to which learning objectives have been met, which includes the assessment (testing) of the competence of the participants;
— Feedback from the participants immediately following the training, which gives them the opportunity to comment on the course (i.e. their likes and dislikes and its strengths and weaknesses);
— Results evaluation, which is used by the sponsoring organization to determine the success of the training in meeting its original aims and goals;
— Independent audits: an independent evaluation or audit may be considered from time to time.

### 5.4.1. Assessment of the competence of participants

The assessment procedure described in Section 5.2.5 provides information to the participants, the trainer, the employer and the regulatory body on the skills and knowledge acquired by the participants. If the majority of participants meet the learning objectives, it can be assumed that the course has been a success. Conversely, if most students fail to meet the objectives, a careful analysis may indicate how the training needs to be revised and modified. Behavioural evaluation of the participants by the trainer or supervisor assesses their practical ability, safety culture and attitudes developed in the training.

### 5.4.2. Feedback from participants

During and after the training the trainer, the training provider or the training organization may obtain the participants’ reactions to the training through the use of a questionnaire or other appropriate means. Annex VII provides an example of the type of questionnaire which may be used. This reaction or feedback information is intended to show what the participants thought of the training, including the quality of the training materials, methods used, technical content, proficiency of the trainers, administrative matters and the extent to which their needs and expectations were met.

Questionnaires should normally be collected before the end of the training period so that the responses may be discussed with the participants.

### 5.4.3. Evaluation of the impact of training

In order to build competence in radiation protection, the effectiveness of the training should be evaluated and the results used to modify future training programmes. The impact of the training would also be assessed to determine whether the goals of the sponsoring organization or country, in terms of radiation safety, have been achieved. Evaluating the impact of training involves identifying parameters for the safe operation of the facility or process, for example has the training resulted in lower occupational or collective doses, or in a reduction in accident rates? This type of evaluation is typically longer term and should use trending data or performance indicators [2].

### 5.4.4. Independent audits

In addition to the evaluations described above, there is merit in having periodic (independent) assessments of training by individuals who have expertise in the subject matter and in training methodologies. Such reviews would typically take place every two or three years and include an evaluation of training in terms of course content, presentation methods, qualifications of the trainer, course organization, lesson plans, training materials, participant assessment, record keeping and administrative procedures. An evaluation of this type is essentially an independent audit of the training. Annex II shows examples of criteria for accrediting training courses that are also useful for independent audits.

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## Annex I

## STANDARD SYLLABUS OF THE POSTGRADUATE EDUCATIONAL COURSE IN RADIATION PROTECTION AND THE SAFE USE OF RADIATION SOURCES

The standard syllabus of the Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources has a modular structure [I–1]. It has eleven parts and each part is divided into modules, as can be seen below. The detailed syllabus can be obtained from the Internet site http://www.iaea.org/ns/rasanet/training/promedutra.htm.

### PART I. REVIEW OF FUNDAMENTALS

I.1. Introduction.
I.2. Basic physics and mathematics used in radiation protection.
I.3. Interaction of radiation with matter.
I.4. Sources of radiation.

### PART II. QUANTITIES AND MEASUREMENTS

II.1. Quantities and units.
II.2. Dosimetric calculations and measurements.
II.3. Principles of radiation detection and measurement.

### PART III. BIOLOGICAL EFFECTS OF IONIZING RADIATION

III.1. Effects of radiation at the molecular and the cellular level.
III.2. Deterministic effects.
III.3. Stochastic somatic effects.
III.4. Stochastic hereditary effects.
III.5. Effects on the embryo and foetus.
III.6. Epidemiological studies and issues.
III.7. The concept of radiation detriment.

PART IV. PRINCIPLES OF RADIATION PROTECTION AND THE INTERNATIONAL FRAMEWORK

IV.1. Conceptual framework.
IV.2. The role of international organizations in radiation protection.
IV.3. The development of safety culture.

PART V. REGULATORY CONTROL

V.1. Legal framework for radiation protection and the safe use of radiation sources.
V.2. Regulatory system.
V.3. Assessment of the effectiveness of the regulatory programmes.

PART VI. ASSESSMENT OF EXTERNAL AND INTERNAL EXPOSURES

VI.1. Assessment of occupational exposure due to external sources of radiation.
VI.2. Assessment of occupational exposure due to intakes of radionuclides.

PART VII. PROTECTION AGAINST OCCUPATIONAL EXPOSURE

VII.1. Organization and management.
VII.2. Methods of protection and the safe use of radiation sources; optimization.
VII.3. Individual and workplace monitoring.
VII.4. Health surveillance.
VII.5. Potential exposures.
VII.6. Protection against occupational exposure in industrial radiography.
VII.7. Protection against occupational exposure in industrial irradiators and accelerators.
VII.8. Protection against occupational exposure in the use of nuclear gauges.
VII.9. Protection against occupational exposure in the use of tracers.
VII.10. Protection against occupational exposure in well logging devices.
VII.11. Protection against occupational exposure in radioisotope production plants.
VII.12. Protection against occupational exposure in diagnostic radiology.
VII.13. Protection against occupational exposure in nuclear medicine.
VII.14. Protection against occupational exposure in radiotherapy.

VII.15. Protection against occupational exposure in nuclear installations.

VII.16. Protection against occupational exposure in the mining and processing of raw materials.

PART VIII. MEDICAL EXPOSURES IN DIAGNOSTIC RADIOLOGY, RADIOTHERAPY AND NUCLEAR MEDICINE

VIII.1. Scope and responsibilities.

VIII.2. Justification of medical exposures.

VIII.3. Optimization of protection for medical exposures.

VIII.4. Quality assurance.

VIII.5. Accidental exposures in medical applications.

PART IX. EXPOSURE OF THE PUBLIC OWING TO PRACTICES

IX.1. Sources of exposure of the public.

IX.2. Responsibilities and organization.

IX.3. Safe transport of radioactive material.

IX.4. Safety of radioactive waste.

IX.5. Environmental dose assessment.

IX.6. Source and environmental monitoring.

IX.7. Consumer products.

IX.8. Dose assessment.

IX.9. Monitoring of public exposures.

PART X. INTERVENTION IN SITUATIONS OF CHRONIC AND EMERGENCY EXPOSURE

X.1. General principles and types of events.

X.2. Basic concepts for emergency response.

X.3. Basic concepts for emergency preparedness for a nuclear accident or radiological emergency.

