Radiation Protection in NDT

Proposals for Training Standards

(Prepared under Contract Number : TREN/06/NUCL/507.64366)

Contents

1. Introduction

Adequate and relevant training is a cornerstone at all levels in radiation protection. The endpoint of the training process should be an effective workforce, that is, a workforce with a satisfactory level of competence in the roles undertaken and suitable for the industry in which the work is undertaken.

With respect to radiation protection in industrial radiography there is wide range of training provided across Europe. While many of the courses, events and training schemes appear to address the topics that might be expected for industrial radiography the view has been expressed that there is perhaps a lack of (safety) competence among industrial radiographers. In the following sections proposals are put forward for training standards for both basic radiographer and for Radiation Protection Officers; in both, the intention has been to specifically address the issue of competence.

2. Basic training for industrial radiographers

2.1 Requirements and pre-requisites

i) Requirements

In the context of radiation protection the only responsibility held by an industrial radiographer is that he undertakes his work in a safe manner. However, it should be stressed that this is not only with respect to his own safety but also to that of his colleagues and clients. In general terms, "working safely" here means following instructions and procedures with the extent the required ability being to recognize atypical and/or potential dangerous situations and to formulate the appropriate consequential actions. Such ability can only be assumed if there is an understanding of the magnitude of the hazard and the degree of risk presented. This being the case the requirements (or aim) of any basic radiation safety training for industrial radiographers must be to ensure that the radiographer:

- understands the basic nature and magnitude of the hazard
- knows the precautions to be taken
- understand the importance of compliance with employers' procedures
- recognizes an atypical or potentially dangerous situation

These general requirements are summarized in table 1.

Table 1: Industrial radiographers – required competence

Function/Responsibility	Required competence	Aim of training
To work in safe manner, in accordance with the employers' procedures.	Individual must be *able* to • Work in a safe manner • Follow instructions and procedures	To provide • Understanding of nature & magnitude of the hazard • Knowledge of precautions to be taken • Understanding of the importance of following procedures

ii) Pre-requisites

It must be recognized that radiation protection training is not a “stand-alone” event but complementary to any technical instruction and training undertaken by individuals en-route to becoming qualified industrial radiographers. While obviously an essential component of the wider training, radiation safety training is arguably a secondary aspect. This being the case, it is not appropriate to advise a prescriptive pre-requisite educational level for the radiation protection training as the educational level of individuals is pre-determined by the discipline itself.

That said, industrial radiography is a discipline that requires reasonable numerical, technical and literary skills, as well as a degree of maturity in the individual and an education to at least secondary level would be expected. It is, however, important that individuals undergoing the training have had some prior familiarization with the equipment and techniques employed. (This may be as little as some time spent “shadowing” or observing colleagues undertaking the work).

2.2 Format and content

Initial radiation protection training should ideally be undertaken in the early stages of qualification as an industrial radiographer. The training could be undertaken as part of the overall qualification scheme – possibly included with relevant technical aspects – alternatively, it may be a separate specific event. Arguably, the latter is preferable as the focus can be on radiation protection and there is perhaps less risk of the issues becoming confused.

Whether as part of a more comprehensive training scheme or as a stand-alone event it is important that the format of the training is appropriate to the attainment of the training objectives, that is, a mixture of classroom presentations with practical and desk-top exercises. The latter are particularly important, radiation protection can often be perceived as rather “alien” (compared to other health and safety issues in the workplace) and, as such, facilitating understanding can be difficult; it must not be assumed that the simple provision of information will be sufficient. A competent industrial radiographer must, for example be able to apply the concept the inverse square law in practice, use a dose-rate monitor appropriately, understand the significance of results obtained, understand the magnitude of doses etc, so a hands-on approach to training is essential.

A proposed syllabus for basic radiation protection training for industrial radiographers detailing content, recommended duration to ensure appropriate coverage of the material, required emphasis on individual subject areas and suggested topics for exercises is given in appendix A. It is suggested that this could form a useful reference standard for such training.

