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The Safety Culture as a part of radiation protection in medical imaging

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Abstract

The safety culture means individual awareness of the importance of safety, competence, commitment, motivation, supervision and responsibility, concerning also attitudes of the staff at all levels. The enhancement of patient safety involves a wide range of actions in the recruitment, training and retention of health care professionals, performance improvement, environmental safety and risk management, equipment safety, safe clinical practice and safe environment of care. To find out some features of the radiation safety culture, several studies in different areas concerning radiation safety officers in diagnostic departments and patient doses were analyzed. The main factors affecting to the safety culture in medical use of radiation were regulatory and organizational environment, management styles, workers and their attitudes, patients' dose optimization as well as technological characteristics. Optimization of image quality and patient dose allows the patient dose to be decreased by more than 50 % in many patient groups. Digital imaging gives possibility to degree dose and still has image quality good enough. The attitudes and fear of change are the biggest barriers to reach the good safety culture. The next step is the establishment of safety culture, which takes into account the attitudes, behavior and other human factors, which have effect on safety.

Introduction

In industry the concept of "safety culture" has been known and in use for long time (Cooper 2000). To the area of radiation it has become from the OECD Nuclear Agency report (INSAG 1988) on the Chernobyl disaster. The safety culture means individual awareness of the importance of safety, competence, commitment, motivation, supervision and responsibility, concerning also attitudes of the staff at all levels. It describes the corporate atmosphere or culture in which safety in understood to be and is accepted as, the number one priority. (Cullen 1990.) International Atomic Energy Authority (IAEA 1991) defined safety culture as "assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance".

A British advisory committee on human factors in nuclear safety identified senior management commitment, management style, management visibility, communication, pressure for production, training, housekeeping, job satisfaction and workforce composition as key indicators of the safety culture. (Flin et al 2000.) Also the concept "safety climate" has been analyzed.

Safety culture does not operate in a vacuum by it self along and without any reflections. It affects to other organizations and is affected by other organizations. In the same hospital all users of medical radiation should have a common and together agreed goal how to apply the safety culture in clinical use and what it includes. The enhancement of patient safety involves a wide range of actions in the recruitment, training and retention of health care professionals, performance improvement, environmental safety and risk management, equipment safety, safe clinical practice and safe environment of care. (Flin 2000, Holopainen 2004, Niemi 2007)

The main trends in safety culture of radiation protection in medical radiology in Finland can be described as shown in Table 1. The Radiation and Nuclear Safety Authority in Finland (STUK) made in 1950's radiation safety measurements in hospitals, because hospitals were not able to do these measurements by themselves. The weight was in the radiation safety of the staff. Later the measurements developed from protection measurements to quality assurance, performance of the unit and patient dose measurements. The radiation safety of the patient was emphasized. Gradually the responsibility from measurements transferred to hospitals and the authority only control these measurements. In the 2000's new activities such as optimization of image quality and patient dose, clinical audit and continuous education and training in radiation protection were started. (Kettunen et al 2007, Holopainen 2004.)

Table 1. The rough schedule of activities in medical radiation protection in Finland. (Kettunen et al 2007)

(Action in Medical Radiation Protection	Year
Safety license and inspections	-1960
Occupational dose measurement	-1960
Radiation safety of the diagnostic units	-1965
Performance of the units	-1970
Quality assurance	-1980
Radiation dose to patients	-1990
Optimization of examination technique	-1990
Clinical audit	-2002
Education and training in radiation protection	-2003
Safety culture	-2004

Trend in radiation protection of medical radiology shows that the clinical audit is the new step to promote good practice because in audits the current clinical written practices are compared to so called 'good practice'. Clinical audit covers the whole imaging chain from writing the referral to imaging examination up to the report of imagines. The hospital is responsible for that action. (European Commission 2009.)

Follow up of the dose reference levels (DRL) can be also seen as a part of good practice (Säteilyturvakeskus 2008). The background of these guidelines and orders is very complex and several steps and organizations are needed (Figure 1).

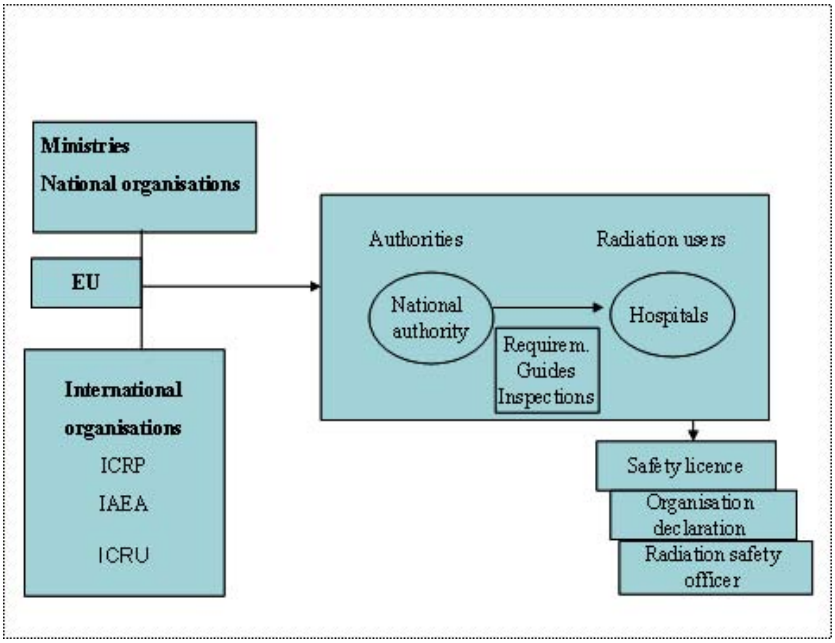

Figure 1. Factors affecting to the safety culture in medical use of radiation. (According to Holopainen 2004).

The latest, very fast development in the area of imagining modalities demands a lot of work in dose and image quality optimization and management. Deterministic harms have been reported both in interventional (e.g. Siromäki 2004) and diagnostic radiology (Yoshimasa 2005).

The next step could be the establishment of safety culture, which takes into account the attitudes, behavior etc human factors, of the staff. This has been already established in nuclear power plants where the consequences of the accident may be remarkable. The errors of the diagnoses reported in literature show high frequencies so the follow up and reporting system should be established. The safety culture may cover all those factors. One model for the assessment of safety culture has been made by IAEA 1998 (Figure 2).

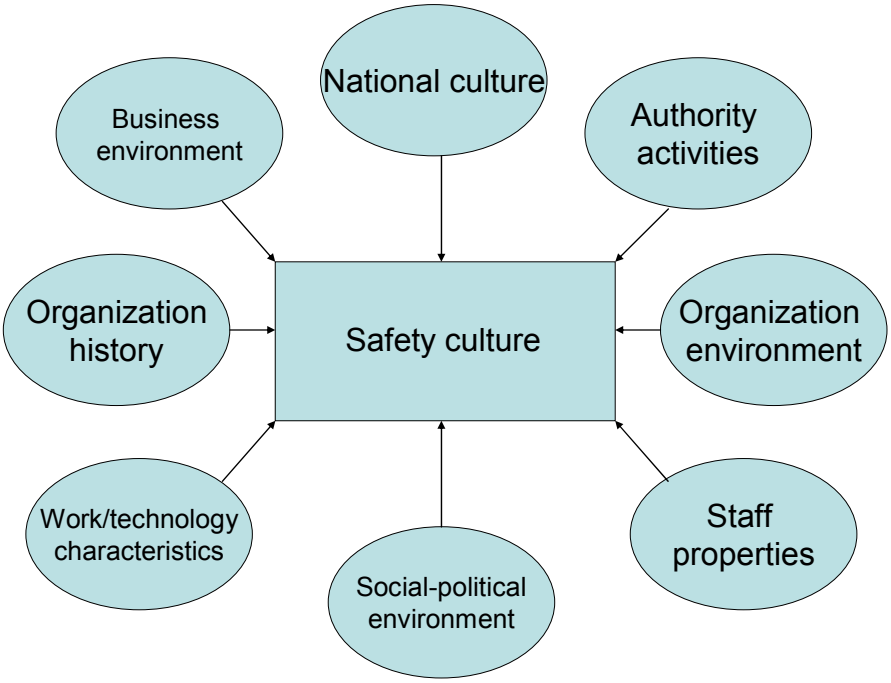

Fig. 2. A model for the assessment of safety culture. (IAEA 1998)

Material and methods

To find out some features of the radiation safety culture in Finland, several studies, reports and articles in different areas were analyzed concerning radiation safety officers in diagnostic departments and patient doses in medical imaging.

The volume of medical radiation activities of medical radiology in Finland has been quite the same level during last ten years. There are about 650 Safety licenses and 1500 x-ray units. Number of radiologists in dose monitoring in 2007 was 543 and number of radiographers in dose monitoring in 2007 was 2583.All personnel in health care in dose monitoring in 2007 was about 4900 including nurses, bioanalytics, dental personal, surgeries, orthopedics etc. (Rantanen 2009, Lehtinen 2008)

Radiation and Nuclear Safety Authority has given reference levels for adult patient in common projection examination, in computed tomography examinations and cardiac angiograms. There are also DRLs for nuclear medicine examinations as well DRLs for children in projection examinations. The adult's DRLs have been updated in 2009. (Säteilyturvakeskus 2008.) The Regulatory Guides on radiation safety (ST Guides) are updated approximately once in five years.

Two studies concerning radiographers' work and one concerning radiation safety officers work and attitudes where analysed as well a group of papers about the doses to patients or to patients groups. Examples of dose and image optimisation are given based on results of small optimisations in clinical practice made by the staff and radiographer students.

Results

The safety culture is divided here in two parts. First the group of people and their role in safety culture and second the dose management as a part of safety culture.

Regulatory and organizational environment, management styles, workers and attitudes as well as technology characteristics were the main factors affecting the safety culture. Niemi (2006) found four shared meanings in radiographer's safety culture in the medical use of radiation. The meanings were challenges of knowledge and skills structuring safety culture, dimensions of cooperation enabling safety culture, disorientation conditioning safety culture and multidimensional professionalism as the foundation of safety culture. The significance of radiation protection was emphasized but the radiographers were confused by the different directions and practices in implementing it.

Paalimäki-Paakki (2009) described ethical dilemmas in radiographer's work in diagnostics. Most important ethical dilemmas were found to consider the use of radiation, patient care, and radiographer's work community. In the use of radiation, implementation of justification and optimisation principles were found to be lacking. Dilemmas in work community consisted of problems among employees and insufficient practice. The radiographers noticed some times that the colleagues did not work as said in quality handbook (written good practice). Dose and image quality optimisations and the use of lead shields were not good enough. According to Paalimäki-Paakki is due the lack of safety culture.

Radiation safety officers are the key persons in the radiation safety culture of medical radiology. The study concerning radiation safety officers show that organizational aspects are the main factors in the safety culture of radiation protection in medical radiology. The most remarkable developing targets were stated the clarification of field of activity of radiation safety officer, possibility to affect decisions, increase of education and increase of cooperation with other radiation safety officers in various hospitals. New active partners in this field have appeared (quality assurance, education and training, occupational dose measurements, accreditation, clinical audit etc) secure the sufficient status and empowerment in the organization. Regulatory and organizational environment, management styles, worker as well as work/technology characteristics were the main factors affecting the safety culture of safety officers. (Holopainen 2004, Servomaa, Holopainen 2005.)

In the study of newborn premature babies 118 chest x-ray examinations to 43 newborns (gestational age from 26 to 42 weeks) were estimated. The effective dose from one chest radiograph varied from 7.5µSv to 54.8µSv. Retrospectively, the total number of radiation examinations to these newborns totalled 399 during the study; the mean was 9.3 (range 1-40). 98% of the examinations were produced during the first treatment period after birth. The total effective dose per child varied from 0.31 mGy to 3.7 mGy. (Kettunen 2004.) The smaller the baby is the more x-rays are usually needed for the follow-up during the first living months (Siironen 1994)

The study of pregnant woman' examinations showed that there was no common practice on how to exclude the possibility of pregnancy and the dose to a foetus was not estimated either before or after the pelvic x-ray examination. (Kettunen 2004.)

The dose study of pediatric reflux patients showed that about 6. 9 examinations / patient were made up to the age of 16 years. Average effective dose was 4.3 mSv and maximum dose about 11 mSv (Table 2). (Kettunen et al 2003.)

Table 2. Numer of examinations and effective dose, average and range to 12 patients under 16 years due to examinations of vesico-uretal reflux. (Kettunen et al 2003)

	MCU	MCU TC99m	Urography	Kidney with Tc99m	Total Number of examinations
Total Number	40	15	20	2	77
Average (range)/ one patient	3.8 (1-7)	1.3 (0-3)	1.7 (0-7)	0.2 (0-1)	6.9 (1-15)
Effective dose /patient annos(mSv)	1.7 (0.6-3.5)	0.25(0.15-0.6)	2.0(1.3-8.1)	0.3(1.9)	4.3(0.7-11)

The study of radiological examinations made for young accident patients showed that average number of examinations varied between 9-59 and effective dose varied between 5.3-33.9 mSv. (Huusko, Räsänen 2002, Servomaa & Kettunen 2005.)

These studies show some special groups of patients which need a lot of attention and especially tight indications for x-ray examinations. Next results will show how dose and image quality optimization can be applied with small steps in everyday clinical work.

The new full field mammography equipment had Dose- and Standard (STD) programs. The vendor recommended to use the STD program. The radiographers wanted to evaluate the difference in the dose and image quality between these programs. From ten females in mammography were exposed randomly either left or right breast with STD-program and other with Dose-program. Three experienced radiologists (used to read screening mammograms) evaluated them “blind” without knowing which are taken by which technique. All mammograms were good enough for diagnostic. There were no difference find between images taken by STD- or Dose-programs and now all mammograms are taken by Dose-program and lower dose. The dose reduction was about 30 %. The AEC (Automatic exposure Control) was tested in order to reach lower dose level. In Lumber spine lateral examination -16 % decrease and in hip joint -27 % dose decrease was achieved very easily image quality was still good enough. The PACS (Picture Archiving and Communication System) offered opportunity to analyse the quality of images afterwards. The use of air grid is not very common in Finland. In hip axio-lateral project the use of air gap (30 cm) instead of a grid decreased skin dose two thirds (Figure 2). (Henner et al 2009.)

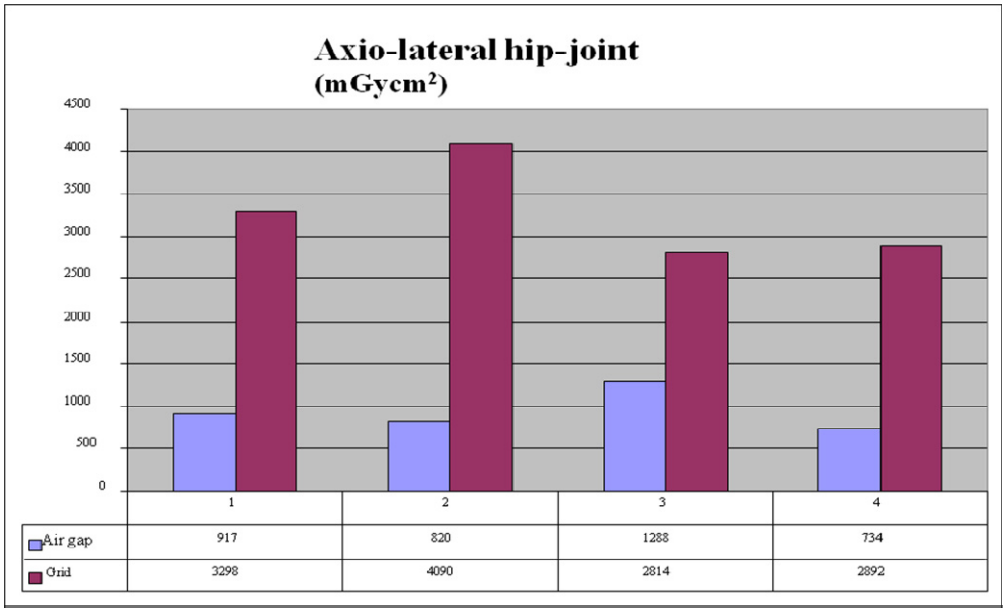

Figure 2. DAP in Axio-lateral hip joint with Grid and Air Gap. (Henner et al 2009)

Because in the lower extremity mechanical axis the required image quality for a diagnosis is not high, the results showed that the patient radiation dose could be lower when additional filtration and higher voltage were used. The results also showed that by using different AEC classes the patient dose could be affected and thus should be used. According to these results it is not necessary to use a grid while imaging a normal size patient, because the quality of the image does not need to be as high as for example when diagnosing a fracture. While imaging the hip predetermined exposure charts should also be considered. (Hilli, Hirvelä 2010.)

Discussion

The concept of safety culture and safety climate is not yet well-known and they are quite difficult to find out in every day clinical practice. Problems in healthcare all over the world are common: less money, more seriously ill patients, expensive equipments and medication, lack in education, more work and less staff. The role of Radiographer is expanding to new areas partly because of higher education and partly because lack in radiologists and physicists. Better equipment means better image quality with higher dose. Does this mean also more harms due to radiation? Who is responsible for the dose optimisation? As seen from the results of Niemi (2006) and Paalimäki-Paakki (2009) stress, hurry, new demands and more complicated situations are parts of radiographers work, every day. They are barriers to work as well as they want. They also purchase the further development of work conditions and dose and image optimization.

Radiation and Nuclear Safety Authority has given reference levels for adult patient in common projection examination, in computed tomography examinations and cardiac angiograms. There are also DRLs for nuclear medicine examinations as well DRLs for children in projection examinations. The doses have to be monitored at least every third year. (Säteilyturvakeskus 2008.) This part of safety culture has been applyid very well since 1996. The Regulatory Guides on radiation safety (ST Guides) are

updated approximately once in five years and the guidelines are applied in all radiological departments. Second round of clinical audits is running (Faulkner et al 2009).

There are special patient groups which are exposed quite often (children with scoliosis or vesico-uretal reflux, premature babies). The new technical solutions offer a lot of possibilities for dose reduction, if we want. (e.g. Al Khalifah., Brindhaban 2004, Arreola, Rill 2004, Bush 2004, Hamer et al 2005 Uffman 2008, Geijer 2009, Lanca et al 2009).

One model for the assessment of safety culture has been made by IAEA 1998 is too large for this kind of work. It should be divided to smaller parts in research. Other vise there are a lot of very congregate and everyday ways to develop the safety culture. The management and legislation offer the basics but the work must be done among those who are working in radiological departments.

Conclusions

Optimization of image quality and patient dose allows the patient dose to be decreased by more than 50 % in many patient groups. Digital imaging gives possibility to degree dose and still has image quality good enough. The attitudes and fear of change are the biggest barriers to reach the good safety culture. The next step is the establishment of safety culture, which takes into account the attitudes, behaviour and other human factors, which have effect on safety.

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The role and responsibilities of the medical physicist as the radiation protection adviser in the healthcare environment

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Abstract

In the European Member States, the use of ionising radiation in the healthcare environment is regulated by the transposition into national legislation of Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposures.

EFOMP noted the definition of the Medical Physics Expert and the involvement of this expert in radiotherapeutic, diagnostic nuclear medicine and other radiological practices in this Directive. EFOMP has for many years sought to harmonise and promote the best practice of medical physics in Europe and has in this respect issued Policy Statement No. 9 in response to the above directive.

The EFOMP strategy is directed towards the recognition of the European Medical Physicist and for this purpose the Federation's approach has been to encourage registration schemes (on a voluntary basis) where no regulated scheme (as imposed by law) exists. EFOMP recognised that the most appropriate way to achieve harmonisation of standards across the whole of Europe was to express the duties and competencies

expected of the Medical Physics Expert (MPE), as set out in the 1997 Directive, in very practical terms.

A framework of five levels of competency that covers the whole career structure of the medical physicist was developed including the duties of the MPE. A system for recognised Continuing Professional Development is recommended by EFOMP and has been described in a Policy Statement.

This paper aims to present EFOMP's efforts to harmonise the education, training and competences of the Medical Physicist in Europe and thus to meet the role and responsibilities of the MPE as specified in the above directive.

Introduction

In the European Member States, the use of ionising radiation in the healthcare environment is regulated by the transposition into national legislation of Directive 97/43/Euratom of 30 June 1997 (EC, 1997) on health protection of individuals against the dangers of ionising radiation in relation to medical exposures. This directive supplements Directive 96/29/Euratom (EC, 1996) laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising form ionising radiation.

In these directives, the definitions of the professionals involved are subject to various interpretations. For example under article 2 of directive 97/43/Euratom, the definition of the Medical Physics Expert is given as:

"Medical Physics Expert: an expert in radiation physics or radiation technology applied to exposure, within the scope of this Directive, whose training and competence to act is recognized by the competent authorities; and who, as appropriate, acts or gives advice on patient dosimetry, on the development and use of complex techniques and equipment, on optimization, on quality assurance, including quality control, and on other matters relating to radiation protection, concerning exposure within the scope of this Directive."

In the above directive extract, the recognition of the MPE is left to the national competent authorities and this has been recognised at different levels of competence in most of the European Union Member States, as evident from the latest EFOMP survey (Eudaldo, 2008). Furthermore Article 6 clause 3 of the same directive states:

"In radiotherapeutic practices, a medical physics expert shall be closely involved. In standardized therapeutical nuclear medicine practices and in diagnostic nuclear medicine practices, a medical physics expert shall be available. For other radiological practices, a medical physics expert shall be involved, as appropriate, for consultation on optimization including patient dosimetry and quality assurance including quality control, and also to give advice on matters relating to radiation protection concerning medical exposure, as required".

The phrases "closely involved", "shall be available" and "shall be involved, as appropriate" take a different interpretation in each and every setting. It is again left to the local competent authorities to interpret these phrases. The EFOMP survey (Eudaldo, 2008) has in fact shown that there is a large variation between the European Union Member States.

In a similar fashion Directive 96/29/Euratom defines Qualified Experts as:

"Qualified Experts: Persons having the knowledge and training needed to carry out physical, technical or radiochemical tests enabling doses to be assessed, and to give advice in order to ensure effective protection of individuals and the correct operation of protective equipment, whose capacity to act as a qualified expert is recognized by the competent authorities. A qualified expert may be assigned the technical responsibility for the tasks of radiation protection of workers and members of the public".

The term "Qualified Expert" is mentioned in a number of places in this directive implying a different professional such as Medical Physicist Expert, Radiation Protection Expert, Radiological Practitioner, etc. Again the competence of the Qualified Expert is recognised by the national competent authorities (which may in fact be different from those deciding the competencies of the MPE). Furthermore the role and responsibilities of the various Qualified Experts are not clearly stated in this Directive but are left to the National Competent Authorities and others to specify.

Therefore within the European Union, we have two directives relevant to radiation exposures in the Healthcare Environment and 27 national sets of legislations and regulations. This is due to the interpretation being understood differently, taking into account the culture, language and other political influences present in each national setting. This is hindering the harmonisation of the education, training, competences, roles, responsibilities and effectively the mobility of the professionals responsible for implementing the various functions covered by these directives.

With respect to the MPE, EFOMP noted its definition and the involvement of this expert in radiotherapeutic, diagnostic nuclear medicine and other radiological practices in this Directive. EFOMP has for many years sought to harmonise and promote the best practice of medical physics in Europe and has issued Policy Statement No. 9 (EFOMP, 1999) in response to the above directive.

In this Policy Statement, EFOMP lists in general terms the involvement of the MPE as follows:

"
- *to carry out the physical measurements related to evaluation of the dose to the patient and to take responsibility for dosimetry;*
- *to improve any conditions that will lead to a reduction in unnecessary patient dose;*
- *to lay down tests in the field of quality assurance of the equipment;*
- *to assure the surveillance of the installations with regards to radiological protection;*
- *to choose equipment required to perform radiation protection measurements and to give advice on medical equipment;*
- *to take part in the training of medical practitioners and other staff in relevant aspects of radiation protection;*
- *to provide skills and responsibilities that complement those of medical practitioners."*

This Policy statement gives further guidance with respect to the education, training and continuous professional development of the MPE. These will be discussed in this paper.

Recently the Commission has undertaken a simplification of Community legislation in the area of radiation protection and has proposed the consolidation into a single text of the following Directives:

- Council Directive 96/29/ Euratom of 13 May 1996, laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation,
- Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure,
- Council Directive 89/618/Euratom of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency,
- Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas,
- Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources.

The latter four Directives cover different specific aspects complementary to the overall Basic Safety Standards (the first Directive).

The task of consolidation was given to the Euratom Treaty Article 31 Group of Experts. Their task was finalised in February 2010 and their "Draft Euratom Basic Safety Standards Directive" (This document is not yet publicly available) has been submitted to the European Commission for its approval and further submission to the European Council and Parliament for the necessary political scrutiny.

Definitions have evolved over time and have been adjusted to specific scopes. While many requirements may fit in the original context they could not be extended to act as a general application of the Standards, so the consolidation proceeded through a recast rather than a simple codification of the original texts.

From the latest publicly available summary reports of the Group of Experts (GoE) referred to in Article 31 of the Euratom Treaty meeting (EC, 2009a, 2009b), the new European Basic Safety Standards (BSS) Directive appears that will be defining the roles and responsibilities of services and experts who should be involved in ensuring that technical and practical aspects of radiation protection are managed with a high level of competence. It further appears that will be defining the role, responsibilities and competences of the Radiation Protection Expert (RPE) and the MPE and appears to be introducing the function of the Radiation Protection Officer (RPO).

It also appears to be strengthening the requirement for information, training and education addressing these in a specific title in order to highlight the importance of education and training in radiation protection. In the medical area, education and training should also raise the awareness of the medical profession, in particular with a view to risk communication with patients.

Changes may, however, be made before the Directive is approved and finally published in the Official Journal of the European Union.

Discussion

From what is known at the moment about the recast version of the European Basic Safety Standards Directive, it would seem that an overall improvement to the existing directives is being made. It is acknowledged that the role, responsibilities and competence of the RPE and RPO in facilities outside the healthcare environment are

essential for the radiation protection of the workers and the public at large. There could, however, be considerable ambiguity with the roles, responsibilities and competence of the MPE within the healthcare environment. It is therefore necessary that clear guidance is produced to clarify the different roles and responsibilities of the RPE, RPO and the MPE, as well as the need for collaboration between them.

An attempt is made here to assist in the interpretation of these functions (MPE, RPE and RPO) from the EFOMP point of view.

Firstly ionising radiation is used in a large range of different healthcare facilities, from the dentist's office with a simple dental radiographic unit to the large university hospitals with highly sophisticated devices such as Multi-Detector Computed Tomography (MDCT) systems and Positron Emission Tomography (PET) and in their radiotherapy departments systems such as Linear Accelerators (LINACS) using highly complicated treatment procedures such as Image Modulated Radiation Treatments (IMRT) and Image Guided Radiation Treatments (IGRT), not to mention Tomotherapy and Cyberknife systems.

Secondly it is very important to accept that the definitions, roles, responsibilities and competence of the RPE, MPE and RPO are functions that are required to be fulfilled and are not necessarily separate professions or even individuals.

The unique feature of healthcare is that it is the only application of ionising radiation where there is a need for optimisation. Radiation Protection can never be seen in isolation for image quality (in diagnostic radiology) and tumour control (in radiotherapy). This is one of the reasons that radiation protection is part and parcel of the education process of medical physicist.

The continuous application of the radiation protection principles and the routine implementation of any daily quality assurance programme to assure the correct performance of the equipment would be the role of the RPO. The number of RPOs will depend on the number of modalities and sophistication of the healthcare facility. The function of the RPO may be undertaken by any individual with the appropriate training and competence (for example an appropriately trained technologist). The RPO must be a permanent staff of each facility. It is not acceptable to outsource the function of the RPO.

The function of the MPE is an inherent role of the Qualified Medical Physicist (QMP) and in more sophisticated facilities this function may need to be the role of a Specialist Medical Physicist (SMP) (Eudaldo and Olsen, 2010). It can be outsourced for small healthcare facilities, or it can be assigned to in house medical physics services, again taking into consideration the sophistication of the modalities and the workload of the healthcare facility.

Within the healthcare environment the function of the RPE can be undertaken by a QMP or in more sophisticated facilities by a SMP, since the role and responsibilities of the RPE within the healthcare environment are part of the education, training and competence of the QMP and SMP (Dendy, 1997), (EFOMP, 1997 and 1999). The function of the RPE can be outsourced for small healthcare facilities, or it can be assigned to in house medical physics services, again taking into consideration the sophistication of the modalities and the workload of the healthcare facility.

The EFOMP strategy is directed towards the recognition of the European Medical Physicist and for this purpose the Federation's approach has been to encourage

registration schemes (on a voluntary basis) where no regulated scheme (as imposed by law) exists (EFOMP, 1995, 1998 and 2001). EFOMP recognised that the most appropriate way to achieve harmonisation of standards across the whole of Europe was to express the duties and competencies expected of the MPE, as set out in the 1997 Directive, in very practical terms.

As far back as 1997, a framework of five levels of competency, covering the whole career structure of the medical physicist was developed including the functions of the MPE (Dendy 1997):

"Level 1 - relevant first degree or equivalent
Level 2 – completion of specialist expertise
Level 3 – completion of practical experience
Level 4 – advance practical experience
Level 5 – mature overview and greater responsibility."

Over the years these were further refined with the latest version given in Policy Statement 12 (Eudaldo and Olsen, 2010). This framework now also includes an extensive requirement of Continuous Professional Development. Also other initiatives have taken place, which are briefly discussed here.

European School of Medical Physics

This is an annual event in collaboration with the European Scientific Institute - ESI and takes place in Archamps, France. The first school was held in 1998. Originally it consisted of five weeks of intensive training in Medical Physics (EFOMP, 1998b). One week is spent on covering each of Medical Imaging with Non-ionising Radiation, Medical Imaging with Ionising Radiation, Medical Computing, Physics of Modern Radiotherapy, Brachytherapy. As from 2008 a sixth week was added on Radiation Protection.

EFOMP Sponsoring Programmes

The sponsorship of meetings and congresses is instrumental in disseminating and encouraging the adoption of the policy statements. EFOMP organises, co-organises, supports and recognises meetings, congresses and courses together with its National Member Organisations (NMOs). Guidelines that explain the above terms and the requirements for interested NMOs to collaborate in such events can be found on EFOMP's website.

The purpose of these Guidelines is to help NMOs to obtain EFOMP sponsorship for their events by setting out the steps that they need to take and the conditions that must be fulfilled.

The biggest event is the biennial European Congress on Medical Physics. Note that there are detailed guidelines on the requirements for this event.

Furthermore, EFOMP collaborates with other European and International Organisations (ESR, EANM, ESTRO, ESMRMB, IOMP, IFMBE, IRPA) by having joint sessions at their conferences, with the objective of promoting its activities, mainly on Education, Training and Professional matters of the Medical Physics Profession (Caruana et al, 2009), (Christofides et al, 2008, 2009a, 2009b, 2009c).

Lifelong Learning

On the 23rd of April 2008, the European Parliament and the Council issued recommendations on the establishment of the European Qualifications Framework (EQF) for lifelong learning (EC, 2008). With these recommendations the European Union is encouraging its Member States to compare and align their education and training qualifications with the eight (8) levels of learning outcomes described in these recommendations.

The purpose of EFOMP's work in education and training is to position the various stages of the Education, Training and CPD of the Medical Physicist in Europe, as stated in the various EFOMP Policy Statements, within the eight levels of the EQF) for lifelong learning and identify any gaps that need to be addressed.

Figure 1 shows the preliminary results of the various stages of the education and training of the Medical Physicist in Europe according to EFOMP Policy Statement No.12 using the eight levels of the EQF for lifelong learning.

The level of graduation (Master's level) of the Medical Physicist corresponds to level 5 of the EQF for lifelong learning and the level of the QMP correspond to level 6. The level of the SMP corresponds to level 7.

Level 8 of the EQF for lifelong learning goes beyond the EFOMP Policy Statement No.12 and it corresponds to the Medical Physicist holding a Doctoral Degree (PhD) or higher, working in a research environment (University or Research institution).

EFOMP needs to develop a Policy Statement to bridge the gap between level 7 and level 8 of the EQF.

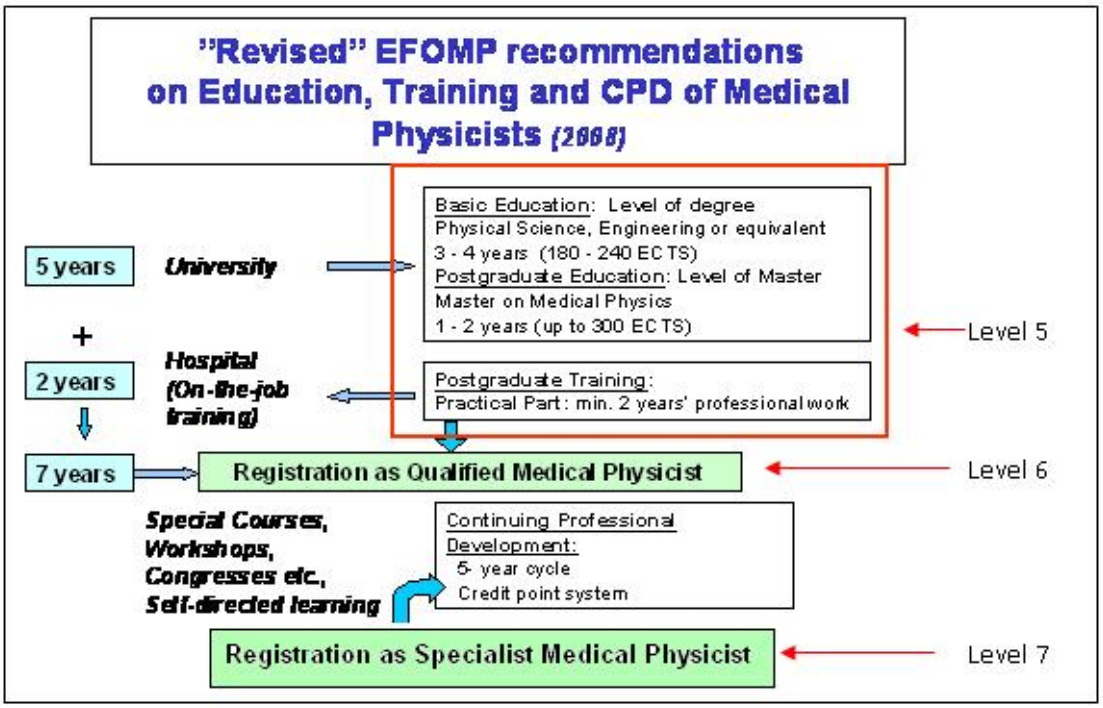

Fig. 1. The various stages of Education and Training of the Medical Physicist in Europe according to EFOMP Policy Statement No.12 using the 8 levels of the EQF for lifelong learning.

Medical Physics as a Profession

In due consideration of the following facts, EFOMP believes that Medical Physics should be recognised by the European Union as a regulated Health Profession in accordance with the EU Directive on the recognition of professional qualifications (EC, 2005):

a) Medical Physicists have a formal education and training in Anatomy, Physiology and Radiation Protection as applied to medical activities.
b) Medical Physicists have the necessary skills to manage the quality of the performance of the equipment used in hospitals.
c) Medical Physicists have a relatively long practical training in Hospitals.
d) Clinical professionals regard medical physicists as invaluable specialists who facilitate the safe use of radiation in hospitals.
e) Quality Assurance and Quality Control in Radiotherapy, Nuclear Medicine and X-Ray diagnosis is, normally, done by medical physicists. The results of these activities have clear implications on patient diagnosis, treatment and safety.
f) Medical Physicists have the experience to perform basic and applied physics research in medicine.
g) In a number of European Countries Medical Physics is a profession regulated by law.

There is more than enough evidence to prove all the above statements apart from two very important issues:

a) The education and training of the medical physicist is not harmonised across Europe according to the EFOMP Policy Statement No. 12.
b) The Medical Physics Profession is not regulated in all European Member States.

These two issues can only be resolved by the individual Member States by applying the EFOMP recommendations.

EFOMP participation in European Projects

The importance of medical physics in the area of radiation protection in medicine and the lack of uniformity in training and education has led the European Commission to commission research projects with aim the ultimate definition of the MPE with the required education, training and competencies. To this end, the Commission has tendered two research contracts in both of which EFOMP is a partner. These are:

- the European Medical ALARA Network –EMAN (Contract No: TREN/09/NUCL/SI2.542127), and
- the European Guidelines for the Medical Physics Expert (Contract No: TREN/09/NUCL/SI2.549828).

The contribution of EFOMP to these projects was considered essential by the European Commission and it was a condition that EFOMP should be represented in all of their work packages.

Conclusions

By accepting the fact that the role, responsibilities and competences of the MPE, RPE and RPO are functions to be undertaken by recognised professionals and that this recognition will be according to the complexity of the modalities of any given healthcare facility, then the new European Basic Safety Standards Directive can be implemented by the European Member States in a more harmonised way so facilitating the mobility of these professionals within the European Union. Additional guidance will be required to assist in the implementation and interpretation of the provisions of this directive.

Some of the activities of EFOMP in the area of Education, Training and Professional Development of the European Medical Physicist, with emphasis on Radiation Protection have been discussed.

These activities can only materialise through the collaboration of all the Medical Physicists of EFOMP's National Member Organisations (NMOs). The NMOs must actively adopt and implement the guidelines of the policy statements as well as participate in the various events organised by EFOMP in collaboration with its NMOs.

The contributions of all interested parties are more than welcome in order to further develop the harmonisation of the education, training and professional status of the Medical Physicist in Europe.

Acknowledgments

EFOMP acknowledges all those that have contributed to the development of its policy statements as well as all those involved in the organisation of educational and training events under its auspices.

EFOMP also would like to express its sincere thanks to all those that through the years have contributed actively in promoting the Profession of Medical Physics.

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Computer based radiation protection course for workers in the health care sector

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Abstract

Radiation protection aspects in the health care sector are a primary concern due to the very different kind of occupational activities and to the large number of people involved with ionising radiation (I.R.), for instance in a large hospital.