X.4. Developing a national capability for response to a nuclear accident or radiological emergency.

X.5. Overview of assessment and response in a radiological emergency.

X.6. Overview of assessment and response in a nuclear reactor emergency.

X.7. Monitoring in a nuclear accident or radiological emergency.

X.8. Medical management of radiation injuries.

X.9. Communication with the public.
X.10. International co-operation.

PART XI. TRAINING THE TRAINERS

XI.1. Training needs.
XI.2. Being a lecturer.
XI.3. Setting up a training course.

## REFERENCE

[I–1] INTERNATIONAL ATOMIC ENERGY AGENCY, Standard Syllabus for a Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources, Training Course Series, IAEA, Vienna (2001).

## Annex II

## ESTABLISHMENT OF A TRAINING CENTRE

### II–1. PURPOSE OF A TRAINING CENTRE

Training courses in radiation protection and the safe use of radiation sources may be provided by a range of training providers, including colleges, universities, radiation protection institutions and training consultants. However, there may not be suitable training centres providing relevant training courses in some countries in which there are many workers in need of training, in which case it may be useful to create a centralized training facility in the form of a national or regional training centre.

A national or regional training centre has many benefits in that it ensures a consistent approach to training, facilitates the development and use of common training materials and programmes, and provides a central point of reference for the qualification of personnel.

In addition to training, a centre may also provide information to interested parties on applications of ionizing radiation in the form of leaflets, articles in magazines and journals, videotapes and visual displays. This will help to increase the general level of awareness in the country of the benefits and potential hazards associated with the use of ionizing radiation.

### II–2. ISSUES TO CONSIDER IN THE ESTABLISHMENT OF A TRAINING CENTRE

The most important factor to be considered prior to the establishment of a training centre is the ability of the country to sustain it. A feasibility study could be used to identify the categories and numbers of individuals who need training, the types and numbers of courses required to meet their needs, cost estimates for setting up and operating the centre and a clear identification of the availability of resources and funding. A long term commitment of the country or region to provide resources to sustain the training programme would be appropriate.

Once the need for a training centre and the availability of resources have been determined, the issues discussed below need to be addressed.

#### II–2.1. Policy

The policy of the centre needs to be drawn up in accordance with the training requirements of the relevant authority (or authorities), and to address the scope of the national or regional programme for radiation protection and the safe use of radiation sources and define the expected impact of the training. The policy needs to include the training prerequisites in terms of academic and job related qualifications, work experience and personal attributes, as well as any restrictions on the nationality or residency status of applicants. It needs to encourage also the interaction of relevant organizations (national atomic energy commissions, regulatory authorities, universities, colleges and professional associations). The policy on who provides the resources or support for the training of various categories of participants needs to be clearly defined.

### II–2.2. Structure and procedures

The administrative structure of the centre has to be documented. This documentation should include the specific responsibilities and duties for positions such as the centre director, course managers, trainers, proctors and invigilators.

Procedures for the design, development, implementation and evaluation of training, including participant assessment and course evaluation, also need to be documented.

### II–2.3. Records

Appropriate records need to be maintained, which need to include the names and addresses of the participants, participant identification numbers, the dates and training in which the participants were enrolled, course syllabuses, training evaluations and assessment results (for each candidate marked examination papers, examination marking scheme and examination certification numbers). The duration of retention of the records should be in accordance with national policies. Records of training materials may be retained for technical reasons, such as for future reference by training providers. If records of participants' performance and related information fall under the confidentiality laws or regulations of some countries, then care needs to be taken to ensure that this confidentiality is maintained and that personal information is not released to third parties.

### II–2.4. Facilities and resources

A national or regional training centre needs to provide facilities and resources that are at least equivalent to those described in Section 5.3.2 of this Safety Report. For a national or regional facility, up to date training equipment is normally expected to be provided.

## II–3. ACCREDITATION OF TRAINING COURSES

The quality of the training provided may be supported by accreditation of some or all of the training offered. Courses may be accredited by the regulatory body or by an independent body, such as a professional association recognized by the regulatory body [II–1].

The accreditation procedure normally involves the presentation of a formal submission to the accreditation body, which then analyses the information against established criteria. The submission should include information on the following factors:

- The aims and learning objectives of the course.
- The training syllabus.
- The type of training (e.g. whether it is classroom based training, distance learning or on the job training).
- The training schedule (including the length of the training) and lesson plans if appropriate.
- The training materials and resources available.
- The practical exercises.
- The maximum number of participants.
- The qualifications and experience of the course manager and trainers (including technical abilities in the training topics, teaching and/or training skills and communication skills).
- The academic management of the course (for defining policy, monitoring and evaluating the training or deciding on changes to the training).
- The prerequisites of the course.
- The means and criteria of assessment of the participants' competence by examination and other means of assessment; the procedures for preparing and approving examination questions; the secure production and storage of examination papers; the procedures for reporting results.
- The quality assurance procedures, internal audits and the mechanisms for evaluation and feedback on the training.

After a suitable review of this information, the accreditation body needs to determine whether the training meets the standard for accreditation and, if so, the accreditation should be publicly listed. The validity of accreditation may be in effect anywhere from one to five years depending on the extent to which the accreditation body wishes to review and revisit the training. Feedback from trainees on the quality and delivery of the training may also be used as an indicator of whether the accreditation needs revision. Accreditation may also lead to the establishment of credits towards an academic qualification.

## II–4. ACCREDITATION OF A TRAINING CENTRE

In some cases, accreditation of a training centre rather than of individual courses may be considered. Such an accreditation will depend on the capability of a centre to identify, develop, conduct and evaluate training in a manner that will ensure quality and be consistent in the provision of suitably trained individuals. In order to be accredited a centre usually needs to demonstrate that its administrative structure is adequate to ensure that it can meet ongoing training needs, that its trainers have the qualifications listed in Section 5.3.5 of this report, and that it has a demonstrated record of developing and conducting training that meets accreditation standards. Alternatively, the suitability of a training centre can be verified by the accreditation body by setting independent examinations which the trainees have to pass. Details of specific criteria and methods for accrediting an organization such as a national training centre are beyond the scope of this report, however.

## II–5. EVALUATION OF A TRAINING CENTRE

At periodic intervals the appropriate authority may consider carrying out an evaluation of a training centre to determine the effectiveness of the training programme. The long term sustainability of a centre will depend on both the ability to provide training at a reasonable cost and the overall level of demand for training within the country. The evaluation with respect to cost effectiveness of the operation of a centre is a separate matter from the evaluation for accreditation purposes. Nevertheless, the two are related because the issue of effectiveness in meeting training needs is clearly related to the quality of the training programme [II–1]. Accordingly, information on accreditation constitutes useful input for the evaluation of cost effectiveness.