2.3 Assessments

As noted in the introduction, in order for competence to be achieved, an individual must be armed with the relevant knowledge and skills. This cannot be assumed merely from attendance at a training event – however relevant that event might be – consequently, some form of assessment on completion of training is considered to be essential. It is considered that some form of assessment on completion of the training is essential. However, care should be taken as what exactly is assessed; the assessment of competence is perhaps not straightforward in practice.

Although it is common practice to require students to undertake a written assessment or examination on completion of radiation protection training there is a limit as to what can be assessed by this means. At best it can only be an assessment of knowledge gained and perhaps of some understanding, although the latter with some difficulty. It is suggested that the optimum approach would be to provide students with a (simple) written test of knowledge <u>combined</u> with practical assessment of understanding and ability. With regard to the former, there are facts that an industrial radiographer would be expected to know, for example, the maximum dose-rate at the boundary of a controlled area, the fact that gamma and x-radiation can penetrate human tissue, the appropriate units to use in measurement etc.. Considering the latter it would be reasonable to expect a student to be able to successfully undertake a series of tasks chosen specifically to demonstrate the required level of competence, for example

- demonstrate correct use of a dose-rate monitor
- estimate individual dose with a knowledge of dose-rate and exposure duration
- undertake appropriate checks on safety systems and warning devices
- be able to use emergency equipment.

It is important that the assessment process be simple and straightforward and, in essence, be a test of basic ability. Testing of academic ability or in-depth understanding of background science (eg, radiation physics) should be avoided. The objective should be that a "pass" in the assessment provides an indication to the employer that the radiographer understands the basic radiation protection issues and is capable of working in a safe manner. A record of both attendance at a training event and of a "pass" in the assessment should be provided.

2.4 Refresher training

As with any health and safety issue, refresher training is considered to be essential; technical aspects can move on (for example, introduction of new equipment), legislative requirements can change and, of course, it is always appropriate to reinforce basic understanding.

It is commonplace for an interval <u>not exceeding 5 years</u> to be cited as a timeframe for refresher training and this is considered to be equally appropriate for radiation protection training. However, it is important that employers recognise the fundamental requirement to maintain an adequately trained workforce and, as such, consideration may need to be given to the provision of refresher training at more frequent intervals.

It is difficult to be prescriptive with regards to the exact content of format of refresher training. In many ways the simplest approach is for radiographers to undergo the full training again, but of course this may not always be cost-effective. The objective of refresher training should be to make sure that the radiographer has maintained/can maintain basic competence, as such reinforcement of practical issues, reminder of fundamental radiation protection principles and an update on legislative requirements may be all that is required. However, it is suggested demonstration of competence (as outlined above) should be required and, again, a record of “pass” in any assessment provided.

3. Training for radiation protection officers

3.1 Requirements and pre-requisites

Requirements

The role of the Radiation Protection Officer (RPO) is primarily a supervisory role and as such, the RPO has additional radiation protection responsibilities. Consequently, the required competences and hence the requirements/aims of training provided are wider ranging than for basic radiographers. These differences are summarised in table 2.

Table 2: RPOs – Required competence

Function/Responsibility	Required competence	Aim of training
Supervision; the RPS has an important role to play in ensuring observance and adherence to the Local Rules.	RPO must be able to • work safely and follow instruction • assess and understand the degree of radiation hazard in his work environment • analyse a situation and make a decision on an appropriate course of action • supervise others effectively	To provide • Knowledge and understanding of regulatory requirements • Understanding of the precautions to be taken and the extent to which these will restrict exposures • Knowledge of what to do in the event of an emergency *NB: The ability to supervise others effectively is an issue of “suitability” - this is not something that can be achieved via radiation protection training.*

ii) *Pre-requisites*

It is expected that anyone appointed to the role of RPO would have prior experience as an active radiographer. As stated above this is primarily a supervisory role; this being the case a sound or understanding of the work and the associated radiation protection is required. It is also expected that individuals are given sufficient authority to carry out the role effectively. It is suggested that potential RPOs should have spent at least 9-12 months as fully qualified industrial radiographers before being appointed to the role.

Potential RPOs should also have a level of radiation protection competence equivalent to that that would be attained by attendance at training reflecting the syllabus for basic level training given in appendix A.