The Government of the Tuscany Region (Italy) has promoted the realisation of a computer based radiation protection training course for all I.R. workers of the National Health Service within the Tuscany region.

The challenging goal of this project is to provide the basic safety information in such a complex field, where people with very different education levels and duties do work together, with the aim of fulfilling the specific educational requirements of Directive 96/29/EURATOM as introduced in the Italian legislation.

The course is devoted to provide radiation protection education to all health workers, with special attention to those without high level of education in the I.R. field (i.e. physicians outside the radiology area, surgery room staff, nurses in nuclear medicine or radiotherapy and laboratory staff).

The course is composed of five sections dealing with the general aspects of radiation protection (basic I.R. physics, biological effects, regulatory system, dosimetry and radiation protection principles) while four other sections deal with sector specific radiation protection aspects: radiology, nuclear medicine, radiotherapy and laboratory. A further special chapter, summarising all aspects treated in the course, is devoted to workers with poor educational level or no-background in the field of physics, radiation protection and current legislation. Each section includes a multiple choice test with hint function, numerical examples, a glossary and bibliographical references.

First feedback outcomes and multiple choice tests results from hospital workers are also reported.

Introduction

According to EC regulation, all persons whose work may be associated with ionising radiation risk must be adequately educated to ensure that they are informed about the potential health risks which could result from radiation exposure, the basic principles of

radiation protection and the relevant radiation protection regulations as well as safe working methods and techniques in radiation zones.

Radiation protection (RP) aspects in the health care sector are a primary concern due to the very different radiation sources, kind of occupational activities and large number of people involved with ionising radiation (I.R.), for instance in a large hospital.

The Government of the Tuscany Region in Italy has promoted the realisation of a computer based training RP course for all I.R. exposed workers of the National Health Service (N.H.S.) within the Tuscany region. The project was developed by the Health Physics Department of the Florence University Hospital (Azienda Ospedaliero-Universitaria Careggi) as leading institute, in collaboration with the other Health Physics Departments of the Tuscany N.H.S. The course is also open to contractors' personnel as complementary information in addition to the RP training they must receive from their own employers.

The main challenge of the project is to provide the basic safety information in such a complex field as the health care sector, where people with very different education levels and duties do work together (e.g. in a radiological interventional room).

In Fig. 1, the distribution of Tuscany region health care workers exposed to I.R. is shown. In the "Others" group are included, biological lab staff, logistics and cleaning staff and medical physicists A total amount of roughly 6000 I.R. exposed people work in the NHS of the Tuscany region, servicing a population of about 3.7 million inhabitants. In Fig. 2, the Tuscan NHS exposed workers distribution between health care activity sectors is reported.

The goal of the project is to fulfil the specific educational requirements of Directive 96/29/EURATOM as introduced in the Italian law.

In this paper we present a description of the course as well as an evaluation of the course effectiveness as resulting from the outcomes of the multiple choice tests.

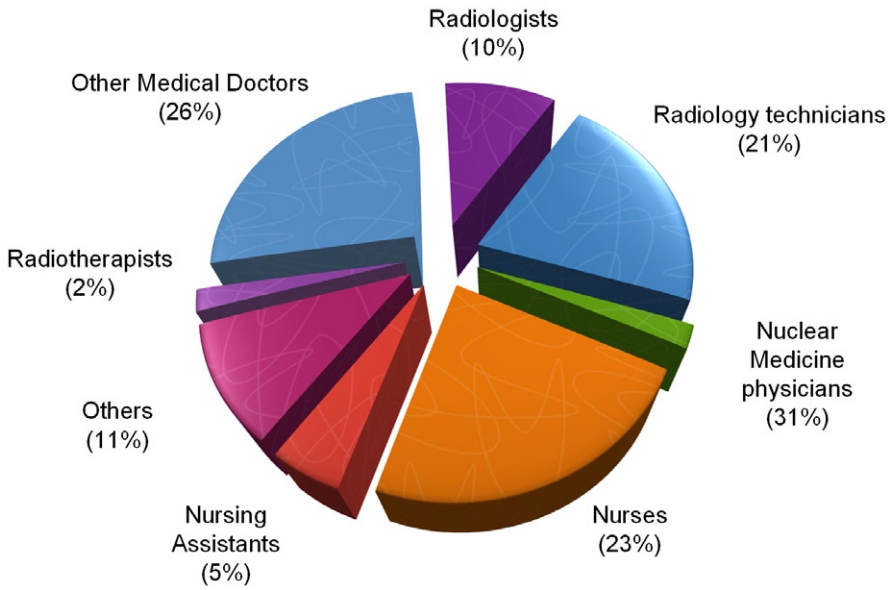

Fig. 1. Distribution of exposed workers, according to their professional role, in Tuscany region health care sector.

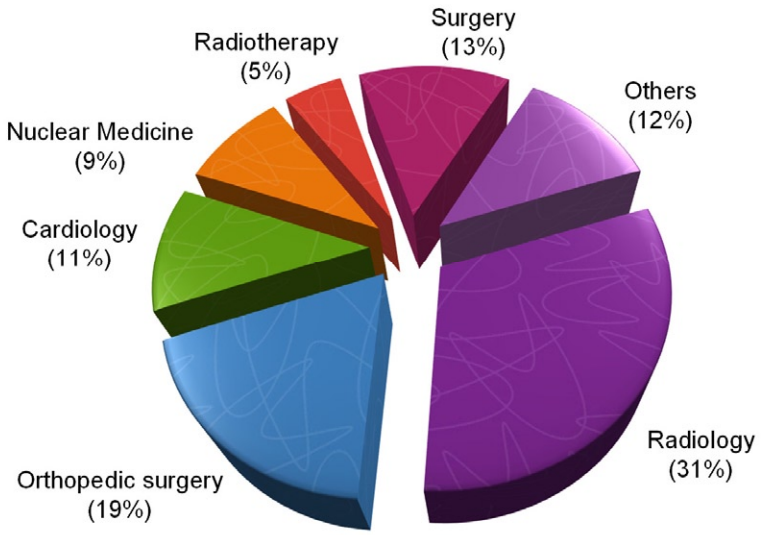

Fig. 2. Distribution of exposed workers according to medical specialties in the Tuscany region.

Material and methods

The course is addressed to all people working in the health care sector, with special attention to workers without high level education in the I.R. field (medical doctors outside the radiology area, surgery room staff, nurses in nuclear medicine or radiotherapy departments, laboratory staff, etc.)

Course description

The main course is composed of a few sections dealing with general aspects, covering the main topics of radiation physics, biological effects of I.R., national regulatory system, dosimetry and RP principles. The other sections deal with the specific aspects of RP in radiology, nuclear medicine, radiotherapy and laboratory. A special section, summarising all the fundamental notions of the course, is devoted to workers with poor educational level or no-background in the field of physics, radiation protection and related legislation, that is: hospital auxiliary staff, workers belonging to external service providers (i.e. cleaning services) and non-health (i.e. logistics) workers. In this section, each sub-section contains detailed information on how to act (things to do/ not to do) and a list of Frequently Asked Questions (FAQs) with related answers.

The main aspects of safety procedures, definitions and health hazards are stressed through a series of numerical examples, pictures and warning text boxes spread out in each chapter. Moreover, besides those data coming from international/national literature and reference publications (e.g. ICRP, IAEA Publications), lots of the data reported in tables and/or used in examples come from direct measurements carried out in several hospitals within Tuscany region in the typical operating conditions.

A summary of the course content, divided in chapters and sections, is reported in Table 1.

Table 1. Radiation protection course content.

Section	Sub-sections
1. Ionizing radiation (I.R.) principles	1.1. Atomic structure 1.2. Ionizing radiation 1.3. Sources of I.R. 1.4. Radioisotopes 1.5. Artificial radiation sources 1.6. Basic physical quantities and units
2. Biological effects of I.R. and epidemiological information	2.1. Radiation Interaction with cells and tissues (deterministic and stochastic effects) 2.2.Epidemiological information and radiation protection
3. Radiation dose and its measurement	3.1. Radiation dosimetry 3.2. Basic dosimetric quantities 3.3. Dose measurement 3.4. Personal dosimetry service
4. Introduction to radiation protection	4.1. The radiation protection principles 4.2. Types of radiation exposure, radiation hazard warning signs 4.3. Dose reduction principles 4.4. Protection devices
5. Radiation protection regulations	5.1. Introduction 5.2. The basis of radiation protection regulation 5.3. Italian national regulation 5.4. Classification of workplaces 5.5. Classification of workers 5.6. Limitation of doses 5.7. Employer's duties 5.8. Workers' duties 5.9. Special protection during pregnancy and breastfeeding
6. Radiation protection in diagnostic and interventional radiology	6.1. Radiation sources and risk sources 6.2. Hazard Assessment 6.3. Radiation safety measures 6.4. Local rules and operational procedures
7. Radiation protection in Nuclear Medicine	7.1. Radionuclides for diagnostic uses 7.2. Radionuclides for therapeutic uses 7.3. Hazard Assessment (External exposure, Contamination and internal exposure) 7.4. Radiation safety measures 7.5. Local rules and operational procedures 7.6. Decontamination procedures 7.7. Handling of radioactive wastes
8. Radiation protection in Radiotherapy	8.1. Radiation Sources (External beam radiotherapy, Brachitherapy) 8.2. Hazard Assessment (External Beam Radiotherapy, Brachitherapy) 8.3. Radiation safety measures 8.4. Local rules and operational procedures 8.5. Biological irradiators
9. Radiation Protection in clinical analysis and biomedical research laboratories	9.1. Radiation Sources 9.2. Hazard Assessment (External exposure, Contamination and internal exposure) 9.3. Radiation safety measures 9.4. Local rules and operational procedures 9.5. Decontamination procedures 9.6. Handling of radioactive waste
10. Radiation protection for non experts	10.1. Ionizing radiation 10.2. Sources of ionizing radiation 10.3. Biological effects of ionizing radiation 10.4. Dose measurement 10.5. Introduction to radiation protection (Classification of workers, Classification of workplaces, Radiation hazard warning signs, Dose reduction principles, How to prevent contamination) 10.6. Radiation protection regulations (Incl. Workers' duties) 10.7. Radiation protection in diagnostic and interventional radiology 10.8. Radiation protection in nuclear medicine 10.9. Radiation protection in Radiotherapy 10.10. Radiation protection in laboratories

Each section includes a multiple choice test, a glossary, a reference list and a "Focus on" sub-section for further information on specific topics.

The entire radiation protection course counts about 150 web pages, and about 6 hours of study are estimated being necessary in order to proficiently acquire the basic knowledge and to become able to correctly answer the test questions. A learning time of 3 hours is estimated for not experts workers, as they are supposed to read the section "Radiation protection for non experts" only.

A web based user interface was chosen to take advantage of the flexibility, in terms of information search and retrieving, hyper text features, document storage capability and eventual future upgrading. Other advantages are inexpensive distribution, reduced technical support and cross platform delivery.

The course provides additional learning tools, such as:

- interactive glossary: in order to make learning easier. When passing the pointer over a term defined in the glossary, a "mouse over" function interactively opens a box with that term definition
- hint function for the multiple choice tests: in case of wrong answer a pop up window linked to the web page containing the right information is opened
- PDF documentation of main national (i.e. Italian) regulations concerning exposure to ionising radiation
- links to external web sites of prominent international radiation protection committees and agencies
- bibliographic notes and links
- links to complementary material and curiosities related to radiation exposure.

In a first stage the course is distributed cost free as an interactive CD-ROM to all radiation workers in Tuscany.

In Fig.3 and Fig.4 the screenshots of two pages are shown as example.

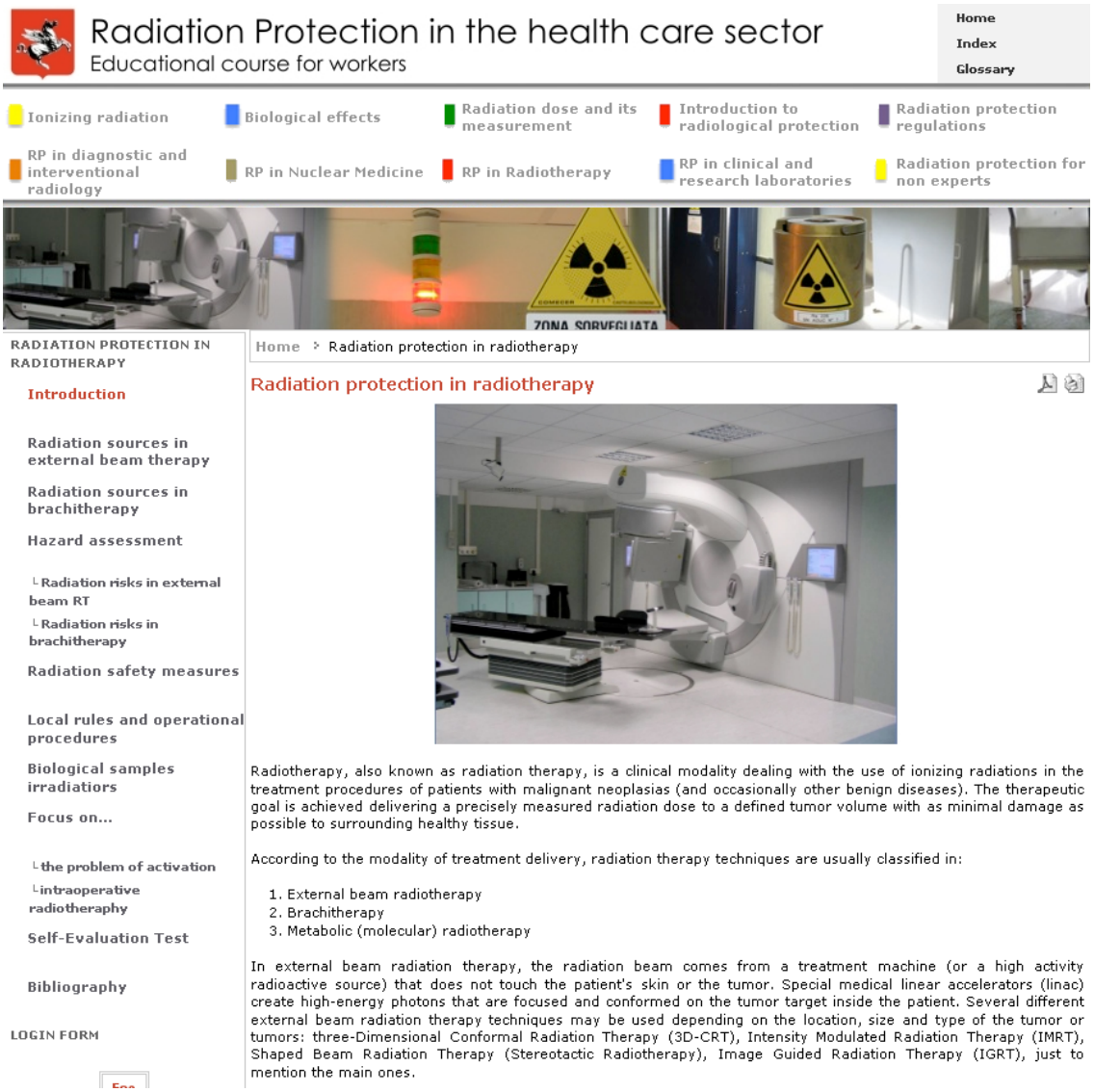

Fig. 3. Screenshot of a course page, showing the web user interface.

Course evalutation

A release candidate version of the course has been made available in February 2010 either on CD-ROM and online to a testing group of 49 workers for evaluation. The workers engaged in the testing group have been selected according to their competence profile. The testing group composition is the following:

- 12 radiological technicians
- 14 professional nurses in a radiological area
- 5 physician specialized in a radiological area
- 12 physician not specialized in a radiological area
- 6 non experts (2 cleaning staff and 4 auxiliary staff)

Each tester was asked to read only the group of chapters appropriate for its job. A test with multiple choice questions concerning RP topics was given before and after the reading of the content. The course has been submitted to the testers along with an assessment and satisfaction questionnaire concerning the relevance of the subject

treated, the quality and usefulness of the information presented, the clearness of the explanations and in general the usability of the course and of the learning tools available (more details in the *Results* section).

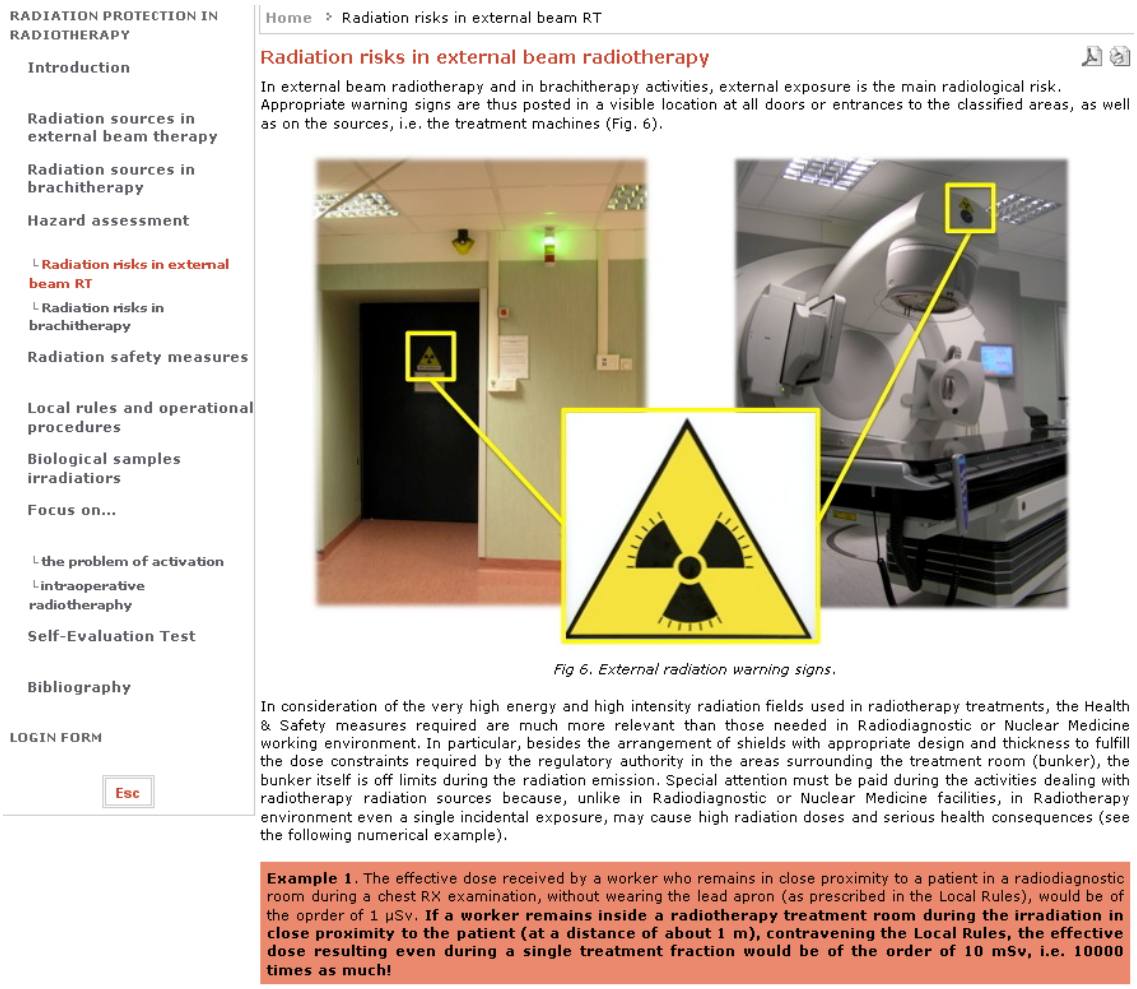

Fig. 4. Screenshot of a course page containing a numerical example.

The effectiveness of the course has been evaluated by comparing the results from the tests performed before and after the course delivering.

Results

The overall results of the satisfaction questionnaire is reported in Fig.5, together with the investigated aspects. Users were asked to express a four steps judgement (from "Insufficient" to "Very Good") to rate the course educational features.

The multiple choice test results, expressed as wrong answer percentage, are shown in Fig. 6 for the tests performed before and after the course delivering. The educational effectiveness is reported for the different professionals groups and as average.

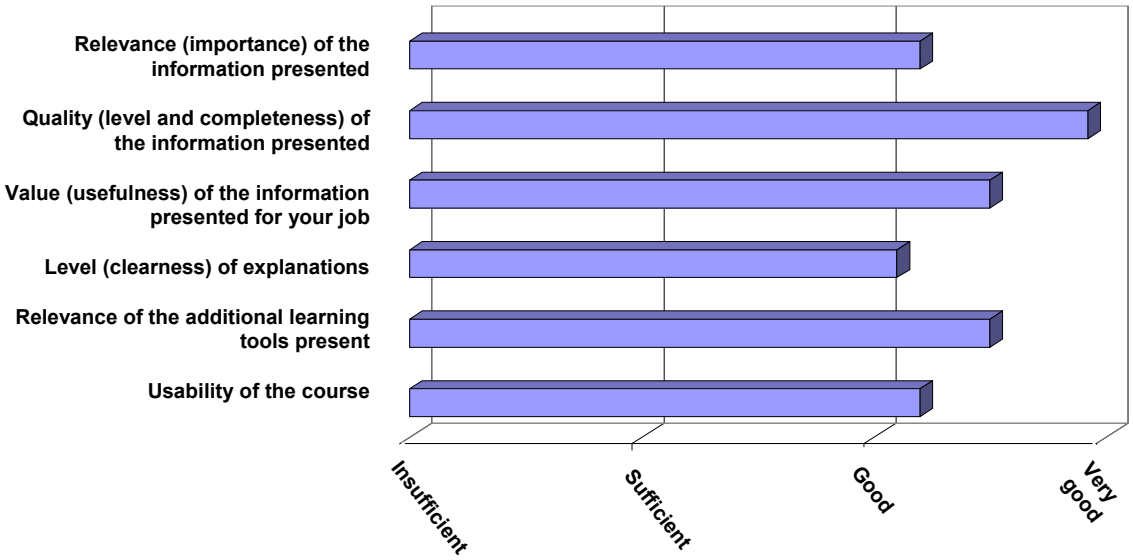

Fig. 5. Synthetic outcome of the assessment questionnaire returned by the workers of the testing group.

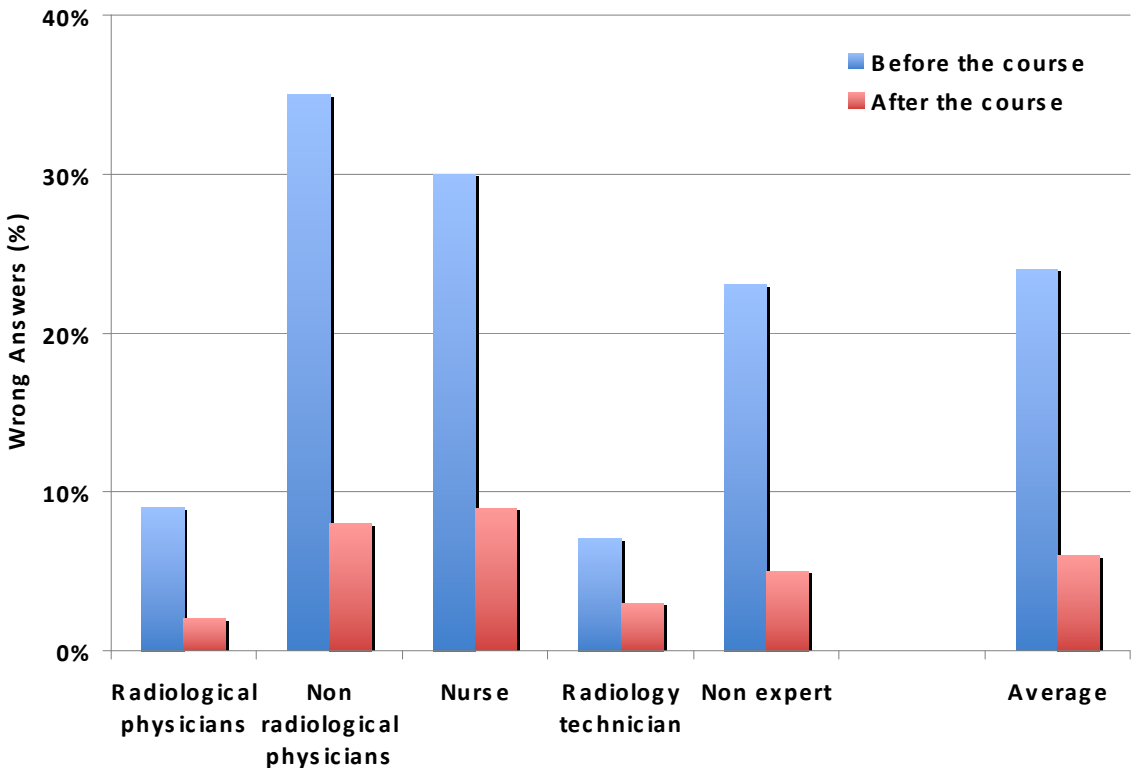

Fig. 6 Multiple choice tests results (expressed as wrong answers percentage) for the different professional groups.

Conclusions

A computer based radiation protection course for all radiation exposed workers of the National Health Service within the Tuscany region, Italy, has been developed. The main challenge of the project is to provide the basic safety information in such a complex field as health care sector, where people with very different education levels and duties work together. The course is addressed to all people working in the health care sector, with special attention to workers without high level education in the I.R. field (medical doctors outside the radiology area, surgery room staff, nurses in nuclear medicine or radiotherapy departments, laboratory technologists, etc.) The main course is composed of a few sections dealing with the general aspects, including basic radiation physics, biological effects of I.R., national regulatory system, dosimetry. Other sections deal with the specific aspects of RP in radiology, nuclear medicine, radiotherapy and laboratory. A special section, summarising all aspects treated in the course, is devoted to workers with poor educational level or no-background in the field of physics, radiation protection and current legislation concerning the exposure to ionising radiation.

First feedback outcomes and multiple choice test results from hospital workers are also reported. The response of first users resulted quite positive according to the questionnaire and the educational content proved to be well suited for the intended target user.

In a close future the course is going to be implemented as a Web Based Course to make it accessible to a larger number of workers, possibly outside the Tuscany region, on an e-learning platform. In the latter case the course could become part of the institutional CPD programme in any hospital.

e-Learning in DAP-measuring

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Abstract

According to studies lower limits for radiation dose setting can be established for computed radiography (CR) systems to produce diagnostic quality images than the standard values used for film/screen systems. This is especially important in examinations performed for the children. Flat panel Detectors (so called direct radiography, DR) gives even more possibilities for dose reduction and still having at least as good image quality as with CR. One of the most important quality assurance procedures is to evaluate the doses delivered to patients who undergo x-ray examination. The DAP-meter is a real-time patient dose monitoring system for auditing patient doses. Technical data from each exposure and for every examination type can be collected. Radiography students and lecturers of Metropolia University of Applied Sciences produced an e-based learning module about DAP-measuring in co-operation with Metropolia degree programme in multimedia technology and Finnish Radiation Protection Authority. In this presentation the contents and pedagogical solutions of this module are presented. Also the development process of this learning module is depicted. The educational module consist of articles to be read, different kinds of tasks to be solved e.g crossword about central concepts of dose-area product-meter (DAP). The group also made a film that shows how to measure patient doses with DAP when using digital radiography (DR) technology.

e-Learning philosophy and structure for a Nordic education project in evidence based radiography

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Abstract

Helsinki Metropolia University of Applied Sciences has initiated a Nordic project to increase competence of radiographers by evidence-based training in quality in radiographic imaging. The members of this project are radiography lecturers, principal lecturers and physicists from universities in Finland, Norway and Sweden. The goals of the project are to produce curricula and learning materials using internet solutions for ground-, master and PhD-level web-based education and finally to implement the education and evaluate the training program and the materials produced. The main contents will be evidence-based digital imaging, dose optimization and quality assurance of digital imaging systems. The main principle for the education project is that the way of training as well as the contents will be evidence-based. In according to this the members of the project group apply evidence-based way of working in planning the education and in the contents. To give the students understanding, knowledge and tools for working evidence-based, the training program will start with an introduction to evidence based knowledge and its use in radiography, which is elementary in the whole education. The training program applies various web-based methods depending on the subject and the expected learning outcomes. In some cases the method used will be group activities like lectures by videoconference, face to face meetings on the web and discussions in groups synchronously or asynchronously via Wiki-based IT-solutions. Some subjects will be suitable for individual studies by self-paced e-learning online e.g. when searching articles or offline e.g. in learning dose area product measuring or other procedures. Students from the participating universities are even involved in the project from the very beginning e.g. by writing thesis for the needs of the project.

Developing a radiation protection culture at school

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Abstract

Since September 2007, actions to develop a radiation protection culture have been undertaken in several schools in cooperation with experts from the Institute of Radiation Protection and Nuclear Safety (IRSN), the Nuclear Protection Evaluation Centre (CEPN) and the centre for scientific culture (Pavillon des Sciences – Franche Comte). The aims are to provide school-students with scientific and social bases on radiation protection in order to be better prepared for dealing with societal issues, to promote a scientific and technical culture, and to allow the students to better understand the "world" of radiation protection.

Each year, this approach includes two steps:

One part is dedicated to training during the school-year; each school works on different topics chosen according to local concerns (e.g. radon in dwelling, medical radiation protection, radioactivity in the environment, radiobiology…). In order to facilitate the development of this culture, practical aspects are favoured, notably with experiences and visits to laboratories, hospitals, … Special attention is given to multi-disciplinary approach including physics, chemistry, biology, philosophy, geography, economy… This task is lead by school teachers in cooperation with experts.

The other part consists in participating to a "student workshop" allowing them to present their work and to exchange with other students and experts. In 2008, the first workshop was held in Montbeliard (France), the second one, involving French as well as German, Ukrainian and Belarussian schools, was held in Poitiers (France) in 2009 and the third one was held in Paris in March 2010, involving more than 200 participants from French and foreign schools (Belgium, Belarus, Germany, Italy and Ukraine).

This paper details the actions developed during the last years and discusses the lessons drawn on the way to address radiation protection with young people combining scientific issues and social concerns.

Introduction

There is an increasing trend to involve stakeholders in radiation protection management. Some issues will be of particular importance in next years: radioactive waste management remains a sensitive issue, new development of nuclear energy is anticipated, medical exposure increases drastically, management of radon exposure needs to be improved… However, members of civil society need basic knowledge in radiation protection together with practical experimentation to be able to improve their level of protection regarding radiation exposures, to express their concerns and expectations on these issues and to play a role in the related decision making processes.

Therefore, Institute of Radiation Protection and Nuclear Safety (IRSN), Nuclear Protection Evaluation Centre (CEPN) and the "Pavillon des Sciences de Franche-Comte" (a centre for scientific and technical culture) decided in 2007 to initiate a pilot programme with some high schools (lycee) in France.

Material and methods

The programme is based on cooperation between school professors and radiation protection experts either from IRSN, CEPN, universities or environmental NGO.

In order to develop multidisciplinary approach, professors teaching biology, physics, philosophy, arts … are involved. School students, from 15 to about 19 years old, participate, on voluntary basis, in small group(s) up to 20 students in each high school.

Each school year, the programme includes two parts: the first one concerns practical experiments performed by school students with their teachers and the second one consists in the organisation of a workshop, involving all the schools, held in Spring.

The following topics are proposed: biological effects of radiation, cancer epidemiology in exposed population, radiation detection, radon exposure, radioactivity in the environment, medical use of radiation, ethics…

Each high school chooses topics, according to regional or personal interest.

For each topic, a radiation protection expert is identified on voluntary basis to accompany professor and students.

Experiments are designed for the students to cope with radiation protection bases through practice and to identify the issues at stake for the management of radiation protection in specific situations (mining residues areas, environmental surveillance around nuclear installations, radon management in dwelling, radiation protection at hospital,…). Protocols for experiment are defined in order to avoid risks for participants.

Figure 1 summarizes the approach adopted for developing a radiation protection culture at school.

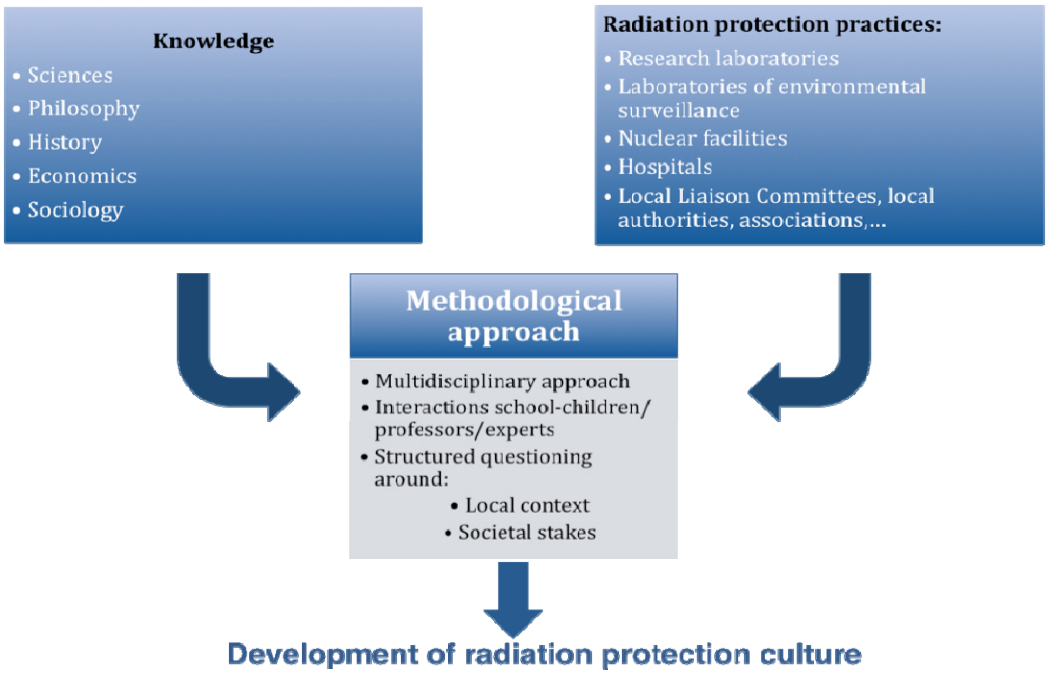

Fig. 1. Approach adopted with schools.

Besides, instruments needed must be either simple ones used in high school (colorimeter, computer, microscopes…) or tools which could be lent by experts (portable dosimeters…).

In most cases, first step is a meeting between professor(s) and expert to define experimental protocol. As second step, expert makes a short presentation of the topic to the students. Then, the experiment is performed by students with their professor, the expert remaining as support if necessary. Often, this step is followed by a technical visit of a unit specialized in the corresponding field; it allows students to discuss their results and work performed in the unit. Visits and discussions are also organised with practitioners form nuclear installations, surveillance laboratories, elected people, local liaison committee members around nuclear installations, …

The Workshop is an opportunity for students to present their work and exchange with the other students, but also with experts. It includes thematic sessions with oral presentations by students, as well as some lectures by experts on special topics. The Workshop programme also includes technical visits and entertainments.

Results

The programme has now been operated for three years. Except for special circumstances (retirement of school professor…), high schools remained involved through the years.

The programme was initiated with French high schools. From second year, schools form Belarus, Ukraine and Germany were involved, and during the third year schools from Italy and Belgium joined the programme, although the language used was French to facilitate exchanges.

For the year 2009-2010, 14 schools and about 230 persons participated to this action. Figure 2 presents the evolution of the participation to this action.

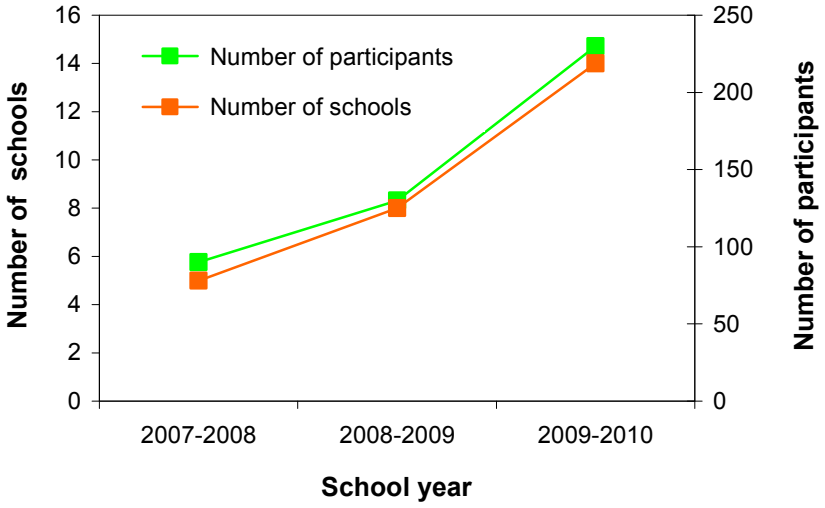

Fig. 2. Evolution with time of the numbers of schools and participants.

Each year, over 20 experts, who are technicians, engineers or researchers, participated to this action, with a large participation from IRSN.

From practical experiments, students learned about physical, biological, regulatory… bases in radiation protection. For instance, biological dosimetry experiment was organised to study effects of radiation. Students had to identify and count chromosome aberrations (dicentrics) on metaphase spreads from blood samples irradiated at various doses; after defining calibration curve, they had to evaluate dose on an unknown sample. From chromosomal aberrations, students learned about radiation induced DNA damages, cell death… Search of hidden sources with different dosemeters or analysis of tissue proportional counter spectra gave them an opportunity to study, for different radiations, interactions of radiation with matter, radiation detection, energy deposition at micrometer level... Students exposed radon dosimeters in various conditions: basement, living rooms, caves…; analysis of results gave them the opportunity to learn about radon exposure. To understand radionuclide release in the environment, students took samples in environment surrounding a nuclear facility, these samples were then analysed in laboratories.

In addition, the multidisciplinary approach together with the interaction with different experts and stakeholders give the opportunity to engage a reflection on the societal issues associated with different radiation protection practices. Inquiries have been performed by students around nuclear installations for example on the type of information available for the population. A measurement campaign has been organised with an environmental NGO in addition to the visit performed in a nuclear installation. Students living in territories contaminated by the Chernobyl accident in Belarus and Ukraine worked on the memory of the accident and the current consequences in the day-to-day life.