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## Annex III

## CLASSROOM BASED TRAINING IN RADIATION PROTECTION FOR INDUSTRIAL RADIOGRAPHERS

This annex shows a simplified version of the design and development of a training course in radiation protection for industrial radiographers. A general outline of the main elements of the design and development is given, but no attempt is made to describe them in detail.

### III–1. TARGET AUDIENCE

The target audience for this course is industrial radiographers and assistant radiographers performing gamma and X ray radiography on-site and in shielded enclosures.

### III–2. AIMS

The aim of this course is to provide a basic awareness of the radiation hazards associated with industrial radiography using gamma and X ray devices, performed on-site and in shielded enclosures. It also gives practical guidance on acceptable work practices to keep doses in accordance with regulatory requirements and on appropriate actions in abnormal conditions.

### III–3. LEARNING OBJECTIVES

Upon completion of this course the radiographer should be able to do the following:

— Describe the nature and properties of gamma and X ray radiation and its associated hazards;
— Use the standard terminology for radiation protection correctly;
— State the regulatory requirements related to the safe use of radiation sources in industrial radiography;
— Apply basic concepts of radiation protection (i.e. the behaviour of the factors of time, distance and shielding) and be able to perform calculations with these factors;

— Apply practical methods for reducing doses;
— Be able to demonstrate acceptable work practices, proper performance of radiation surveys, the setting up of necessary boundaries, and daily inspections and the correct operation of equipment;
— Be able to recognize an unusual situation and take the appropriate immediate actions to control doses;
— Provide accurate records and reports.

## III–4. MATERIALS AND EQUIPMENT NEEDED

The following materials and equipment are needed:

— Survey meters: Geiger–Müller counters and ionization chambers.
— A dummy source assembly.
— An industrial radiography device, source changer and associated equipment (e.g. controls, guide tubes, warning signs, shielding materials and barriers).
— Radiation protection equipment.
— Personnel monitoring equipment (film badges, thermoluminescent dosimeters and direct reading dosimeters).
— Operation and maintenance manuals for the equipment in the local language.
— Worksheets.

## III–5. SYLLABUS

### III–5.1. Fundamentals

1. Basic concepts: introduction to atomic structure, radioactivity, sealed sources and X ray production.
2. Radiation quantities and units: activity, absorbed dose, exposure, equivalent dose, effective dose and related rates.
3. Radiation detection and measurement. Detectors: Geiger–Müller counters, ionization chambers, proportional counters and scintillators. Measurement techniques and parameters: methods of surveys (laboratory session), reference surveys and surveys to determine whether sources have been returned to their stored position.
4. Biological effects of radiation: interaction of radiation with matter, effects of acute and/or chronic radiation exposures, deterministic and stochastic effects, and calculations of exposures to hands.

### III–5.2. Principles and concepts of radiation protection

1. System of radiation protection.
2. Regulatory control: regulatory requirements (for workers and the public).
3. Basis of dose levels and/or risk.
4. Classification of areas: supervised and controlled areas.
5. Optimization: definition of ‘as low as reasonably achievable’ (ALARA), responsibility of management and workers to keep doses ALARA, and safety culture.
6. Limitation and investigation levels.

### III–5.3. Overview of sources and equipment

1. Protection from external radiation. Source outputs, $^{192}$Ir, $^{60}$Co and X ray units, time, distance, shielding, basic theory and formulae for radioactive decay and dose calculations, practical examples (worksheets). Use of half-value layer and tenth-value layer: definition, actual values for lead, steel and concrete, typical dose levels from equipment and during radiography, practical applications, surveys, set-ups, communication, safety warnings, interlocks and procedures.
2. Types of equipment used (laboratory session): sealed sources, devices, X ray tubes and ancillary equipment, demonstration of equipment, general design considerations and limitations, basic operational considerations, typical dose levels from equipment, performing an exposure, performing a source exchange, and inspection and maintenance of equipment.

### III–5.4. Protection against exposure

1. Organization and management.
2. Individual monitoring: types of equipment, theory and limits.
3. Work practices to limit doses: use of shielded enclosures, use of collimators, use of longer controls and/or shorter guide tubes, use of available shielding within workplaces, film and/or screen choice and interlocks.
4. Mobile sites: setting up controlled areas, use of example scenarios and/or calculations, control of areas during radiography and verification that no unauthorized personnel are inside the controlled area.
5. Current international standards and checking that the equipment is properly operated and maintained.
6. Safety and security of sources (e.g. storage and inventory).
7. Case histories in industrial radiography (lessons learned), root causes, prevention of similar incidents and emergency response (actual recovery).

### III–5.5. Radiation protection programme

1. Responsibilities and qualifications of radiation protection officers and radiographers.
2. Establishment of local rules: performing an exposure, connection, crank out, retraction and termination, proper surveys to be performed, setting up a controlled area, daily inspection prior to use, formal maintenance, dose limitation, personnel monitoring and emergency response. Radiographer: restriction of the area and notification of the radiation protection officer. Radiation protection officer: assessment of the situation and determination of an appropriate response.
3. Record keeping.
4. Audits and/or quality assurance (QA): periodic audit of radiographers, periodic audit of the programme, investigation levels, corrective actions to be taken and reviewed by management.

### III–5.6. Additional modules

1. Safe transport of radioactive material (to and from the work site).
2. Public protection (control of areas).

## III–6. TRAINING SCHEDULE

Day 1: fundamentals and principles of radiation protection.
Day 2: overview of sources and equipment.
Day 3: protection against exposure.
Days 4 and 5: radiation protection programme and additional modules.

## III–7. LESSON PLAN

Only the lesson plan for Module 1, Lecture 1.1: Basic Concepts is given here. Similar lesson plans would need to be prepared for the other training sessions.

### III–7.1. Basic concepts

Available material: Basic Concepts (BC) lecture notes, BC visual aids BC1–BC17, video: “Radiation Safety: An Overview” (IAEA), model of an X ray tube, dummy radiography source and a remote exposure container.