3.2 Format and content

The general comments made in section 2.2 with respect to the ideal format for industrial radiographer training are equally valid with respect to radiation protection training for RPOs. Obviously the training aims and objectives are slightly different and the scope of the training must be broader in order to reflect the wider responsibilities of the RPO but it is suggested that the approach to the training, ie a mixture of presentations and exercises is the same.

A proposed syllabus for radiation protection training for RPOs, detailing content, recommended duration to ensure appropriate coverage of the material, required emphasis on individual subject areas and suggested topics for exercises is given in appendix B. Again, It is suggested that this could form a useful reference standard for such training.

3.3 Assessments

Again, a similar approach as that described for basic level training is recommended but clearly the assessment must be against the attainment of the specific training objectives and the RPO syllabus.

3.4 Refresher training

A similar approach as for the basis level training is recommended.

4. Training providers

It is vital that those providing radiation safety training in the field of industrial radiography, whether it be at the basic radiographer level or at the level of the RPO, have –

i) a sound knowledge and understanding of operational industrial radiography

ii) a sound understanding of the fundamentals of radiation protection in general and of the specific radiation protection issues associated with industrial radiography in particular

iii) a knowledge of (national) legislative requirements

iv) relevant resources (for example, equipment for practical exercises)

v) a proven ability to communicate the issues to effect.

It doesn’t matter whether the training providers are primarily specialist radiation protection organizations or perhaps NDT training schools (arguably the latter is advantageous as students are likely to source other training at such schools) as long as the above criteria are satisfied.

In a number of European countries training providers are “approved” by the Regulatory Authority or national radiation protection body. Although not essential, it is considered that such an approach is of value as it provides a degree of validation and traceability of the training provided.

5. Summary

i) The key aim in radiation protection training should be to provide those undergoing the training with the knowledge, understanding and basic skills necessary for (safety) competence in the workplace.

ii) Syllabi, along with some supplementary guidance for training at both the basic level and at the level of the RPO, are provided in appendices A and B. These are proposed as useful reference standards at the European level.

iii) It is considered that assessments should be provided on the conclusion of radiation safety training. However, such assessments should be focused on the assessment of competence rather than assessment purely of retention of knowledge or academic ability.

iv) Routine refresher training (at all levels) is essential. Such training should be carried out as necessary in order to maintain competent and adequately trained workforce, but it is recommended that intervals between training do not exceed a maximum of 5 years.

v) Training providers should possess the appropriate knowledge, skill and resources to ensure effective provision.

RADIATION PROTECTION TRAINING FOR INDUSTRIAL RADIOGRAPHERS

The following are proposals for an approach to radiation protection training for industrial radiographers. Included are:

A.1 Guidance on target audience, training aims and objectives
A.2 Syllabus*
A.3 Guidance with respect to sequence and duration of presentations
A.4 Suggested resources required

* It should be noted that a syllabus is merely a list of topics to be covered, the guidance included in section A.3 provides some details on how these topics should covered, where emphasis should be placed etc..

A.1 The course

Target audience: Pre-requisites

No previous knowledge of, or training in radiation safety is required; however, an understanding of the techniques involved in industrial x and gamma radiography is assumed.

Aims and objectives

The overall aim of this training is to provide attendees with the knowledge and understanding of practical radiation safety in relation to X and Gamma radiography (both in enclosures and during mobile radiography) necessary to facilitate competence in the workplace.

On completion of the training, those attending should:

- Be aware of the nature and origins of X and gamma radiation
- Be familiar with the terminology used in radiation protection
- Have knowledge and understanding of the potential doses associated with industrial radiography
- Know the effects of exposure to radiation
- Understand the importance of restricting exposure so far as is reasonably practicable
- Be aware of the measures that can be taken in practice to restrict exposure
- Know and understand the importance of adhering to Written Procedures
- Know how and when to use a dose-rate monitor
- Understand how accidents can be prevented
- Know the practical steps to take in the event of an emergency.