Fig. 3. Schools students searching for hidden sources.

The Workshop is an opportunity for the students to present their work, share the knowledge they had acquired, express their view on the societal issues at stake, exchange about their experience and discuss with experts.

In addition, few experts gave lectures on topics such as recent discoveries in radiobiology, SOCATRI accident in France, sources of exposure to ionizing radiations of French population, management of post-accident situations…

Fig. 4. Student lecture and presentation during workshop.

Discussion

Each year very different topics were selected, but interestingly radon, which is not generally considered as a sensitive issue by population, was over selected every year.

Since each group cannot work on all topics, part of the bases are not acquired directly, but though exchanges with other students. It would be interesting to check how far they are able to understanding the technical and scientific aspects of radiation protection issues as well as their capability to address societal issues at stake with different radiation protection practices.

So far, experts who participated to this programme are enthusiastic about sharing their knowledge and experience, but they are almost exclusively issued from institutions. It would be interesting to widen the spectra by involving more members of civil society.

One important condition is to work on voluntary basis to involve highly motivated professors, students and experts.

It is interesting to underline that this approach could contribute to favour the participation of citizen to the debate on radiation protection issues. Besides radiation protection purpose, this programme could also promote scientific careers at a time when interest for this field is sharply decreasing in France.

Conclusions

This pilot programme has been rather successful, in demonstrating that scientific and technical bases of radiation protection, which are known as complicated, can be rather easily acquired by school students. It has also demonstrated the interest of addressing the radiation protection issues with practical experiments and within local contexts. The challenges are now to adapt the programme to cope with anticipated increase of participants, to define a charter to precise conditions of participation, to involve a wider panel of experts and to further investigate the best approach for the diffusion of the radiation protection culture for school students.

How to share with children the basic knowledge about radioactivity and nuclear Risks?

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Abstract

This paper presents the strategy of IRSN to increase the basic Knowledge of young of children about radioactivity and nuclear risks in partnership with associations. 58 reactors are built on the French territory but a review performed by M Vroussos in 2004 highlighted that French people have a very poor knowledge about radioactivity and nuclear risk. This was confirmed by the Eurobarometer surveys. The consequences of such a low background knowledge should be, first, that the public cannot reduce the doses due to natural, medical exposition. Second, in case of nuclear event (example Tricastin 2008) or nuclear accident, the behaviours of concerned people and French consumers could create strong social and economical effects due to inadequate representations of the accident impacts. Third, in a more general way, citizens have few knowledge to discuss the nuclear renewal.

In order to diffuse a better knowledge IRSN and IFFO RME decided to have a partnership to develop tools for teachers and children. The Gafforisk fan was the first tool, with the objective to give fundamental knowledge about natural radioactivity, nuclear reaction, accident fallout, crisis management with a special emphasis on behaviour recommendation in case of nuclear crisis.

The tool was developed in a mobile exhibition which can be used by local information commission (CLI), for example during crisis exercise. The paper will present in detailed the strategy, the partnerships the different tools and their use.

Introduction

In 2004, after a large review to reinforce radioprotection in France, in his report asked by the French Nuclear Safety Authority (ASN), Pr Vroussos concluded that French people have a very poor knowledge about radioactivity and nuclear risk and he suggested main ways to improve Radioprotection. One of them is “to invent, or at least to experiment, new modes of information and dialogue with the population to share the knowledge and try to establish a dialogue between the citizen and the services in charge of the control, and to allow each one to form its opinion, in particular on the question of the risks connected to the use of the nuclear energy”.

To make it in a pragmatic way, he recommended "a strong action with the Ministry for Education so that the programs of the secondary education integrate the physical and biological bases of the effects of ionizing radiations, their diverse applications and the radioprotection within the citizen-centred approach to the environment topics and to the sustainable development".

In its strategic plan for 2010-2012, the ASN makes a commitment to associate more widely the public with the process of decision-making and to explain its decisions. For it, it would be necessary to increase the level of information of the public. According to the Eurobarometer about nuclear Waste (2005) [1], 22% of French people declared not to be informed on nuclear waste, and the knowledge on this topic was tested by 5 questions. As a result, France is eighth (60% of good answers), three first ones are Slovenia (72%), Finland (68%), Sweden (68%), countries where the number of nuclear installations is less than in France. This can be explained by the very long period (until 2006) during which many documents and recommendations on safety issues were not available to the public, thus without debates with the society.

The consequences of such a low background knowledge should be (1) in a more general way, citizens have few knowledge to discuss the nuclear renewal. (2) the public is not able to reduce the doses due to natural, medical radioactive risks to which they expose themselves and, (3), in case of nuclear event (example Tricastin 2008) or nuclear accident, the behaviours of concerned people and French consumers create strong social and economical effects due to inadequate representations of the accident impacts. Because, as said by M Covello in the conference in Bethesda in March 8, 2010 about risk perception, "when people are stressed and upset, the gap between perceptions and reality often becomes wider.", "perception equals reality", "that which is perceived as real is real in its consequences.".

For these reasons, the French Institut de Radioprotection et de Surete Nucleaire (IRSN) wondered about the best way for developing a knowledge on the nuclear power and the radioactivity in particular towards the school pupils, the citizens of tomorrow. Recognizing that the pedagogy was not its field of expertise, IRSN decided to have a partnership with the French Institute of Trainers at the Major Risks and Environment (IFFO RME) [2]. In this association, half of the 800 adherents are voluntary teachers to educate their pupils at the major risks (natural and industrial risks also too little handled in course of study), other are coming from French public services involved in risk management or risk specialists.

The most challenging aspects for education

The first step of the partnership was to well identify the most important challenges of the common work.

Nuclear accident seems to be the topic where the knowledge is the lowest and with the most important consequences on society if it occurs. IRSN risk barometer 2009 [3] shows that French people consider the accident in nuclear plant as the most important potential risk (fig 1). But they have little knowledge on it and on the risk management in such a crisis. They don't know who give information. In this area, authorities have a poor credibility [4] (fig 2), these verbatim are very frequent: «they lied to us. The cloud of Chernobyl stopped on the border", "they do not say to us everything ","If we do not die at once, we shall die from cancers ", "they speak about

nuclear safety but not about risks". This shows that in the representations of the population on the nuclear risk, Chernobyl consequence and its management in France takes an important place and contributes nevertheless to a certain consciousness of the risk..

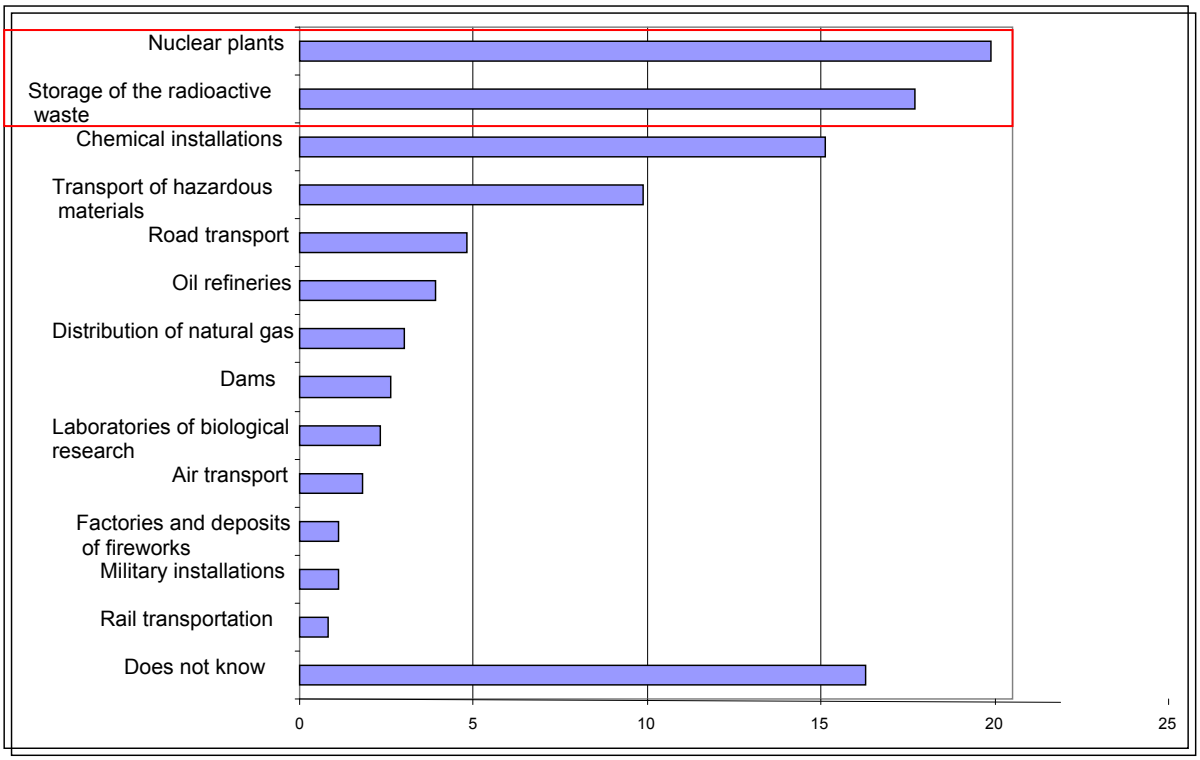


Fig. 1. IRSN risk barometer 2009 : Percentage of answers to this question " Among the diverse industrial or technological activities following ones, which are the ones which risk most to provoke a grave accident or a disaster in France? " (3 possible answers)

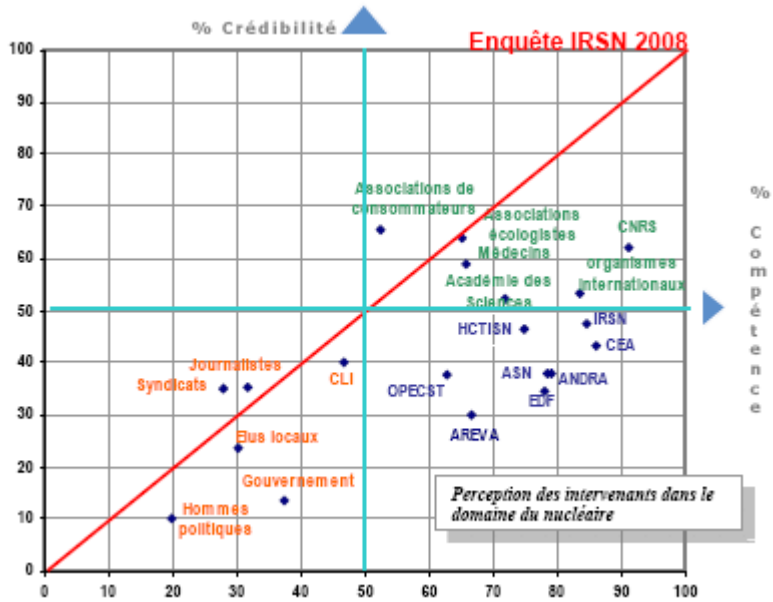


Fig. 2. " This picture give the rate of credibility and the rate for competence given to different actors. This shows that the credibility of ASN (nuclear safety authority) and IRSN is less than the average and the greater credibility is given to scientist and ecologist associations. "
From the IRSN barometer 2008

More, the population knows rather little the major risks which could occur as well as measures of prevention and protection they have to use in a crisis. Besides, the partners recognize that without a minimum of knowledge about a topic, it is impossible to ask questions and participate as a citizen in a nuclear debate. So, two major difficulties were identified to change the tendency: it is needed to popularize a scientific and technical domain (viewed as an elitist topic) and to take the heat out of the debate, without which we cannot build of information and educational.

So, for that, other partners join the working group such as Commission locale d'information (CLI), Association nationale des Commissions locales d'information (ANCLI), ACRO (Association pour le Contrôle de la Radioactivité de l'Ouest), Versailles Academy. The concerns of all the partners were to lock the cursor for the center and not to overturn into the debate "for" or "against". The approach was guided by Dr V. Covello principes in [5] on Risk Communication recommendations: the risk Communication is an interactive process of exchanges of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk, not strictly about risk, but also legal and institutional arrangements for risk management.

The past experience of IFFO RME on risk education

Since 1990, the IFFO RME association worked about education on risk. But some recent laws reinforce their actions. Some events occured in France have drastically changed the policies on natural and industrial risk management and crisis organisation, to reinforce the regulations in prevention and in preventive information of the populations. The Ministry in charge of Environment prepared the Law N 2003-699 of 30/07/03 relative to the prevention of technological and natural risks and to the repair of the damages, the Interior Ministry, the Law n°2004-811 of August 13th, 2004 of modernization of the civil protection, and the government promulgated the Law N 2006-686 of June 13th, 2006 relative to the transparency and to the safety in nuclear domain.

This information will be perceived all the better than it will take support on an early educational approach instead of waiting the treatment of event only by the media. To train the future citizen in responsible behavior, the education in the prevention of major risks joins in an education the environment, the safety and the health, in other words in the sustainable development education. In this perspective, speak about nuclear risks need to consider the overall nuclear activities from the mine extraction to the energetic and medical uses. This education calls to the notions of country planning, scales of time (management with more or less long terms for wastes or spoilt soil contamination and radioprotection measures) and spaces (solidarity / responsibility international). This education to the complexity develops the critical thinking and the education in the choice. It puts the thought of accepting a certain level of risk towards our needs.

One of the last tool developped by the IFFO RME association was "the major risk and me", an exercise book. Its various exercises are proposed based on, first, the observation of local risks (it can be a nuclear plant or installation) in its immediate environment and, second, on personal research. The booklet also identifies the major risk players and offers thinking on collectively and individually safety. In this

progressive educational approach, the knowledge is build step by step. Pupils can work on this book in class or independently. In this case, the tool takes part of education.

The experience shows that it is very important that teachers participate to the design of the tool and to give their feeling about the pedagogical approach. They have to be stakeholders in the educational development. They must find anchors in the syllabus of geography, of life sciences and earth, of history, of languages, of sports in link with civics education. The major risk education is fostered by interdisciplinary work In parallel to the work done to create the manual, web pages have been designed to support teacher. They specify the general approach of the support, the level of targeted instruction, the anchoring discipline, the knowledge and skills which have to be developed from the teaching notes and always the basic knowledge for the own use of teachers.

More, schools have to organize the pupil's safety inside their buildings, in case of major risk crisis, waiting for emergency assistance teams. In France the specific plan for safety, named PPMS, is recommended by the Education Ministry. To prepare such a plan, the entire school community (adults, students, parents) need to be mobilized and to trigger appropriate behaviour and solidarity. For being well understood and applied, this organisation have to be based on pedagogical approach: in order to know why this plan, what for, what to do, in which case, against which danger.

To conclude, two essential objectives are pursued by IFFO-RME. First, the cultural one: the construction of a risk culture which enlighten citizen and make him the actor of the public debate. Second, the operational aspects, which permit the comprehension of the procedures of crisis and its management. The stake is double and of equal importance because, if somebody does not understand source data, he cannot subscribe to the message of the authorities in a crisis.

An overall strategy

From this 15 years experience of IFFO-RME, 3 complementary levers can be activating to build a nuclear risk education or modestly hope to build a conscience of nuclear risk for young people (and indirectly for parents):

1. Partnership between scientists, teachers and administrations: The exercise was difficult, it is necessary to find the consensus between the rigor, the detail of the scientist and the popularization which does not infer false representations (ex: the cooling tower never produces radioactive fallout). A common understanding of partners and the conception of a common speech takes time. The partnership between IFFO-RME and IRSN permits to share knowledge without which the population could not understand and adopt the adequate behaviour in a nuclear crisis based on the knowledge of a nuclear institution but with the wording of the users.
2. Tools: In a society which is ceaselessly called, sought by the visual communication, the visual appearance's tools "funny", "attractive", "coloured" is a key to catch the attention and interest of young people on a difficult subject. It is not a question of using the competences of the communication "to sell yoghurts", but to put these in the service of the education. The tools are always developed with an additional document for the teachers use where more detailed information is given.
3. Adults trainings: special training are organized for teachers and trainers (with various background) to let them able to ask questions and to have a deeper knowledge.

The final decision of partners was to center the purpose of tools on the nuclear risk (and not nuclear energy), in a perspective of radio-protection aspects of accident, crisis and post-accident issues.

This overall strategy includes a diffusion plan for schools (duplication of tools, the manpower-ressources, downloading on internet) where key people coming from National Education are involved. Without them the project can be unsuccessful…
However, education is not the exclusivity of schools but it is built all the life. So, the planning of itinerant exhibition includes cities and public services.

The development of tools and events

The first tool was the fan "Gafforisk", developed for fourteen year old children even if nothing in their school programme is in link with the information. Ten pages (recto verso) the first ones gives information about major risks, then one page for general knowledge about atoms and material, radioactivity and radiations. An other one for the origins of the radiations received by the population in France and their percentage in the exposure doses.

One page about the use of fission reaction giving energy in nuclear plant, and the fission product problem in case of accident, another page summarized the Chernobyl catastrophe. The various radiation uses and the different layers for protection are illustrated in other pages,. The units to measure radioactivity and its impact on the body are explained. Differences between Irradiation and contamination are illustrated. Four pages are used to explain the crisis management: alert signal, seclusion and stake under cover. Some exercises are proposed to make active children.

To build this tool, partners discussed a lot to find the last word. The selected words were not the most scientific ones but the most understandable ones for a 14 years old children.

IRSN and the French Ministry in charge of environment and Sustainable Development bought more than 35 000 copies of this fan to be broadcasted in schools with the help of the IFFO RME net.

One itinerant exhibition was created : 14 panels pulled by the fan Gafforisk were published to be posted in the schools and places where an in deep discussion was wanted. A trainer or an IRSN specialist accompanied the exhibition. Taking care of the remarks of trainers, education experts and users, 2 panels were added on the specific topic of the Chernobyl consequences. Due to the French context, these panels are very important for allowing each one to get it of his chest on the management of this accident in France and to hear the information coming from the posterior studies on this subject At the national level, three copies of the exhibition can be borrowed for various events..

For example, it can be used when a crisis exercice is organised near a nuclear plant and when school participate to it, using the PPMS (the pupils confine themselves to the school), or when the mayor wishes to give an information to the city hall during the distribution of pastille of iodine to the inhabitants. Because in case of crisis, the key to risk management success is anticipation, preparation, and practice.

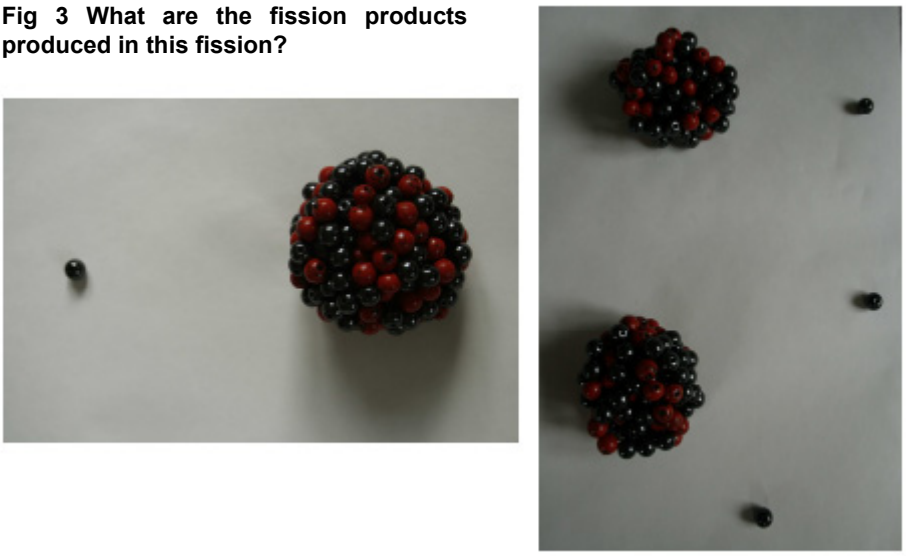
An other way to use it is during French education events such as the Week of sustainable development, or the days of Science Festival.

The lessons learnt is that that is exhibition is easy to used as well with the adults without any knowledge on radioactivity and nuclear that with the children (the youngest were 10 years old). The speaker has to adapt his language to the public.

Additional kits were developed to be used in front people to explain fission and fission products (235 +1 magnetic hematite pearls, 92 painted in red) in order to produce the

feeling to be able to understand this elitist topic and to understand what is the iodine problem…They can feel what is a scientific approach and go very far in their understanding.

Fig 3 What are the fission products produced in this fission?



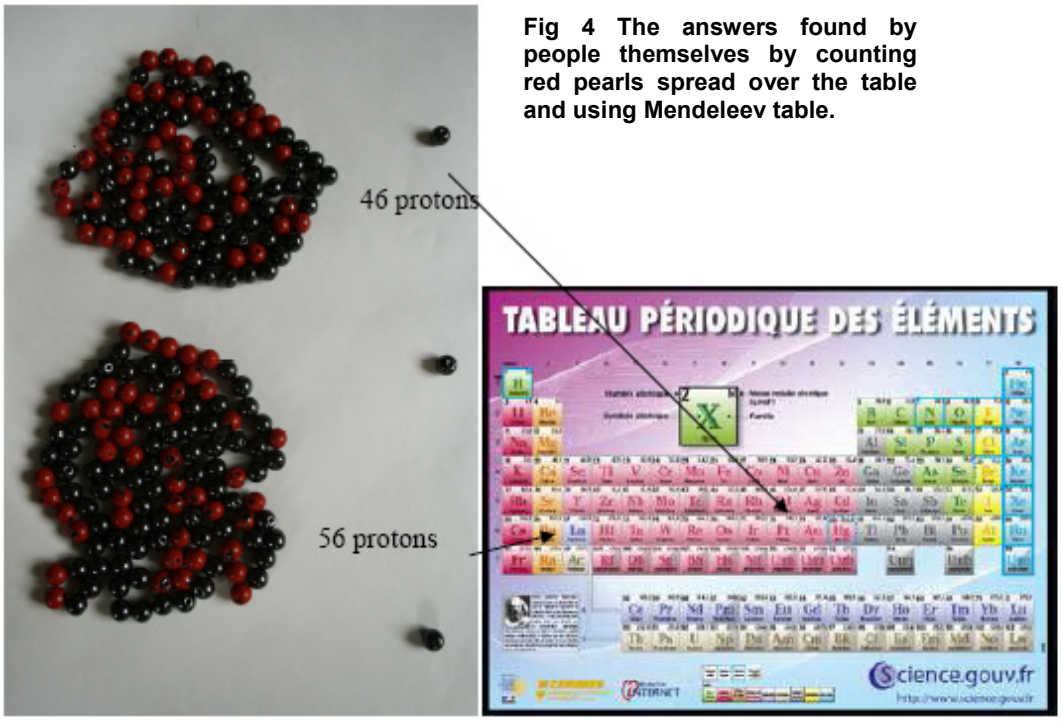


Fig 4 The answers found by people themselves by counting red pearls spread over the table and using Mendeleev table.

A local guide of exhibition

This document, composed with the partner "Local commission of information of the nuclear research center of Saclay" (CLI de Saclay) based on the fan Gafforisk. It was developed to be given to the public, alone in the exhibition when no speaker is present.

The booklet presents the exhibition in 5 parts and gives local informations. The five parts :

1. What's the radioactivity?
2. For what to do?
3. Minor incident or major accident?
4. What to do in case of crisis?
5. How to inform myself?

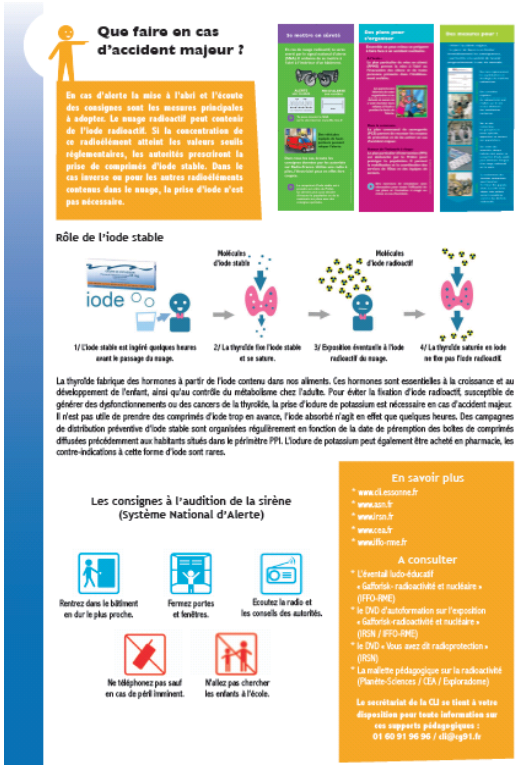


Fig 5 In this last part of the booklet, the behaviours recommended during crisis situation and protection against iodine radioactive contamination by distribution of iode tablets are explained.

Proposal of teachers training and trainer's tools

Because it is not easy to trust in ourself when we are not a specialist of the domain, trainings or tools for self-training must be developed for the attention of the voluntary persons. The academy of Versailles had organized in partnership with IRSN and IFFO-RME a session of 3 days about "radio-activity and nuclear". The training was opened to every voluntary professor to form on this subject. Professors of physics and natural sciences were present but also professors in industrial techniques as well as professors of geography, history, civic instruction, French. This unit of training will be renewed next year and suggested to others French academy.

DVD for trainers

Otherwise, IRSN and IFFO RME are preparing a DVD for auto-training based mostly on videos, free on internet, because new tools and media can be efficient vehicles for our purpose. Because, most of the concerns and questions of upset or concerned people can be predicted and prepared for in advance. It was considered as possible to anticipate them and to develop answers which will remind the aims developed in the panels of exhibition. The commentaries will be given by teachers and specialist of crisis management. There will be additional topics to about diseases, international responsibilities.

It will contain some practical experimentation about the atoms, the fission, the produce of fission, the dispersal of radioactive cloud…

Conclusion

In the context of sustainable development, the nuclear issues arise in terms of society choice: what are the risks/benefits of this choice.

To build an education on nuclear energy and especially on nuclear risk, we have to imagine various systems (paper, video, kits) with multiple sources of education messages. The messengers of education have to be diverse to multiply the meets between the citizen and rational representations of risks. So the citizen could access to information, understand it and take a better part to his security.

In the framework of the nuclear renewal, several questions arise.

- How different States can combine their efforts in the field of education in nuclear risk and radioprotection ?
- What international working group on teaching practices would allow the construction of white book of best practices and adapting existing tools in the countries concerned
- What evaluations of educational strategies in nuclear risk would measure its effectiveness in the long term.

These actions contribute to a better society resilience.

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European ALARA Network: – Evolution, operation and key activities

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Abstract

The new ICRP recommendations (ICRP 103), and in particular the detailed treatment of optimisation in the ICRP Publication 101, define optimisation of protection as a source-related process aimed at keeping the likelihood of incurred exposures, the number of people exposed and the magnitude of their individual doses as low as reasonably achievable, also below constraints, taking into account economic and societal factors. The implementation of the optimisation of protection into practice is supported by the ALARA principle. The term ALARA is an acronym for "As Low As Reasonably Achievable". In essence, the ALARA principle requires that radiation exposure of man and environment be kept as low as reasonably achievable (also below constraints) when using ionising radiation. Practical implementation and further development of the ALARA principle has been achieved for many years now by the successful cooperation of experts from different European organisations; first as pioneers by establishing the European ALARA Network and then by enthusiastically supporting the activities of the network itself. This contribution presents the evolution, operation and key activities of the European ALARA Network (EAN) in the last years; the successful cooperation of experts from different professional backgrounds, advocating the ALARA principle in a range of radiation protection areas, and contributing to its further development by trading experience and networking. The interaction between the EAN and international organisations, which support the ALARA principle by including relevant activities in their work programmes, is described, as well as the cooperation between EAN and other networks to identify the role of ALARA in the process of improving radiation protection culture.

ENETRAP-II: development of European training schemes for RPE's and RPO's

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Abstract

ENETRAP II, aims at developing reference standards and good practices for education and training programmes for radiation protection experts and officers, reflecting the needs of these professionals in all sectors where ionising radiation is applied. The introduction of a radiation protection training passport as a mean to facilitate efficient and transparent European mutual recognition of these professionals is another ultimate deliverable of this project. It is envisaged that the outcome of ENETRAP II will be instrumental for the cooperation between regulators, training providers and customers (nuclear industry, research, non-nuclear industry, etc.) in reaching harmonisation of the requirements for, and the education and training of, radiation protection experts and officers within Europe, and will stimulate building competence and career development in radiation protection to meet the demands of the future.

Introduction

Radiation protection (RP) is a major challenge in the industrial applications of ionising radiation, both nuclear and non-nuclear, as well as in other areas such as the medical and research area. As is the case with all nuclear expertise, there is a trend of a decreasing number of experts in radiation protection due to various reasons. On the other hand, current activities in the nuclear domain are expanding: the nuclear industry

faces a so-called "renaissance", high-tech medical examinations based on ionising radiation are increasingly used, and research and non-nuclear industry also make use of a vast number of applications of radioactivity.

Within this perspective, maintaining a high level of competency in RP is crucial to ensure future safe use of ionising radiation and the development of new technologies in a safe way. Moreover, the perceived growth in the different application fields requires a high-level of understanding of radiation protection in order to protect workers, the public and the environment of the potential risks. A sustainable education and training (E&T) infrastructure for RP is an essential component to combat the decline in expertise and to ensure the availability of a high level of radiation protection knowledge which can meet the future demands.

Today's challenge involves measures to make the work in radiation protection more attractive for young people and to provide attractive career opportunities, and the support of young students and professionals in their need to gain and maintain high level RP knowledge. This can be reached by the development and implementation of a high-quality European standard for initial education and continuous professional development for radiation protection experts (RPEs) and radiation protection officers (RPOs), and a methodology for mutual recognition of these professionals on the basis of available EU instruments, such as the European qualification framework (EQF) and/or the directive 2005/36/EC.

Within the framework of this project, the RPE and RPO should be interpreted as:
Radiation protection expert (RPE): *an individual having the knowledge, training and experience needed to give radiation protection advice in order to ensure effective protection of individuals, whose capacity to act is recognized by the competent authorities.*
Radiation protection officer (RPO): *an individual technically competent in radiation protection matters relevant for a given type of practice who is designated by the undertaking to oversee the implementation of the radiation protection arrangements of the undertaking.*

These are the definitions proposed by ENETRAP 6FP (www.sckcen.be/enetrap) and EUTERP (www.euterp.eu) to the EC DG TREN and Article 31 group, who is working on the revision of the Basic Safety Standards.

Project details

Determined to build further on the achievements of 6 FP ENETRAP, most ENETRAP partners participate in 7FP ENETRAP II (www.sckcen.be/enetrap2). The overall objective of this project is to develop and implement European high-quality "reference standards" and good practices for E&T in RP, specifically with respect to the RPE and the RPO. These "standards" will reflect the needs of the RPE and the RPO in all sectors where ionising radiation is applied (nuclear industry, medical sector, research, non-nuclear industry). The introduction of a radiation protection training passport as a mean to facilitate efficient and transparent European mutual recognition is another ultimate deliverable of this project.

With respect to the RPE the overall objective is to be achieved by addressing both education and training requirements.

In the field of education this project deals with high-level initial programmes, mainly followed by students and/or young professionals. It is foreseen to analyse the European Master in Radiation Protection course, which started in September 2008. Broadening of the consortium and quality analysis of the providers and the content of the modules can be performed according to, primarily, the standards and guidelines for quality assurance in the European higher education area (ENQA) and, secondly, to the ENEN standards.

In the field of RPE training the ultimate goal is the development of a European mutual recognition system for RPEs. Hereto, the ENETRAP training scheme initiated as part of the ENETRAP 6FP will be used as a basis for the development of a European radiation protection training scheme (ERPTS), which includes all the necessary requirements for a competent RPE. In addition, mechanisms will be established for the evaluation of training courses and training providers.

With respect to the RPO role the desired end-point is an agreed standard for radiation protection training that is recognised across Europe. Data and information obtained from the ENETRAP 6FP will be used to develop the reference standard for radiation protection training necessary to support the effective and competent undertaking of the role.

Furthermore, attention is given to encouragement of young, early-stage researchers. In order to meet future needs, it is necessary to attract more young people by awaking their interest in radiation applications and radiation protection already during their schooldays and later on during their out-of-school education (university or vocational education and training). Radiation protection experts and officers work more and more on a European level. It is therefore important bringing together all the national initiatives at a European level: tomorrow's leaders must have an international perspective and must know their colleagues in other countries.

It is envisaged that the outcome of ENETRAP II will be instrumental for the cooperation between regulators, training providers and customers (nuclear industry, medical sector, research and non-nuclear industry) in reaching harmonisation of the requirements for, and the education and training of RPEs and RPOs within Europe, and will stimulate building competence and career development in radiation protection to meet the demands of the future.

Specific objectives of the ENETRAP II project are to:

- develop the European radiation protection training scheme (ERPTS) for RPE training;
- develop a European reference standard for RPO training;
- develop and apply a mechanism for the evaluation of training material, courses and providers;
- establish a recognised and sustainable ERPTS "quality label" for training events;
- create a database of training events and training providers (including OJT) conforming to the agreed ERPTS;
- bring together national initiatives to attract early-stage radiation protection researchers on a European level;

- develop some course material examples, including modern tools such as e-learning;
- develop a system for monitoring the effectiveness of the ERPTS;
- organise pilot sessions of specific modules of the ERPTS and monitor the effectiveness according to the developed system;
- development of a European passport for CPD in RP.

The objectives of ENETRAP II 7FP will be reached by several activities dealing with

- the analysis of job requirements (RPE and RPO);
- the design and implementation of appropriate training standards and schemes to support these requirements;
- development and application of a quality assurance mechanism for the evaluation of the training events, used material and training providers;
- setting up a database of training events and providers conforming to the agreed standards;
- the development of training material (traditional texts, as well as the introduction of more modern tools such as e-learning modules) that can be used as example training material;
- monitoring the effectiveness of the proposed training schemes.

The final goal is the development of a European mutual recognition system for RPEs and the introduction of a training passport.

The different work packages (WP) defined in this project are:

WP1	Co-ordination of the project
WP2	Define requirements and methodology for recognition of RPEs
WP3	Define requirements for RPO competencies and establish guidance for appropriate RPO training
WP4	Establish the reference standard for RPE training
WP5	Development and apply mechanisms for the evaluation of training material, events and providers
WP6	Create a database of training events and training providers (including OJT) conforming to the agreed standard
WP7	Develop of some course material examples (text book, e-learning modules, …)
WP8	Organise pilot sessions, test proposed methodologies and monitor the training scheme effectiveness
WP9	Introduction of the training passport and mutual recognition system of RPEs
WP10	Collaboration for building new innovative generations of specialists in radiation protection

ENETRAP II 7FP is realised by 12 partners, each having relevant experience in policy support regarding E&T projects on radiation protection. It concerns SCK•CEN (Belgium), CEA-INSTN (France), Karlsruhe Institute of Technology, Centre for

Advanced Technological and Environmental Training KIT-FTU (Germany), Federal Office for Radiation Protection BfS (Germany), the Italian National Agency for New Technology, Energy and Environment ENEA (Italy), NRG (The Netherlands), CIEMAT (Spain), Health Protection Agency HPA (UK), the ENEN Association (France), the Nuclear and Technological Institute ITN (Portugal), the Budapest University of Technology and Economics BME (Hungary), and University Politehnica of Bucharest (Romania). Staff members of the different partners who play a key role in this project, have also proven to be highly involved with E&T matters, on national and international levels, and are member of several E&T networks. Most of them also have an advisory role towards the national regulatory authority.

ENETRAP II (grant agreement number 232620) is a coordination action that runs under the theme "Euratom Fission Training Schemes (EFTS) in all areas of Nuclear Fission and Radiation Protection" (Fission-2008-5.1.1). The project will run over 36 months.

Results

Although this project is still in its first phase, some work packages have already reached intermediate results. In the following paragraphs a summary is given of the work carried out in the different WPs, and the first achievements are highlighted.

Requirements and methodology for recognition of RPEs

WP2 deals with the requirements for recognition of RPEs and the development of a methodology for the recognition of RPEs. Although the execution of any recognition process is the responsibility of the national regulatory authority, ENETRAP II will put forward a harmonised methodology, in line with the national approaches. The existence of this European methodology will facilitate the ultimate goal: a European mutual recognition process for RPEs. Qualification, competence, and continuous professional development will be discussed and elements for these three requirements will be defined. An outline of the proposals for key elements of a national scheme for RPE recognition was put forward at the most recent ETRAP conference (Lisbon, November 2009 (http://www.euronuclear.org/events/etrap/index.htm). Here, also a questionnaire was presented which was sent out to all participants, EUTERP contact points and other relevant stakeholders. The results of the questionnaire are currently being analysed and will be used to provide guidance with respect to national schemes for recognition of RPEs. From there, a mechanism will be developed for the mutual recognition of RPEs between Member States.

Requirements for RPO competencies and establishment of guidance for appropriate RPO training

WP3 deals with requirements for RPO competencies and the establishment of guidance for appropriate RPO training. Employees, appointed to act as RPOs in hospitals, industrial companies or teaching and research institutions should have an adequate level of understanding of concepts related to radiation protection and understand the radiation protection issues pertinent to their radiation application. Therefore the level and format of training required by an RPO is dependant on the complexity of that application. It is therefore essential, on the EU level, (i) to define requirements for the competencies of

RPOs according to their area of work and specific radiation protection tasks, and (ii) to establish European reference standards for RPO training. The first intermediate report on this topic is submitted.

Establishment of the reference standard for RPE training

WP4 continues on the achievements of WP2. Here, it is the aim to develop appropriate European radiation protection training schemes (ERPTS), with objectives, target audience(s), audience prerequisites, required topics, suggested durations and evaluation methods for both initial and refresher training of RPEs, taking into account the nature and requirements of the RPE role. The starting point is the ENETRAP 6FP training scheme. Furthermore internationally recognised training material such as the material developed by the IAEA will be incorporated. The ERPTS should meet the requirements of the revised definitions of the RPE and should eventually replace Communication 98/C133/03, as a guide for the Member States to develop, or evaluate, their national strategies for RPE qualification and recognition.