Introduction to atomic structure

| Topic | Visual aid to be shown |
|---|---|
| Atomic structure | BC1 |
| Fundamental particles (p, n, e) | BC2 |
| Electric charge and mass of the fundamental particles | BC3 |
| Definitions of mass number and atomic number | BC4 |
| Simple explanation of isotopes: use hydrogen (H, $^{2}$H, $^{3}$H) as an example; scientific notation for isotopes, for example $^{192}$Ir | BC5 |

Radioactivity

| Topic | Visual aid to be shown |
|---|---|
| Ionizing radiation: types | BC6 |
| Electromagnetic radiation: zero mass and charge, often accompanying alpha or beta decay, and radiation energies (eV, keV, MeV) | BC7<br>BC8 |
| Process of radioactive decay: decay curves and half-lives | |
| Examples of half-lives | BC9 |
| Range of gamma radiation in air, tissue, concrete and lead | BC10 |
| Common radionuclides for industrial radiography: $^{192}$Ir and $^{60}$Co | BC11 |
| Summary of this topic | Video: Radiation Safety: An Overview — Modules 1 and 2 |

Sealed sources

| Topic | Visual aid to be shown |
|---|---|
| Definition of a sealed source | Dummy radiography source |
| Sealed source construction | BC12 |
| Dangers associated with a damaged source — explain contamination | BC13 |
| Brief explanation of the use of a remote exposure container | Remote exposure container |
| Use of collimators for the reduction of scattered radiation | BC14 |

X ray production

| Topic | Visual aid to be shown |
|---|---|
| The mechanism for the generation of X rays — characteristics and bremsstrahlung | BC15 |
| A simple X ray set | Model of an X ray tube |
| Heat production in the anode and methods of cooling | BC16 |
| A brief description of a typical X radiography set | BC17 |

## III–8. ASSESSMENT OF THE COMPETENCE OF A PARTICIPANT

A written and practical examination should be administered by the radiation protection officer of the facility.

## III–9. EVALUATION OF THE TRAINING

The course should be evaluated by the participants by means of a questionnaire given to them before to the end of the training.

## III–10. CERTIFICATION

A certificate should be awarded to the successful participants at the end of the course.

## III–11. BIBLIOGRAPHY


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Radiation Protection and Safety in Industrial Radiography, Safety Reports Series No. 13 (1999).

Regulatory Guidance on Industrial Radiography Incorporating Procedures Manual, IAEA-TECDOC (in preparation).

## Annex IV

## ON THE JOB TRAINING IN RADIATION PROTECTION FOR INDUSTRIAL RADIOGRAPHERS

This annex shows a simplified version of the design and development of an on the job course in radiation protection for industrial radiographers. A general outline of the main elements of the design and development is given, but no attempt is made to describe them in detail.

### IV–1. TARGET AUDIENCE

The target audience is industrial radiographers and assistant radiographers who have successfully attended a previous classroom based training course which has provided them, as a prerequisite, with a basic awareness of the radiation hazards associated with industrial radiography using gamma and X ray devices, performed on-site and in shielded enclosures.

### IV–2. AIMS

The aim of the on the job training is to provide the participants with the ability to operate industrial radiography on-site and in shielded enclosures, observing the regulatory requirements and relevant guidelines on safe work practices and safety of sources, and on doses to workers and members of the public.

### IV–3. LEARNING OBJECTIVES

Upon completion of the on the job training the radiographer should be able to do the following:

- Recognize the source he or she is dealing with;
- Read and interpret any technical information directly relevant to the source, the radiography device and all the associated equipment;
- Choose the best work conditions to limit the dose;
- Operate industrial radiography equipment safely on-site and in shielded enclosures;
- Read and interpret the results of the radiography;

— Respond to an abnormal situation;
— Record all relevant data;
— Read and interpret the results of workplace monitoring and take appropriate measures.

## IV–4. MATERIALS AND EQUIPMENT NEEDED

The following resources are needed for the training:

— Survey meters: Geiger–Müller counters and ionization chambers;
— An industrial radiography device, source changer and associated equipment (e.g. controls, guide tubes, warning signs, shielding materials and barriers);
— A dummy source assembly;
— Personnel monitoring equipment (film badges, thermoluminescent dosimeters and direct reading dosimeters);
— Operation and maintenance manuals for the equipment in the local language;
— Operation instructions and procedures;
— Worksheets.

## IV–5. SYLLABUS

The syllabus covers all the practical aspects of radiation protection and safety associated with industrial radiography. It may be specific to the facilities available.

— Technical aspects of the industrial radiography process: technical information about the equipment, source, instruments, physical properties of the material to be submitted to radiography, operational use of each part and component of the device, and types of radiography methods.
— Applying knowledge to the workplace: procedures to be used to choose the radiography method, to put the device to use and to make an exposure, source accountability, the procedure for moving the sources on-site, storage and security of spent sources and apparatus, procedures for interim storage and security of sources for activities in shielded enclosures, safety procedures for transport, procedures for establishing the boundaries of the controlled area and procedures for replacing sources.
— Quality control: recording procedures, the leak testing programme and the maintenance programme for the equipment.
— Responding to abnormal situations.
— Gaining enough experience to be able to act autonomously.

- Working in shielded enclosures: facility layout, controlled areas, radiation levels, points of access to the irradiation room, safety control (alarms and signals), safety system and interlocks, fire control, checklists and procedures for safe operation.
- Working on-site (checklists and procedures): procedures for handling equipment, procedures to initiate operational activities, transport of the source, procedures to control exposure in public and operational areas, dosimetry and procedures to conclude operational activities.
- Working in an urban zone: procedures as listed above and imposed constraints to observe annual dose limits for the public.

## IV–6. SCHEDULE FOR ON THE JOB TRAINING

A training schedule should be prepared according to the syllabus and the learning objectives. It is important to prepare the schedule in conjunction with the trainee, establishing the tasks to be performed and the duration of each part of the training. In establishing a training schedule, it is good practice that the participant does not advance to a higher level of practice and understanding until his or her performance at the lower level is satisfactory. The participant should first observe a task, then perform that task under close supervision. It is necessary to provide time for the participants to explain in their own words their understanding of specific tasks.

The schedule has to be flexible enough to take advantage of opportunities and lessons learned from infrequent situations or activities (e.g. abnormal situations or replacing the source), and to identify any weaknesses in the performance of the participant and to discuss with him or her how to avoid a recurrence and give a further opportunity for training in that area.