A.2 Syllabus

Basic Concepts

Structure of matter	-	atoms, elements, isotopes, radioisotopes
Radioactive decay	-	alpha, beta, gamma
Activity and half-life (T ½)		
Origin of radioisotopes		
Radioisotopes used in Industrial Radiography		
Production of x-rays		
Radiation energies		
Terminology	-	“closed” sources, special form
	-	external and internal exposure routes (contamination)
	-	ionisation

Radiation Quantities & Units

Activity	-	Becquerel (Bq), [Curie (Ci)]
Radiation dose (Sv)		
Concept of dose-rate (μSv/h etc)		
Commonly used prefixes		

Radiation Hazards and Dose Limitation

Deterministic effects	-	erythema, depilation, burns, decreased blood count, radiation sickness
Stochastic effects	-	cancer, hereditary effects
	-	concept of radiation risk, comparison with other risk
Dose limitation	-	justification, optimisation (ALARP), dose limits
	-	concept of dose investigation levels

Summary of National Legislation

A summary of national legislation in place relevant to industrial radiography.

Principles of Protection from External Radiation

Radiation outputs	-	gamma, x-ray (typical values for common sources/parameters used)
Time		
Distance (concept of inverse square law)		
Shielding	-	appropriate materials, concept of HVT and TVT

Practical Protection from External Radiation

Gamma radiography	-	sources, wind-out containers, collimators
X-Radiography	-	x-ray sets, accelerators
Compounds	-	basic design, control of exposure, effective devices
Site radiography	-	declaration of area, exclusion of persons
	-	supervision and communication
	-	warning signals and notices

Control of Work in Practice

Concept of risk assesments

Classification of areas- controlled and supervised

- demarcation and restriction of access
- requirement for monitoring
- application to site and compound
- outside workers

Local rules, RPOs

Co-operation between employers

Personal Monitoring

Dose assessment	-	film, TLD, personal alarms
	-	care of dosemeters
Classification	-	health and dose surveillance
	-	record keeping
Investigations	-	purpose, trigger/investigation levels

Workplace Monitoring

Direct and indirect reading monitors

Making measurements (correct use of monitors)

Requirements for monitor testing

Frequency of monitoring, record-keeping

Safety and Security

Source storage

Source accountancy

Leak testing

Equipment testing and maintenance

Transport of Radioactive Sources

Transport containers	-	type, labelling, transport index
Vehicles	-	placarding, ADR plates, fire extinguishers
	-	contamination checks
Documentation		
Responsibilities	-	driver (consignor and consignee)

Accident Case Histories

Accident and incident case histories

Emergency Preparedness

Emergency plans

Emergency equipment

A.3 Sequence, duration and format of presentations

The suggested sequence in which the topics listed in the syllabus should be covered is detailed below along with some guidance on the duration of each topic (NB topics do not have to be covered in a single session – suggested durations are for total time required) Overall it is considered that this material could be adequately covered in a maximum of 2-3 working days.

TOPIC	SUGGESTED DURATION
Basic Concepts of Radiation	1.0 hr – 1.5 hr
Quantities and Units	0.5 hr
Summary of National Legislation	0.5 hr
Radiation Hazards and Dose Limitation	1.0 hr – 1.25 hr
Principles of Protection • Including desk-top exercises	1.5 hr – 2.0 hrs
Practical Protection	1.0 hr
Safety and Security	0.75 hr – 1.0 hr
Control of the Work in Practice	1.0 hr
Workplace Monitoring	0.5 hr – 0.75 hr
Practical Exercises (*examples)* • Setting up a barrier • Radiation survey of an x-ray facility	1.0 hr – 2.0 hr
Personal Monitoring	0.5 hr – 0.75 hr
Transport of Radioactive Material	0.5 hr
Emergency Preparedness	0.75 hr – 1.0 hr
Practical Exercise (*examples)* • Source Recovery	1.0 hr
Accident Case Histories	0.75 hr

The table below provides some guidance as to the objective and structure of sessions covering the topics listed in the syllabus.