Development and application of mechanisms for the evaluation of training material, events and providers

In the EU, a vast number of training events, material and providers exist. Given that formal recognition is required for RPEs, it would be prudent for training providers involved in the RPE training process to also be formally recognised. The aim of this WP5 is to develop a mechanism for the comparison, through a transparent and objective methodology, of training materials, courses and training providers, which can be used by regulatory authorities to evaluate their national radiation protection training programme for compliance with the ERPTS. First results are presented at this conference.

Database of training events and training providers

It is foreseen in WP6 to create a database of training event and providers conform to the agreed standards. The database will be made public through the ENETRAP II website and will thus be available for all interested parties. It is the aim that such a move would add credibility to the recognition process and would help to provide reassurance to RPE candidates and to employers that the training obtained satisfies an agreed European standard. It is foreseen that this database will also incorporate an overview of institutes hosting on-the-job-training possibilities. First announcements are foreseen by the end of 2010.

Development of course material

In order to provide examples of standardised training material, meeting the requirements of the ERPTS, WP7 foresees a European textbook for several modules of the ERPTS. It is suggested to launch a "cyber book", using the MOODLE platform that was introduced in ENETRAP 6FP. The modules that will be treated in this book are to be decided from the 66 entries WP7 received to their survey amongst the partners regarding the available course material. An additional suggestion is to create a sonorized (video + audio) PowerPoint presentation.

Pilot sessions

In the framework of ENETRAP II, pilot sessions of the European reference training scheme will be organised. The date put forward for the first pilot session, containing the basic RP modules and a specialized module on radiation protection issues in nuclear power plants, is spring 2011. This will be organised at KIT-FTU, Germany. Another specialized module on NORM issues will be organised at HPA, UK. At this conference the pilot sessions are presented in a poster presentation.

Introduction of a training passport and mutual recognition system

The ultimate goal of the ENETRAP II project is the introduction of an EU mutual recognition system for RPEs. In WP9 coordinating actions will be undertaken to establish such a system. Furthermore, the European training passport will be introduced as a tool for facilitating an efficient and transparent mutual recognition system.

Whenever possible, a collaboration will be established with the "training" working groups of the three EU "platforms" that were launched in 2007 (in particular, to discuss the added value of a "European training / skills passport" and the balance between theoretical and practical training that is desired to improve both the quality and the mobility of nuclear experts in public as well as private sector). The results of this WP are expected in the last phase of the project.

Building new innovative generations of specialists in radiation protection

Those people who developed concepts in radiation protection and held leadership positions at universities and research institutions to further develop radiation research and educate and train the next generation in the EU are retired or starting to retire. We are facing the same situation for numerous radiation protection experts and officers who devoted their knowledge and experience to build up a high level of radiation safety in all radiation applications in industry, medicine and research in the EU. In order to maintain this high level and to further develop a European safety culture, it is necessary to attract more young people by awaking their interest in radiation applications and radiation protection. More young people must be inspired to take an interest in radiation research and prepared to take leadership positions at universities and radiation applications in industry, medicine and research in the EU. Because high-level RP professionals often work in a European context, tomorrow's leaders will benefit from having an international perspective and knowing their colleagues in other countries.

Summary and conclusions

Based on the outcome of the ENETRAP 6FP, ENETRAP II 7 FP aims at contributing further to the EU harmonisation of E&T of radiation protection professionals. With the introduction of a modular European reference training scheme and European recognition methodologies, key issues will be delivered for the development and implementation of mutual recognition system of RPEs. In this way ENETRAP II meets the EC requirements to rely on the principles of modularity of courses and common qualification criteria, a common mutual recognition system, and the facilitation of teacher, student and worker mobility across the EU. ENETRAP II will structure research on radiation protection training capacity in all sectors where ionising radiation is applied. End users and specifically regulatory authorities are represented through

foreseen participation in the advisory board which will advise about the best balance between supply and needs, thereby ensuring stable feed back mechanisms. The tasks defined in this project maximise the transfer of high-level radiation protection knowledge and technology, addressing young as well as experienced radiation protection workers. In this context, the proposed project will thus contribute to meeting the objectives of the EURATOM research and training work programme.

A Training Programme for Regulatory Inspectors under ISO 17020

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Abstract

The Radiological Protection Institute of Ireland (RPII) is the competent authority for all matters pertaining to ionising radiation in Ireland. In fulfilment of its statutory responsibilities it oversees a regulatory programme (licensing, inspection, enforcement and the provision of technical guidance and advice) for all users of sources of ionising radiation.

In December 2008 the RPII was awarded accreditation to ISO 17020: General Criteria for the Operation of Various Types of Bodies Performing Inspection by the Irish National Accreditation Board (INAB). In achieving this award the RPII became the first regulatory authority in Europe engaged in radiation protection inspections to be accredited for its inspection services under this standard. The RPII's quality manual and quality procedures describe in detail how its inspection programmes are planned, carried out and reviewed as well as setting out training requirements for inspectors.

This presentation will describe the formal training programme that was developed for a new inspector who joined the RPII's Regulatory Services Division in October 2007. The programme was developed in accordance with the requirements of the ISO standard and audited by technical assessors from INAB. The programme clearly identifies all aspects of training, both technical and non-technical, that a new member of staff has to undertake in order to be warranted as an inspector/authorised officer.

In addition to the development of a formal training programme for new inspectors the ISO standard also required the RPII to develop a formal programme for assessing the on-going competency of existing inspectors. This is achieved through a programme of inspection witnessing of individual inspectors by their technical managers. Inspectors are deemed competent provided their technical manager is satisfied with their knowledge and performance as witnessed during inspections.

Introduction

In 2005 the RPII commenced work on developing a quality management system for all of its work activities associated with the inspection of licensees holding sources of ionising radiation. The primary motivation for this work was the desire to ensure that the RPII performed all activities associated with inspections, such as planning and carrying out inspections, issuing of inspection reports, follow-up actions and inspector training, to the highest international standards. Through the development of an

externally audited quality management system, containing elements such as documented work procedures, programmes of continual review and formalised inspector training programmes the RPII could ensure that all inspections are carried out in a professional and competent manner ensuring consistency of inspections and the approach taken by inspectors.

The RPII originally commenced work on developing a quality management system under ISO 9000 for all of its licensing and inspection activities. However, following meetings with the Irish National Accreditation Board (INAB), the national body with responsibility for accreditation in Ireland, a more appropriate standard for the RPII was identified, namely *ISO 17020: General Criteria for the Operation of Various Types of Bodies Performing Inspection* (ISO, 1998). This standard is typically sought by inspection bodies whose functions include the examination of materials, products, installations etc. and the determination of their conformity with requirements, including the subsequent reporting of the results of these activities. As the RPII has a statutory responsibility to license all holders/users of sources of ionising radiation, and to carry out inspections, it determined that to seek accreditation to the ISO 17020 standard would be the most appropriate standard for it.

Over the course of two years the RPII developed a quality manual which described in detail the systems and processes it had in place to address the requirements of the ISO 17020 standard. The quality manual was further supported by a comprehensive set of quality procedures that documented all the work activities that support its inspection programmes. A list of the quality procedures is given in Table 1.

Table 1. RPII Inspection Quality Procedures.

Procedure No	Title
QP01	Corrective/Preventative Action Procedure
QP02	Document Control Procedure
QP03	Management Review Procedure
QP04	Audit Procedure
QP05	Annual Inspection Programme
QP06	Pre-Inspection Procedure
QP07	Inspection Procedure
QP08	Post-Inspection Procedure
QP09	Inspectors Meetings
QP10	Training Programme Procedure
QP11	Equipment Procedure

In relation to the training of new inspectors the RPII's quality manual identifies a number of criteria which must be met:

- Staff responsible for inspections shall have appropriate qualifications, training, experience and a satisfactory knowledge of the requirements of the inspections to be carried out;
- The RPII shall establish a documented training system to ensure that the training of inspectors is kept up-to-date;

- The training shall depend upon the qualifications and experience of persons involved, and shall include an induction period, a supervised working period with experienced inspectors and continuation training to keep pace with developing technology;
- The RPII shall provide guidance on the expected conduct of inspectors.

The quality system went "live" in September 2007 and was operated for a full year before INAB carried out a pre-registration assessment visit over two days in September 2008. As well as reviewing the quality manual and all the documented procedures the INAB auditors witnessed RPII inspectors carrying out an inspection of a nuclear medicine department in a major teaching hospital as well as an inspection of a licensee carrying out non-destructive testing work. The INAB auditors were satisfied that the RPII had met the requirements of both the ISO standard and the IAF/ILAC guidance document (IAF/ILAC, 2004) and subsequently awarded it accreditation to ISO 17020 in December 2008.

Inspector Training pre accreditation

Prior to the introduction of a formal training programme under ISO 17020, the RPII had informal procedures for training new inspectors. Due to the limited usage of ionising radiation in Ireland, it is difficult to recruit inspectors with several years experience of working with sources of ionising radiation and, in practice, most new inspectors are employed straight out of university, the majority of them having studied physics.

Newly recruited inspectors would undergo an induction period during which they would be provided with on-the-job training in relation to the licensing and inspection processes and are provided with a full set of relevant legislation and guidance documents. The emphasis during this training focused on the hard skills such as knowledge of the applications of ionising radiation, inspection procedures, use of radiation monitors, report writing etc. rather than on the softer skills such as interviewing techniques and communication skills.

Over the course of their first couple of months a newly recruited inspector would accompany experienced inspectors to observe how inspections were conducted across all sectors. Prior to 2005, inspectors did not specialise in particular areas and were trained to be able to undertake inspections across all sectors such as medical, veterinary, industrial, education research etc. In 2005 it was decided that two distinct categories of inspectors would be created: those who would specialise in carrying out inspections in the medical, dental and veterinary sectors and those would conduct inspections in the industrial, educational and research sectors. This specialisation meant that inspectors could focus on relevant sectors and attendance at appropriate conferences, meetings and training courses could be arranged.

New inspectors would continue to observe inspections across a wide range of activities until such time as the experienced inspectors felt that the new inspector could lead an inspection with their assistance, and under their supervision. Once the inspector was deemed competent by their technical manager, the Board of the RPII would be asked to issue a warrant to the new inspector.

While this approach had worked very well over the years it was acknowledged within the RPII that its inspector training programme should be formalised to ensure consistency in how its inspectors were trained. The programme would include

milestones indicating when new inspectors could be deemed competent to undertake inspections on their own and accordingly be issued a warrant. It was also acknowledged that the focus to date had been on teaching a new inspector how to plan and undertake inspections and that softer skills, such as interviewing techniques, assertiveness training and chairing meetings, all of which are necessary when carrying out inspections, were not given as high a priority.

In practice, during the period 2004 – 2007 there were only two new inspectors appointed. One inspector returned from working as a medical physicist in a large hospital to the RPII, having previously worked as an inspector in the 1990s, and required relatively little training to bring her up to date. When a member of staff transferred from a different department within the RPII into the Regulatory Services Division (RSD) it provided an opportunity to trial the new inspector training programme that was in the process of being developed.

Inspector Training under ISO 17020

Shortly after switching on its new quality management system in September 2007, the RPII recruited a new inspector to the Medical, Dental & Veterinary Section within the RSD. The new inspector joined the team responsible for licensing, inspection and enforcement activities in these sectors and was the first inspector to go through the formal inspector training programme developed under the quality management system.

The specification drawn up for the post required candidates to hold an honours degree in physics or in electrical, electronic, mechanical or clinical engineering. Additionally candidates were advised that experience working as a medical physicist was desirable.

The new inspector commenced work in October 2007 as a Scientific Officer. Holding a diploma in applied physics and a BSc in physics and physics technology she had previously worked as a research assistant in a third level college and as a field service engineer for a major semiconductor company. In the year prior to joining the RPII she completed an MSc in medical physics.

Training Programme

The RPII's quality management system allows for some flexibility when drawing up a training programme for a new inspector, as he or she will have different skills and experience. For the newly recruited inspector a formal training programme was drawn up and mutually agreed though discussions during her first week. As well as focusing on the skills required to carry out inspections the training also looked at wider training requirements, particular as this person was coming from the private sector into the public sector. The training programme was broken into 13 modules, which are summarised below:

- Introduction to the RPII: internal structures; relationship with/to government departments;
- Introduction to regulatory responsibilities: licensing; inspection; enforcement; provision of guidance and advice;
- Inspector behaviour: RPII staff handbook; code of business conduct; inspector's code of conduct;
- Health and Safety: RPII health & safety management system; manual handling; construction site safety (Safe Pass); fire safety;

- ISO 17020 Quality Management System: quality manual; quality procedures;
- Legislation: primary & secondary legislation; legal workshop; courtroom skills;
- Information technology: licensing & inspection database; IT usage policy;
- Equipment: personal protective equipment; types and use of radiation monitors; personal dosimetry;
- Inspection procedures: planning; reporting; follow-up;
- Inspections: observation phase; supervisory phase; competency assessment;
- Incident investigation: accidents; personal dosimetry investigations;
- RPII business planning: strategic planning; annual business planning, Performance Management Development System (PMDS);
- Training: on-the-job training; formal courses; technical meetings; conferences.

Based upon discussions between the new inspector and her technical manager it was agreed that she would accompany experienced inspectors on a total of 20 inspections as part of the observation phase of her training programme. These 20 inspections would cover diagnostic and therapeutic applications across the medical, dental and veterinary sectors. Over the course of these inspections the new inspector would gain experience of how inspections are planned and arranged, witness firsthand how an inspector interacts with the licensee during all stages of the inspection and how the findings of inspections are reported and followed up.

This would then be followed by a supervisory phase where the new inspector would lead five inspections supported by one of the experienced inspectors. She would be responsible for arranging and conducting the inspection as well as issuing the final report and dealing with follow-up actions. Finally, her technical manager would assesses her competence by witnessing her carrying out an inspection in each of the modalities of diagnostic radiology, nuclear medicine and radiotherapy in the medical, dental and veterinary sectors as appropriate. This graded approach to the competency assessment means that the inspector can be signed off for simple inspection types e.g. dental radiology, DXA etc. working up to more complex inspection types such as nuclear medicine and radiotherapy as she gains more experience.

As each phase of the training was completed both the trainee (new inspector) and trainer would formally sign off her training record.

On-the-job training

The RPII has developed inspection audit forms, which are part of the quality system, for all sectors which inspectors complete during inspections. Specific audit forms have been developed for modalities within individual sectors, such as diagnostic radiology, nuclear medicine and radiotherapy within the medical sector. As well as being an *aide-memoir* for inspectors the forms also ensure that different inspectors cover the same areas during inspections i.e., there is consistency among different inspectors on the issues examined during inspections.

At the outset of the training programme for the new inspector it was agreed that she would witness a total of 20 inspections by accompanying experienced inspectors. By the end of this phase of her training she had in fact witnessed 27 inspections. Table 2 summaries the inspection types observed during the period October 2007 – July 2008.

Table 2. Inspections observed during observation phase of training programme.

Inspection Type	Number of inspections observed
Diagnostic Radiology (Medical)	14
Nuclear Medicine (Medical)	1
Radiotherapy (Medical)	4
Diagnostic Radiology (Dental)	4
Diagnostic Radiology (Veterinary)	2
Equine Nuclear Medicine (Veterinary)	1
Distributor of Radioactive sources	1
Total	27

Following this period of observation the experienced inspectors deemed her competent to lead an inspection under their supervision. In practice this meant that she was the lead inspector but was assisted by one of the experienced inspectors. However, in order for her to be able to lead an inspection she had to be formally appointed an inspector by the Board of the RPII, in accordance with the provisions of the Radiological Protection Act 1991 (RPA, 1991). In July 2008, the Board of the RPII was advised that the inspector had reached a stage in her training where she had been deemed competent to lead an inspection, under the supervision and with the support of an experienced inspector. In order to complete her training she would be required to be appointed as a warranted inspector so that she could lead inspections. Accordingly, nine months after joining the RPII she was appointed as an inspector and issued with a warrant.

As part of the supervisory phase of her training programme she ended up leading six inspections, four in diagnostic radiology facilities within hospitals and two dental practices, assisted by an experienced inspector. She also participated on the inspection team for two radiotherapy and one diagnostic radiology inspections during this phase of her training.

In January 2009, for the final phase of her inspector training her technical manager assessed her competency as an inspector. It is important to note that as her technical manager had to assess her and sign off on her training he could not be involved directly in her training as this would present a conflict of interest i.e., he couldn't both train her and be the person responsible for determining that she had been fully trained. Over the course of two days she was witnessed carrying out inspections of diagnostic radiology facilities in two hospitals, a dental practice and a veterinary practice. After each inspection her technical manager reviewed her performance during the inspection, posing a series of hypothetical scenarios in order to further assess her technical competence. Later that month, after all the inspection reports had been issued and follow-up issues closed out, the new inspector was formally deemed to have completed her initial inspector training and could undertake diagnostic radiology inspection on her own. To lead radiotherapy or nuclear medicine inspection teams she would have to be further assessed by her technical manager.

Formal Courses

While on-the-job training is very effective for developing hard skills, such as knowledge of legislation, using radiation monitors there are many soft skills that a new inspector needs to acquire. These soft skills include interviewing techniques, conflict management, negotiating skills, communication and presentation techniques, chairing meetings etc., all of which are put into practice each time an inspector carries out an inspection. As part of her training programme suitable training courses and opportunities were identified which cover both hard and soft skills. While it was possible to identify some of these at the outset of the programme, others only came to light as the training programme progressed. In addition to her initial training programme the new inspector continues to attend relevant training courses as part of her personal development. The courses attended by the new inspector since joining the RPII in October 2007 are listed below:

- "How to inspect" – a foundation course in non-technical aspects of inspection, Irish Medicines Board (Dublin) – October 2007;
- Quality customer services training, RPII (Dublin) – October 2007;
- A Course in Radiotherapy Physics, Royal Marsden Hospital & The Institute of Cancer Research (London) – March 2008;
- WHO Co-ordination Meeting - Radiation Safety in Healthcare Settings, WHO (Geneva) – June 2008;
- ICRP Seminar, ICRP (Dublin Castle) – September 2008;
- Presentation skills course, Irish Times Training (Dublin) – October 2008;
- "Radiation Protection in Nuclear Medicine", IPEM meeting, IPEM (London) – November 2008;
- Radiation Physics for Nuclear Medicine - Madiera Course, EC funded (Milan) – November 2008;
- Auditor training, RPII (Dublin) – May 2009;
- ADR basic training, (Dublin) – May 2009;
- ADR Class 7 specialisation course, One Photon Consultancy (Louth) – May 2009;
- Three week technical placement in Medical Physics Department, Royal Surrey County Hospital, Guildford, UK - June 2009;
- Radiological Protection Summer School 2009, IBC Global Academy (Cambridge) – July 2009;
- Court room skills: *The Expert Witness*, La Touch Legal Training (Dublin) – August 2009;
- Workshop on Incident Management, Health Protection Agency (Dublin) – October 2009;
- Legal training workshop, Harry Mooney & Co Solicitors (Dublin) – November 2009;
- Assertiveness Skills, Irish Times Training (Dublin) – February 2010;
- Safe Pass: Health and Safety Awareness Training Programme for the construction industry (Dublin) – April 2010.

Inspection witnessing

One of the requirements of the ISO 17020 standard is that the inspection body must have procedures in place to be able to assess the on-going competence of all its inspectors. To address this requirement the RPII has developed a programme of inspection witnessing whereby each inspector is witnessed by his or her technical manager carrying out a series of inspections.

In the medical sector inspections are divided into four broad categories: diagnostic radiology (including medical and dental), nuclear medicine, radiotherapy and the activities associated with the distribution of X-ray equipment and radioactive sources. Each inspector must be witnessed carrying out an inspection at least once each year and in each of the four categories at least once every three years. The technical manager for the Medical, Dental & Veterinary Section is in turn witnessed by the technical manager for the Industrial Section, and vice versa. A set of inspection witnessing audit forms have been developed which the technical manager completes as he witnesses the inspection. The competency assessment covers the entire range of activities associated with inspections, from the planning stages, though the actual inspection itself and finally the inspection reporting. In particular, the following issues are audited:

- Did the inspector plan and document all pre-inspection arrangements?
- Did the inspector bring photographic identification, his/her inspector's warrant, relevant legislation and appropriate personal protective equipment on the inspection?
- Did the inspector follow all leads in an objective and resolute manner?
- Did the inspector use an open/probing questioning style?
- Did the inspector use test or inspection equipment correctly and was it fit for purpose?
- Did the inspector investigate all areas pertaining to the scope of the inspection?
- Could the inspector answer all questions raised by the licensee?

Following each witnessed inspection the technical manager meets the inspector to discuss how the inspection went, posing a series of challenging scenarios to the inspector. Provided that the technical manager is satisfied with the inspector's performance the inspector is deemed competent to continue to inspect within that category.

This system of formal inspection witnessing ensures that all inspectors carry out inspections in a manner that is both consistent with their fellow inspectors and with the objectives of the RPII quality management system.

Conclusions

The RPII has successfully developed and implemented a formal training programme for new inspectors under its ISO quality management system. As well as providing a structured approach to training, it also provides both new staff and their technical managers a clearly defined set of training modules which are mutually agreed at the outset of the programme. The programme is flexible and can be tailored to suit the

training needs of trainee inspectors, taking account of the expertise they bring to the organisation.

In addition to the development of a training programme for new inspectors, the RPII has also introduced measures to assess the on-going competency of all inspectors through its inspection witnessing programme. This programme provides a formal mechanism where the technical competence and ability of all inspectors are assessed on an annual basis. As well as providing reassurance to the RPII it also provides reassurance to licensees that the RPII has procedures to ensure that its inspectors are performing their duties to the highest standards.

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A European survey addressing needs for safety culture training

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Abstract

Nuclear Safety Culture is a topic of paramount importance for nuclear operators as well as those working with radiology and radiotherapy. Safety culture is a combination of individual and group beliefs, values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment and the proficiency of an organization's safety management. Implementation of safety culture requires continuous and multilateral efforts involving not only technical but also human and social aspects. Many principles of safety culture are generally applicable , and could be disseminated through seminars on best practices, case studies, feedback studies, pilot sessions, etc. Such dissemination would contribute to harmonisation according to high standards, and it would promote the mutual recognition of training throughout Europe.

A consortium of 19 partners working together in a 4 year project, TRASNUSAFE, will develop and test relevant training schemes on Nuclear Safety Culture, based on an evaluation of the training needs in a European context. Special attention will be given to the links between the ALARA principle currently used in the radiation protection community and the safety culture of the nuclear industry. Two user groups, involved throughout the entire development process, will contribute to the training schedule by providing their input and feedback and by participating in the training modules.

Training needs will be assessed throughout Europe using a questionnaire to be separately developed and validated prior to the assessment. The actual assessment of training needs will make use of web based surveys, e-mails and regular mails, telephone conversations with correspondents, as well as seminars and site visits.

This paper will focus on the training needs analysis. It will explain the methodology and will give a report of the first results.

Managing medical exposure through education

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Abstract

Nuclear physics is providing medicine investigation and treatment methods of a priceless value. During over one hundred years, radiological equipment become more and more performing from the point of view of easy handling and rapid answer, quality of radiation beams and, not the last, radiation protection of operators and patients.
Physicians' enthusiasm due to these possibilities and society concern for individual health risk to transform these achievements from friends to enemies of health due to their excessive utilization.

It is important to estimate supplementary cancers expected by un-relevant computer tomography examinations but it should be more adequate to develop measures and methods for preventing transformation of these potential figures into real ones.

In this context, education could be used as a mean to present both sides of these special applications involving individuals, on one hand by public information and on the other hand by improving physicians' education.

Public education could begin even from elementary school by graduate introduction of the necessary notions to understand the specific aspects of radiation biologic effects. It could continue through mass media communication and by physicians at their surgeries.

This paper proposes to represent guidance for patients' education in order to involve them in the medical act. Being aware of radiological examinations specific aspects, people would participate more active to the implementation of individual monitoring systems.

As a result of the international actions already initiated, it is presumed that prescribes would become more restrictive when recommending radiological examinations and radiologists and non-radiologists physicians would become more aware to comply with the regulatory requirements on justification of each examination.

Introduction

Taking into account that each science progress depends of its efforts to integrate the results of other sciences, it could be noticed that medicine took an impressive advantage in the 20th century, as a result of cooperation with other sciences, such as physics, chemistry, biology, materials science, information technology.

This multidisciplinary approach determined the development of new branches, such as radiology, bio-chemistry, cell biology, etc., (attached to medicine) or medical physics, radio-biology, bio-materials, drugs production (attached to other sciences).

Medical radiation exposure

For Nuclear Physics, cooperation with Medical Sciences started in 1895, after X Rays discovery. X Rays applications for diagnosis rapidly extended (in one to three years) in all Europe and out of it and since then they have been continuously developed.
Three major directions could be identified in this expansion:

1. extension of applications in medicine by
   - using of radioactive sources (sealed and unsealed) beside Roentgen generators and electrons accelerators (in the last decades)
   - adding to radiological examination for diagnosis densitometry and interventional radiology
   - extending use of ionising radiations in radiotherapy and stereo tactic surgery.
2. technical development and improvement of equipment and data systems by developing more versatile equipment with fluorescent screen or film, image amplifier or image digitalization (with different handling and storage possibilities) and from 2D imagines to 3D (CT) or 4D. It is estimated that it was obtained a reduction of dose per examination by a factor of a few tens between the first and the last generations of radiological equipment.
3. development of regulations in compliance with the development of the extension of applications in medicine and technological development to reduce the biological risk for medical personnel and patients. Looking behind, it could be noticed that regulations implemented after the development of applications. Over 30 years of X Rays utilization in diagnosis were necessary to establish the International Commission on Radiological Protection (1928) – nongovernmental organization which suggests rules for ionising radiations utilization for protecting users against their adverse effects. Radiation protection concept appears as a definition of assembly of measures/rules for health protection and limitation of risks in radiation sources utilization after 1928. Radiation protection requirements addressed exclusively to operators of radiological facilities because they were the first persons who developed symptoms of over exposure and could be monitored during their activity.

Increase of radiological examinations procedures and extension of applications in other medical fields determined an important increase of population exposure. Medical exposure is the most important artificial source of exposure for population and it has an increasing tendency.

Consequently, the IAEA in cooperation with other international organizations introduced, in 1996, through the International Basic Safety Standards, the first requirements on patient protection that involved the importance of justifying and optimizing radiation doses.

Recent UNSCEAR estimations shows that medium dose per patient is about 200 times higher than that of medical personnel. Analyses of radiological practices in many states underlined an overuse of radiological examinations due, mainly, to medical system: lack of education in radiation protection of physicians (especially non

radiologists), poor communication between different departments/hospitals and even technical mistakes.

These evaluations determined an international action plan for radiological protection of patient, involving a number of international organizations, such as UNSCEAR, ICRP, WHO, PAHO, European Commission, International Electro-technical Commission, International Organization for Standardization, medical physics (IOMP). All these actions dedicated to reducing medical public exposure take into account solutions such as:

- new requirements of training in radiation protection of medical personnel, including prescribes
- monitoring of each exposure and recording of all examinations per patient
- implementation of a national electronic health recording system which could also be accessed by EU countries

These initiatives should be easier performed if they are completed with educational and informing programmes for patients. Educated patients should cooperate with medical staff and other involved bodies to control their own exposures, being directly interested in results.

Programmes dedicated to education of patients should be developed in cooperation with the national education system and nongovernmental organizations for social assistance. If for physicians doctors it was considered worthy to issue a"guide on the utilization of radiological examinations and imagistic procedures", an adapted guide for patients on such applications would be useful, too.

In some states these kinds of initiatives coming from medical side are already in place, consisting in dedicated websites. They could be completed by oral presentations in schools, universities and clinics. Oral presentations have the advantage of adjusting the information to auditors' level of knowledge and interest for the subject and permit dialogue with participants. They could be completed by printed documents including images and graphics, attractive and easy to understand. For some countries the websites' communications are quite restrictive and utilisation of direct communication is very suitable.

No matter how we address to the (potential) patients and their interest, we have always to answer to the same questions:

What are X-rays?
How do X-rays tests work?
What is the difference between X-rays tests?
What is the amount of radiation we receive from each of them?
How the organism responds to that amount of radiation?
What is the risk of developing cancer or other diseases from having X-rays tests?
What is the number of x-ray examinations that are advisable in one year?
What is the minimum period between two examinations?

To respond to these questions, accessible and friendly means and methods should be used, based on similitude with well known notions, such as: comparison of X rays with radio waves, light or ultraviolet rays, comparison of doses administrated in each examination with natural exposure expressed in days or months of exposure, graphics or images to compare different X ray tests.

Special attention should be given to the possibilities of minimizing risks of exposure in case of:

- repeating in short time some higher-dose X-ray tests (for example a CT scan or a barium meal or enema)
- being pregnant, or thinking you may be (your doctor and radiographer may look for other ways to make their diagnosis (If an X-ray is required in this situations, the test will either be delayed or supplementary preventive measures will be used to protect the unborn child).

Asking for a pregnancy test before having an X-ray procedure is, surely, the safest method to avoid an undesired exposure for young women.

One must know that if he/she needs to have an X-ray test soon after another one he/she would tell doctor about that. One of these examinations should be sufficient and another one would not be necessary. Patients should be educated to keep their own record on X-ray history to help medical decision.

To avoid a successively exposure due to patients movement during examination, they have to know before being tested that most X-rays and scans are entirely painless. Although a mammogram for example can be uncomfortable and for a number of scans an injection of dye into the arm is necessary, there is usually no other discomfort.

For children and their parents or accompanying persons it is necessary to be informed on special means used during the exposure if it is case, taking into account their possible reactions in unknown situations.

If a child is undergoing an X-ray test and their parents have been asked to hold him or her during examination, they have also to be protected with a lead apron.

Conclusions

- Radiology is an important method of investigation.
- Justification is necessary for each test.
- Medical stuff has to appreciate the importance of the test for establishing the diagnostic and decide when it is necessary and patients would make an option. Both medical staff and patients need information for a right decision.
- Basic education is important for both categories. If information may be required from the medical system, educational support should be provided by society.

Improving radiation protection culture: Social representations, attitudes towards risks and stakeholders involvement

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Abstract

The culture in RP is an integral part of the safety and prevention culture and it includes the complex of all those risk-based approaches chosen to set the standards and the philosophy governing those standards. The level of ambition against risk has evolved during the time on the basis of new information about the effects of radiation and considering changes of attitude towards risk. The concern on environmental protection is an emblematic example. Often it has been asked if really RP has been and continues to be a model with the capability to also influence the protection against risks of different nature than radiation, as regards to the proposed approaches in risk assessment and evaluation. In this paper the authors are proposing a multidimensional approach to the study of the RP culture by carrying out: 1) a comparative analysis of the various and different approaches which, during the past years, have been adopted in managing the technological risk both in the RP area and in other areas of technological and scientific knowledge; 2) the historical reconstruction of the evolution of the collective imagination about the possible risks connected with nuclear radiations. In the context of the modern societies, in fact, a wide range of factors of socio-cultural, ethic and political nature contribute to determine the social representations on which the attitudes to accept or to reject the technological innovation and its related risks are founded. We are convinced that by deepening the nature of the close connections of the co-evolution between the collective imagination about radiations and the different approaches to the governance of the technological risk, starting from the inclusion of different stakeholders, by also taking into consideration the lessons learned from experiences in other fields of activities, it will be possible to define useful cognitive tools aimed to strength the RP culture.

The EUTERP Platform: Towards a European approach for harmonisation in education and training for radiation protection professionals

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Abstract

In Europe, a common vision for maintaining competences in radiation protection is emerging, focussing on a common denominator for qualification of radiation protection experts (RPEs) and radiation protection officers (RPOs), and for mutual recognition and mobility of these professionals across the European Union and related countries. Started as an initiative of the European Commission the European Platform on Training and Education in Radiation Protection (EUTERP Platform) has been transformed into a legal entity under Dutch law. The Platform facilitates a permanent dialogue between all involved parties by the use of its website (*www.euterp.eu*), by issuing newsletters and by organising workshops. From the workshops several recommendations based on common agreement among the participants - were given to the EC, IAEA, IRPA and national authorities including proposals for definitions of the RPE and the RPO. Currently, the possible consequences for national legislation and E&T activities and guidance needed in relation to this proposed definitions of RPE and RPO that will be implemented in the Euratom BSS are the main focus of the EUTERP Platform. The role of EUTERP concentrates on the objectives to strengthen and harmonise education and training, and to facilitate the development of mechanisms of mutual recognition, based on a common approach. EUTERP will be provided with input from the ENETRAP II project. With these results it will: develop guidance on a methodology to compare the quality of training courses and training material; develop guidance on a standardized methodology of assessing the recognition of RP professionals as a basis for future mutual recognition, based on a description of roles and duties, education, training and work experience; develop guidance for a formal recognition process of the competences of RPEs and RPOs. EUTERP aims for being a European body on harmonisation of criteria and qualifications for and mutual recognition of RP professionals.

ENETRAP II: WP5 Develop and apply mechanisms for the evaluation of training material, events and providers

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Abstract

To maintain a high level of competency in Europe regarding radiation protection and to facilitate harmonisation and (mutual) recognition of Radiation Protection Experts (RPEs) and Officers (RPOs) quality assurance and quality control might play an important role. The ENETRAPII project (FP7-EURATOM) aims at developing European high-quality 'reference standards' and good practices for education and training in radiation protection. In Work Package 5 (WP5) the quality issue is addressed. Therefore, WP5 deals with the development and application of mechanisms for the evaluation of training material, training events and training providers by means of a transparent and objective methodology. The results can be used by regulatory authorities to benchmark their national radiation protection training programme and will be communicated to other networks, e.g. EUTERP. This paper addresses the first results of WP5: the comparison of training material. Training material is defined within WP5 as books and duplicated lecture notes.

The reference table that is developed for the comparison of training material is used to compare two Dutch text books for RPE/RPO training, and showed that the demanded content of this training is covered by both books on most of the subjects. For the remaining subjects additional material has to be used.

Introduction

The FP7 European Network for Education and Training in Radiation Protection II (ENETRAPII) project is a specific tool for EURATOM policy for E&T implementation in the radiation protection field and towards a mutual recognition of professional qualifications. The project will last three years.

Today's challenge in the field of radiation protection involves measures to make the work in radiation protection more attractive for young people and to provide attractive career opportunities, and the support of young students and professionals in their need to gain and maintain high level knowledge in radiation protection. These objectives can be reached by the development and implementation of a high-quality European standard for initial education and continuous professional development for Radiation Protection Experts (RPEs) and Radiation Protection Officers (RPOs).

For the purposes of this project the Radiation Protection Expert is defined as :

"An individual having the knowledge, training and experience needed to give radiation protection advice in order to ensure effective protection of individuals, whose capacity to act is recognized by the competent authorities."

and the Radiation Protection Officer as:

"An individual technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of the requirement of the Standards.".

These are the definitions as proposed by the second EUTERP workshop in 2008 in Lithuania and submitted to the Euratom Article 31 Group of Experts.

To reach high-quality European standards for initial education and continuous professional development, there has to be agreement between the European countries concerning the duties and responsibilities of both RPEs and the RPOs. These standards are developed in Work Packages 3 and 4 (WP3 and WP4) of the ENETRAPII project.

When these standards are known, each country will be able to access and benchmark its own education and training against the European standards. It will also be possible for a country to benchmark an RPE or RPO, educated and trained in another country, to their own national standard. Shortcomings in education and training materials, events and providers become clear, when it is possible to compare education levels and national standards to the European standard. Therefore, one of the cornerstone work packages in ENETRAPII is Work Package 5 (WP5), entitled: *Develop and apply mechanisms for the evaluation of training material, events and providers*.

WP5 has started with an inventory of topics, items and subjects that need to be addressed in the education and training of the RPE and RPOs. These main subjects are subdivided in a reference table to come to a methodology of comparison. With this reference table each country can compare its own training and education methods with that of the European Standard (WP3 and WP4).

Material

The inventory has started with the subjects addressed in the syllabus EG133 (EC, 1998), the IAEA syllabus (IAEA, 2002), the European Master's degree in Radiation Protection syllabus – EMRP - (result of WP8 ENETRAP, www.sckcen.be/enetrap), the existing tables of subjects for education and training in radiation protection and similar

tables used in different countries. This has to lead to a common reference table, which can be used to compare training material. Training material in WP5 is defined to be a text book or duplicated lecture notes.

IAEA Basic Syllabus PGEC

The IAEA basic syllabus (IAEA, 2002) can be used for post graduate students to become a qualified expert. The basic syllabus is split up in 11 modules, which cover the whole basic radiation protection. The duration of the course is 18 weeks.

Each module is divided in main subjects and these are subdivided in more detailed subjects. Only for the modules the number of hours spent is clear. For each main subject lecture notes and practical exercises are given.

EG Basic Syllabus 98/C133/03

In its communication 98/C133/03 (EC, 1998) the European Council guides the European countries in how to implement the basic safety standards 96/29/EURATOM in their own legislation. In this document the basic syllabus for the qualified expert in radiation protection is published as a list of subjects to be addressed in radiation protection training. Most of the subjects mentioned in the basic syllabus are not subdivided in detail. No information can be found about the hours spent on the different subjects, except for the statement: "the depth to which topics of the syllabus should be covered should depend on the level of advice/input required from the qualified expert". The listed subjects cover the basic radiation protection training and additional training in five different fields: nuclear installations, general industries, research and training, medical applications, and accelerators.

ENETRAP training scheme

The ENETRAP training scheme of the ENETRAP 6th FP project is based on the IAEA syllabus, the European basic syllabus, the EUTERP recommendations and other ENETRAP output. The scheme consists of different modules. The first three modules are the basic modules. Afterwards at least one additional module has to be followed, concerning the area of interest. This area can be Nuclear power plants or research reactors, waste management and decommissioning, non-nuclear research or oil and gas, medical, or NORM.

The ENETRAP training scheme modules are divided in main subjects, with the numbers of hours spent on all the main subjects. The main subjects are subdivided in more detail. It is not clear which level of education is required to enter the ENETRAP training scheme. The duration of the whole course is 42 days.