## IV–7. ASSESSMENT OF THE COMPETENCE OF THE PARTICIPANT

The purpose of assessment is to verify that the participant has acquired competence in all of the areas defined in the learning objectives of the training. To fulfil this purpose, the assessment should be composed of two parts:

— Continuous evaluation by the supervisor during the on the job training (e.g. work reports, using training files, operational records and on the job training checklists);
— An assessment of industrial radiography based on a real operation, on-site and/or in shielded enclosures.

## IV–8. EVALUATION OF ON THE JOB TRAINING

The evaluation of on the job training by the participants should be done through a questionnaire given to them prior to the end of the training.

## IV–9. CERTIFICATION

A certificate should be awarded to the successful participants at the end of the on the job training.

## Annex V

## VISUAL AID MATERIALS

Training can be made more effective by the appropriate use of visual aid materials. Inappropriately used or poorly prepared materials may reduce the impact of the information being presented. Good materials cannot, however, compensate for a poorly prepared presenter. This annex provides some suggestions for the preparation and presentation of effective visual aids that will enhance the quality of the training.

Several types of visual aid can be used in a training session; careful preparation identifies which type of aid is appropriate and how it can be used to help make a point more effectively.

Transparencies, slides or a computer presentation can be used to guide the order of presentations, to highlight the main points and to show graphic representations. Colour makes aids more attractive and can be used for clarification. Photographs may be used directly in slides or transparencies or scanned for computer presentations. It is always effective to distribute copies of the material being presented, especially if it contains figures, equations and graphic representations, so that the participants can focus on the presentation itself rather than on recording the information shown visually.

Videotapes and video clips can be useful as standalone material for distance learning or for self-study training programmes, and as visual aids in classroom based training. In the latter, videotapes or video clips can be used to show scenarios, action and real life examples. Training videotapes are usually modular and short (typically less than five minutes per module), while video clips will contain selected scenes, will be shorter (about one minute) and can be incorporated into a computer presentation. Videos of simulations (for example of an emergency response exercise) can be used as a basis for discussion.

### V–1. PREPARATION OF TRANSPARENCIES, SLIDES AND COMPUTER BASED PRESENTATIONS

A logical plan for delivery should be prepared and the presentation ordered in the following sequence:

— Title of session, presenter’s name, logo and organization;
— General content, outline and learning objectives of the training session;
— Relevant background and introduction to the subject;

— General overview of how the topics to be presented fit together;
— Individual topics (refer to the following section for helpful information on preparation);
— Summary of what has been presented;
— Details of where to get more information (other training sources: books, articles, websites).

The following should be considered when preparing individual transparencies, slides or screens:

— Use standardized templates in landscape format.
— Set the margins at least 3 cm from the edge of the frame to ensure that all the information is readily readable and nothing is lost.
— Number each page sequentially.
— Include no more than four messages, in the form of text or graphics, on the same theme per transparency or slide.
— Simplify the sentences: use up to six to eight words per line at the most and a maximum of six lines per transparency, slide or screen.
— Limit numerical data and tables: provide only essential values or summaries and refer to the complete material in the lecture notes.
— Use charts, graphics and illustrations wherever possible instead of text.
— Do not use symbols or acronyms unless they have been explained previously or all of the audience can be expected to be well acquainted with them.
— Proofread and check everything and then ask someone else to check it.

Colour makes visual aids more attractive, but the indiscriminate use of colour reduces its effectiveness. Colour is more effective and visual aids are more attractive if they are limited to a few colours. Colour is best used for emphasis, simplification or codification and its use needs to be consistent throughout the presentation. Colours denote different things to different people; for example, red is associated with heat, importance, danger, stop. Contrast is also important: black on white, or dark red or blue on a background of a pale shade of blue shows up well on transparencies.

If text is copied from a book or report, the type will always be too small and the content invariably too detailed. It is counterproductive to flash on a screen an entire page of text as no one will pay attention to what you are saying as the audience will be trying to read and understand the text. The suggested minimum font size is 24 points. A good test is whether the transparency itself is legible from 2 m away. Arial font is more legible when projected than, for example, Times New Roman and therefore may be the best font to use in visuals. Bold typeface and/or different colours can be used to emphasize certain points. Larger lettering for titles and subtitles is preferable.

When designing transparencies, slides or screens, try to consider the eye action of the viewer reading it. Minimize the vertical movement necessary and try to avoid the need for constant shifting of the eyes to gain information. Try to make everything read horizontally. Design the visual aid so that the audience is with you, not ahead of you.

Graphic representations include line graphs, histograms and pie charts. They can provide data, show trends or improve the understanding of results. Graphic representations need to be simple and clear enough for readers to get the message immediately and with the minimum of associated text.

A well designed graphic representation can be used to show several trends and relationships at once, but it is best not to include too many data in one figure; a maximum of five data sets, preferably less, depending on the amount of data or if the line graphs cross, is suggested. Colour can be used effectively. Use the same symbols and same type of line to describe data when the same entities occur in several figures, and use the same co-ordinates and scales for different figures if values are to be compared between them.

It is preferable to avoid the use of three dimensional graphs or graphs showing multiple variables, unless it is to summarize data presented previously.

Lower case lettering for labelling graph axes should be used and bold face should be avoided. Normal lettering running vertically (with the letters sideways) is more easily read upwards. Use units in the singular and placed between parentheses. Never extrapolate a curve beyond the measured or observed points without reminding the reader of the hazards of drawing conclusions from an extrapolation, and make sure that the extrapolated portion of the graph is clearly identifiable by using different colours or symbols.

Flow charts and block diagrams show the elements of a system and their relationships to one another, for example a flow chart should be used for the explanation of software logic and a block diagram for the organizational chart of an installation. The elements should usually be represented by boxes and their relationship by lines between the boxes. In the case of flow charts, these lines represent a flow of activity between the elements. The main flow should be clearly and simply stated, and subsidiary movements, feedback and paths are best displayed so that they do not distract from the main flow. Logic is also needed where there are ‘yes’ and ‘no’ alternatives; for example, ‘yes’ lines could exit downwards parallel to the main flow, while ‘no’ lines could exit towards the right. There is a need to keep a visual logic.

## V–2. PRESENTATION OF VISUAL AID MATERIALS

The presentation of visual aid materials is as important as their preparation. Some basic rules and procedures are suggested below. They are intended to facilitate and enhance comprehension and to keep participants focused on the learning process.