Topic	Objective/Structure
Basic Concepts of Radiation	No previous knowledge of the type or properties of radiation should be assumed. Emphasis should be on ensuring understanding of the nature of x and gamma radiation, the fundamental difference between the two and on the definition of radiation protection terms. If practicable, demonstrations using low activity sources should be included.
Quantities and Units	The emphasis must be on ensuring that radiographers understand the quantities used in radiation protection. Practice in manipulating mulitiple/fractions of basic units (eg, µSv/h, mSv/h, MBq, GBq etc) should be provided as well as conversion from Bq to Ci.
Summary of national legislation	Objective should be to indicate the range of legislation that might impact on the work. Not appropriate to address detailed requirements as these should be addressed in subsequent presentations. Important that radiographers understand that many of the procedures etc that they are required to follow are specific requirements of legislation.
Radiation hazards and dose limitation	Practical radiation protection only requires a very basic understanding of biological effects; material should be presented in a very straightforward fashion and detailed discussion on the interactions of radiation sin human tissue should be avoided. Objective should be to describe principal injuries that may arise and to ensure an understanding of the need to keep exposures ALARP. Dose limits should be stated.

Principles of protection	Key objective is to create an understanding of the principles of output, time, distance and shielding affect dose received. An understanding of how dose-rate varies with distance is required. An understanding of the concept of TVT and HVT is desirable although radiographers would not be expected to calculate shielding thickness. Radiographers must have an understanding of the significance of results, relative magnitude etc. Ideally all concepts in this topic should taught via relevant worked examples
Practical Protection	This is an opportunity to provide an overview of the safety features used to restrict exposure. The session should be very practical with liberal use of photographs and actual equipment study. Both enclosure and mobile radiography should be addressed.
Safety and Security	Objective is to highlight steps required to ensure ongoing safety and security of sources and equipment. Aspects such as accountancy, storage, checks etc are likely to undertaken by radiographers; material should be covered in sufficient detail to ensure that requirements are understood. HASS should be specifically addressed.
Control of Work in Practice	The primary objective should be to create an understanding of the terms used eg, "controlled area" and what these mean/require in practice. Discussion of expected content of procedures/local rules is expected. Understanding of precise legal definitions is not expected provided the conches are clear.

Workplace Monitoring	This must be an interactive session with monitors available for demonstration. Radiographers require a good understanding of practical aspects of monitoring as well record-keeping requirements.
Personal Monitoring	The primary objective should be to provide a good understanding of the practical aspects of using and caring for dosimeters. Examples of dosimeters, both active and passive should be available for demonstration. Discussion of classification and its requirements should be straightforward.
Transport of radioactive material (road)	Coverage should focus on the responsibilities that may lie with driver with respect preparing the transport container, QA checks, parking restrictions, stowage during transport etc. Detailed discussions of various container types are not required.
Emergency Preparedness	Radiographers should be able to understand the circumstance of an emergency and be able to take practical steps. The facts that emergency plans should be available (with examples) and the importance of rehearsing these should be discussed. Ideally this topic should be supported by practical exercises.
Accident Case Histories	A point of emphasis in this presentation should be that there is the potential for significant doses if things go wrong. Discussion of case histories must include discussion of “lesson learned”.

A.4 Suggested resources required for exercises and demonstrations

- Small gamma test source
- Various filters to include lead (various thicknesses), Steel (various thicknesses)
- Sensitive radiation monitor (e.g. scintillation detector)
- Copies of relevant legislation, guidance, codes of practice etc
- Dummy radiography source
- Radiography source container
- Collimator
- Barrier Tape
- Warning notices
- Information notices
- Portable warning lights / Sirens

- Source accountancy record
- Leak test certificate
- Example local rules

- Radiation Monitors
- GM Tube
- Compensated GM Tube
- Ion Chamber
- Instrument Test Certificate
- Monitoring Record
- TLD Dose meter
- Film Badge Dose meter
- Health Record
- Dose Record
- Electronic personal dosemeter
- Transport labels
- Car signs :
    - Orange plates
    - Fireproof plates
    - Vehicle placards
- Transport document

- Emergency equipment:
- Long reaches
- Lead pot
- Lead shot
- Wire cutters

- Simulated gamma radiography source and detector
- IAEA publications on accidents

- Area that could be used for demonstration of mobile radiography

And if possible, a radiography enclosure (preferably x-ray) with fully operational safety systems.