Tables of issues in radiation protection training

In the Netherlands a reference table – The first and the two last columns in Table 2 - is used since the 1980's for different levels of training in radiation protection. This table is divided in main subjects and subdivided in more detail. There are no numbers of spent hours in this table, but only a characterisation of the level of detail at which the detailed subjects are covered during the training, together with its training goal (Table 1). The advantage of using grades above hours spent on the different subjects is that the

entrance level of students doesn't have to be set. Theoretical people with different levels can enter all courses.

Table 1. Grades at which subjects are covered in training material.

grade	Covered	goal
0	not covered	–
1	global, qualitative	aware of the subject
2	important subjects covered, quantitative	understanding of the subject
3	Detailed, quantitative	detailed understanding of the subject and able to work with it

Results

Since the main subjects of the different syllabi and reference tables are more or less the same, it does not matter which table to use. The reference table of the Netherlands is used, because it was ready to use.

As explained before, in this table no hours or pages spent on different subjects can be found, but only grades, corresponding to the grades in Table 1. The advantage is that the entrance level of students does not matter, just like the number of pages spent on a topic.

This reference table will be used for the comparison of training material and for the comparison of training courses. If the reference table is filled with the demands for the RPE, RPO and radiation worker (RW), it can be used to see which material can be used for which course and when other, additional material is needed.

The reference table is applied in a comparison of training material, i.e. two text books, to determine whether this table is suitable for this purpose. The first part of the comparison table can be seen in Table 2. In the first column the main subjects and more detailed subjects can be found. In the second and third column the grade of the different subject can be found for respectively book A and book B. Both books are written to educate student in radiation protection to the same end level. In the fourth and fifth column the demands for RPE are displayed for respectively small and large 'users' in the Netherlands.

The table shows that the books cover most of the items as asked for by the government. There are some minor deviations between the books, caused by the interest of the authors.

An exception is the mathematics which is not covered by either book. Therefore, an additional book has to be used during the training course.

In reality however, there is a difference between the levels of the books. This results in the usage of book A as study material for basic level RPE in small companies or institutions while book B is used for a more advanced level for small and basic level for large companies or institutions. This is not obvious in the reference table, since this is caused by the more detailed description of the topics covered in book B.

Table 2. The first part of the comparison table of training material. Book A and book B are compared to each other and to the demands in knowledge of the different RPE functions in the Netherlands.

grade	Subjects of basic radiation protection training covered	Goal
0	not covered	–
1	global, qualitative	aware of the subject
2	important subjects covered, quantitative	understanding of the subject
3	Detailed, quantitative	detailed understanding of the subject and able to work with it

	level of competence			
	book A	book B	3 (RPE of small institutes)	2 (RPE of large institutes)
Math				
- Differentiate, integrate, differential equations	0	0	2	2
- Exponential function	0	0	2	2
- Graphs (linear and logarithmic axis)	0	0	3	3
- Statistics (distribution, standard deviation)	2	2	2	2
General physical and chemical subjects				
- Composition of the matter	3	3	3	3
- Ionisation, excitation	3	3	3	3
- Nuclide Chart	3	2	3	3
Radioactivity				
- Proton - neutron ratio	3	3	2	2
- Radioactive decay, half-live	3	3	3	3
- Decay formula and –constant	3	3	3	3
- Mother - daughter relation	3	3	2	2
- Specific activity	3	3	3	3
- α-, β-, γ-decay, electron capture	3	3	2	2
- X-rays, Auger electrons	3	3	2	2
- Decay schemes	3	3	3	3
- Particle- and energy fluence and density	2	3	2	3
Activity from natural sources				
- U- and Th-decay diagram	3	2	2	2
- Cosmic radionuclides	2	2	2	2
- Other natural radionuclides	2	2	2	2
- Cosmic radiation	2	2	2	2
- Dose due to natural radioactivity	2	2	2	2
Artificial radioactivity				
- Nuclear fission, fission products	1	1	1	2
- Nuclear reactions, cross section	2	2	2	2
- Other sources	1	1	1	2
- Dose due to artificial radioactivity	2	2	1	2

Discussion and conclusions

The reference table can be used for the comparison of training material. All main subjects of the different syllabi can be put in this reference table and can be compared in detail with regard to these main subjects. Also, the different additional modules can be put in this table. For the competencies that need to be covered in the study material a similar table can be made.

When the table is filled out with the detailed grades of subject that have to be known by RPEs, RPOs and RW, the table can be used to show which book can be used by which part of the training modules for RPE, RPO and RW.

The reference table is probably too extensive to be used for a lot of comparisons. For this purpose the table can be made more condensed by taking some subjects together.

A further study will be carried out towards the usefulness of this reference table in the comparison of training modules and towards the usefulness of a competencies reference table in the comparison of training material and training courses.

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About implementation of EU requirements on education and training

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Abstract

The Council Directives require that each Member State shall take the necessary measures with regard to teaching, education and vocational in radiation protection. Moreover, it is foreseen that each Member State shall fulfill the requirements on establishment of an appropriate curricula and recognition system of competences in radiation protection and the undertaking is obliged to provide appropriate radiation protection training and information programmes for their personnel. In order to establish a harmonized framework and to avoid overlapping with national regulation, EU strategy on establishment of a common infrastructure for education and training in radiation protection throughout the European Union should be built. It should be defined the European agreement on the qualifications for training and education and requirements for mutual recognition of the competencies. Following the EU directions, each Member State should revise the national strategy in order to establish the national training needs, the system for credentialing radiation protection programs, national policy on the selection and training of trainers and to comply with the EU mutual recognition system. Participation in EUTERP and ENETRAP meetings on this subject represents a good opportunity for sustaining these proposals.

European Medical ALARA Network (EMAN): Supporting the ALARA principle in the medical field

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Abstract

The main objective of this project is to establish a sustainable European Medical ALARA Network (EMAN) where different stakeholders within the medical sector will have the opportunity to discuss and to exchange information on different topics relating to the implementation of the ALARA principle in the medical field. This network will also support the European Commission (EC) in its activities in this field. In addition, EMAN will aim to:

- Disseminate up-to-date information about literature, studies, research and good practices relating to the ALARA principle in the medical sector,
- Identify and communicate to the EC needs for development and update of European Union guidance,
- In particular cover the areas of education and training as well as continuous quality improvement as requested in the Directive 97/43 EURATOM
- Formulate proposals to the EC on harmonization issues,
- Propose to the EC solutions of identified issues at the European level,
- Establish co-operation with appropriate international organizations and associations.

To fulfil these objectives, EMAN will especially rely on:

- Three Working Groups, where three specific topics, all deserving special attention, will be widely discussed by professionals of the medical area:

on optimisation of patient and occupational exposures in CT procedures,
on optimization of patient and occupational exposure in interventional radiology,
on radiological safety for patients and personnel in activities using X-ray equipment outside the X-ray departments,

- A website to widely diffuse the information gathered and the work done by the network and to facilitate the exchange of information within the members of the network,
- A final workshop to present and discuss the work performed in the scope of the network and of the three working groups and to propose recommendations to the EC for improving the optimisation of radiation protection in the medical sector.

EMAN – the project

On the 23 October 2009 the European ALARA network project started. The project's main objective is to create a network supporting optimisation of medical and occupational exposures in the medical sector. Methodology of networking will be studied and efforts will be spent on setting up the network to create conditions favourable for its long term survival.

Three working groups will work with the optimisation process in different areas of medical applications, for computed tomography examinations, cardiac and non-cardiac interventional radiology procedures and x-ray examinations performed outside the radiology department, respectively. Much effort has been spent on recruiting highly experienced experts to the different working groups.

The project management consists of seven organisations with different perspectives and experiences of the field. The consortium consists:

- **Strålsäkerhetsmyndigheten (The Swedish Radiation Safety Authority), SSM, Sweden**
- **Bundesamt für Strahlenschutz (Federal Office of Radiation Protection), BfS, Germany**
- **Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire, (Nuclear Protection Evaluation Center), CEPN, France**
- **European Federation of Organisations for Medical Physics (EFOMP)**
- **European Federation of Radiographer Societies (EFRS)**
- **European Radiation Dosimetry Group (EURADOS)**
- **European Society of Radiology (ESR)**

In the consortium key professions are represented such as, radiographers, radiologists, medical physicists. It is planned during the project to broaden the medical competences involved, for example with prescribers, cardiologists and surgeons. Other stakeholders having an impact or interest in the optimisation process, such as manufacturers, hospital managers or the general public, will also be involved in the project. When the project ends in 2012 the objective is to have created an independent functioning European Medical ALARA network with a large potential to expand to the various fields involving medical exposures.

EMAN – the network

There exist many types of constellations called networks. Some networks are rather unstructured driven by common interests, others with a formal structure and management. Some are sponsored by organisations and some rely on voluntary work only. In the project we will investigate and make use of experiences from other networks in order to find the success factors and an optimised structure for EMAN.

Networking relies on communication and transparency, both internally and externally. Different communications tools, e.g. on information technology, has to be used efficiently. The opportunities for exchanging information are endless today. The project must develop a strategy for what tools to use and be flexible to use new tools.

Networks, both professional and personal, exist for different topics in the medical sector, and also in the radiation protection community. The future network will collaborate with other networks and organisations. Therefore it is necessary that the network, its mission and its vision is know by the other networks. Work has to be allocated to informing about the network.

EMAN – the working groups

During the project work of specified topics is going to be performed in 3 working groups.

- WG 1 on optimisation of patient and occupational exposures in CT procedures,
- WG 2 on optimization of patient and occupational exposure in interventional radiology,
- WG 3 on radiological safety for patients and personnel in activities using X-ray equipment outside the X-ray departments.

Each working group, in its special field of medical activity will:

- Collect up-to-date literature, on-going clinical studies and current reports concerning good practises on optimisation of radiation protection for patients and workers.
- Identify needs for development and update of guidance on optimisation of RP for patients and workers.
- Identifying needs and collect proposals to improve the European legislation on radiation protection in these medical fields.
- Contribute to the elaboration of the final workshop.

These working groups are also functioning to experience how collaboration and work can be performed in the future.

EMAN – the website

The EMAN website has been created at the beginning of the project with two main objectives:

- Facilitate the effective and efficient information exchange between the members of the network.
- Provide information to concerned stakeholders on the life of the network and on topics linked with ALARA in the medical field.

The web portal is organized into different sections. First of all, a specific section describes the objectives and the organisation of the network, and makes available a list of the network's members. Each of the Working Groups created in the scope of the network has a dedicated web page, where information on the work of the Working Groups will be found. Links to appropriate websites and to international organisations and associations cooperating with EMAN are also provided. After the final workshop of the project, the abstracts and slides of the oral presentations as well as the conclusions and recommendations will be made available.

The website will be regularly updated with news concerning the work undertaken by the network, publications, regulations, etc. related with ALARA in the medical field.

In order to collect information on the potential interested members of the future network, it is possible for any interested persons to register on the web site to the project newsletter which will be published regularly, as well as to register to a specific directory giving the names and contact of other interested persons.

EMAN – the workshop

In spring 2012 a European workshop is going to be arranged with the aim to widely diffuse the information gathered and the work done by the working groups and by the network in general and to facilitate the exchange of information within the members of the network. This workshop will also be an opportunity to draw and disseminate conclusions and recommendations from the network as well as to elaborate and discuss further actions to be made by the network.

EMAN – the future

The rapid change introducing new equipment and examinations is a huge challenge for all involved in the medical sector. A consequence of the increasing demand on productivity is that the optimisation process needs to be efficient. To have an efficient optimisation process will be very important but very demanding. More than ever it will be important to exchange experience and to share information in this field.

We believe that EMAN will contribute positively in this field; we have to work further on the methodology and gather experience from others and also listen to colleagues and interested parties in order to create an attractive network.

EMAN – contact information

All information can be found on the web site: **www.eman-network.eu**

Acknowledgements

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Thinking about stakeholders and safety culture in the ionizing radiation medical field

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Abstract

This works treats about:

1. The need to have a well built radiation protection frame not only from de scientific and technical point of view but from that of the organization and the stakeholder perception.
2. The importance of knowing how to relate and communicate to:
   Regulators
   Organization Directors
   Exposed and not exposed workers
   Patients
   People; media; judges and lawyers.
3. The need to improve and maintain the safety culture.

Conclusions:

- A deep built radiation protection organization system maintained and actualized is needed.
- The radiation protection experts must have a continuous training related to technical radiation protection aspects and how to communicate to stakeholders.
- The safety culture must be a part of the quality assurance program with a systematic incidents' review and the spread of the measures taken to minimize the appearance of errors.

Introduction

In relation to the majority of other risk agents presents in our actual society the ionizing radiations (IR) are one of the most studied and known ones. The justification, optimization and limits system is logic and a well built system.

Though many things should be susceptible of harmonization, the expert's language is understandable and common between them. Magnitudes, calculation units and so on, are well defined and there are plenty of reference organism publications and guides to support that. But, when we go into the social field the issue gets complicated and we go into other world with more and not so well defined variables. So we can say that if we are good experts but we do not control the play rules in every case, we are not doing our work well enough.

Nowadays, and after great efforts, the IR Medical Physics and the related RP , is included into the Health Sciences field specialities like that of medical doctors under the name of "Radiofísica Hospitalaria" (RFH) and his activity is developed in: Radiotherapy. Radiology, Nuclear Medicine and laboratories that use IR, including in, all these areas: The patient, workers and public RP.

The RFH title is obtained passing an exam similar to that of medical doctors, but referred to physics, and three years (we are asking for four actually) working at one hospital with a Health Ministry Accredited Teaching Unit.

The RI Spanish legislation that applies to heath field, is numerous and systematically updated [1, 2, 3, 4, 5]. The quality is contemplated in three laws, divers national quality protocols related to: Radiotherapy, Radiology and Nuclear Medicine and a dynamic Health Forum with participants of the: Two reference Spanish societies; Medical Physics (SEFM) and RP (SEPR) and so of the CSN (Regulator Organism). Looking at this we can say that the frame to support and develop the system is solid.

Material and methods

Our "Radiofísica y Radioproteccion" Service is integrated by seven RFH, five technicians and a secretary, but we have to work also at centres outside the hospital with Nuclear Medicine in two of them and plenty of RX units.

The actual philosophy of our hospital, concerning to RI field, is to get the ISO 9001/2008 certification. Our service and the Nuclear Medicine one have already gotten their certificate. Radiotherapy and Radiology Services are in process to achieve it this year. Besides that way, the hospital got, last year the 14001 Certification for environment.

Our certification is referred to:

- Patients, exposed workers and public RP.
- Physical and clinical dosimetry.
- Equipment quality control
- Radioactive installations management.
- RFH Teaching Unit.

Our "Radiofísica & Radioproteccion" Service is integrated by: Seven RFH , five technicians and a secretary, but we have to work also at centres outside the hospital with Nuclear Medicine in two of them y plenty of RX units.

The Service Head has, also, the RP Responsible title according to CSN requirement.

Results and discussion

Thinking about, a good ISO Organization, we must have efficient and practical procedures for:

- Making appropriate technical reports within the legal framework and to enable its compliance.
  Giving a rapid and scientific response in "special" situations, incidents and accidents.

Radiophysics and RP procedures should be indicated as a reference for medical services mentioned above; and a good management of the whole system must have an active role in the development and implementation of quality programs.

With respect to RP training programs for all workers exposed to ionizing radiation, there is a national program for physicians who are doing their specialty. This training is based on a 6-hours course that is organized by the RFH and RP services in each hospital. The course is mandatory for most medical specialties and it carried on during the early days after their incorporation to the hospital. In addition, for those who are more concerned with IR, there is 4-6 hours more of training. Those who are working in: Radiology, Nuclear Medicine and Radiotherapy have a 50 or more training hours which includes a course approved by the CSN. Technicians and some nurses of these services also have an accreditation or license granted by the CSN.

We believe that in order to have an effective system, day by day, there is a need for continuing education in open, practical, and enabling participation sessions and seminars without forgot interdisciplinary meetings in critical situations.

To organize and actively participate in all this is a very important job in the role of the RFH and RP Services.

The information of unexposed workers, patients and people who contribute to his comfort and the information associated with critical situations has to be translated from a technical language into something understandable and that built up confidence in the auditorium.

It is very important to disable the unfounded and unreasonable fear for radiation and prevent, in some cases, the use of this fear to obtain unjustified "collateral benefits", but, at the same time, we must properly listen to the stakeholders in every circumstance and know their problems and perceptions. We must answer to them in an understandable language but without losing the technical foundation. It must seem truthful.

We must avoid the use of RP for other purposes. For instance, the porters, who transfer patients to RX services for radiological probes, said that they wanted personal dosimeters like the ones the technicians have. We organized briefing session for them and we realize, they felt something pejorative when we said they are classified as common public. We had to make clear all about the limits for the public and so on.

Information to patients and caregivers also has its own characteristics. It is important that the information shall be contained in clear and brief notes adapted to each set of circumstances but, at the same time, there should be an open communication line to resolve particular questions (this often occurs in the case of patients receiving radiopharmaceuticals, pregnant women etc).

Excessive exposed and unexposed workers IR fair may create situations of improper alarm or confusion. For instance, in a hospital, the Patient Care Service received a complaint letter from a father who accompanied his young son in a big common room in the Intensive Care environment area because he observed that when the RX technician went into the room to make a radiography to another baby he shouted ¡¡ RAYS!! And then all the staff leaved the place running. It is necessary that, in such situations, both, the technician that manage the RX equipment and the rest of the professionals act properly and inform the family that at a certain distance of that RX equipment, a person does not receive any measurable radiation.

It is obligatory to have visible written rules, but the process requires something more: To keep an open contact with the workers periodically; to collect impressions and feed back and to take into account the different perceptions, mainly for new workers.

Concerning Media issues related to external events, the SPR must have appropriate minimum information but the issue can be channeled to reference scientific societies experts well prepared for that.

With respect of internal issues, we have to act quickly but with the security that technical data provides.

There are two kinds of media: The scientific and documental and the "daily" one. In the first case we have time and possibility to use a logical and technical treatment of the problem. The real challenge is to manage the second one. It is frequent to listen something that "good news are not news" and " the bleeding news are more engaging for the auditorium". Then the RP experts should prepare themselves for that, because another kind of response and attitude is required.

In relation to lawsuits, the "linear not threshold hypothesis" can generate problems, if the judge finds that any microsievert can be carcinogenic, even if the RP system is correct and according to the norm.

If a negligible amount of radiation can have this consideration, the system ALARA would not support itself, and workers and those present in the radiation facility would have an excessive weighting factor and unjustifiable risk considerations. We must give an appropriate weight to radiation and not create unfairness to other agents.

We must add that the Radiation Protection Service should work together with the Occupational Risk Prevention and the hospital Health and Safety Commission in which there are trade union representatives who must be informed.

National and international organizations (ICRP, IAEA etc) have a great concern for the safety of radioactive sources. It is necessary to efficiently organize the safety of equipment and radiation sources in RT and MN. The safety of patients in RT is based on a good quality program that affects to equipment, facilities and treatments. All interdisciplinary team: Medical doctors, RFH and technicians must know their work very well, case by case, and they must interact appropriately between them in each patient.

Open communication, progressive incorporation of well informed new workers, regular sessions and good incidents follow up is essential.

This approach can be adapted to nuclear medicine and radiologic therapeutic interventional procedures.

Conclusions

- A deep built radiation protection organization system maintained and actualized is needed.
- Radiation protection experts must have a continuous training.
- The Clinical Medical Physicist; Qualified Expert in Radiological Protection, should include, into his skills, the relation with a broad stakeholders field.
- Each stakeholder group has to be listened and well considered but each special problem must be, always, managed under the suitable technical framework.
- The ionizing radiation workers need to be well informed and protected but shouldn't be treated better than other workers with similar level of risk

- The safety culture must be a part of the quality assurance program with a systematic incidents review and the spread of the measures taken to minimize the appearance of errors.
- A well informed media could be one of the best paths to spread the radiation protection
- Adequate Conduct Code (IRPA, IAEA, Montbeliard[6] … should be incorporated to the practice.

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Better evidence-based quality in radiographic imaging by e-Learning?

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Abstract

The change from film-screen radiographic imaging systems to digital imaging systems has brought vast challenges in medical imaging services. Firstly, new general guidelines and working models optimising the radiation dose and image quality are needed.. Secondly, the challenge derived from the first one is to update the competence of the staff working with imaging units and to train the new health care personnel so that their competence could match the needs of the new technique.

The project's purpose is to increase the competence of staff working in imaging units by evidence based education in digital imaging, and dose optimisation according to the principles of the ICRP and DIMOND3 in the three Scandinavian countries: Finland, Sweden and Norway. The specific objectives of the project are to:

1) Plan and implement Scandinavian evidence-based course in digital imaging and dose optimisation, and the materials needed on the basis of national and international regulations about the subject in 1st, 2nd and 3rd cycle education degree and life long education,
2) Produce the materials for the education and
3) Evaluate the evidence-based course plan in quality of digital imaging and the materials produced.

The project management group consists of radiography lecturers, principal lecturers and physicists of College University of Gjøvik - Norway, Karolinska Institutet - Sweden, University of Oulu –Finland, Oulu University of Applied Sciences – Finland and Helsinki Metropolia University of Applied Sciences – Finland. Also students of these organizations are involved in the project from very beginning.

The project is realized between autumn 2008 and spring 2011. In the presentation the main results of the project tills summer 2010 are presented.

Introduction

The change from the film-screen (conventional) radiographic imaging systems to digital imaging has brought great challenges in medical imaging services. Firstly, general new guidelines and working models optimising the radiation dose and image quality of radiographs. Secondly, the obvious challenges derived from the first one are to update the competence of the staff working with imaging units and educate the new health care personnel who are in the middle of their studies to match the needs of the new technique.

According to the studies (e.g. Al Khalifah & Brindhaban 2004), lower levels of radiation dose setting can be established for computed radiography (CR) systems than the standard values used for film-screen systems to produce diagnostic images of equal quality. This is especially important in the examinations performed for children (Livingstone et al. 2008). Flat panel detectors (so called direct radiography, DR) gives even more possibilities for dose reduction and still gives at least as good image quality as with CR (e.g. Willis & Slovis 2004; McEntee M et al 2006; ICRP 93 2004) At the European level, European Councils Directives about radiation protection define at least the minimum criteriafor quality of imaging services (Directive 84/466/, 96/29/ and 97/43/Euratom). The Council Directive 97/43 Euratom defines Quality assurance as ‘’all those planned and systematic actions necessary to provide adequate confidence that a structure, system, component of procedure will perform satisfactory complying with agreed standards.’ The latter part of the Directive describes more specifically the general principles of radiation protection. At the moment Radiation Safety Authorities in all the Scandinavian countries are working on to make national guidelines for digital imaging taking account both the quality assurance and dose and image optimisation. They do this in co-operation with universities and Universities of Applied Sciences that are educating health care personnel who use radiation in their work.

Guidelines and working practices in radiography must be done systematically by using research findings and best available evidence as the basis. Evidence based medicine (EBM) has been defined as ‘the conscientious, judicious and explicit use of current best evidence’ in clinical decision making (Sackett et al. 1996). In studies in the radiography area, in addition to the concept *evidence-based radiography* (Keenan et al. 2001; Ebrahim 2005), also terms such as *evidence-based medical imaging* (e.g Smith 2008), *evidence-based practice* (e.g. Pitt 2004; Pickersgill 2007), *evidence-based clinical practice* (Bonnetti et al. 2006) and *evidence-based medical practice* (e.g. Omorphos & Kontos 2003; Banerjee & Van Dam 2006) are generally used.

In this project, our purpose is to increase the competence of staff working in imaging units by evidence-based education in digital imaging and dose optimisation according to the principles of the ICRP and DIMOND III in the three Scandinavian countries: Finland, Sweden and Norway. Targeted objectives are to: 1) plan and implement Scandinavian evidence-based course plan in digital imaging and dose optimisation and the materials needed on the basis of national and international regulations about the subject in 1st, 2nd and 3rd cycle education degree and life long education. 2) produce materials for the education and 3) evaluate the evidence-based course plan in quality of digital imaging and the materials produced.

The project unifies the Scandinavian knowhow in the radiography field in different levels of professional and adult education. It also fosters the professional

status of the radiography education and radiography science. The competence of imaging units staff working in hospitals, health centres and clinics will be developed in a area of digital imaging and dose optimisation. As a result of this, quality of digital imaging will be developed and radiation doses of the patients will be lowered.

Material and methods

Organization of the project

The project group consists lecturers (radiography and physicists) and principal lecturers in higher education institutions. They give first cycle Bachelors level (juvenile and adult) and second cycle Masters level education in radiography and radiotherapy in three Scandinavian countries. From Finland the network includes two Universities of Applied Sciences, from Sweden one University and from Norway one University College.

The steering group of the project consists of the members of Radiation protection Authority in Finland (STUK), Oulu University, Finnish dentists association Apollonia and member of Finnish Research Society of Radiography.

The projects' working principles and ee-learning philosophy

The project group meets approximately once a month in a web conference via Adobe Connect Pro (ACP) videoconferencing system, and twice a year face to face. Mean while the project group members work in the Moodle-platform in the web. The project group uses evidence-based way of working: seeking consensus of peers, experts and member of radiation protection authority, making literature surveys, taking into account national and international guidelines about digital imaging quality assurance and radiographers competency and consulting the radiography departments' staff. Also radiography students take part the project. They prepare some contents and learning material for the e-based course, comment and test it. They work in a co-operation with the multimedia technology students preparing technical solutions for the course.

The learning philosophy of the course was chosen in the beginning of the project on the basis of the basic idea of the project, which is to learn evidence-based radiography. At first the core competencies of the course module were formed on the basis of literature survey (e.g. Medina & Blackmore 2006; Cronin 2009 a and b; Kelly 2009 a and b), national (STUK 2004) and international recommendations (e.g. DIMOND III 2003; ICRP 2004), critical views of project group members and experts. On the basis of core competencies, the core contents of the learning modules were derived. On the basis of core competencies and core contents, learning technological solutions were chosen. This means that the mode of learning is mainly chosen according to the substance to be learned.

Timetable of the project

The project started in autumn 2008, and it operates for two years, untill autumn 2011. During the autumn 2008 and spring 2009 the project organisation and common principles of action were formed. The Scandinavian project group had its first meeting in Helsinki in December 2008. It started planning the core competencies of the evidence-based course plan for the juvenile level. During autumn 2009 the core

competencies and some of the learning material became ready. Also the first part of the course module was tested in Helsinki University of Applied Sciences. During spring 2010 the curriculum and learning materials for the Bachelor level was finished and tested. Experiences of those were collected and used for revision of the course. The group also started planning the core contents and learning materials for the Masters level course.

During autumn 2010, the project group will finish the Masters level educational package and test it in Oulu University and Metropolia University of Applied Sciences (Masters Programme in Clinical Expertise). During the spring 2011, the project aims to make PhD level course ready, and if possible, also to test it at least by some radiographers having their PhD studies in the Scandinavian Universities. Also the final evaluation of the learning materials and evidence-based course plan in quality of digital imaging will be performed. In the summative evaluation the aims of the project are compared to the achievements of the project. Also unintended results of the project are evaluated. The value of the educational program for the needs of the working life is asked (theme interviews for key persons at the imaging units) and evaluated. (see e.g. Frechtling et al. 2002)

Results

Evidence-based radiography is a learning philosophy as well as learning contents of the project. This is to say, evidence-based radiography is learned by evidence-based method. In evidence-based learning philosophy, the research evidence and other best knowledge (e.g. national and international guidelines and recommendations) combines with the technical and clinical experience of the student, his/her peers and experts. E-based learning fits to this kind of learning philosophy very well. That is why the project group started to call it ee-learning.

As a result of the project groups' evidence-based way of working described in Materials and Methods section of this article, ten core contents and respective themes of the learning module were formed for 1st cycle Bachelors level education. These were: 1) The basic concepts, methods and process of evidence-based radiography, 2) Decision making in radiography, 3) Technical Quality Features of Digital Images, 4) Visualizing the important information of the image in an optimal way, 5) Applying demands for positioning and collimation for digital radiography, 6) Managing digital radiographic equipment, 7) Applying diagnostic requirements in projection radiography, 8) Applying post processing techniques to improve diagnostic image quality, 9) Assuring and optimizing image quality, and 10) Motivating multiprofessional way of working and documentation. When defining core competencies and core contents of the learning module, it was taken into account that they apply European Qualifications Framework level six adopted by the European Council on 23 April 2008. The EQF is a common European reference framework, which links countries' qualifications systems together, acting as a translation device to make qualifications more readable and understandable across different countries and systems in Europe. (European Council 2008)

It was also defined core contents for each theme based learning module. As an example core contents for the theme 'The basic concepts, methods and process of evidence-based radiography' were defined as follows: The student knows concepts, principles and purpose of evidence-based health care, recognizes the phases of

evidence-based radiography, is able to differentiate between sources of evidence, knows what are the most central health care databases, knows how to use scientific databases correctly, knows how evidence-based knowledge is applied to the decision making and development of radiographic practice, is able to make narrative reviews, is able to read and understand systematic reviews and recognizes the connection between radiography science and evidence-based radiography.

Core contents for learning module ‘ Technical Quality Features of Digital Images’ were defined as: The student applies Fryback´s and Thornbury´s model of the efficacy of diagnostic imaging, understands the dilemma technical vs. diagnostic image quality, applies basic properties of a digital image: features relating to (technical) image quality (contrast, noise, geometric distortions, artefacts), and effect of exposure settings (kV, mAs, filtration, grid use….) and object positioning on image quality.

From the viewpoint of e-learning, the project applies mixed mode setting. Individualized self-paced e-learning is used online e.g. when the students search for evidence-based knowledge about the quality assurance (QA), and offline e.g. in learning dose area product measuring (DAP-meter). Also the modes of group-based e-learning synchronously (e.g. videoconference lectures and face-to-face meetings on the web) and asynchronously (e.g. in discussing about problem cases in QA via Wiki-based IT technical solution) are used.

Discussion

Working in a multinational and multiprofessional project group has been very interesting and challenging. It took for half a year for the project group to form a common view about what is quality assurance in digital imaging and how it should be defined in this project. This difficulty came up because radiographers responsibilities in quality assurance differ in Finland, Sweden and Norway. We had to find out what are the central competencies radiographer in all these countries should possess. A great help in this work was achieved through literature reviews and discussions with peers, experts and radiation protection authority. We also had to define the basic level presupposed when the students enter the course. It was defined what the students should know about evidence-based radiography and digital imaging quality assurance before starting this course. Although half a year in a two years project is quite a lot, as an experience we would say that it was a right thing to do. After having a clear view about what to do, the rest of the project is just to do it.

Project group works mostly at the web by using the Moodle platform and Adobe Connect Pro (ACP) videoconferencing system. At first, using the Moodle was a bit difficult at least for those who were not familiar with it. We had not clear user’s instructions in English language, which caused that the learning method was consulting each other and trial and error. After some difficulties in the beginning, the Moodle proved to be quite a handy platform of working in this kind of project. The ACP videoconferencing system suited also very well for the work. Seeing each othe’s faces and hearing the speech is quite different from just communicating via text. It gives a sense of belongingness to the project group and this can and was in our project been seen straight as a productivity of the project group.

Radiography students of the higher education institutes taking part of the project were involved in it at the early phase. The project was integrated to their studies. The

students reported that they liked a lot studying in this kind of 'real' project, although it was sometimes very challenging. They learned many kind of things while doing the project: evidence-based way of working, English language, digital imaging quality assurance, problem solving skills, team work and project management. The students wrote articles about their working at the project and took part project groups'work in face to face and ACP meetings.

As the parts of the learning module were tested with the radiography students, it was reported that most of the students had difficulties in understanding the English vocabulary. However they felt that the content of the course was mostly easy. There were some difficult concepts, which needed clarification. A large part of the students hoped that the course would be in Finnish or at least have an English-Finnish dictionary for the difficult words. The course will continuously be tested by radiography students as well as by radiographers working at the hospitals. It will be revised according to feedback received between the testings.

The project group will translate the course to national languages after the project will be finished. The course has been built up to the Moodle in a way that it can be transferred to other web based platforms. This is necessary because higher education institutions use different platforms in their e-based teaching and there is no point bothering the students to learn the use of new platform for one course. Instead of it they can concentrate on learning the contents of the course.

So far the project has proceeded approximately in its timetable and reached its' objectives. The project produces common Scandinavian understanding about what is evidence-based radiography and digital imaging quality assurance. As unintended outcome of the project, R&D networking on the area of radiography among Scandinavian countries has got some impetus, which we hope, will continue.

Conclusions

As a result of the project, a learning module consisting of ten core contents and respective themes for evidence based digital imaging quality assurance was formed for 1st cycle Bachelors level education. The learning module also comprises learning material and learning tasks. In the multinational and multiprofessional quality assurance project one of the most challenging things is differing responsibilities of radiation using staff. This will become easier in the future as the national guidelines for digital imaging will be developed. According to the experience of this project evidence and e-based way of working is very useful to develop new applications in the field of radiation use quality assurance. Ee-learning has also proved to be a useful learning philosophy in radiography.

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Monte Carlo based PCXMC-program as a tool of learning dose optimisation in plain (project) radiography

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Abstract

Effective dose can be defined for X-rays as the sum of the weighted average absorbed doses in all the tissues and organs of the body. International Commission on Radiological Protection (ICRP) has produced a list of tissue weighting factors for a number of organs and tissues. The calculation of effective dose is based on the Monte Carlo technique or direct organ dose measurements. PCXMC is a widespread and well tested Monte Carlo program for calculating patients' organ doses and the effective dose in medical X-ray examinations. The anatomical data is based on the mathematical hermaphrodite phantom models of Cristy (1980). The program computes doses in freely adjustable x-ray projections and other examination conditions. The program describes patients of six different ages: newborn, 1, 5, 10, 15 -year-old and adult patients. Radiographer students calculated effective doses to patients of different age and changed technical parameters one by one. They analysed the results and compared their own result to those found in literature. With PCXMC it is also possible to evaluate the risk to the patient due the x-ray examination and compare the difference in organ doses calculated based on the data of the ICRP publications 60 and 103. The students have found out the benefits of PCXMC in dose optimisation. It is easy to point out, what kind of changes have to be done and how much the changes help to decrease the dose.

Introduction

It is well known that ionising radiation may course harms. From stochastic point of view, there is no evidence at present of a threshold to the radiation dose below which there is no risk. The probability - but not the severity - of stochastic harm increases along with increased dose. In addition, the latest studies have indicated that there may also be effects on the lower levels and consequently the optimisation of an individual dose is important. (Hall et al 2004, International Commission on Radiological Protection 103 2007.)

The effective dose was developed by ICRP to reflect the fact that some organs are more sensitive than other organs. They have a higher risk of producing a cancer or another deleterious effect. The effective dose also helps in evaluating the biological effects of radiation (International Commission on Radiological Protection 103 2007).

The effective dose is the sum of the effective doses for exposed organs. The calculation of these doses requires knowledge of the size and configuration of the individual, the geometrical projection of the beam, size and location of the primary and scatter beams, Entrance Surface Dose and x-ray beam energy spectrum. The radiation quality factor is needed because of the different biological effects when interacting with tissue. For x-rays, the quality factor is unity (Lampinen 2000), which according to International Commission on Radiological Protection 74 (1997) and Marttila (2002) means that the effective dose can be defined for x-rays as the sum of the weighted average absorbed doses in all the tissues and organs of the body. The unit is Sv (Sievert). International Commission on Radiological Protection has produced a list of tissue weighting factors for a number of organs and tissues and they are mean values for the whole population. The factors were published first time in Publication 16 (1970), re-evaluated in Publication 60 (1991) and once again in Publication 103 (2007).

. The calculation of effective dose is based on the Monte Carlo technique described in NRPB-R186 (Jones, Wall 1985) or direct organ dose measurements by TLD (McCollough, Schueler 2000). The anatomical data in PCXMC is based on the mathematical hermaphrodite phantom models of Cristy (1980), which describe patients of six different ages: newborn, 1, 5, 10, 15 -year-old and adult patients. PCXMC is a widespread and well tested Monte Carlo program for calculating a patient's organ doses and the effective dose in medical x-ray examinations (e.g. Tapiovaara et al. 2000, Geijer et al. 2001, Tort et al. 2001,Dimov, Vassilieva 2002, 2002, Hansen et al. 2003, Uffam et al 2005). The height and weight of the patient can be set from a real patient. All organ doses calculated by PCXMC relate to the patient entrance air kerma (free-in air, without backscatter) at the point where the central axis of the x-ray beam enters the patient. The datum can be obtained by combining data on the examination techniques and the radiation output of the x-ray source or by using the surface dose or Dose-Area Product measurements of actual patient examinations. (Tapiovaara et al. 1997, Tapiovaara et al 1999, Tapiovaara, Siiskonen 2008.) This enables the calculation of the effective dose related to the x-ray field size and provides a technique for monitoring the collimation of the x-ray field.

Material and methods

The concepts like absorbed dose, entrance surface dose, Dose Area Product, organ dose and equivalent and effective dose are first discussed and clarified. The PCXMC program is introduced to students by two hours lesson and demonstration. After that the students practice by them selves to calculate the doses according the given examples in small groups for two hours supervised by the lecturer. They calculate first dose to an adult person and then the perceptions are discussed with the whole group. The aims of this part are at first to make the program familiar with the students so that they understand the concepts used in PCXMC program and secondly that they can use the program independently in a correct way.

After that the students get the written tasks. First they calculate doses for five patients in some examination. This data has been collected earlier in clinical practice for the ESD (Entrance surface dose) calculation. Next they pick up one patient and calculate doses changing parameters one by one. The changed parameters are: Tube potential (kV), added filtration, height of exposed field, width of exposed field,

projection (ap /pa), age and focus to skin distance and finally both kV and mAs (e.g. kV from 70 kV to 80 kV and from 20 mAs to 10 mAs to keep to dose on the same level). Students evaluate the effect of changes to the whole body effective dose and organ doses organ by organ. They also have to calculate effective doses to a new born, 1, 5, 10 and 15 years old child in one examination e.g. chest ap. The risk analyses are made based on some of those calculated effective doses. The PCXMC program calculates the whole body effective dose according to tissue weighting factors from ICRP 60 (1991) and ICRP 103 (2007). It is easy to find e.g. the differences in effective dose between female and male with the same dose as well as the correlation between the risk and age.