- Study the audience and gear the technical content and language to their needs.
- Familiarize yourself with and practice using equipment such as projectors and other facilities in the lecture room.
- Have a backup plan of what to do without the aid of the visuals if the equipment fails.
- Set out the presentation so as to inform and entertain the participants, and to be able to enjoy the presentation yourself.
- Be on time for the sessions and do not exceed the allotted period.
- Do not talk with your back to the participants.
- Try not to exhibit nervousness.
- Maintain eye contact, especially if a participant asks a question.
- Do not spend too much time on one transparency, slide or screen.
- Do not read your transparency, slide or screen; instead state the same message in a different way and give examples.
- Do not stand between the visual aids and the participants.
- Only discuss what you are showing; if a transparency or slide is needed more than once, separate it from the pile and reserve it for easy access (or simply prepare a duplicate).
- Dress and present yourself professionally.
- Relax, smile and be natural: stand up during the presentation so as to focus attention on yourself.
- Speak with confidence, loudly, clearly and in short sentences.
- Use gestures and visual aids whenever appropriate.
- Make use of questions to participants, and encourage participation and active learning.
- Vary the pace of delivery and the pitch of your voice according to the emphasis you want to give to certain details.
- Think and speak positively and constructively.

## Annex VI

## PRACTICAL EXERCISES

Standard practical exercises are an important part of a curriculum. A list of practical exercises is suggested below for each part of the standard syllabus for the Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources [VI–1] (see Annex I). The type of exercise for each training topic (e.g. demonstrations, laboratory exercises, case studies, simulation exercises or technical visits) is also described. In compiling the list, the following points have been considered:

— Illustration of the scientific principles presented in the theoretical part of the course and provision of practice in the actual technique;
— Preparation for actual work conditions and common approaches to questions concerning radiation protection and the safe use of radiation sources in everyday work;
— Use of apparatus and facilities that are likely to be available.

### VI–1. PREPARATION OF THE MATERIAL FOR PRACTICAL EXERCISES

In order to help with the practical exercises and to guide the participants, worksheets should be prepared that include the following sections:

— Introduction: the theoretical background that is essential for a good understanding of the practicalities.
— Aim: the purpose and expectations of the practical exercise.
— Apparatus: the apparatus needed to do the practical exercise (e.g. materials, equipment, set-up and scenario).
— Experimental procedure: a step by step outline of the procedures, or guidelines for a structured approach to solving the problem.
— Results: adequate space in the worksheet for recording and analysing the results.
— Problems and solutions: additional questions with model answers to stimulate the analysis and interpretation of common situations.
— References: for further reading.

## VI–2. LIST OF PRACTICAL EXERCISES

A list of practical exercises is suggested in Tables VI–I to VI–XI for each part of the standard syllabus for the Postgraduate Education Course on Radiation Protection and the Safe Use of Radiation Sources. The selection of practical exercises for a given training activity needs to take into account the learning objectives and the backgrounds of the participants.

If radiation sources are used in the exercises, the doses to participants will need to be monitored and controlled and kept as low as reasonably achievable. The participants need to be given written instructions on the procedures to be followed for radiation protection, and personal dosimeters should be provided when appropriate. In some cases it may be preferable to use simulated radiation sources. As an introduction to a laboratory exercise or simulation, it could be useful to demonstrate the correct procedures and operations in order to avoid unnecessary exposure or damage to equipment.

TABLE VI–I. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART I: REVIEW OF FUNDAMENTALS

| Module No. | Practical exercise | Type |
|---|---|---|
| I.1 | Presentation of different types of radiation source and explanation of their application, natural and human made radionuclides, and consumer products | Demonstration |
| I.2 | Demonstration of radioactive decay: charts of nuclides, use of books and software as sources of nuclear data | Demonstration |
| I.3 | Application of the radioactive decay equation and the use of some simple mathematical codes | Exercise |
| I.4 | Measurement of half-life | Laboratory exercise |
| I.5 | Counting of statistics using a Geiger–Müller or similar counter and a radioactive source, and verifying the statistical distributions | Laboratory exercise |
| I.6 | Radon emanations | Demonstration |
| I.7 | Ranges of alpha and beta particles | Demonstration |
| I.8 | Moderation and absorption of neutrons | Demonstration |

TABLE VI–I. (cont.)

| Module No. | Practical exercise | Type |
|---|---|---|
| I.9 | Demonstration of the shielding properties of different materials and examples of shielding calculations | Demonstration |
| I.10 | Demonstration of backscattering of beta radiation | Demonstration |
| I.11 | Demonstration of absorption of beta radiation within sources of different thicknesses (‘self-absorption’) | Demonstration |
| I.12 | Determination of maximum energy levels of beta radiation by absorption | Laboratory exercise |
| I.13 | Study of attenuation of gamma radiation as a function of thickness and atomic number Z | Laboratory exercise |

TABLE VI–II. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART II: QUANTITIES AND MEASUREMENTS

| Module No. | Practical exercise | Type |
|---|---|---|
| II.1 | Demonstration of each type of portable monitor for alpha, beta, gamma and neutron radiation and explanation of the respective applications, and use and consultation of equipment manuals | Demonstration |
| II.2 | Calculational exercises on quantities | Exercises |
| II.3 | Determination of the characteristics of Geiger–Müller counters: counting rate versus voltage curve and the response to different radiation energies | Laboratory exercise |
| II.4 | Determination of the background level of radiation | Demonstration |
| II.5 | Measurement of beta radiation levels for beta emitter samples and determination of total efficiency | Laboratory exercise |
| II.6 | Use of a low background Geiger–Müller system for the measurement of low activity beta emitting sources | Laboratory exercise |
| II.7 | Calibration of a gamma scintillation spectrometer in terms of energy and activity | Laboratory exercise |

TABLE VI–II. (cont.)

| Module No. | Practical exercise | Type |
|---|---|---|
| II.8 | Analysis of a complex gamma spectrum using semiconductor detectors | Laboratory exercise |
| II.9 | Calibration of an alpha spectrometry system in terms of energy and activity | Laboratory exercise |
| II.10 | Calibration of a ZnS(Ag) scintillation counter for alpha activity measurements | Laboratory exercise |
| II.11 | Reading of photographic films for individual dosimetry that have been exposed to different types of radiation at different energies | Demonstration |
| II.12 | Reading of thermoluminescent dosimeters | Demonstration |
| II.13 | Making measurements with track etching systems | Demonstration |
| II.14 | Making measurements of low activity of $^{3}H$ and $^{14}C$ by liquid scintillation counting systems | Laboratory exercise |
| II.15 | Neutron detection and spectrometry using BF3 detectors and polyethylene moderator spheres | Laboratory exercise |
| II.16 | Identification of unknown radionuclides | Laboratory exercise |
| II.17 | Preparation of standard uranium sources | Laboratory exercise |