RADIATION PROTECTION TRAINING FOR INDUSTRIAL RADIOGRAPHERS

The following are proposals for an approach to radiation protection training for Radiation Protection Officers in industrial radiography. Included are:

B.1 Guidance on target audience, training aims and objectives
B.2 Syllabus*
B.3 Guidance with respect to sequence and duration of presentations
b.4 Suggested resources required

* It should be noted that a syllabus is merely a list of topics to be covered, the guidance included in section B.3 provides some details on how these topics should covered, where emphasis should be placed etc..

B.1 The course

Target audience: Pre-requisites

It should be assumed that attendees have experience of x and gamma radiography, have already undertaken primary training in radiation protection, and as such have a working understanding of practical radiation protection.

Aims and objectives

The overall aim of this training is to re-enforce the fundamental principles and legal requirements for radiation safety in x- and gamma radiography, sufficient to provide the necessary competence to fulfil the role of Radiation Protection Officer.

On completion of the training, prospective RPOs should have:

- Knowledge and understanding of the nature and properties of ionising radiations.
- Knowledge of the terminology used in radiation protection.
- Knowledge of relevant requirements of national legislation
- A sound understanding of he need to restrict exposures so far as is reasonably practicable.
- A sound understanding of the potential radiation doses associated with industrial radiography and how the restriction of exposure can be achieved in practice.
- An understanding of good working practices (use of radiation monitors, planning work effectively etc).
- Knowledge and understanding of the role of the RPO in supervising the work and helping the employer to achieve regulatory compliance.

B.2 Syllabus

Basic Concepts
As for “Basic Radiation Safety”

Radiation Quantities & Units

Activity	-	Becquerel (Bq), Curie (Ci)
Activity concentration	-	Surface contamination (Bq/cm^2)
Radiation dose	-	equivalent dose (Sv), effective dose (Sv)
Concept of dose-rate	(μSv/h etc)	

Commonly used prefixes

Radiation Hazards
Cellular radiation damage, radiosensitivity

Deterministic effects	-	erythema, depilation, burns, decreased blood count, radiation sickness
Stochastic effects	-	cancer, hereditary effects
	-	concept of risk, sources of risk data, comparison with other risks

Chronic and acute exposure

Dose spectrum, sources of individual exposure

National Legislative Structure
Summary of national legislation relating to radiation protection

Dose Limitation

Basic principles	-	justification, optimisation, dose limits
ALARP		
Dose limits	-	values, basis

Dose investigation levels
Reference values (eg 7.5 μSv/h)

Preparation for Radiation Work
Requirements for notification, registrations, authorisations as relevant
Appointment and role of Qualified Expert

Control of Work

Classification of areas	-	controlled and supervised
	-	demarcation & restriction of access
	-	requirement for monitoring
		- application to site and compound
		- outside workers

Local Rules, RPO

Role of the Radiation Protection Officer

Suitability of RPO

Record Keeping - source accountancy requirements
- leak testing requirements
- maintenance, checks on safety systems

Co-operation between employers

Information, instruction and training

Principles of Protection from External Radiation

Use of units

Basic influences - source activity/kV & mA
- time
- distance, inverse square law
- shielding materials, HVT & TVT

(Application of the above by worked examples)

Practical Protection from External Radiation

Hierarchy of controls

Gamma radiography - sources, wind-out containers, collimation

X-radiography - x-ray sets, accelerators

Compounds - adequate shielding, basic design, control of exposure, effective devices

Mobile radiography - minimisation of controlled area, exclusion of persons
- supervision and communication

Warning signs and notices

Storage of radioactive sources

Workplace Monitoring

Requirements for routine monitoring

Types of detector
- ionisation chamber, gm tube, compensated gm, scintillation detector
- energy response, response time

Interpretation of results

Conversion factors

Instrument testing

Correct choice of instrument, practical aspects

Monitoring regimes

Personal Monitoring

Dose assessment	-	film, TLD, electronic dosemeters, personal alarms
	-	care of dosemeters
Classification	-	dose record keeping, radiation passbooks
	-	health surveillance, health records
Investigations	-	ALARP, over-exposure, accident dosimetry