The students write also a report in pairs about what they have done and found. The results and observations must be compared to those from literature at least with ten scientific articles. They also have to evaluate and reflect their own experiences and learning outcomes as well as how to use the program later in clinical practice.

Some examples of these reports are shown and the students own learning outcomes has been analysed by content analysis method.

Results

The students understood the basic concepts of the PCXMC program during the two hours lesson and demonstration. The two hours training in small groups clarified the concepts and the students could after that session use the program correctly in order to calculate doses. In small groups the students had different examination (chest, pelvis and lumbar spine ap (anterior-posterior) and pa (posterior-anterior). the results were discussed and there was a lot of discussion about the differences and how to transfer them to clinical practice. The next tables will demonstrate one student's calculations in adult patient's chest examination (Table 1).

Table 1. Five patients in chest examination used in calculations.

	Length	Weight	kV	mAs	BMI	ESD (mGy)
Female	170	55	125	1,26	19.03	0.07
Female	178	80	125	1,73	25.24	0.11
Male	175	86	125	1,79	28.08	0.11
Male	166	60	125	1,08	21.77	0.07
Female	164	77,6	125	1,65	28.85	0.1

All patients are adult. BMI is body mass index calculated from the patient's height and weight. The ages varied from 23 to 55 years.

Table 2. Organ doses and effective doses according to ICRP 60 (1991) and ICRP103 (2007) for five patients introduced in table 1 calculated with PCXMC program in chest examination.

Organ	Dose (mGy)				
	Female 179/55	Female 178/80	Male 175/86	Male 166/60	Female 164/78
Bone marrow	0.009411	0.010732	0.010377	0.007748	0.010495
Breasts	0.008188	0.008722	0.008362	0.006013	0.007866
Colon	0.000241	0.000271	0.000354	0.000287	0.000506
Lungs	0.025360	0.031904	0.030964	0.021119	0.029790
Heart	0.012914	0.014500	0.013495	0.009985	0.013336
Thyroid	0.003530	0.004531	0.003427	0.003492	0.003874
Effective dose ICRP60 (mSv)	0.007070	0.008187	0.008047	0.006305	0.008884
Effective dose ICRP103 (mSv)	0.007849	0.009013	0.008939	0.006516	0.009112

The results in Table 2 show that effective dose is dependent of the patient's size and there is difference in doses calculated according to the ICRP 60 and ICRP103.

Table 3 shows differences in doses with same patient with different technical settings. In chest ap / pa it is easy to find the benefit in pa projection both in organ doses and in effective doses. Most important difference is in the dose of breasts and active bone marrow. Also the thyroid dose decreases in pa projection although it was not in the primary beam. The effective dose in chest ap is increasing more with the ICRP 103 weighting factors due the change in breasts factor. Added filtration decrease all doses and Cu more than aluminium. Higher tube potential and lower mAs decreases also all doses.

Change in the size of exposed area decrease patient dose also: two centimetres smaller area in height gives 18 % decrease in effective dose. Distance is also one parameter influencing to patient dose. With 30 cm longer distance from the x.ray tube focus to patient's skin, the dose to patient is lower and in digital imaging the mAs and kV can be on the same level, the image quality is still equal.

Table 3. Doses to one adult female patient in chest examination calculated with PCXMC program with different parameter settings (on the first row the basic dose with 125Kv, 3mmAl, FID 200cm, 125kV, 2,4 mAs, in others only documented parameter has been changes from the basic settings**)**

Parameters	Average dose in total body	Effective dose mSv (ICRP 60)	Effective dose mSv (ICRP103)	Breasts mSv	Lungs mSv	Active bone marrow	Thyroid	Oesophagus
Pa	**0.014488**	**0,016581**	**0,018372**	**0.017273**	**0.065154**	**0.021996**	**0,005304**	**0.037316**
Ap	0.014182	0.023271	0.029565	0.107345	0.055809	0.012905	0.008714	0.028139
Filtration +2mmAl	0.011650	0.013596	0.01506	0.014530	0.052790	0.017851	0.004491	0.031598
Filtration +1mmAl+0,1Cu	0.010305	0.012232	0.013608	0.013378	0.046896	0.015943	0.004156	0.029293
kV135, mAs1.2	0.008726	0.010116	0.011221	0.010731	0.039393	0.013369	0.003296	0.023265

The students also make risk assessment with the program. Figures 1 and 2 show the difference in risk with same dose and age between male and female. The risk is very small due one chest pa projection but, as seen, female has higher risk. Due to one chest x-ray a female has loss of life expectancy is 0,3 hours and and male 0,1 hours. In other risks the male has higher rate.

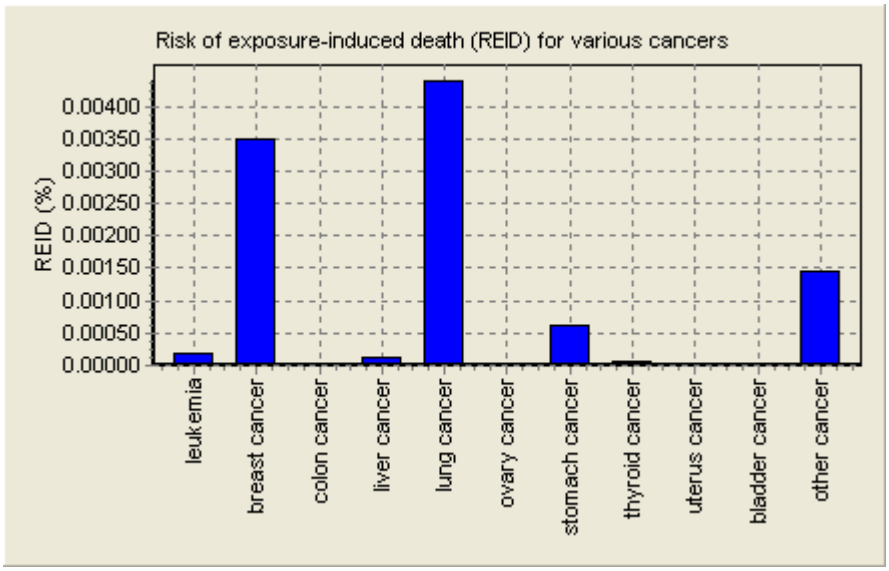

Figure 1. Radiation risk assessment: Stochastic radiation risks (Finnish mortality data). 20.0 year-old female, Expected length of remaining life 59.5 years, Risk of exposure-induced cancer death (REID): 0.000176 %, Cancer mortality for other causes; not related to this exposure 17.1 % , Loss of life expectancy (LLE): 0.3 hours.

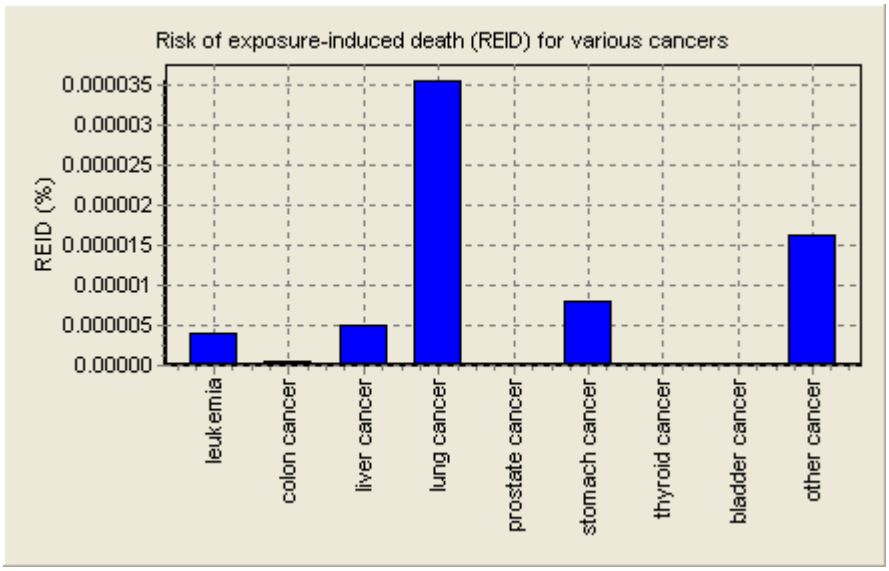

Figure 2. Radiation risk assessment: Stochastic radiation risks: Finnish mortality data, 20.0 year-old male, Expected length of remaining life 52.9 years, Risk of exposure-induced cancer death (REID): 6.95E-5 %, Cancer mortality for other causes; not related to this exposure: 20.1 %, Loss of life expectancy (LLE) 0.1 hours

The younger the child is the higher is the risk. It is also possible calculate cumulative risk due to many x-ray examinations.

Discussion

The PCXMC program can be used as a new tool to evidence the effects of the technical parameters and projection view to the patient dose. There are several examinations which can be taken either as an ap or pa projection. In dose optimisation it is easy to calculate both organ doses and effective dose and compare the difference between them and make the decision based on the evidence based results. It is also possible to calculate the dose to a foetus, if needed, especially during the first half of pregnancy (Perisinakis 1999, Kettunen 2004).

Tube potential (kV) affects to the contrast of the image. With higher kV the radiation beam is more penetrative and may for that reason cause loss in image quality especially in soft tissues and ribs (Uffman et al 2005). They used the PCXMC program to evaluate the effective dose and image quality with different kV levels (90, 121 and 150 kV) and as a conclusion they recommend lower kV at a constant effective patient dose.

Most x-ray equipment has possibility to use different added filtration in x-ray tubes. The effect of added filtration has been evaluated by Hamer et al (2005) and they pointed out about 31% reduction in ESD with 0,3 mmAl Cu-filtration. Decrease in effective dose can be found also in effective dose with PCXMC program.

PCXMC evaluates also the risk to the patient due the x-ray examination. As well known the children are more sensitive to radiation than adults (Paile 2002, ICRP 2000). There are also some special groups among small children and young people, which are frequently x-rayed, e.g. a child with scoliosis, heart problems, vesico-uretal reflux etc. Also premature babies might be exposed tens or even hundred times during the first

living months. The risk assessment may give more evidence for the dose optimisation. (Kettunen et al 2003, Kettunen 2004., Servomaa, Kettunen 2005.) The program reports the risk as a loss of life expectancy or as a cancer mortality. The program shows also the cancer mortality due to other risks and that gives perspective to risk assessment.

The new detectors offer a good possibility for dose reduction. It is still quite difficult in clinical practice, because the more radiation is used; the better is the image quality. (Correa et al 2008,Geijer et al 2009.) The staff get more motivation to dose and image quality optimisation when they notice the effect of the change to the patient's dose. The students reported a lot of possibilities to use PCXMC program to demonstrate how to optimise dose and what is the effect of each technical parameter or direction of the projection. It is amazing to find out how small changes can effect so much to the patient's dose.

Conclusions

The students have found out the benefits of PCXMC program in dose optimisation. It is easy to point out, what kind of changes have to be done and how much the changes decrease the dose. Also the meaning of critical organs clarifies. The age –dependence in risks due to ionising radiation can be demonstrated as Students analyse their findings and compare them to the results of scientific articles published during the last years.

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Radiation protection of the staff in operating theatres

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Abstract

Purpose: The universal features of the safety culture are individual awareness of the importance of safety, knowledge of competence, commitment, motivation, supervision and responsibility. In Finland nurses and medical doctors are allowed to use the c-arm in operating theatres and emergency rooms. The purpose of this study is to point the key factors affecting to the radiation protection and safe use of mobile c-arm in operating theatres and emergency.

Methods and materials: About 40 courses (1,5 ects) concerning the safe use of mobile c-arms have been given to nursing staff all over Finland. The course consist of 5 areas given in EU legislation: Fundamentals of Radiation Physics and Radiation Biology, Radiation Protection Provisions, Radiation Safety Measures at the Workplace and Procedures Involving Exposure to radiation. In demonstration all features of that c-arm are shown step by step. In the end of the course there is a written exam and more than 1300 answers have been analysed for this research.

Results: About 80% of the participants passed the test in first exam and only 1% needed third exam. Mostly participants are nurses but also some medical doctors and other staff. According to this study the most difficult areas are the basic concepts: radiation and it's features, effects of radiation at the molecular, cellular and tissue levels, deterministic and stochastic effects of radiation and their identification, radiation user's organization, dose motoring and categories A and B and what they mean in everyday work, controlled and supervised areas and monitoring of radiation exposure of workers. The operational radiation protection is quite well known.

Conclusion: During the courses there has been discussion about factors influencing the interpretation of fluoroscopic images procedures exposing children and pregnant women to radiation. The nursing staff is very willing to involve to good safety culture. More hands on training is needed to the nursing staff.

Radiation protection training in the Joint Research Centre of Ispra

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Abstract

The Joint Research Centre of Ispra, one of the research Sites belonging to the European Commission, Directorate General JRC, was created in the late '50s, in order to steer European research on nuclear industry. It hosts numerous nuclear facilities, some of which are maintained in operation, while others were shutdown in past years, namely: two research nuclear reactors, hot cells facilities, radiochemical laboratories, one Cyclotron (still in operation), facilities for studies on fissile material (in operation), and some facilities for the treatment and storage of liquid and solid waste (in operation). The JRC accounts for 21 nuclear licences, 14 Controlled Zones and 12 main Surveilled Zones, on its Ispra Site. The Radiation Protection Sector has developed, during the last years, a new approach for training in Radiation Protection: this includes an improvement and extension of the traditional classroom-based training to Exposed Workers, and:

1. the generation of new training modules on radiation and radiation risks, specifically addressed to non-exposed Personnel;
2. on-the-job training to newcomers and Radiation Protection Officers;
3. development and operation of mock-up facilities for specialized training (glove boxes, high contamination areas, etc.).

Evaluation of training effectiveness has also been modified and enhanced. Moreover, the need for a more comprehensive set of "education and training" actions in the field of Radiation Protection is becoming a priority, in Italy, due to the reduced availability of competent Technicians in the Radiation Protection market. The JRC-Ispra is currently studying the possibility to re-evaluate its training offer to the market, in order to further improve, according to its mission, the dissemination of technical and scientific knowledge in this field.

Radiation protection related teaching in Estonia and using of web-tools

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Abstract
This paper will provide a time-line overview of the progress on teaching of radiation protection in Estonia following the 1991 declaration of independence. We will address several important factors and the means which promoted the teaching, and give the overview of different tools used for that. Also it is our intention to share the experience in order to facilitate the learning process.

Introduction
The Republic of Estonia (area of 45 227 km², population of 1.34 million) is situated in North-East of Europe, on the eastern coast of Baltic Sea. Estonia regained its independence in 1991, which created a need for changes in many areas, including radiation protection. During the Soviet period there was research in the field of nuclear physics and nuclear-related courses were taught at the universities. However there were no courses in Estonian universities about radiation protection or nuclear safety.

After regaining the independence a sudden need appeared to build up the radiation protection system in the country. Also taking into account the heritage sites – nuclear submarine training centre and uranium mining and milling facility, there was need for educated people. The first radiation protection courses were taught at the University of Tartu. These courses were addressed mostly to the students of environmental physics and were based almost entirely on the environmental radiation. Soon the courses concerning the use of ionizing radiation in the medicine followed. During the last decade the scope of the courses taught at several universities has been widening, so that currently the topics covered are wider and the courses are addressed for the several specialities.

From late nineties the radiation protection course is taught also in the Türi College of University of Tartu, where most of the environmental specialists of Estonia are educated. Türi College is a relatively small institution, which actually has only one curriculum – Environmental Regulation and Planning. Taking also into account that Türi is a small town (population of about 6000) situated in the middle of Estonia, without any research facilities, national environmental institutions or big universities, qualified lecturers usually will be available only during the lecturing course for three to

four days. However the college has good technical facilities, including the special web-teaching rooms for students with good internet connection. Considering this, and also the lack of teaching materials available in Estonian language, the main radiation protection lecturers at the Türi College decided after almost 10 years of teaching to develop the web-based teaching tool.

Material and methods

Developed web-based teaching course is basic radiation protection course, which is part of the required curriculum for Türi College students. However the same course is available also for other students of Tartu University on optional basis, if they care to travel to Türi. There are no special requirements to students in order to enroll, however some knowledge about mathematics is useful. The course aims to provide the knowledge of basic principles of radiation protection, and to give the ability to assess some easier cases including activity estimation or simple shielding calculations for radioactive sources. At the end the student should also have understanding about the sources of ionizing radiation, biological effects caused by ionizing radiation and principles of the nuclear energy. The course covers also terminology and units used in radiation protection.

The Blackboard Learning System (Blackboard Inc, 2010) was used in preparation of the web-based course. The Blackboard Learning System is a web-based server software platform, which features include course management, a customizable open architecture, and a scalable design that allows for integration with student information systems and authentication protocols. Its main purposes are to add online elements to courses traditionally delivered face-to-face and to develop completely online courses with few or no face-to-face meetings. The options available in the system include for example announcements, discussions, mail, calendar, learning modules, assessments, assignments, media library, etc (Fig. 1). Regarding the quite specific terminology used in radiation protection, that students may not be familiar with, one of the most useful application in Blackboard system is the Glossary. Course developer can insert new terminology into the Glossary and particular word in the teaching material will become a hyperlink, clicking on which results a new window opening with the particular explanation from the Glossary (Fig. 2 and 3).

Fig 1. Student view of a learning material about III generation nuclear reactors. On the left side is visible the list of Blackboard capabilities used in this course.

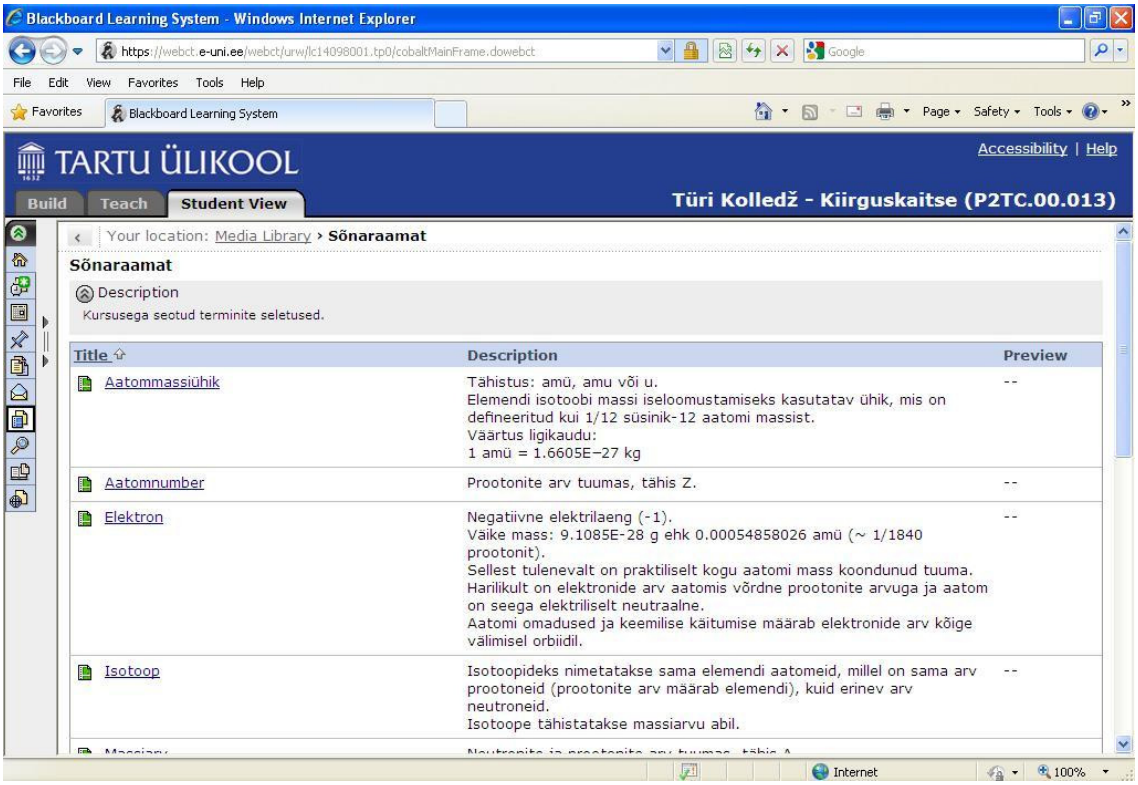

Fig 2. Example of a Glossary application.

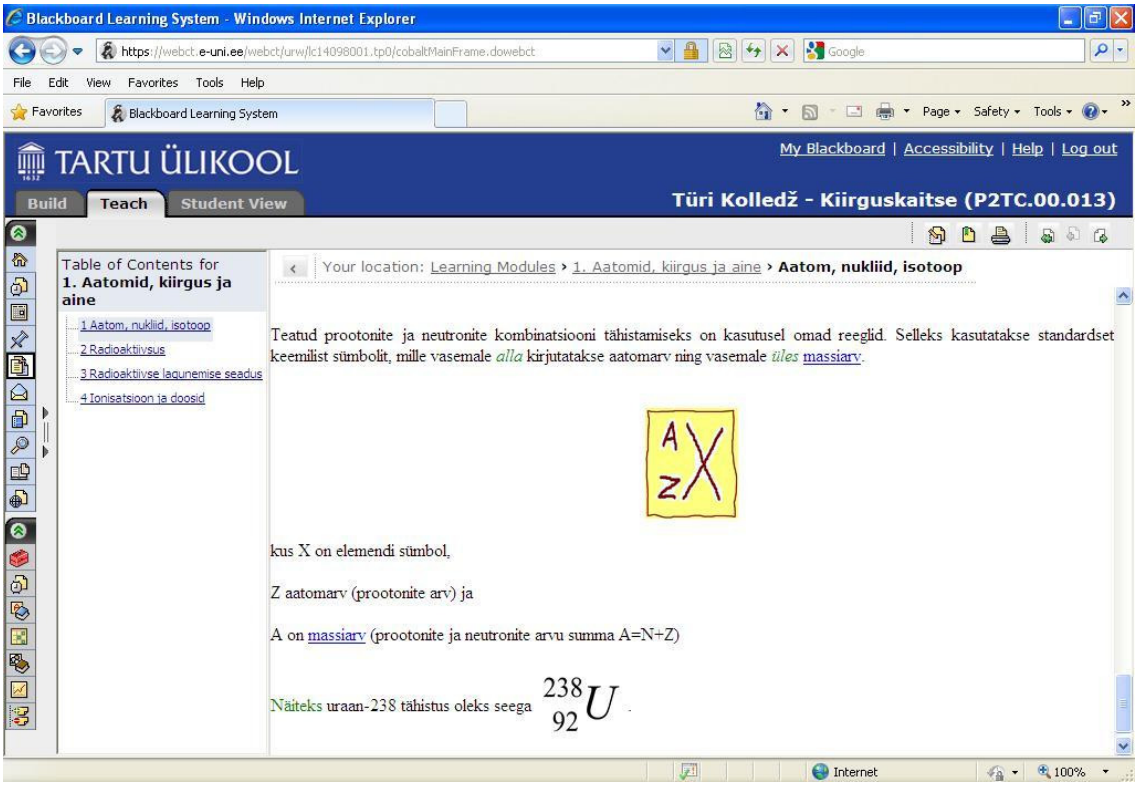

Fig 3. Example of teaching material. As you may see the word "*massiarv*" is automatically formated as a hyperlink, because it is defined in a Glossary seen on Fig. 2. On the left side of the screenshot is visible the Table of Contents for the first chapter of the course.

Results

The web-based teaching tool helps to facilitate better interaction between the lecturer and students while residing in different regions of Estonia, and also provide them learning environment with additional information. The preparation of current web-based course was started in spring 2009, it was finished and tested first time in autumn 2009. The prepared web-based basic radiation protection teaching course consisted of 6 learning modules:

1. Atoms, ionizing radiation and dosimetry

   Giving an overview of topics like: atom, nuclide, isotope, radioactivity, radioactive decay law, ionization and dosimetry.

2. Natural and man-made radiation sources

   Consisting of: environmental radioactivity, decay chains, radon, internal radiation, uses of radiation sources, medical radiation, industrial applications of ionizing radiation, results of nuclear weapons testing, accidents.

3. Biological effects caused by ionizing radiation

   Which includes: biological effects of ionizing radiation, four stages of the interaction between ionizing radiation and human cells, DNA and direct and indirect effects of ionizing radiation, deterministic and stochastic health effects, cancer development, hereditary effects, acute radiation syndrome.

4. Nuclear Energy

   Giving an overview of: nuclear energy and radioactive waste management, pressurised water reactors, boiling water reactors, III generation reactors, fuel cycle and waste, radioactive waste jurisdiction, releasing radioactive waste into the environment, liquid, solid and gaseous radioactive waste, used nuclear fuel, decommissioning.

5. System of Radiation Protection

   Covering the topics of: history of radiation protection, organizations, main principles of radiation protection, justification, optimization, limitation, national radiation protection system.

Different materials and experiences gathered were used in preparation of the course. One of the main supporting materials was booklet "Radiation, People and the Environment" (Lust *et al* 2006*,* Wrixon *et al* 2004). The book, which was produced by the IAEA in close co-operation with the UK National Radiological Protection Board, provides a broad overview on the subject of ionizing radiation, its effects and uses, as well as the measures in place to ensure it can be used safely. It also discusses the benefits and risks of practices that use such radiation in medicine, industry and energy production and considers some topical concerns about environmental pollution, waste management, emergencies and transportation safety. The book was translated and published in Estonia in 2006.

The course is usually held in the autumn semester. The course calendar will provide the exact dates for the assessments, assignments, lectures and exams. The teaching will be held as mix of the auditorial work and self-based work online, the course will start with introductory lecture. Each learning module provides explanation of the topic with a lot of illustrative material – photos and schemes. Considering that basic radiation protection course consists mostly of new information to read, different colours for text were used to make it easier for the student. Additionally each learning module has assessment and assignments. The assessments (Fig. 4 and Fig.5) were usually organized in self-testing form and consist of questions or calculation exercises. In order to pass the course the student has to do all the assessments. Most of the supporting materials were provided online. The final step will be passing the exam, which can be done online as well. This has been also quite an important feature in order to provide the security for the results. After collecting the information from the learning modules provided in the course, the result was booklet consisting of 111 pages.

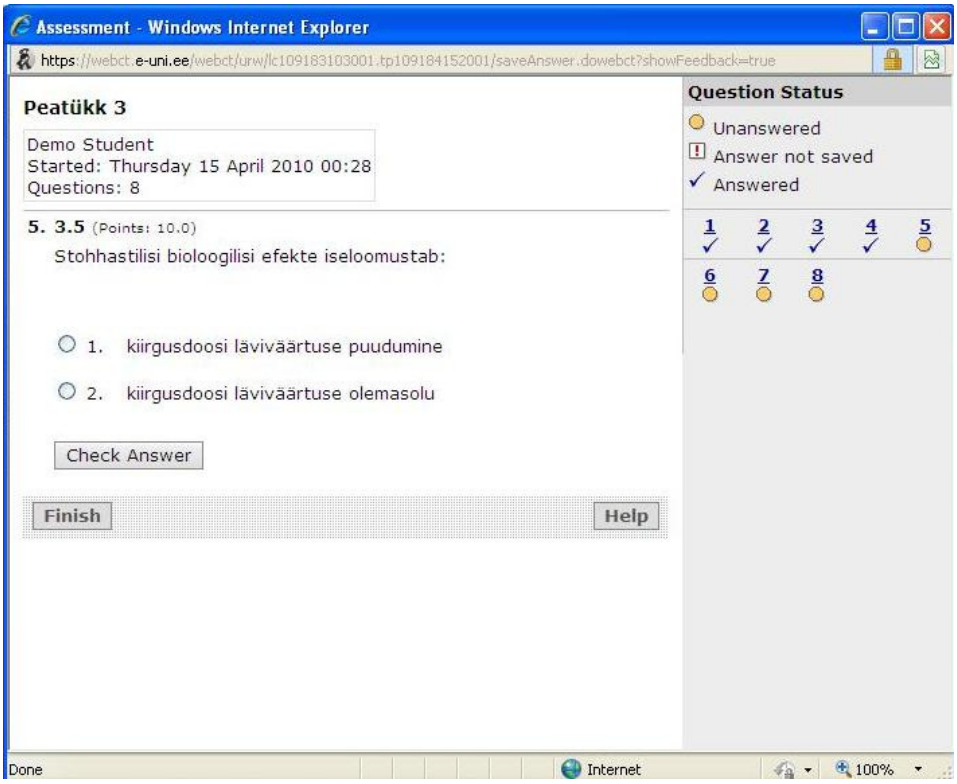

Fig 4. Example of a multiple-choice type self-assessment test. Questions are taken randomly from the question-bank filled by the teacher.

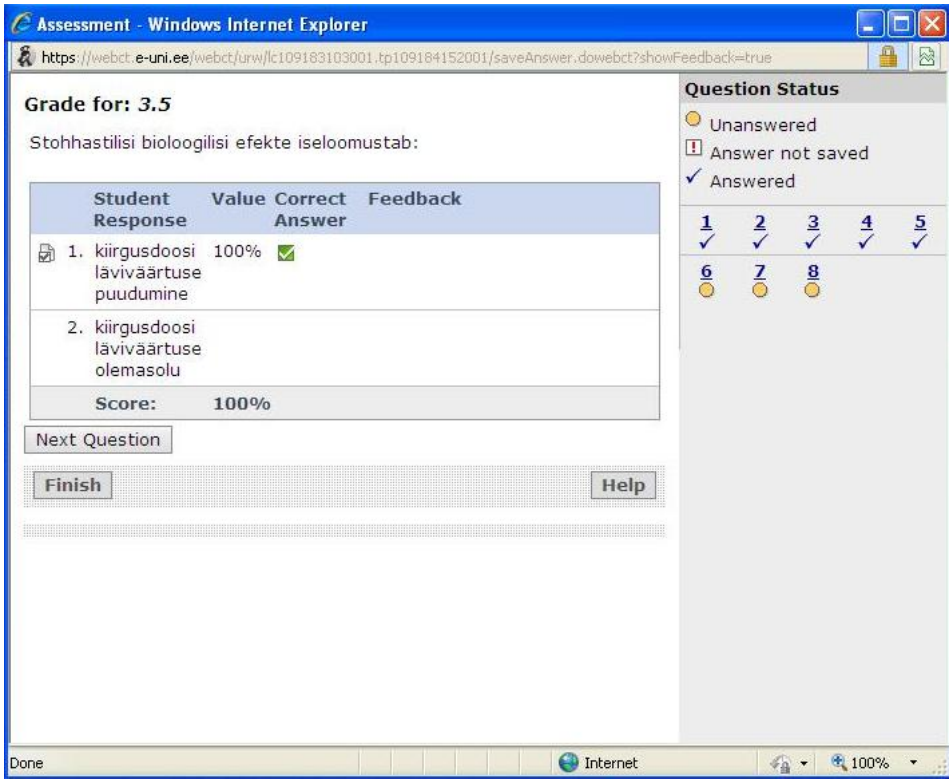

Fig 5. Instant feedback for the student that the answer to the 5th question on the self-assessment test was correct.

Discussion

Around year 2000 started the first courses for the users of radiation sources. Most of the first courses were organized through international co-operation projects, but during the years there has been teaching of the local trainers. This has lead to the situation, where basic radiation protection education for the operators can be provided by local experts. Estonian Radiation Protection Centre (since February 2010 known as Radiation Safety Department of Environmental Board) has facilitated translation and publication of several radiation protection related publications and has used its web-pages as a tool for providing the information. Now additionally the information gathered through preparation of the course can be used and published for wider public as well.

Other future applications and expansions of such a course may also relate more closely to nuclear energy. Taking into account the vision approved by the Parliament in June 2009, which lists the nuclear development as one of the possible future scenarios, there is a great need for education in nuclear safety. University of Tartu and Tallinn Technical University have started the preparation of nuclear safety and nuclear energy master course. The first students are supposed to be admitted in the autumn of 2011. The prepared course can be used in the curriculum of these master courses as well.

Conclusions

Estonia started building up the radiation protection infrastructure a bit more than 10 years ago. There was no clear governmental mandate and no accompanying support training system to start with. During the last decade the remarkable steps have been made in providing the information related to radiation protection to the public and also in preparation of the specialists at the universities. There is still much work to do, however using the technical tools available, the current human resources can be used much more wisely. The web-based course prepared last year passed the first test successfully and it also provides a good platform, which can be used in several occasions.

Acknowledgement

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Radiation protection education and training activities at the Belgian Nuclear Research Centre SCK•CEN

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Abstract

The scientific world of radiological protection (RP) is in constant motion, triggered by new research as well as by developments and events in the daily industrial and medical sectors. In addition, national and international regulatory policies try to streamline and guide daily practice along procedures that guarantee the protection of workers and public, and that at the same time also ensure optimization of all peaceful uses of applications of radioactivity. Harmonization and coordination are in this sense of the utmost importance, not only 'on the work floor', but also with regard to education and training (E&T). Within this spirit, the international school for Radiological Protection (isRP) of the Belgian Nuclear Research Centre SCK•CEN participates to several E&T activities: SCK•CEN experts lecture several courses within existing academic programs, and give guidance to Master and PhD students in the framework of their thesis. We also organize courses on a wide variety of RP topics for professionals of the nuclear and medical sector and - in parallel - we aim to play a role in national and international policy through active participation in several European networks.

Introduction

The Belgian Nuclear Research Centre SCK•CEN was created in 1952 in order to give the Belgian academic and industrial world access to the worldwide development of nuclear energy. It is a Foundation of Public Utility, with a legal status according to private law, under the tutorial of the Belgian Federal Minister in charge of energy. Since 1991, the statutory mission gives priority to research on issues of societal concern such as safety of nuclear installations, radiation protection, safe treatment and disposal of radioactive waste, fight against uncontrolled proliferation of fissile materials and fight against terrorism. The Centre also develops, gathers and disseminates the necessary knowledge through education and communication, and provides all services asked for in the nuclear domain (by the medical sector, the nuclear industry and the government). Today, about 630 employees advance the peaceful industrial and medical applications of nuclear energy, and realize a turn-over of about 85 M EURO.

Thanks to its thorough experience in the field of peaceful applications of nuclear science and technology, the Belgian Nuclear Research Centre SCK•CEN has garnered a reputation as an outstanding centre of not only research, but also education and training. SCK•CEN is an important partner for training projects in Belgium (to the nuclear sector, the medical and non-nuclear sector), as well as at the international level (IAEA, EC, …). The Centre's know-how and infrastructure are available for education and training purposes. One of the research topics that is strongly developed at SCK•CEN's Institute for Environment, Health and Safety, is radiation protection. From years of experience and recent knowledge that results from the latest innovative research, an extensive range of course modules has grown. Our courses are directed to the nuclear industry, the medical and the non-nuclear industry, national and international policy organizations, the academic world and the general public.

Academic collaborations

SCK•CEN experts are involved as lecturer in several academic programs, at Belgian and foreign universities and technical universities. They also deliver contributions to courses set up on specific occasions such as the courses given in the framework of ENEN, CHERNE, WNU, etc.

Radiation Protection Expert

Together with XIOS Hogeschool Limburg, ISIB and IRE, SCK•CEN organizes the Radiation Protection Expert course, given in Dutch and in French. This course broadens the scientific and technological basic knowledge of radiological and nuclear techniques with special attention for practical radiation protection. It is aimed at professionals working with ionizing radiation, in all sectors. The program is in line with the legal requirements of the Belgian Royal Decree of July 20 2001, mentioning the prerequisites for accreditation as Radiation Protection Expert by the Belgian Federal Agency for Nuclear Control. SCK•CEN collaborators contribute to the Dutch course, for 96 of the total 120 hours.

Guidance of PhD students

In a conscious desire to increase its pool of highly specialized young researchers and to tighten the links with the universities, SCK•CEN embarked in 1992 on a program to support PhD candidates and post-doctoral researchers. Since 1992, about 100 students started a PhD in collaboration with SCK•CEN and more than 50 post-docs joined our Centre. Today, about 35 young scientific researchers perform their work in research fields that reflect the priority programs and R&D topics of SCK•CEN, about half of them are working within the field of radiation protection.
Next to this, SCK•CEN experts also work with Master students, and even high school students (sixth year) have the opportunity to use our laboratories and other infrastructures in order to perform scientific experiments to support there thesis work.

Training courses for professionals

Training courses of the international school for Radiological Protection of SCK•CEN cover a very broad offer. Different modules are foreseen as a "standard", but in

principle all our courses are tailored to the specific needs, field of operation, and level of the trainees.

Basic modules

The course series *Background and Basic Knowledge* collects general and more specific technical courses on radiological protection. The series consists of seven modules and provides the theoretical and practical knowledge required for implementing technical aspects of radiological protection in a medical or industrial working environment, both in the daily practice and in the management in the long term:

- Basic principles of nuclear physics
- Interaction of radiation with matter
- Radiation and dose measurements
- Biological effects of ionizing radiation
- Gamma spectrometry
- Standards and legislation
- ALARA and safety culture

Referring to questions such as *'what is radioactivity?'*, *'how can we use it?'* and *'how can we protect ourselves against it?'*, the series starts with an introduction to nuclear physics that is then linked to a practice-oriented part on radiation and dose measurements and spectrometry. The module on biological effects of ionizing radiation presents an understanding of the effects of high and low level doses of ionizing radiation on the human body. The series is completed with a state-of-the-art overview of standards and legislation and a rationale on ALARA and safety culture, including a demo session with virtual dose assessment software tools.

When composing a custom-made program, the course could start from this basic series, but some modules may be omitted and other more specialized modules can be added upon request.