TABLE VI–III. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART III: BIOLOGICAL EFFECTS OF IONIZING RADIATION

| Module No. | Practical exercise | Type |
|---|---|---|
| III.1 | Analysis of chromosomal aberrations | Demonstration |
| III.2 | Interpretation of epidemiological data | Case study |
| III.3 | Assessment of the risks associated with doses | Case study |

TABLE VI–IV. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART IV: PRINCIPLES OF RADIATION PROTECTION AND THE INTERNATIONAL FRAMEWORK

| Module No. | Practical exercise | Type |
|---|---|---|
| IV.1 | Description of the elements of the system of radiological protection and of the safety culture for any given practice | Case study |
| IV.2 | Principles of protection and safety and national or international experience | Case study |
| IV.3 | Simple evaluation of safety culture for a given organization | Case study |

TABLE VI–V. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART V: REGULATORY CONTROL

| Module No. | Practical exercise | Type |
|---|---|---|
| V.1 | Preparation of a conceptual regulatory framework for a country with a defined type and number of radiation sources | Case study |
| V.2 | Use of computer aided materials for an information system for a regulatory body (for example the IAEA Regulatory Authority Information System (RAIS)) | Demonstration |
| V.3 | Study of the licensing process for an industrial or medical practice | Case study |
| V.4 | Conduct of a safety review for a licence application for an industrial radiography facility or other type of practice | Case study |
| V.5 | Evaluation of an application for the use of radioactive sources in smoke detectors or other consumer products (the principle of justification being taken into account) | Case study |
| V.6 | Preparation of a press release by a regulatory body on a topical issue | Case study |

TABLE VI–VI. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART VI: ASSESSMENT OF EXTERNAL AND INTERNAL EXPOSURES

| Module No. | Practical exercise | Type |
|---|---|---|
| VI.1 | Development of a routine monitoring programme (internal and external exposures) | Case study |
| VI.2 | Use of thermoluminescent dosimetry and film dosimetry for personal dose assessment | Demonstration |
| VI.3 | Interpretation of measurements made with a personal dosimeter | Case study |
| VI.4 | Demonstration of practical monitoring systems for areas, surfaces and air | Demonstration |
| VI.5 | Calibration of different dosimeters | Technical visit to a secondary standard dosimetry laboratory |
| VI.6 | Measurement of the radionuclide content of the body by whole body counting | Technical visit to a whole body counting facility |
| VI.7 | Measurement of radionuclides in urine samples | Laboratory exercise |
| VI.8 | Calculation of internal doses using ICRP models for acute and chronic exposure | Case study |

TABLE VI–VII. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART VII: PROTECTION AGAINST OCCUPATIONAL EXPOSURE

| Module No. | Practical exercise | Type |
|---|---|---|
| VII.1 | Visit to an industrial radiography facility | Technical visit |
| VII.2 | Visit to an irradiator or accelerator for industrial or research use | Technical visit |
| VII.3 | Visit to a department of nuclear medicine in a hospital | Technical visit |

TABLE VI–VII. (cont.)

| Module No. | Practical exercise | Type |
|---|---|---|
| VII.4 | Preparation of an organizational chart and highlights of a radiation protection programme for a hospital (e.g. radiotherapy, diagnostic radiology or nuclear medicine) and for an industrial facility (e.g. industrial radiography or an irradiator) | Case study |
| VII.5 | Shielding calculations for an X ray facility | Exercise |
| VII.6 | Application of the ‘as low as reasonably achievable’ (ALARA) principle for occupational exposure | Case study |
| VII.7 | Leak testing of sealed sources | Laboratory exercise |
| VII.8 | Use of personal protective equipment | Demonstration |
| VII.9 | Choice of a personal dosimeter and monitoring instruments | Demonstration |
| VII.10 | Preparation of a laboratory to work temporarily with unsealed sources | Simulation |
| VII.11 | Monitoring a workplace for external radiation, selection of instrumentation and interpretation of results | Simulation |
| VII.12 | Monitoring a workplace for surface and air contamination and the use of gross alpha and beta measurements and gamma spectrometry | Simulation |
| VII.13 | Decontamination of surfaces | Laboratory exercise |
| VII.14 | Determination of individual dose due to air contamination | Case study |
| VII.15 | Management of personal dose records, dose reduction measures, special monitoring and follow-up measures | Case study |
| VII.16 | Comparison of predicted doses to personnel on the basis of workplace monitoring with the results of individual monitoring in mixed radiation fields | Case study |

TABLE VI–VIII. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART VIII: MEDICAL EXPOSURES IN DIAGNOSTIC RADIOLOGY, RADIOTHERAPY AND NUCLEAR MEDICINE

| Module No. | Practical exercise | Type |
|---|---|---|
| VIII.1 | Determination of doses to patients | Case study |
| VIII.2 | Optimization of doses to patients in diagnostic radiology | Case study |
| VIII.3 | Optimization of doses to patients in nuclear medicine and radiotherapy | Case study |
| VIII.4 | Measurement of the absorbed dose in the body for a unidirectional exposure to $^{60}Co$ using phantom and thermoluminescent dosimetry detectors | Laboratory exercises |
| VIII.5 | Visit to a hospital: departments of radiology, radiotherapy and nuclear medicine, demonstration of procedures and specification of the information to be recorded | Technical visit |
| VIII.6 | Analysis of accidents in medical exposure | Case study |

TABLE VI–IX. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART IX: EXPOSURE OF THE PUBLIC OWING TO PRACTICES

| Module No. | Practical exercise | Type |
|---|---|---|
| IX.1 | Procedures for the transport of materials, characterization of materials and selection of the optimum type of package | Case study |
| IX.2 | Packaging of radioisotopes for transport | Laboratory exercise |
| IX.3 | Preparation of shipping documents for transport by road and air | Laboratory exercise |
| IX.4 | Collection and segregation of waste: monitoring, preliminary conditioning and labelling | Laboratory exercise |

TABLE VI–IX. (cont.)