Transport of Radioactive Materials

Transport containers	-	types A, B and C
	-	transport index (TI)
	-	labelling
Vehicles	-	placarding, ADR plates, fire extinguishers
	-	contamination checks
Documentation	-	transport documents, local rules
Responsibilities	-	consignor, driver, carrier, consignee
Driver training		

Emergency Procedures

Case studies of incidents related to industrial radiography
Emergency preparedness and emergency plans
Emergency equipment
Rehearsal of emergency plans

B.3 Sequence, duration and format of presentations

The suggested sequence in which the topics listed in the syllabus should be covered is detailed below along with some guidance on the duration of each topic (NB topics do not have to be covered in a single session – suggested durations are for total time required). Some topics covered should be by way of refresher, for example Basic Concepts. Overall it is considered that this material could be adequately covered in a maximum of 3-4 working days.

TOPIC	SUGGESTED DURATION
Basic Concepts of Radiation	1.0 hr – 1.5 hr
Quantities and Units	0.5 hr
Requirements of National Legislation	0.5 hr – 0.75 hr
Radiation Hazards	1.0 hr
Dose Limitation	0.5 hr – 0.75 hr
Principles of Protection • Including desk-top exercises	2.0 hr – 2.5 hrs
Preparation for Radiation Work • Exercise on planning a change of work	1.0 hr 0.75 hrs
Practical Protection	0.75 hr -1.0 hr
Control of Work	1.0 hr
Workplace Monitoring	0.75 hr
Practical Exercises (*examples)* • Application of the inverse square law • Radiation monitoring protocols • Risk assessment of facility	1.5 hr – 3.0 hr
Personal Monitoring	1.0 hr
Transport of Radioactive Material	0.75 hr
Role of the RPO	1.0 hr
Emergency Preparedness	0.75 hr – 1.0 hr
Practical Exercise (*examples)* • Managing a source Recovery • Locating a lost source	2.0 hr
Accident Case Histories	0.75 hr

The table below provides some guidance as to the objective and structure of sessions covering the topics listed in the syllabus.

Topic	Objective/Structure
Basic Concepts of Radiation	The material in this session should be familiar to the students. It may be useful to start with some simple, general questions to gauge initial knowledge. The emphasis should be on ensuring delegates understand the nature of x and gamma radiation, the fundamental difference between the two and the definition of terms.
Quantities and Units	The emphasis of this presentation is to refresh the audience's knowledge of the SI quantities used in radiation protection. Radiographers must understand the relevance of the units in practical terms (eg, describing a radioactive source in terms of activity, or understanding that a localised exposure is described differently to a whole body exposure); and legislative terms (eg how dosemeter results, or measured dose rates relate to the statutory dose limits).
Radiation Hazards	Much of the material presented in this session should be by way of refresher for the majority of radiographers. As such, the emphasis should be on ensuring that the key terms are understood and the fact that the potential for both types of effect must be taken into consideration.
Requirements of national legislation	Primary objective is to instruct on the range of legislation that might impact on the work. Care should be taken not to discuss the requirements of the legislation in any detail, as these are addressed in later presentations

Dose Limitation	It is important that the whole system of dose limitation is emphasised to delegates, including the restriction of exposure and individual annual dose limits. Maximum dose-rates must be stated with reference to the controlled area boundary during mobile radiography.
Principles of protection	Focus should be as follows: • that the output from gamma radiation sources will vary according to the radioisotope, and that the output increases with gamma energy; • that radiation output from gamma sources will increase directly with activity; • that the output from x-ray sets depends on the kV and filtration of the set, and that the output increases directly with tube current; • how dose rate changes with distance, and how distance is used in practice to help restrict exposure (ISL). • how the dose received depends on the duration of an exposure, • What materials provide suitable shielding against x and gamma radiation.
Preparation for Radiation Work	The objective of this presentation to guide the RPO through the initial actions which help to ensure subsequent regulatory compliance. Many of the requirements described are, strictly, the responsibility of the employer although the RPO may be involved in implementing these.
Practical Protection	This presentation focuses on the way in which the restriction of exposure is achieved in practice and should be largely a refresher session. This should be a very practical session, and examples of the features being described will be useful. The audience will