Specialized modules

The *nuclear and radiological expertise modules* are follow-up modules that fit in directly with the basic course series, but provided sufficient foreknowledge, they may be taken separately. The series addresses technical practice-oriented issues with a link to radiological protection and relies fully on the nuclear expertise of SCK•CEN. The series include amongst others:

- Transport of radioactive materials
- Radon and increased natural radioactivity
- Ethical aspects of the radiological risk
- Management of radioactive waste
- Internal dosimetry assessment from bioassay measurements
- Quality assurance in nuclear safety
- Decommissioning and dismantling techniques
- Good safety practices in controlled areas (practical training)
- Organization of emergency planning
- Misuse of radioactive materials: prevention and response (safeguards)
- Radiochemistry

Practical exercises and visits

In the course programs, lectures and practical training sessions can be alternated with visits to relevant laboratories and installations of the SCK•CEN. These technical visits enable to enrich and illustrate the participants' acquired knowledge with the practice of 'real-life' situations, as well with regard to safety culture in controlled areas, as the techniques and know-how of the applications of radioactivity as such. SCK•CEN installations and laboratories that can be visited include:

- BR1, the 'natural uranium – graphite – air' type research reactor;
- BR2, the high neutron flux material test reactor;
- BR3, the first prototype Pressurized Water Reactor in Europe, and the first now in dismantling phase;
- The HADES underground laboratory for waste disposal research;
- The radioactive decontamination wing of the medical services;
- The emergency planning and follow-up room;
- The whole body counter laboratory (antropogammametry);
- The radiobiology and microbiology laboratories;
- The radioecology laboratories;
- The nuclear calibration services.

Practical organization

The international school for Radiological Protection is based on the site of the Belgian Nuclear Research Centre SCK•CEN in Mol, Belgium. The regions of the municipality of Mol and the adjacent municipality of Dessel have a historical concentration of nuclear activities of more than half a century, hosting research, nuclear fuel fabrication and waste treatment and storage.

All installations and labs that are taken up in the list of possible technical visits are located on the SCK•CEN site. On request, the course lectures can also be organized in the SCK•CEN offices in Brussels, or at the venue of the trainees, eventually completed with technical visits to laboratories and installations on the technical domain of SCK•CEN in Mol.

Lecturers

Among the isRP lecturers are technicians, physicists, biologists, medical doctors, engineers and social scientists who all bring insights and ideas from their specific background into the course programs. As SCK•CEN staff members, they have a solid knowledge and experience in their field, and can thus directly transfer their theoretical knowledge and practical experience into the various courses.

Transdisciplinary aspects

Understanding the benefits and risks of radioactivity requires technical insight and training, but also an insight in the context and a sense for the social and philosophical aspects of the situation. isRP concentrates on how to integrate this transdisciplinary approach in education and training programs.

In cooperation with the SCK•CEN PISA group (program of Integration of Social Aspects into Nuclear Research), isRP has build up experience with the theory and practice of participation and involvement in technology assessment and has set up a

course module on ethical aspects in radiation protection. On various occasions, the two groups organize round tables, workshops and focus groups with schools and local communities, and this on topics such as medical applications of radioactivity, (nuclear) energy policy and radioactive waste management.

Policy support

The implementation of a coherent approach to education and training becomes crucial in a world of dynamic markets and increasing workers' mobility. Through networking and participation in international programs, SCK•CEN contributes to a better harmonization of education, training practice and skills recognition on a national and international level.

Covering electricity production, medicine and several activities within the non-nuclear sector the spectrum of applications of ionizing radiation is very wide. Although working with a variety of responsibilities and specific professional aims, practitioners have a triple common need:

- basic education and training providing the required level of understanding of artificial and natural radiation,
- a standard for the recognition of skills and experience,
- an opportunity to fine-tune and test acquired knowledge on a regular basis.

From an executive perspective, education and training are undoubtedly the two basic pillars of any policy regarding safety in the workplace. The radiological protection rationale that serves as the basis for this policy is the same all over the world, going beyond cultural differences and disciplinary applications. In this sense, the implementation of a coherent approach to education and training in radiological protection becomes crucial in a world of dynamic markets and increasing workers' mobility.

Through networking and participation in international programs, SCK•CEN aims to contribute to a better harmonization of training practice and skills recognition on a national and international level. In this frame, specific issues of interest to SCK•CEN in general and the isRP in particular are the standard requirements for course programs and educational material, the development of transdisciplinary training programs, e-learning and distance learning, the link between radiation safety and conventional safety, the organization of experience feedback, international exchange of knowledge and experience and the sharing of lecturers, training facilities and educational source material. These are the topics covered in European networks such as EUTERP (European Training and Education in Radiation Protection Platform – www.euterp.eu) and ENETRAP (European Network for Education and Training in Radiation Protection – www.sckcen.be/enetrap2), in which SCK•CEN is playing a prominent role.

Nuclear Training Centre experience in radiation protection culture

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Abstract

This paper aims to present Nuclear Training Centre (CPSDN) Romanian experience in education and training in order to achieve the required competences in radiation protection with a view to future recognition within the EU countries.

Carrying further education and training activity started with almost 50 years ago by the Institute of Atomic Physics and University of Bucharest-Faculty of Mathematics and Physics, CPSDN organized over 750 programs and trained more then 18500 participants.

For each of these programs, CPSDN take into account the following objectives:

- provide adequate training for workers, for radiation safety officers and specialists
- comply with the authorities regulatory requirements
- develop syllabus for general education, specialized training courses and upgrading programs in compliance with CE RP 116 and IAEA recommendations for the groups of professionals that have been identified
- contribute to the national radiation protection infrastructure
- establish the necessary mechanism and to provide appropriate administrative support, qualified and experienced trainers, practical demonstrations and exercises
- cooperate with national organizations developing activities in the field, for example the Romanian Radiation Protection Society, University of Physics, research institutes, main stakeholders.

Being concern by the continuously improvement of its services, CPSDN applied for TUV-CERT certification for the quality management system according to ISO 9001/2000, in 2007.

Introduction

Placed between the Faculty of Physics and the National Institutes of Research and Development for Physics in Magurele Platform, Nuclear Training Centre is developing post secondary school and post university training of the personnel involved in the nuclear field and/or in related areas, contributing, through its activity, to the human

resources development and to the implementation of research results of "Horia Hulubei" National Institute of Physics and Nuclear Engineering and the other institutes from Magurele Platform.

Established through the Decision of Ministers Council No. 148/1970, Nuclear Training Centre (CPSDN) assumed the organization of the post university specialization programme entitled "Courses on the Utilization of Radioactive Isotopes" (CUIR), initiated since 1956 by the Institute for Atomic Physics (IFA) in cooperation with the Faculty of Mathematics and Physics of Bucharest University.

Organized as legal unit under the authority of the State Committee for Nuclear Energy (CSEN), CPSDN has yearly developed training methods suitable for the tackled applications, by categories of degrees of responsibilities in radiological safety assurance, such as: training courses, qualification and post qualification courses, post secondary school and post university specialization courses, endorsement and accreditation courses, managers dedicated courses. Training programmes curricula were permanently adjusted both to the technical upgrading of the envisaged fields and to the growing regulatory requirements.

As an illustrative example is the programme for the non destructive examination area entitled "Industrial Nondestructive Testing", which was organized during 1973 – 1989; it has been upgraded in methods programmes, starting with 1980.

In the medical field the initial "Radioisotopes and Radiation Applications in Medicine" programme has been upgraded and several programmes were developed, such as: "Radiation Protection in Radio Diagnostic Practice", "Protection of Patient and Operators from Nuclear Medicine", "Radiation Protection in Radio Therapy Practice", etc., dedicated to physicians and/or nurses.

Required themes approach envisaged not only participants' information but also their formation as specialists in the related practice by the development of a correct understanding of the physical basic aspects and an individual attitude for the field promotion.

CPSDN constantly benefited of the scientific potential of Physics Institutes from Magurele Platform cooperating with specialists within IFA as lecturers and using the laboratories for the practical applications.

Since 1996 CPSDN has been developed its activities as a Department of "Horia Hulubei" National Institute of Physics and Nuclear Engineering (IFIN – HH).

This kind of organization facilitated CPSDN's access to the IFIN – HH laboratories and specialists.

During 1970 – 2009, CPSDN contribution for training and specialization of personnel involved in practices with radiation sources and advanced physics techniques could be resumed as it follows:

~ 780 training programmes

~ 19.000 graduates.

Main training activities

Taking as reference the technical international bodies recommendations such as ICRP publications, IAEA Basic Safety Standards, European Directives, at the national level the Law No. 111/1996 on the safe deployment, regulation, authorization and control of nuclear activities, republished, was adopted. National Commission for Nuclear

Activities Control, the Romanian regulatory and control body in the nuclear field, issued the Fundamental Norms for Radiological Safety (NSR 01) and other norms requiring the specialization of the staff at the level of operators and mainly at the level of coordinators, with responsibilities in the assurance of radiological protection for population, environment, professionals, patients in medical applications. As the radiological protection aspects were the most significant requirements, CPSDN organized different kind of training envisaging the utilization radiation sources under radiological safety conditions in a specific practice. During the last period the following training programmes are constantly developed:

1. Radiation Protection on the Utilization of Measurement Systems with Radiation Sources
   - Participants are secondary school and university graduates involved in the management or operation of gauges with radiation sources or X fluorescent analyzers, electronic microscope, etc.
   - Schedule: 40 hours, Licensed by CNCAN for the level 1 (licence at operators level)
2. Radiation Protection on the Utilization of Radiological Facilities for Packages Control
   - Participants are secondary school and university graduates operating facilities for packages control (post office, customs, airports, army, etc.)
   - Schedule: 30 hours, Licensed by CNCAN for level 1
3. Radiological Safety in Uranium and Thorium Mining and Milling
   - Participants are university graduates developing activities in the field of uranium and thorium ores mining, processing, transport
   - Schedule: 90 hours. Licensed by CNCAN for level 2 (licence for persons with responsibilities in the controlled units).
4. Radiation Protection in Radio Diagnostic Practice
   - Schedule: 30 hours (Radiologist Physicians)/64 hours (Radiologists nurses)
   - Licensed by CNCAN for level 2
5. Radiation Protection of Personnel and Patients in Nuclear Medicine
   - Participants are university graduates – Physicians, Physicists, Chemists
   - Schedule: 80 hours, Licensed by CNCAN for level 2.
6. Radiological Safety on the Utilization of Radiation Unsealed Sources
   - Participants are university graduates
   - Schedule: 80 hours. Licensed by CNCAN for level 2.
7. Radiological Safety on the Utilization of Radiation Sealed Sources
   - Participants are secondary school and university graduates
   - Schedule: 70 hours. Licensed by CNCAN for level 2.
8. Applications of Radio Isotopes and Nuclear Radiation Sources
   - Post university specialization course for coordinators in laboratories with radiation sources from all fields of activity: mining, industry, medicine, education, research, army.
   - Schedule: 180 hours. Licensed by CNCAN for level 2, all domains
9. Radiological Safety on the Utilization of Sealed Sources (SI)/Unsealed Sources (SD)/Radiation Generators (GR). Knowledge Upgrading
   - Schedule: 30/40 hours. Licensed by CNCAN for level 2.

CPSDN is developing focused programmes for various domains of the nuclear field and, consequently, it organizes, on requirement, training programmes on a certain application, according to the related requirements and competence level.

In this respect, we could mention:

- training of personnel involved in the nuclear power programme, developing activities in the design, equipment and components supply units for Unit 1 of Cernavoda Nuclear Power Plant (NPP)
- radioecology specialization programmes organized for the Ministry of the Environmental Protection
- training programmes for the personnel involved in the activities related to VVR-S Research Reactor decommissioning
- training programmes for radioactive materials carriers
- training programmes on radiological safety in radioactive logging.

Results of the last years

Synthesis of activities developed during the last years (2004 – 2009) represents a relevant example of those above mentioned.

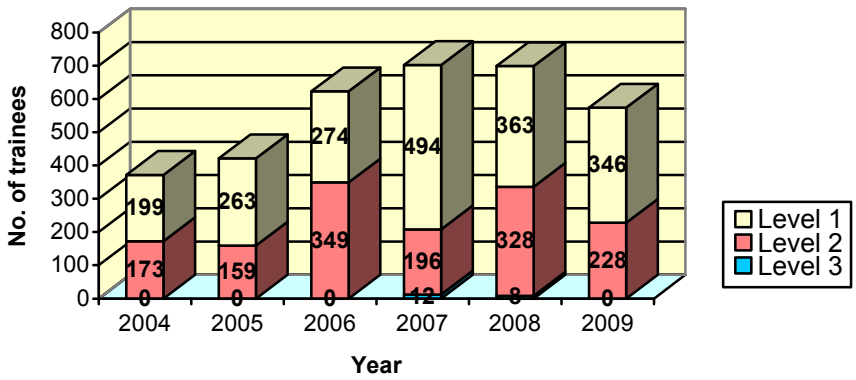

Fig. 1. Training activities during 2004 - 2009 and authorization levels.

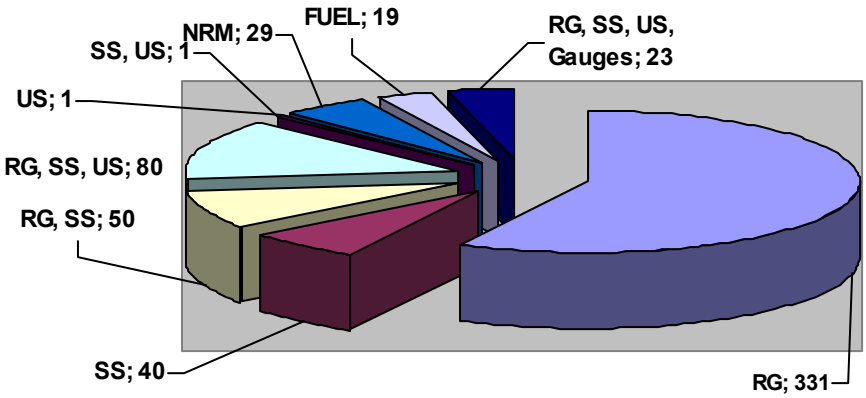

Fig. 2. Trainees and training fields in 2009.

SS – Seales Sources
RG – Radiation Generators
US – Unsealed Sources
NRM – Nuclear Raw Materials
Comparing the results, one may conclude the following:

(i) a spectacular increase in the number of trained persons in compliance with technologival development and new regulatory requirements
(ii) the number of programmes increased and the weight of various programmes reflects a RG and SS higher double specialization.

Future development of the Centre

CPSDN future objectives are in compliance with the CPSDN quality policy major objective, respectively:

Continuous improvement of training services quality by diversifying the training offers and improving services performances.

In this respect, CPSDN activity is focused on the following objectives:

- maintaining the Quality Management System certified by TÜV HESSEN
- diversification of training dedicated to radiation sources practices in the medical applications and other fields
- updating of web page for the dissemination of Centre's activities and improvement of communication with past and future beneficiaries (forum)
- development of web page for improving public information and customer relationship management
- e-learning implementation for knowledge upgrading of licensed workers
- new electronic/carbon copy training materials on radiation protection (manuals, booklets, etc.)
- development of training programmes dedicated to experts in radiation protection according to the national and international requirements.

Conclusions

- CPSDN represents a long history of training in the field of radiation protection.
- Training programmes cover a wide area according to the various requirements and applicants' needs.
- CPSDN resources benefits of continuous upgrading in order to comply with the new challenges in the field.
- CPSDN envisages being much more involved in the European programmes and is ready to develop national and European partnerships to respond to actual training needs.

The study of radon to understand the radioactivity and to know the environment

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Abstract
The work describes the collaboration among many Italian research groups that pursue since seven years the objectives to make students of secondary schools aware of the problematic of the radioactivity and of the ionising radiations, introducing they, when possible, in real research activities. For reach this goal, many approaches where adopted around the main path starting with the measurement of indoor radon concentrations and continuing considering most complex themes. The project obtained very good results from many points of view, and each year many schools that carried out their activity want to insert in the experience new students and news schools joined to the project. This implied a continuous increase of the students that approach themselves these problems and, through this contact, the world of the research and of the university;

Meetings and conferences have been regularly organized, in which the students communicate to a wide public their experience; and often students, teacher or researcher are invited in several contexts to describe the developed activity. Year by year the number of proven techniques increased and from the indoor measurements carried out with passive techniques, it has been passed to the dose measurements, to the analysis of materials, to the comparison of more techniques, to the use of active instrumentation which is often home made. Starting from 2008, the study of the artificial radioactivity in environmental samples, originated by radioactive fallout, began. These results were possible thanks to the 'commitment of research groups involved. A further increase of the schools involved would entail too great an effort to sustain. To avoid that, are being prepared various kinds of materials that can help schools continue to use this useful method of investigation of science topics, usually treated just in schools, but by shifting the focus of the operation on them.

Introduction
The project “ENVIRAD-SPLASH” collects the activities carried out in the within of the National Institute of Nuclear Physics (INFN) in the field of the spread in the Italian schools of the culture of the radioactivity and involves seven groups of six Italian

regions working in the field of the Environmental Radioactivity [Esposito et al., 2005]. Each group has chosen their own strategy to reach this common objective in full autonomy, but privileging always the direct and practical approach of the students to the studied topics [Balzano et al., 2006]. This has been realized of time in time with: their direct participation in the development of simple instruments, in the running of experiments finalized to the measurement of physical and/or radiometric parameters, in the observation and measurement of environmental parameters, in the participation in first person to true research activities. The umbrella of the INFN has allowed to create a network that has optimized the effectiveness of these experiences, creating in this framework easy opportunities of comparison and exchange of experiences between the investigators, the teacher and the students, with positive feedback on the result that such activity can produce.

The inclusion of the students in these activities has produced a very good success in the scholastic community, as it is testified by the great participation and by the continuous demand of new entry. Beyond these good results in the educational field, a secondary but equally important objective reached has been the knowledge of the exposure of the students to radon and its decay products, which, for the region of the South Italy, has been estimated for the first time topics [Venoso et al., 2009].

Material and methods

The general topic proposed at the beginning to the students has been that one of the natural radioactivity, in particular the program consisted in the measurement of the concentration of radon in the scholastic buildings, using passive detector techniques. This continues as the main activity in many cases, also because it answers to a requirement of monitoring and control of sensitive atmospheres, control that in many regions comes completely disregarded. Later on, with the acquisition of experience by the students, the interest, and therefore the activity fields, included also other objectives, like the carrying out of the same measurements in buildings outside of the participating schools, the measurement of the activity concentration in minerals and soils, the measurement of the dose, the practice with more sophisticated instrumentation., the evaluation of the risk depending on the exposition to the ionizing radiations.

An other topic, previewed since the beginning, has been the monitoring of the radon concentrations in the ground, using a system set to point in the frame of the experiment [Roca et al., 2006]. This experience, which started in the schools, had important developments and allowed to begin a research path that will be carried out in collaboration within the Earth Science community.

In the framework of the project, they have been developed also some kits dedicated to specific applications, like the treatment in the schools of passive radon detectors, the realization of simple alpha and gamma-ray spectrometers, built by the students, the measurement of radiometric parameters, like the lifetime of a radionuclide, or the efficiency of a detector All these activities, developed following suitable educational pathways, contributed to approach the students to arguments that the ordinary scholastic programs generally neglect and that instead they touch very actual topics. Simple numerical simulations realized using the ordinary electronic sheets have supplied a useful support to the understanding of basic concepts (comparison between behavior of the single radionuclide and that one of the relative species, analogies

between various phenomena (radioactive decay and interaction of the electromagnetic radiations with the matter), difference between the interaction of directly and not directly ionizing radiations,…) or the estimate of experimental parameters, like the energy resolution of a detector, as well.

Results

In the first place it goes emphasized the dimension of the impact that the experiment had on the world of the school. A row estimate allows to count just about 120 schools for a total of approximately 2500 students directly engaged in the activities. This number can be increased of at least a factor 3-4 if it is believed next to the number of not directly engaged students but that they have been "perceived" from the job of the companions and the teachers. Also in the familiar ambit the experience of the boys had an echo that has brought back terms, data and problematic linked with the radioactivity. Probably, therefore, it is not exaggerated to say that 10000 persons, thanks to this plan, have been encouraged to make reflections more or less complex, on various aspects of the radioactivity This is a argument a lot neglected as well as in the scholastic ambit, how much in that one of the information, where it only bounces in case of accidents and comes systematically and exclusively associated to disaster and risk contexts.

Since the treatment of the passive detectors has been made following well known and correctly applied techniques, the radon concentrations measured with one year long exposures can be considered absolutely correct (on the scientific side) results. This finding is particularly important because, as it as been yet said, for South Italy, these were the first available data relative to this kind of exposure.

An mainingfull aspect of a scientific activity is the communication of the results. To aid the students in this part of their work, each year a series of annual meetings has been carried everywhere, in which the students presented very effectively the job carried out in front of hundred of their colleagues, with the participation of academic authorities, personality of the INFN, experts of the national agencies that take care of the measurement and the effects of radiations (ENEA, APAT, ISS), managers of local agencies and the participation of representatives of the press.

Result obtained within this experience have been shown to national and international conferences. Many result have been produced also in other fields, and their have consisted in doctorate and bachelor thesis, participation to various initiatives, like the International Year of the Physics, the activation of courses in the curricula of the School of Specialization to the Instruction, contacts between different thematic areas, contacts with the local agencies, that often have been transformed in full collaborations and also have some times carried financial contributions in the project.

Discussion

A careful reflection on the developed activity has allowed to evidence the following points

The plan seems to be deep-rooted in the zones in which has been lead. The schools find its follow-up natural, year after year, and therefore they encourage the participation of new students in substitution of those which complete their cycle of studies

New schools that have indirectly known the project ask to participate to it, demonstrating to appreciate the contribution that the character naturally to multidisciplinary of the dealt arguments supplies to the continuous attempt to l ink the ordinary scholastic issues, than generally are considered from the students like not communicating sections. The degree of agreement and assimilation of the new topics by the students has been also studied proposing to they some questionnaires whose analysis has supplied information useful to correct the carried out action

In these years of collaboration with the schools, they have been tried and predisposed various study patterns, informative material, many experimental projects, laboratory kit directly entrusted to the students and their teachers, and a lot of other material that has been experimented on the field and that opportunely selected and organized it could continue to produce positive results in the future.

Also the university and in general the world of the research draws advantage from an activity that serves to establish with their basin of user a stable tie, deriving from a engagement of articulated common job on two years. For this community, moreover, also good scientific data come from the work with the schools.

All these considerations have convinced to bring at the project some modifications suggested from the experience, from the availability of schools and teachers who already have lived this experience, from this historical moment, that sees reopen the debate on the nuclear energy, and with the aim to place the bases of a stable activity to put on hand of the schools also to outside of the logic of a classic experiment, which usually is strictly limited in the time. In short, a new proposal will be soon made, based on few strategic and methodological points. On the strategic side, more attention will be dedicated to organize data produced from the students campaign, extending the look also to the search in the environment of radionuclides of artificial origin and proposing in the more favourable situation (motivated teaching expert and interested classes) more complex problematic, deriving more or less directly from the job already carried out;

On the methodological side, a critical analysis of the applied methods and of the available materials will be accomplished, in order to predispose a catalogue of arguments, projects, suggestions, instruments, didactic materials, verification test, useful to aid the work of the students groups interested to start or to continue the work in the project. These instruments will be all thought for two levels: the first useful to the activity of the schools that for the first time enter in the plan, oriented to a basic formation in the field of the radioactivity; the second, made of more specific arguments, destined to students already expert (as an example students of the fifth year with already a pair of years of experience) and followed from the more able and interested teachers.

A great attention will be turned at the formation of the teachers. In fact, indispensable circumstance so that the proposed piano runs and that the offered catalogue can be useful for the students, is that the teachers are capable to ménage the activity and the instruments that are included into it. To allow the developing of these points, the redaction of an adequate and detailed program is underway.

If this result will be reached, two objectives strictly linked will be reached together. Te set to point of a method to introduce students to the study of then radioactivity and to its practice, and the possibility to obtain in this framework results that, from a scientific point of view are fully valid.

In this way, the system constituted by the researcher community and the involved schools, will produce both didactical and scientific results. This method, which produced so useful results in the field of the evaluation of the radon daughters exposure, could be expanded to study of other parameters interesting for a better knowledge of the environmental. The topics which can be studied in this way are in fact many. The first one could be the search in environmental samples of artificial raduonuclides. The presence in the environment of small ^{137}Cs concentration is well known and easy to verify and quantify. Its systematic observation could be an useful "zero point" for the environmental monitoring in view of the possible re-starting, in Italy, of the activities linked to nuclear energy production.

Conclusions

The project Envirad-Splash pursues the objective of carry out in the secondary schools an experimental activity in the field of the radioactivity, in which the students have an direct and intense implication. Many good results have been obtained up to now, both in the educational and scientific field. This activity has been organized in the framework of the activities of the National Institute of Nuclear Physics and it has been designed as an normal experiment, with a project phase, a run phase and a conclusion. The good reached results have suggested to go over this schema and the experiment has enjoyed more than one extension. To consent to other schools to have such opportunity, a method which could allow to develop this activity also out of a normal experiment is under study.

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Rn-222 concentration measurements at Italian schools: a way to educate, train and disseminate radiation protection culture among young students

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Abstract

In Italy the "nuclear issue" was for a long time a taboo. A lack of information will lead to unwarranted fears, which will distort the risks we take in everyday life. In other words the subjective perception (sensation) of the risk doesn't correspond very often to the objective and real risk of human activity. In particular, our perception of radioactivity is often misleading because of the lack of accurate information. A way to approach this theme to make the public more trusting of nuclear issues is to discuss radioactivity and ionizing radiation starting from young students. An experimental activity that involves secondary school students has been developed. The approach is to have students engaged in activities that will allow them to understand how natural radioactivity is a part of our everyday environment.

On this basis started a project that gave students and teachers of the Italian secondary school system the opportunity to discuss and to experiment with nuclear related experiences. The students were provided basic but correct information and with the added benefit of being able to experiment. The core idea is that: a) to provide the students a furnished laboratory at their school so that they can measure the natural component of the radioactivity that surround us. In this exercise the measurement of the ^{222}Rn concentration is particularly well suited b) to show the different types of radiations including ionizing radiations and how they each relate to the other; c) to demonstrate how easily ionizing radiations can be measured; d) and to prove the fun a student can derive from discovery and detection of ionizing radiation in the environment.

One other interesting outcome has been that the measurements have been made in accordance to Italian radiation protection law. Therefore, the data collected could be used to determine the radon concentration mapping of the school buildings.

RadiaX – Radiac simulation for first responders

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Abstract

As a complement to the training of first responders in their preparedness for accidents and incidents involving radiation, a radiac simulation, called RadiaX, was developed.

RadiaX has a threefold purpose; to teach (i) the handling of specific instruments, (ii) the proper procedures in missions and (iii) basic principles in radiation physics and radiation protection. The simulation is developed as a modification of Half-Life 2, a famous computer game.

Introduction

Swedish preparedness for accidents and incidents involving radiation includes equipping and training first responders with radiation indication instruments. The intensimeter SRV-2000 (Rados Technology Oy, Finland) was introduced in Sweden in 2001 by the Radiation Protection Authority (SSM). 1200 instruments were distributed to about 300 fire brigades as well as 300 municipalities and other organisations involved in the national preparedness organisation. The Swedish Civil Contingencies Agency (MSB) provides annual training on the SRV2000 for all Swedish municipalities and county councils. The training includes a basic education about ionizing radiation and threats (MSB 2007). The missions are predicted to include evacuation, triage with subsequent personal decontamination, establishing boundaries of the safety and security perimeters and, in extreme situations, to secure and move sources (Runesson 2003, MSB 2008). Currently a new, complementary intensimeter with an optional gamma/beta probe is placed in service at fire brigades, emergency rooms and police departments. Training is important for building confidence in the ability to solve the task once an incident occurs, regardless of the likelihood of occurrence. The lack of training instruments and the difficulties and costs of safe exercises on dedicated training areas result in a need for a complementary training solution.

Computer games with an intention to convey to the gamer real life useful skills are categorized under many various labels with even more definitions. One popular label is “Serious Game”, somewhat simplified defined as a game with the goal to educate rather than entertain. A serious game has rules, objectives, and motivated consequences of the player’s actions. (Michael, Chen 2005). Yet another label is “Lightweight Simulation”, which refers to computer-based training systems designed to teach specific mission skills (Alexander et al 2005).

RadiaX has a threefold purpose; to teach (i) the handling of specific instruments, (ii) the proper procedures in missions and (iii) basic principles in radiation physics and radiation protection. Therefore it can fit both the labels mentioned above.

The gamer, the user of RadiaX, is henceforth denoted as the trainee and RadiaX is in the same way simply referred to as the game.

Material and methods

To provide an easily accessed and widely distributed training system the game is made as a modification based on an existing game, Half-Life 2 (HL2). Development cost and time is cut by starting from a released game and modifying and reusing modules from the original game, only adding the needed code for radiation simulation.

HL2 is a commercial computer game of the type FPS (First Person Shooter). HL2 is developed by Valve Corporation (Valve Corporation, USA) and was voted Game of the Year 2004 in several publications and engages over 10 million players. The game uses the 3D game engine Source and a modified version of the Havok physics engine. Utilizing the Source SDK user modifications (mods) are made possible and can be distributed to any holder of a license for HL2.

The levels are created in Valve Hammer Editor, included in Source SDK. It is the official Source mapping tool, and once mastered it is a powerful tool.

Creating levels requires only minor programming experience, and is intended to be attainable by the training instructors for ad-hoc or local debriefings and demonstrations. The existence of a mature content creation tool chain is a major factor in deciding to base a game on an existing engine instead of developing one from scratch.

The radiation model, including radiation sources, background radiation, photon attenuation and dose accumulation (for the trainee and instruments independently), is added to the engine using C++, compiled with Microsoft Visual C++ 2005 Express.

The ambient dose equivalent rate (ICRU 1998) at the trainee's position, $\dot{H}^*(10)_{trainee}$, is calculated momentarily as a function of gamma-ray constants applied to specific ideal point sources (Tschurlovits et al 1992), the distance (inverse-square law) and the attenuation in different materials in the pathway between the radiation source and the instrument (Beer-Lambert law). The calculations are formalized in equation 1 below. The gamma-ray constants, Γ, are given for 1 meter source distance.

$$\dot{H}^*(10)_{trainee} = \Gamma \cdot \frac{A \cdot e^{-\mu \cdot x}}{d^2} \quad [\text{mSv/h}] \qquad (1)$$

where Γ = gamma-ray constant [mSv m^2/MBq h]
A = source activity [MBq]
μ = linear attenuation coefficient of attenuation material [cm^{-1}]
x = material thickness [cm]
d = distance between source and receptor [m]

The existence of attenuating material and its thickness is determined by tracing rays from the radiation source to the specified measurement point. Attenuation coefficients (Hubbell 1982) are chosen from an internal table depending on the material

used (e.g. wood, concrete) for each piece of intersected level geometry (set by the level designer during level creation). This allows the game to use HL2's existing library of materials, and also allows levels to be designed without the level designer having any knowledge of radiation physics. Instead, attenuation accuracy simply becomes a function of mapping accuracy.

Dose accumulation is modelled through summation of discrete dose quanta. At fixed time intervals, for each radiation source the current dose rate is calculated at the trainee's position and the corresponding dose quantum is added to the trainee and to each simulated instrument the trainee carries and have switched on. This is done independently, the actual dose received and the instrument-measured dose may be different. Due to the Source engine design, the maximum attainable frequency at which the dose quanta can be calculated is 50 Hz. However, since the attenuation path calculation is computationally time demanding, the dose accumulation update frequency is intentionally kept lower, at 20 Hz, to keep the systems requirements down.

The radiation sources placed by the level designer are ideal point sources that are invisible and have no physical interaction with the world. They can however be coupled to other physical game objects, allowing movable, fully interactable radiation sources using Source's built-in rigid-body physics engine. When placing radiation sources, the level designer selects a nuclide name (e.g. Cs-137) from a list and specifies an activity (Bq) as seen in Figure 1. Appropriate gamma-ray constants and attenuation coefficients are retrieved from an internal list automatically by the game.

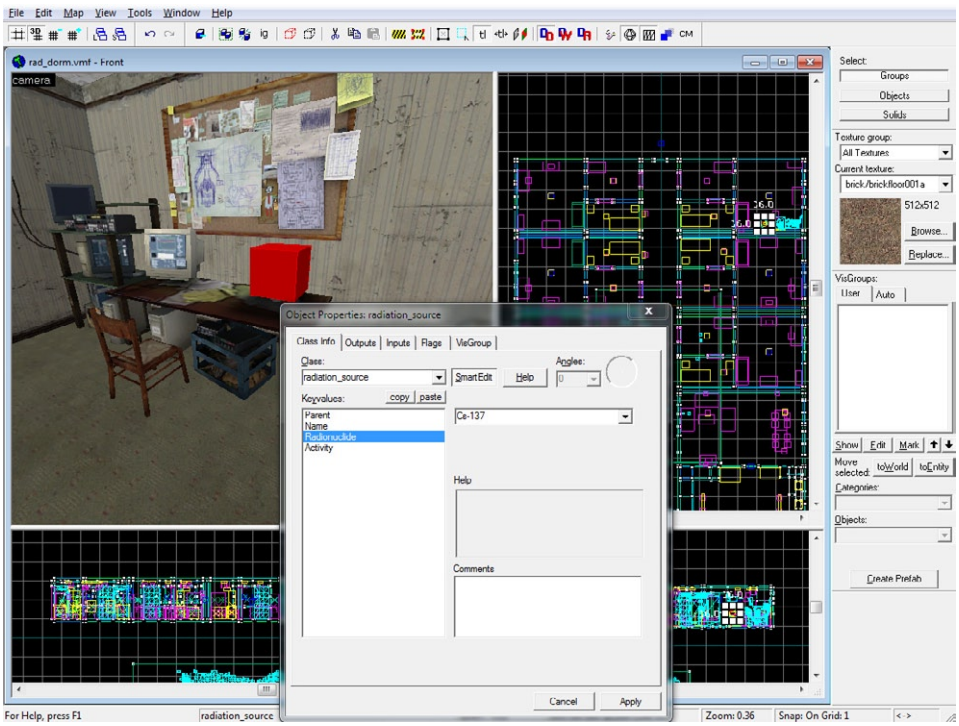

Fig. 1. A screenshot from placing and editing a radiation source using the mapping tool Hammer. The radionuclide (here Cs-137) and its activity is specified in a dialog window. The position of the source is shown in the floor plan (a white square in upper right corner) and in the camera view as a red box. During live training the source itself is invisible but coupled to any other object.

Background radiation is simulated uniformly across each level with stochastic fluctuation around a set mean value.

In accordance with the instrument specifications, inaccuracies are added to the calculated dose rate values, and time constants as well as delays are applied. Alert and alarm signals and adjustable level functionalities are implemented.

The dose rate error is modelled as having both a dose rate-invariant (absolute) component and a dose rate-relative component. This gives good error fidelity under both low dose rates, when the absolute error dominates, and high dose rates, when the relative error dominates. The errors are assumed to be normally distributed, with the deviations set on a per-instrument level.

Levels can be designed to present the trainee with a short in-game debriefing upon conclusion of the mission. This takes the form of a pop-up window showing, among other things, the trainee's accumulated dose during the mission, together with easy-to-understand information of the received dose. This information, e.g. “equivalent to x months' worth of background radiation”, is designed to help the trainee to gain an intuitive understanding of radiation doses and to gauge the real-life risk involved in the simulated tasks.

Supporting tools such as a distance measuring device and a position marker (paint spray can) is added to the arsenal.

The game is complemented by two separate user manuals. The first is intended for the trainee and includes installation manual, optional game settings, the game commands for movement and instrument action and a brief background. The second manual is intended for instructors, extended with more in-depth information (e.g. level design, radiation protection, instrument manuals and dose evaluations).

Results

Specified or observed features of the instrument SRV-2000 are implemented. Each setting and mode is accessed through standard keyboard and mouse by the corresponding buttons on the instrument as in real life. The SRV-2000 is always virtually held in the left hand (Figure 2) in front of the trainee, most of it visible at all times (buttons and display).

Fig. 1. A screenshot from RadiaX. The SRV-2000 is virtually held in the trainee's left hand and the buttons are selected using specified keys or mouse buttons. Each button is highlighted for a second when selected.

Table 1. The present set of game levels with a short description of their contents and purposes.

Game level	Brief description	Learning goals
Exercise: Basic motion	Obstacle course	Move around in the game environment using keyboard and mouse
Exercise: Characteristic features of SRV2000	Pinpoint hidden source among 17 boxes using different indicators	Start-up, buttons and the characteristic time constants of the SRV2000
Exercise: Basic radiation protection, part 1	Approaching a radiation source and observe the inverse-square law,	Fundamental principles of radiation protection: Distance
Exercise: Basic radiation protection, part 2	Different materials of different thickness between source and detector	Fundamental principles of radiation protection: Shielding
Exercise: Basic radiation protection, part 3	Accumulated dose during exercise and time spent.	Fundamental principles of radiation protection: Exposure time
Scenario: Dorm	Suspected hidden source for antagonistic objectives in student dorm	Search for radiation source
Scenario: Warehouse	Incident in warehouse with radiation sources in stock. In-house personnel remaining.	Search for radiation source, evacuate victims, establish boundaries of the safety and security perimeters using distance tool and marker.

The game levels are divided into exercises and scenarios. In the exercises the trainee is guided through the course and the radiation source is often visible. The exercises are either specific for SRV-2000 with the learning goals to teach characteristic features of the intensimeter, or general with the learning goals to teach fundamental principles of radiation protection.

In the scenarios the trainee is expected to solve tasks based on a specific scenario. Current scenarios (Table 1) are a demonstration of the capabilities of the game, while the exercises are general for the game or specific for SRV-2000.

Discussion

A simulation tool is a complement to live training by offering possibilities for debriefing, classroom as well as individual training, demonstration and increasing the repetition frequency as well as the numbers of trainees. Using existing standard PCs the training is cost effective and easy to distribute. This increases the availability of the training and might inspire to "off-hours" individual training.

The learning goal to teach radiation protection includes the awareness of accumulated dose levels in certain circumstances. The doses are maybe lower than the trainee first expects.

Extensive testing is required during development to ensure accurate reproduction of instrument behaviour, as simply reading the specifications might not be enough to cover all cases. If the real-life behaviour of a device differs significantly from the simulated behaviour, simulator training might have a detrimental rather than beneficial effect.