| Module No. | Practical exercise | Type |
|---|---|---|
| IX.5 | Visit to a waste treatment and waste management facility | Technical visit |
| IX.6 | Listing of the components of an environmental monitoring programme for a given installation | Case study |
| IX.7 | Preparation and measurements of environmental samples: air, soil, water and foodstuffs | Laboratory exercise |
| IX.8 | Interpretation of the results of an environmental monitoring programme | Case study |

TABLE VI–X. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART X: INTERVENTION IN SITUATIONS OF CHRONIC AND EMERGENCY EXPOSURE

| Module No. | Practical exercise | Type |
|---|---|---|
| X.1 | Measurement of radon in dwellings and comparison with the action level | Laboratory exercise |
| X.2 | Response to a hypothetical accident: loss of a gamma radiography source | Case study |
| X.3 | Response to a hypothetical accident: environmental release of a substantial amount of radioactive material | Case study |
| X.4 | Estimation of the individual doses following an accidental overexposure | Case study |
| X.5 | Search for a lost source | Simulation |
| X.6 | Response to a hypothetical transport accident involving radioactive material | Simulation |
| X.7 | Communication with the public and with information media after a hypothetical accident: press conference | Simulation |

TABLE VI–XI. PRACTICAL EXERCISES FOR THE STANDARD SYLLABUS. PART XI: TRAINING THE TRAINERS

| Module No. | Practical exercise | Type |
|---|---|---|
| XI.1 | Preparation of a syllabus and programme for a training course on radiation protection and safety for users | Case study |
| XI.2 | Suggested topics for presentation and discussion by the participants:<br>— Occupational radiation protection for a given application of ionizing radiation;<br>— Safety assessment for licensing purposes for a given installation;<br>— Preparation of an inspection in a given installation;<br>— Medical applications of sources of ionizing radiation and safety related aspects;<br>— Limitations and use of radiation protection instrumentation;<br>— Natural radioactivity and radiation exposure to the public;<br>— Conceptual planning to respond to a radiological emergency at a given installation. | Presentations and workshops |

## REFERENCE

[VI–2] INTERNATIONAL ATOMIC ENERGY AGENCY, Standard Syllabus for a Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources, Training Course Series, IAEA, Vienna (2001).

## Annex VII

## EXAMPLE OF A QUESTIONNAIRE FOR THE EVALUATION OF TRAINING BY THE PARTICIPANTS

Title of the course: ____________________ Date: __________ Place: ___________
Your name: ____________________________________________________________

This questionnaire has two goals: to identify the strengths of the training and to point out areas where changes and improvements need to be made. Your part as a training participant is to be thoughtful and honest in your comments. Our part as training organizers is to use the ideas and suggestions you make to improve the training wherever possible.

PART I: GENERAL QUESTIONS ABOUT THE TRAINING

1. We want our training to be *well organized.* That is, we want the training to run smoothly, on time and efficiently. We want the information and tools you need to be available to you when you need them. We want you to have a clear picture of the aims of the course and of your learning objectives. Circle the answer that comes closest to your own view of the organization of the course:

| The training was well organized | Most of the time things were well organized | Basically well organized but some need for improved organization | Training organizers need to work on making the course more organized | The training was disorganized |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Please comment:

2. We want our trainers to be *effective.* That is, we want the trainers to be experts who are well prepared and who explain their subject clearly. We want them to motivate and involve you in learning practical skills and facts, and to answer your individual questions. How well do we live up to our goal that our trainers be effective?

| Trainers were effective | Most of the trainers were effective | Basically effective trainers but some need for improvement | Training organizers need to make trainers more effective | Trainers were not effective |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Please comment:

3. We want the training to result in *good relationships* between participants and trainers. What is your opinion on that?

| I have built many such relations with participants and trainers | I have built some such relations with participants and/or trainers | I have built a small number of such relations with participants and/or trainers | Training organizers need to work on making such relations possible in the course | I have built few or no relations with participants and trainers |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Please comment:

4. We want this course to be *one of the best you have ever attended.* How would you rate this training overall?

| Excellent | Good | Average | Poor | Very poor |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Please comment:

5. We want this training to provide you with useful skills and knowledge to help you work safely. How well did this training meet your needs and expectations?

| Met all my needs and expectations | Met most of my needs and expectations | Met enough of my needs and expectations to help me work safely | Met a few of my needs and expectations | Met none of my needs and expectations |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Please comment:

PART II: FACILITIES AND SOCIAL ACTIVITIES (If appropriate)

1. What is your opinion of the teaching facilities (e.g. auditorium, study rooms and audiovisual aids)?

| | | | |
|---|---|---|---|
| Excellent | ____________________ | Good | ________________ |
| Acceptable | ____________________ | Not acceptable | ________________ |

2. What is your opinion of the accommodation for the participants?

| | | | |
|---|---|---|---|
| Excellent | ____________________ | Good | ________________ |
| Acceptable | ____________________ | Not acceptable | ________________ |

3. What is your opinion of the social arrangements for the participants (e.g. tours and entertainment)?

| | | | |
|---|---|---|---|
| Excellent | ____________________ | Good | ________________ |
| Acceptable | ____________________ | Not acceptable | ________________ |

4. What suggestions do you have for future training activities with regard to social arrangements? (Please be specific.)

5. What suggestions or comments would you like to make with regard to arrangements that do not bear on the technical aspects of the training or its content (e.g. teaching facilities, social aspects and accommodation)?

PART III: SPECIFIC QUESTIONS TO HELP US IMPROVE THIS COURSE

1. Please list below the five topics which were *most useful to you.*
2. Now list the five topics which were *least useful to you.*
3. What was the *best learning activity?* Please name a specific module, lecture, laboratory exercise, discussion, site visit or table-top exercise.

   What made it the *best learning activity?*

4. What did you learn in this course that you can most directly apply when you return home?

5. Indicate the usefulness of each module, lecture or other session to your work and to improving your professional training by putting an X in the appropriate box. If you think a session could be shortened or expanded or the content could be improved, put an additional X in the appropriate position. Please explain your choices and include any other comments and suggestions for improving the efficiency of the training. Add pages if necessary.

| Module | Useful | Not useful | Shorten | Expand | Improve content | Explain |
|---|---|---|---|---|---|---|
| Module 1 | | | | | | |
| Module 2 | | | | | | |
| Module 3 | | | | | | |
| Module 4 | | | | | | |
| Module 5 | | | | | | |

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**Consultants Meetings**

Vienna, Austria: 27–31 July 1998, 15–19 March 1999

**Advisory Group Meeting**

Vienna, Austria: 6–10 March 2000