	have a working knowledge of the equipment, so discussions should concentrate on the *safety* features only.
Control of Work	An audience on this course should be aware of the terms "controlled area" and "supervised area" etc via their day-to- day work, and will have some understanding of what the terms mean. However, this presentation should provide good understanding of what area designation means in terms of changing the work pattern, how local rules can be made effective in restricting exposure, and why an RPO should be appointed. The designation of areas is a matter that an employer should consult a Qualified Expert over, and so delegates should understand that they would not normally have to make this decision alone.
Workplace Monitoring	Students should have previous experience of radiation monitoring, but it will be necessary to refresh their knowledge of the different types of monitor available. This presentation should describe the legal aspects of monitoring, and should enable RPOs to set up effective monitoring programmes, co-ordinate record keeping and select appropriate monitors for the task. This presentation should be interactive, with plenty of resources (ie, radiation monitors) to illustrate the practical aspects.
Personal Monitoring	As RPOs, those attending will require a good understanding of the administrative arrangements for classified workers, and of how dosemeters should be used in practice. Strictly, the co-ordination of personal dosimetry may not be the responsibility of the RPO, but in practice the RPO will often

	take on this role. To achieve this, RPOs should understand, how to wear and care for dosemeters, what to expect of dosimetry services, how to handle non-routine situations (lost dosimeters, incorrect doses) and when further action is required (and seeking advice if necessary).
Transport of radioactive material (road)	The typical duties of the RPO in overseeing the safe and legal transport of radioactive material is the basis for this presentation. Matters over which the RPO has little or no control (eg, the design of type B packages, testing of Special form sources) should not be covered in any depth.
Role of the RPO	Key aspects to cover are: • the legal basis for the appointment of the RPO; • what constitutes adequate supervision of the work, in the field of industrial radiography; • the importance of co-operation between employers, especially prior to mobile radiography; • the various records that the RPO may be expected to keep; and • the legal requirement for leak testing, and source accountancy checks. How the role of the RPO fits with the safety and work management 'hierarchy' within a company should be discussed. Presenters should bear in mind however, that the exact role of the RPO will vary from one company to another; discussion should be encouraged
Emergency Preparedness	RPOs may be required to take the lead following an incident, and so they should understand the importance of good planning and what they should do in practice when an incident occurs. It would be beneficial to draw up example emergency plans as a group discussion, in the middle of the presentation.

	It is important to emphasis that RPOs may need to assess an emergency situation and then decide on, and put in place appropriate actions. Some typical situations should be described in this presentation, however, it should be stressed that accidents will be made unique by the circumstances under which they have occurred. This presentation should prepare RPOs to deal with any incident effectively. This presentation should be supported by a practical session.
Accident Case Histories	Any relevant cases may discussed with emphasis being placed on “lesson learned”

B.4 Suggested resources required for exercises and demonstrations

- Small gamma test source
- Various filters to include lead (various thicknesses), Steel (various thicknesses)
- Sensitive radiation monitor (eg,scintillation detector)
- Copies of relevant legislation, guidance, codes of practice etc
- Dummy radiography source
- Radiography source container
- Collimator
- Barrier Tape
- Warning notices
- Information notices
- Portable warning lights / Sirens

- Source accountancy record
- Leak test certificate
- Example local rules

- Radiation Monitors
- GM Tube
- Compensated GM Tube
- Ion Chamber
- Instrument Test Certificate
- Monitoring Record
- TLD Dose meter
- Film Badge Dose meter
- Health Record
- Dose Record
- Electronic personal dosemeter
- Transport labels
- Car signs :
    - Orange plates
    - Fireproof plates
    - Vehicle placards
- Transport document

- Emergency equipment:
- Long reaches
- Lead pot
- Lead shot
- Wire cutters

- Simulated gamma radiography source and detector

- IAEA publications on accidents

- Area that could be used for demonstration of mobile radiography

And if possible, a radiography enclosure (preferably x-ray) with fully operational safety systems.