Further development

At present only one specific intensimeter is implemented. MSB and the National Board of Health and Welfare together with SSM have recently distributed a complementary instrument with a gamma/beta probe, the Intensimeter 28/T, a slightly modified AN/UDR-13 (Canberra Industries Inc, USA). The Swedish national preparedness organisation under SSM holds a wide and diverse range of instruments. The intensimeter 28/T particularly and many other instruments are justified to add to the arsenal available to the trainee in the game. This extends the target group to include customs staff, medical staff as well as radiation protection experts.

Further development (table 2) aim to include all scenarios listed in table 3. Exercises and tutorials supplementing new instruments and scenarios add to the table. Demonstration and reassess levels of occurred incidents or established training scenarios are of interest.

Giving feedback, perhaps the most important part, is a demanding and often neglected part of the preparations of a radiac exercise. Giving the mission of each game level scenario in-game and presenting the result, e.g. dose, time and effectiveness, to the trainee are important parts of all future game levels.

Table 2. A selection of intended future additional set of game levels with a short description of their contents and purposes.

Game level	Brief description	Learning goals
Exercise: Characteristic features of Intensimeter 28/T	With and without probe	Start-up, buttons and characteristics of the instrument
Tutorial: Basic body scan	Demonstration of body scan procedures	Scan strategies
Exercise: Basic body scan	Body scan with visible sources	Practice scan strategies
Scenario: Decontamination	Body scan and triage	Practice scan strategies for decision support
Scenario: Transport accident	Transport accident involving radioactive material and contaminated victims and bystanders	Search for radiation source, evacuate victims, establish boundaries of the safety and security perimeters. Triage.
Scenario: Urban RDD	RDD in an urban environment	Life saving prior to radiation risk

Table 3. Predicted scenarios (TMT handbook 2009, IAEA 2006).

Suggested scenarios
Radiological Exposure Device (RED)
Radiological Dispersal Device (RDD), “Dirty bomb”
Attack on, or incident with transport of, radioactive material
Contamination of food and water supplies
Attack on, or incident in, nuclear installation or installation containing radioactive material
Improvised Nuclear Device
Uncontrolled dangerous source

Conclusions

RadiaX is a novel complement in radiac preparedness training. It offers easily distributed and changeable training in a non-lethal environment.

Radiac training is well suited for simulation when the fidelity of the instrument is the primary focus and other simulations secondary, since the radiation does not need any tactile or visual simulation.

RadiaX has been demonstrated to training instructors and first responders and was well received.

Further development, with added instruments and scenarios, and evaluation of the training transfer is in progress.

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Radiological emergency exercises facing the collaboration issue of different response authorities

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Abstract

In Sweden, two large radiation emergency exercises with international participation were held in 2001 (Barents Rescue) and in 2006 (DEMOEX). Experiences from these exercises showed that conducting "close reality" emergency situations utilizing real radioactive sources was very valuable in the training of radiation experts and first responders. In the years 2007-2009 this concept of combined training was further developed in a set of smaller-scale exercises called Lärmät. The concept was to break down the large scale scenarios to pieces and learn its radiation protection difficulties in detail. This showed to be a successful and appreciated way of conducting exercises for Swedish specialists. The radiation specialist, however, will never have free hands to handle the situation in case of a malevolent act involving radioactive material. The situation would involve combined actions of several authorities. Therefore, Sweden's combined radiological emergency response has an urgent need for exercises where authorities work closely together across authority borders. This issue was specially addressed in the exercise Lärmät 09. Teams were put together from radiation protection specialists, rescue services, police, the National Laboratory of Forensic Science, The National Board of Health and Welfare and the Swedish Customs. The idea was to let people from each profession present their view (in each different scenario) of the situation in order to solve it safe and not destroying potential evidence. In Lärmät 09 six different scenarios were built with real sources and inspired from real radiation accidents. The radiation doses to the participants were kept low by radiation protection planning and technical arrangements. This paper presents the Lärmät 09 scenarios and lessons learned from this joint "close reality" exercise.

Introduction

Real radiation emergencies are extremely rare and experts and first responders only way to improve their practical and organisational skills are to expose them for unknown radiation scenarios. Training the Swedish specialists in radiation scenarios of different kinds has been one primary task for the Swedish Radiation Safety Authority (SSM) since 2006. This suite of exercises originate from the large and appreciated exercise Barents Rescue in 2001 and was followed by DEMOEX exercise in 2006, (Finck et al.

2008) which has been viewed as the starting point to the yearly training program held by SSM. The training is mostly as close to a real radiation emergency as practically possible without jeopardizing full safety and control.

Prerequisites for the exercises

The National Laboratory of Forensic Science (SKL), gave a brief lecture in crime scene behaviour. This was done to add the dimension of radiological difficulties at a crime scene investigation. The Swedish customs has participated in the radiological emergency exercises DEMOEX (2006), Lärmät 07 and Lärmät 08 with success and shown that also non-specialists benefit from this type of exercises. The focus of Lärmät 09 was to train small teams of radiation specialists, first responders and customs officers working together. The disparate background of the team members makes this a challenge. The participants were divided into teams with two radiation experts, two first responders and one customs officer in each team. All medical radiation physicists and persons working within the field of radiation protection were designated as radiation experts. In each team a radiation expert was selected as a team leader and as responsible for the radiological safety of the team members. It should be noted that the radiological issues were the main goal of the Lärmät 09 exercise. The drill of first responders and laymen came secondary.

The exercises

Activity	Container	Dirty Bomb	Strong Source	Bomb Workshop	Indoor malev. act	Contamina-ted person	Mobile Syst. Disp.
No. of Teams	12	6	6	12	12	12	12
Tot. No. Particip.	60	30	30	60	60	60	60

Fig. 1. Showing the number of teams exercised at each activity and number of exercised participants.

1. Container filled with contaminated scrap metal

1.1 Objective

In the last few years Sweden have had several incidents where companies who recycle scrap metal has caught radioactive material in their portal monitors. The objects has been of different kind, such as water filtration units with accumulated NORM and thorium treated air plane engine parts. The wide range of what might be found and the lack of experience how to safely and effectively sort out the radioactive objects from the rest of the scrap metal, called for a controlled exercise.

1.2 Exercise setup

The task for a team was to locate and identify the radioactive material inside the container using hand held instruments of a mobile emergency preparedness specialist team. The container was filled completely with approximately 20 tons of scrap metal. The inactive metal parts, the bulk, was so large in size and weight so moving them by hand was a very ineffective, if at all possible, way to proceed. An excavator, including

operator was at hand with a scrap metal processing gripper. The container was prepared with 7 sources of different kind. A flight engine part containing thorium, a stainless pipe coupling contaminated with Co-60, smoke detectors of different kinds and instruments with illuminated paint containing Ra-226, were some examples of sources used. In order to complete the exercise in 3.5 hours the team had to plan their work efficiently. The team was informed that they were responsible for the radiation safety of the person operating the excavator.

Fig. 2. Left picture shows the container before activity start, right picture shows a team in action searching for sources or contamination.

1.3 Results

Several teams expressed their unfamiliarity with this type of scenario. In general the teams didn't move the active metal parts away far enough from the container and therefore had problems with finding radioactive objects remaining in the container. Participants also lacked the ability to explain to the operator what they wanted to be done. Some groups didn’t have the correct instrumentation for the task. All sources were found for all 12 teams except one, which missed one NORM object. A few teams found the smoke detectors just by eye. The gloves used by the teams showed low level contamination of NORM activity, such as Thorium, after the completion of the exercise.

2. Dirty Bomb exercise

2.1 Objective

A dirty bomb is a device with the purpose of dispersing radioactive material in the blast. A dispersive device will most certainly have great impact on society infrastructure even if the radiological harm to people is negligible. As emergency teams have to handle a dirty bomb situation properly, training is needed.

2.2 Experimental setup

The scenario was built inside a military Operations Urban Terrain (MOUT) called SIB belonging to the P7 tank regiment outside Revinge in the south of Sweden. A blown up car was placed in a street crossing and the close surroundings of the car were fenced off

to ensure radiation safety. Entering into the marked hot zone was strictly forbidden for all participants. A well collimated Ir-192 source of approx. 440 GBq (12 Ci) with its radiation field pointing upwards was placed on the floor in the car, producing only scattered photons and sky shine. The dose rate around the vehicle was under 0.2 mSv/h and inside the fenced off vehicle close to the source were about 1000 times higher.

On the ground, 35 hot particles in the form of small contaminated metal plates were placed to simulate debris.

Fig. 3. Left picture showing a team assessing the radiation field with the supervisor being the person i yellow to the left. Right picture showing the optimal geometry in search of ground contamination and hot particles.

Also two larger contaminated fragments of metal were placed on the ground close to the vehicle to indicate a blown source container. The activities on the small plates were 1-3 MBq and on the two larger fragments 300 MBq each. The radionuclide used in this exercise was Zr-89 with the half life of 78.4 hours. This radionuclide is both a positron and a gamma emitter and is produced at the cyclotron at Lund University Hospital. The purpose of the Ir-192 source was to create a radiation field that strikes out portable spectrometers by producing very high dead time. This forced the team to take samples for analysis, when the fragmented sources were to be characterized.

2.3 Results

One participant was slightly contaminated on the left shoe. One team had to be told that there were radioactive fragments on the ground. One team missed to equip the person closest to the car with a dose rate instrument at all times. The same team took it for granted that the radiation field levels would stay static in time. Problems with documentation during rain showed need for water proof writing pads and water resistant laptops. Few of the teams had the experience of taking smear samples in practice. The portable instrumentation was not well suited searching of fragments on the ground.

3. Strong source exercise

3.1 Objective

Small and very strong radioactive sources exist in society. Very strong sources impose special problems which are rarely dealt with in exercises. The objective of the strong

source exercise was to familiarize the participants how to assess a strong source situation.

3.2 Experimental setup

Both geometry and source strength was disclosed to the teams before exercise start. A Co-60 radiographic source of 385 GBq (10.4 Ci) was used as the ”strong source” and was collimated to a cone beam exiting along the earth surface. The source was placed 200 meters in at one end of a large (400x1200m) grass field.

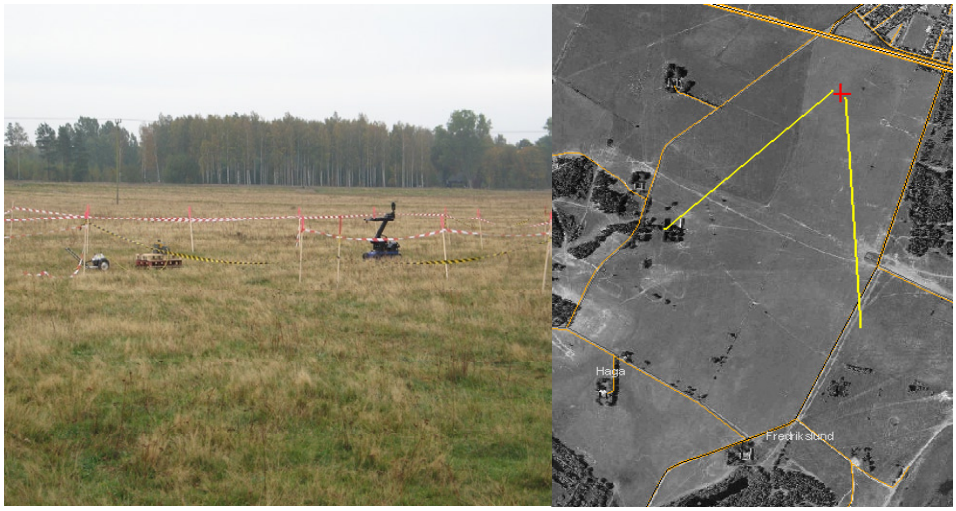

Fig. 4. Left picture showing the police bomb robot closing in on the cobalt source, right picture showing the extent of the radiation field.

Approximately 20 cm of lead and a 4 cm thick tungsten collimator was used as a radiation field delimiter to achieve the desired field geometry. A dose meter with alarm capability was placed close to the shield to indicate if the source got stuck on the way to the collimator or shield. To be able to practice measurements in a safe way, warm- and hot zone was marked by coloured fence posts, positioned at the dose rate levels of 100- and 500 microsievert an hour. The dose rate level was also written on the fence posts for clarification. The participants was allowed to work freely outside warm zone and allowed inside ”warm zone” delimiter only by making a valid request. No participant was ever allowed inside the fenced off ”hot zone” for safety reasons.

3.3 Results

One person chose not to participate in this exercise. The police bomb robot was granted access to the hot zone for practising measurements and also allowed to move freely inside the fenced off area. The Police bomb squad need more practice and guidance to be able to function in situations like this. Almost all teams requested to enter warm in order to test their instrumentation.

4. The Bomb Workshop exercise

4.1 Objective

09 included a exercise scenario illuminating how to preserve forensic evidence at a crime scene contaminated by radioactivity. Earlier exercises have included several

scenarios with gamma emitting nuclides as radioactive contaminant. This time a scenario including only a pure beta-emitter was chosen. The cause for this was mainly to show and train the participants in the complexity of estimating activity and extent of the contamination when only beta sensitive instruments were the proper choice.

4.2 Experimental setup

Two parallel rooms separated from each other where set up with covered windows, a workshop table carefully covered with construction plastic film, necessary tools to construct a explosive device and plastic film covered floors.

Fig. 5. A participant working on mapping the contamination in the Bomb Workshop activity.

Two teams worked on the scenario in parallel without communicating with each other. Contamination was of very low grade but carefully calculated and tested not to give any indication of radioactivity on gamma-only instruments. The nuclide used for this exercise was Y-90, a perfect simulant for the more common Sr-90. The 1.8 MBq/l water solution created a surface contamination of about 10 Bq/cm^2. Invisible, but radioactive, footprints were placed on the floors. On the tables radioactive fields the size of a hand was created to simulate grabbing marks. Not all tools were contaminated and surfaces not likely to have been used were clean.

4.3 Results

Two teams used only gamma detectors when entering the scenario the first time and one of these teams had contaminated members on exit. A couple of teams found it difficult to estimate activity from the beta measurements. Several participants found it hard to do quality measurements with protective suits and mask. Beta instruments with long time constants were hard to use in this scenario. All teams were not properly prepared to convert a cps-value to Bq/cm^2. No instruments were contaminated.

5. Indoor malevolent acts

5.1 Objective

This scenario was compiled out of two different activities introducing different problems. The ”School” scenario was based on a malevolent act playing with the thought of one person wanting to harm school children by placing gamma emitting

sources in the school room. The ”Home” scenario presented a house in which a internally contaminated person had stayed. The objective in both scenarios was to assess the radiation fields and contamination levels. The teams should gather information through measurements and estimate radiation doses in both situations.

5.2 Experimental setup

The ”School” scenario was set up in a big room pretending to be a classroom with four tables and eight student chairs. In front of the classroom a teacher’s desk were set up to add realism. A fairly strong Co-60 in the cellar underneath the classroom enhanced the radiation level in the room to several hundred microsievert per hour. Additionally, four Co-60 point sources were located in the classroom underneath the chairs and tables. The ”Home” scenario was built around a home environment. A room with a kitchen, stairs, dinner table and a bed was set up to simulate a home situation. In order to make a traceable chain of contamination, the water was chosen to be the carrier of the activity. Therefore, all things that could have been in contact with water had to be carefully prepared to fit into the scenario. The nuclide used was I-131. Water I-131 concentration in both the coffee maker and sink had to match the activity concentration and the total activity in the earth of the potted plants as well. Also the bed and a reading chair were contaminated in a way to lead the teams to the conclusion of household water as the course for contamination.

Fig. 6. Left picture showing a team working in the ”Home” activity. Right picture is a view showing the farm house to the right where the ”School” activity was held.

A faked well was prepared outside the building in case the teams would search for a water supply in the close proximity. By placing a 30 MBq Iodine-131 point source in the well, it could be detected from a distance and simulate a real well full of contaminated water. A real sample of contaminated water (1.8 MBq/l in a 250 ml plastic can) was also placed in the faked well. The idea was that the team should use the activity concentration of the well water as a possible starting point for dose assessment calculations.

5.3 Results

In the school scenario several teams had difficulties locating the four point sources as they were obscured by the gamma field from the cellar source. A few teams reported wrongly a surface contamination in the classroom. Two out of six teams found all four point sources and completed all scenario tasks in a correct way.

In the home scenario all teams found the source of contamination and found the water sample in the faked well. All teams kept their members uncontaminated and several samples were taken and analysed. A few teams used their mobile spectrometer to estimate the I-131 water concentration. All teams collected enough information and did correct measurements to be able to correctly estimate the internal radiation dose.

One team showed only a calculation error which presented an accumulated dose 1000 times to low.

6. Mobile gamma system display exercise

6.1 Objective

The development and new commitment made by the SSM to enforce the radiation protection nationwide with new modern equipment, has accelerated the development of methods and new custom made software platforms. To show the first responders what instrumentation and equipment Swedish specialists use, a demonstration type of mobile gamma search was set up.

6.2 Experimental setup

Several systems from the Swedish customs, SSM and National emergency preparedness laboratories were set up aside a straight road to monitor passing cars. Several packages were prepared in advance with manmade radionuclides and some packages also included natural occurring radionuclides. Examples were potassium-40 and uranium ore. These packages were placed in one of four cars passing the measuring teams. The teams had to pinpoint any car containing radioactivity and disclose the radionuclide by means of gamma spectrometry. To enhance the test several cars passed the teams with blank packages. The speed of the car convoy was also varied in order to spot any differences in the ability to detect the content.

6.3 Results

The non-specialists found it hard to in some cases to decide with certainty if a weak source had passed the detector or not. It was not clear to all that mobile detection units (cars) often have different sensitivity for sources passing either on the left or right side of the vehicle. Some participants believed that this exercise was less relevant to them.

7. Contaminated person

7.1 Objective

In a radiological accident situation involving injured people the ability to do a quick, correct search for internal or external contamination is essential. In this exercise the goal was to educate the participants how to handle contaminated persons, in this case a contaminated dummy doll.

7.2 Experimental setup

The teams were given a pre-prepared doll with contamination in the hair, on the clothes, in the lungs and a flesh wound containing a hot particle. The activities used were 6, 60, 0.2 and 30 MBq in the previous given order. The radionuclide used was Tc-99m with 6.05 hour half life. The doll had to be undressed outside in a fenced off area and

brought inside on a stretcher. The teams should estimate the extent of the contamination and make a report on their findings.

7.3 Results

The activity was much appreciated. The teams had problems with finding the lung contamination since the other contaminations dominated instrument response.

8. Follow up meeting

A vital and successful part of Lärmät 09 was the follow-up meeting two months later. The participants were asked to hand in all results and calculations obtained at each scenario prior to this one-day meeting for compilation. Time was also given for general discussion regarding lessons learned during Lärmät 09.

Discussion

The general response from the participants was very positive. All participants were asked to express their views on the different tasks by completing a questionnaire before leaving each scenario. In the Dirty Bomb and School exercises the standard gamma search instrumentation for Swedish teams was not less useful in the high "background" levels encountered. One team measured and mapped dose rate levels around the Dirty bomb vehicle and thereafter dose rate instruments were considered of no more use when working in close proximity to the vehicle. Acting as if a situation is static in radiation dose levels, thinking there is no need to carry a dose rate meter violates the plan of radiation protection optimization.

The Strong Source exercise showed the need for collaboration between specialists and police bomb squad units. The units in Sweden have different equipment and robots. Distance equipments and robots are indispensible dealing with very strong radioactive sources, but further training is necessary in this field. A part of the strong source exercise, the sky shine geometry, was postponed to a future exercise due to time constraints and the complexity of such a radiation field. The lesson learned from the Bomb Workshop scenario was the preconceived assumption that a gamma detector is enough, scanning a contaminated room, must be abandon.

Since several participants were contaminated more training in contaminated environments is needed. No instruments were contaminated. This showed that the participants handled their instrumentation carefully in this aspect, though, better instrument contamination protection was called for by the participants.

In the School exercise all teams made a survey outside the house before entering the building. Based on this survey most teams suspected a strong source in the inaccessible cellar compartment. Only a few teams asked for better search instruments, a Saphymo was at the teams disposal on place, and did not realized that their standard GR-110 and GR-135 instruments were less adequate in the high dose rate levels in the class room. In the Home scenario no instrumental shortcomings were recognized. The erratic dose calculated by one team was later corrected. All teams found the contamination chain and did a water I-131 concentration measurement which all gave correct results. A few teams who measured their samples in their mobile laboratories on site showed the same accuracy as others.

The Mobile Units Display exercise showed the need of trained specialists to discover sources giving weak signal in the gamma detection systems. The relevance of such a activity was discussed and was considered to be good general knowledge and adding dimensions for also non specialists, making them more all-round. The lack of sensitive neutron instrumentation in the National Radiation Emergency Preparedness Organisation was also highlighted.

The Contaminated person exercise introduced the participants on problems with measuring a contaminated person with different types of contamination. The simulated hot particle made it hard to find the much weaker lung contamination.

In general, in a real radiological event, the specialist upon arrival must gather information quickly to compile a first situation estimate and communicate this to the responsible authority. Lärmät 09 revealed that specialists in several cases didn't fulfil this role adequately. In order to function properly the specialists need more education and training. During the exercise the teams collected measurement data and samples in 3.5 hours, the predefined time slot chosen for all scenarios. In a real malevolent situation it can be expected that the demand from media, press and authorities, after such a time interval or less, are strong for a first verbal report from the radiation specialist. Details and calculated doses were later presented by each group during the follow up meeting. This meeting was much appreciated and gave participants and planners a sense of what to expect in present time and what field to focus on for improvements. The issue of effective surveying and reporting is recognized as very important. This will be addressed in Lärmät 10, which is to be held October 5-8, 2010.

Conclusions

The involvement of observers from SKL came out successfully and added new perspectives how to behave at a radiological crime scene. The set of Lärmät exercises has shown to be a good test and indicator of present status of the Swedish emergency preparedness organisation. It is believed that the Lärmät concept of small yearly exercises is a productive way to ensure ability and also control the status of a chosen radiological emergency organisation. The radiation protection planning and optimization kept the radiation doses below 100 microsievert for all participants during Lärmät 09.

Referencies

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New educational technique using radiation sources fabricated from chemical fertilizers

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Abstract

Potassic chemical fertilizers contain a small amount of potassium-40, which is a naturally occurring radioisotope. The potassium-40 emits beta and gamma radiation. Therefore, potassic chemical fertilizers are often used for classroom demonstrations of natural radiation sources along with kelp, mushrooms, sinter, and others.

A previous study proposed a new educational approach to enhance understanding of radiation that is naturally emitted from potassium contained in fertilizer. This educational technique involves the use of radiation sources fabricated from several chemical fertilizers containing different amounts of potassium. In the present study, the educational approach was evaluated using five disk-shaped radiation sources fabricated using a compression and formation method from five chemical fertilizers containing potassium from 5 to 50%. The technique was evaluated by examining the relation between radiation strength (radioactivity count emitted from the fabricated source) and potassium amount of the raw fertilizers based on 10- and 1-minute integration times. Radiation strength was directly related to potassium amount, indicating that the substance emitting radiation must be potassium.

1. Introduction

Many materials on earth contain naturally occurring radioisotopes such as ^{40}K, ^{232}Th, and ^{238}U that release radiation. However, many people do not realize that such naturally occurring radioisotopes exist. Therefore, radiation education is important to improve understanding of the existence of natural radioisotopes and radiation. Chemical fertilizers containing potassium are often used for this purpose in educational courses on radiation. Naturally occurring potassium consists of three isotopes: ^{39}K, ^{40}K, and ^{41}K; the ^{40}K naturally emits a 1.33-MeV beta particle and a 1.46-MeV gamma ray.

A previous study described development of a compression and formation method for fabricating disk-shaped radiation sources from raw materials such as potassium chloride, kelp, chemical fertilizer, and sinter, which contain naturally occurring radioisotopes. The fabricated natural radiation sources were examined for educational use in a radiation protection course. The results indicated that the natural radiation sources were easy-to-use educational tools for demonstrating the principles of radiation protection relating to time, distance, and shield thickness.

In the earlier study (Kawano 2010), the compression and formation method was applied to 13 commercially available chemical fertilizers containing different amounts of potassium. The fabricated disks are natural radiation sources, referred to as chemical fertilizer radiation sources or fertilizer sources. The suitability (size, weight, solidness, and smell) of the 13 fertilizer sources as educational tools for radiation education was examined. Results indicated that all of the fertilizers but one could be used as natural radiation sources. The one exception was too fragile to fabricate into a disk using the compression and formation method. The radiation strength (count rate) and potassium content of the other 12 fertilizers were measured, and the relation between potassium content and radiation count was examined. Results showed that a linear relation existed between the radiation count emitted from the fertilizer sources and the percentage of potassium in the chemical fertilizers. This linear relation demonstrates that the count rate corresponds to the percentage of potassium. Therefore, a new educational technique using the fertilizers can demonstrate that the radiation emitted from the fertilizers can be attributed to the potassium contained in the fertilizer sources. However, these results were obtained by compiling all of the data obtained by 12 fertilizer sources; in some cases the relation between radiation count and potassium percentage was inverted. This inversion might be caused by differences in components other than potassium, nitrogen, and phosphorus. Therefore, to demonstrate that the substance emitting radiation is potassium, the selection of fertilizer source material is very important.

In the present study, five brands of chemical fertilizers containing different amounts of potassium were selected as source materials and fabricated into disks using a compression and formation method. As before, the relationship between radiation count emitted from the fertilizer sources and the percentage of potassium in the fertilizers was investigated based on 10- and 1-minute integration times. The results showed a linear relation with no inversions, indicating that the radiation count was directly proportional to the potassium content.

Thus, this educational technique is useful for explaining that the substance emitting radiation in chemical fertilizers is potassium. The results also show that the radiation sources fabricated using chemical fertilizers can be handled safely and easily in radiation courses.

2. Chemical fertilizer radiation sources

2.1 Chemical fertilizer

Nitrogen, phosphorus, and potassium are three important elements for plants. Chemical fertilizers generally contain all of these elements. As a chemical fertilizer radiation source and application for radiation education, potassium is very important because naturally occurring potassium consists of three isotopes: ^{39}K, ^{40}K, and ^{41}K, of which ^{40}K emits a 1.33-MeV beta particle at a rate of 89% and a 1.46-MeV gamma ray at a rate of 11%. Because the half-life of ^{40}K is long (1.28×10^{9} years), the chemical fertilizer radiation source is suitable for use as an educational radiation source.

In the present study, five commercially available chemical fertilizers were purchased for producing chemical fertilizer radiation sources, which contain different percentages of potassium, a small proportion of which is radioactive potassium-40.

These chemical fertilizer brands were sold for use in the family garden. Consequently, radiation sources fabricated from the chemical fertilizers can be handled safely, since they are only pressed and formed before use in the classroom.

The five brands of chemical fertilizer were called "sulfate of potash," "phosphorus and potash," leaf and vegetable," "organic chemicals," and "bulbaceous fertilizer" (words used in their brand names). The amounts of the main elements in these fertilizers are summarized in Table 1, obtained from ingredient labels on the fertilizer packages. The "sulfate of potash" brand contained 50% potassium out of, which was the maximum amount of potassium in the five fertilizers. The "phosphorus and potash" brand contained both phosphorus and potassium at 16% and 15%, respectively. The other three fertilizers contained all three main components. The five fertilizers each contained five different potassium percentages: 50%, 15%, 10%, 8%, and 5%.

Table 1. Percentages of nitrogen, phosphorus, and potassium in five brands of chemical fertilizers.

Fertilizer	Content (%)*		
	Nitrogen	Phosphorus	Potassium
(1) Sulfate of potash	*	*	50
(2) Phosphorus and potash	*	16	15
(3) Leaf and vegetable	12	8	10
(4) Organic chemicals	8	8	8
(5) Bulbaceous fertilizer	3	7	5

*Based on "Ingredient labels" on the packages

2.2 Method of fabricating chemical fertilizer sources

For fabricating chemical fertilizer radiation sources from the chemical fertilizers, about 20 g of fertilizer were micronized with a mortar. This fertilizer powder was placed into a cylindrical stainless steel form and then pressed. The fabrication setup is shown in Fig. 1. The cylindrical stainless form had an inner diameter of 35 mm and a height of 30 mm. A hydraulic hand pump (Osaka Jack Co. Ltd., Model TW-0.7) and a jack (Osaka Jack Co. Ltd., Model NT20S12.5) were used to compress the fertilizer powder in the form with a force of approximately 160 kN to produce disk-shaped radiation sources from the fertilizers.

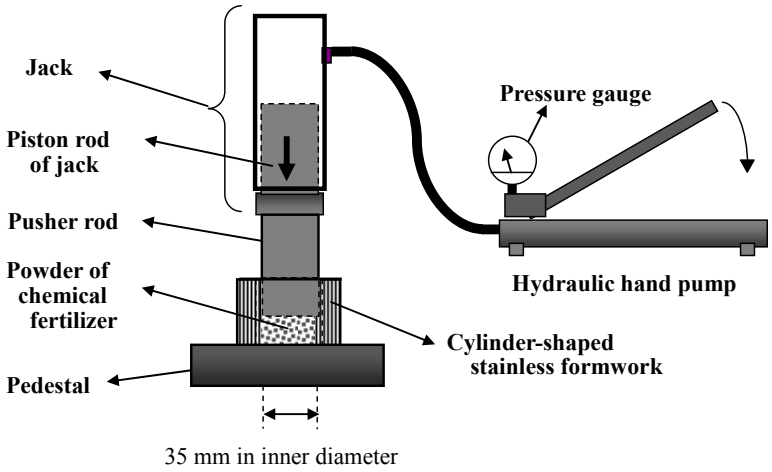

Fig. 1. Fabrication setup for compressing chemical fertilizer powder into disk-shaped radiation sources

3. New educational technique

3.1 Evaluation of new educational technique using five fertilizers

The five fertilizers containing various percentages of potassium were used as raw materials for fabricating radiation sources. The radiation strength of the fabricated fertilizer source was estimated by the radiation count emitted from the fertilizer source. Radiation counts were measured using a GM survey meter (Aloka TGS-146), and were compared with the percentage of potassium among the three main fertilizer elements. The element percentages could be obtained easily from ingredient labels attached to the fertilizer packages. The radiation count was derived by subtracting the background count (measured without the fertilizer source) from that of the fertilizer source. To measure radiation strength, a fertilizer source was placed at the center of the surface of a GM survey meter probe. The measurements were obtained in integration mode. An integration time of 10 minutes was used for both source count and background count, and net count rates at one minute were calculated.

The results obtained are shown in Fig. 2(A)-(C). Figure 2 (A) represents a typical result, in which radiation count is plotted as a function of percentage of nitrogen. It is clear to see that the count does not correlate with nitrogen percentage, because no linear relationship is present. Figure 2(B) shows similar results between count rate and phosphorus fraction. In both Fig. 2(A) and 2(B), radiation counts of about 300 cpm and 120 cpm were obtained from samples with zero nitrogen (A) and zero phosphorus (B), which is explained in Fig. 2(C). Consequently, neither the nitrogen nor phosphorus in the fertilizer sources emits radiation. Figure 2(C) shows the relation between radiation count and potassium percentage. The counts for the five brands of chemical fertilizer were distributed around the line representing the correlation between radiation count and potassium percentage. These experimental results show that radiation strength linearly increases with potassium percentage of the radiation source, meaning that the substance emitting radiation must be the potassium present in the raw fertilizers. Thus, the radiation counts of 300 cpm and 120 cpm observed at zero nitrogen and zero phosphorus, respectively, also result from potassium.

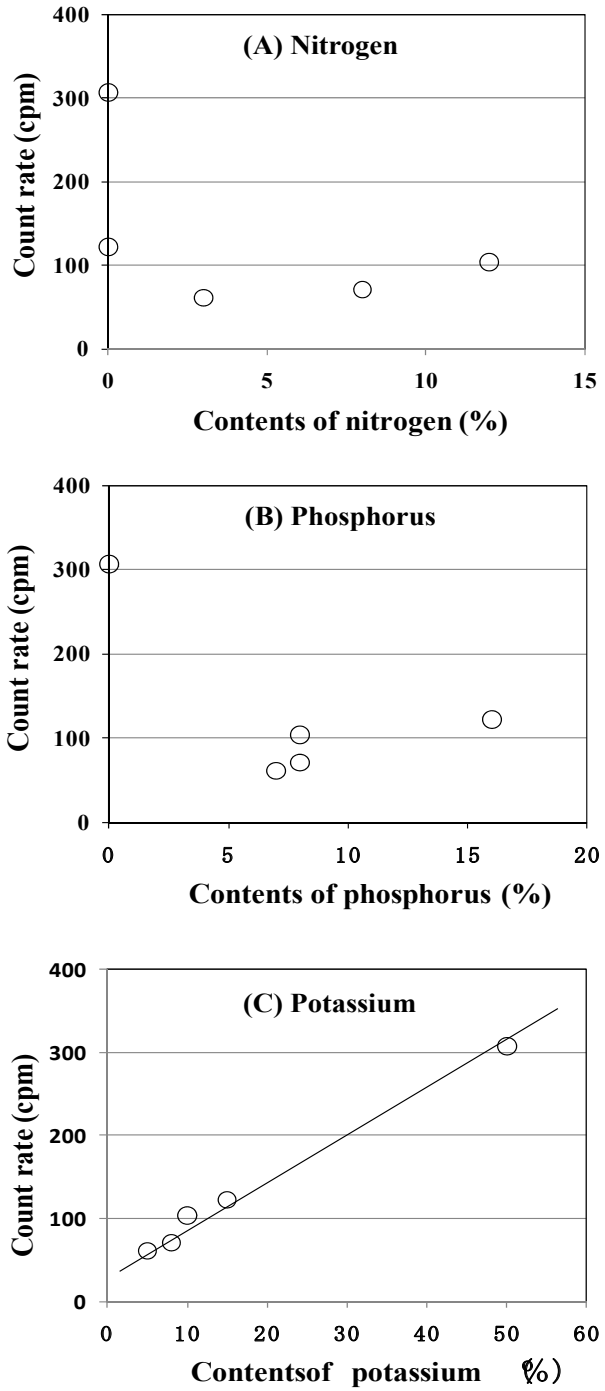

Fig. 2. Relation between component percentage and radiation count obtained with 10-minute measurements

3.2 Evaluation of new educational technique with one-minute measurements

Five fertilizer sources were fabricated from the five chemical fertilizers selected as raw materials. The educational method proposed in a recent study was applied using the five fertilizer sources. Results demonstrated that radiation was emitted from the potassium in the chemical fertilizers. However, this result was based on 10-minute integration time, which may be too long for an actual educational radiation course because younger students may not stay focused for multiple ten-minute measurements. For this reason, the integration time for a single measurement should preferably be one minute or less to allow collection of many data points without loss of student focus. Therefore, further experimental studies were conducted based on one-minute integration times for simulation of an actual educational radiation course.

For the studies using a one-minute integration time, the measurements were repeated ten times. Each set of measurements were conducted for all five fertilizer sources. The results are shown in Fig. 3 and are similar to those shown in Fig. 2(C) based on ten-minute integration time. The average radiation counts for one minute plotted as a function of potassium percentage exhibited a linear relation with a standard deviation of less than 10%, which indicates that count rate reflects the potassium content.

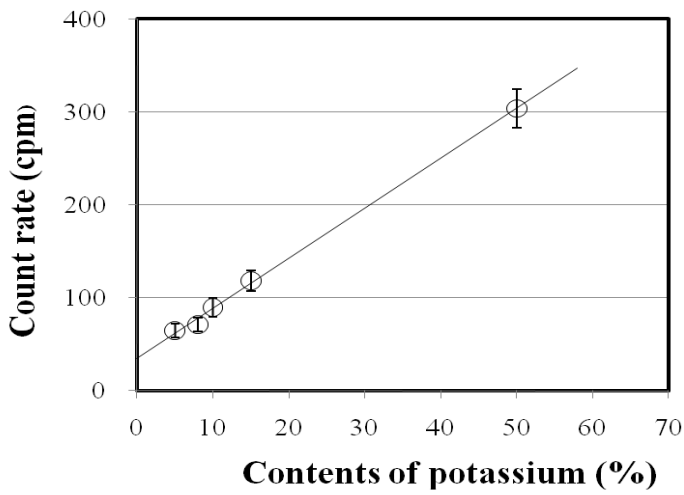

Fig. 3. Relation between potassium percentage and radiation count obtained with one-minute measurements.

4. Conclusions

In a previous study, a new educational tool was proposed for understanding that potassium in fertilizer emits radiation. In the present study, that tool was evaluated from a practical view. Five radiation sources were fabricated from fertilizers containing different amounts of potassium and the relation between radiation count (based on one-minute integration time) and potassium fraction was examined. Results demonstrated that a linear relation existed between radiation count and potassium percentage, confirming that potassium is the source of the radiation from the fertilizer.

This approach can be used to teach students enrolled in a radiation educational course that chemical fertilizers can emit radiation. The experimental portion of the

course can utilize natural radiation sources that allow students to handle naturally occurring radioisotopes and recognize that radiation can be emitted from natural materials. This experience helps students understand that people are irradiated continuously with low levels of natural radiation emitted from materials containing natural radioisotopes.

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Reference

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Organisation of pilot modules of the newly developed European Radiation Protection Training Scheme ERPTS

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Abstract

The ENETRAP II Project (European Network on Education and Training in Radiation Protection) aims at harmonizing the Education and Training in Radiological Protection RP e.g. by reaching harmonization of the requirements of RP experts and officers within Europe. These "Reference Standards will reflect the needs of the RPE and the RPO in all sectors where ionising radiation is applied. Therefore a remodelled modular European Radiation Protection Course has been developed in the ENETRAP first phase project. One major goal of the present project is to monitor the effectiveness of the proposed methodologies by organising pilot sessions of selected training events within Work package 8. The courses are designed for radiation protection professionals such as Radiation Protection Experts (RPE) and Radiation Protection Officers (RPO) according to the agreed standards and include On-the-Job OJT Training as key element. Domains to be chosen are occupational radiation protection in Nuclear Power Plants, Radioisotope Training in Non-nuclear industry and Research, and Specifities of Waste Management and Decommissioning. In this paper the outcome of the pilot sessions as far as available is evaluated and the results summarised. Preliminary improvements are recommended for further performance.