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POSTER SESSION

EDUCATION TO A BACHELOR DEGREE IN THE FIELD OF RADIATION PROTECTION IN SAXONY

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ABSTRACT

In Saxony, a state of Germany, a special mode of education to a bachelor in the field of radiation protection exists. This so called “dual” degree consists of a theoretical part at the Universities of Cooperative Education Riesa and Karlsruhe and a practical part at the Nuclear Engineering and Analytics Rossendorf Inc. (VKTA).
This type of education was started in Saxony in 1992 at the Rossendorf Nuclear Engineering and Analytics Inc. together with the Rossendorf Research Center and the University of Cooperative Education in Karlsruhe. Since 1996 the University of Cooperative Education Riesa received responsibility for the first two years of the science-referred study phase. The so called “dual” degree consists of a theoretical part at the University and a practical part at the Nuclear Engineering and Analytics Rossendorf Inc. and takes three years. Each three months the students change between university and on-the job-training.
Up to the year 2007 the final qualification was the diploma (in German: Diplom). Now the bachelor degree is introduced.
The paper describes the content of the education at Riesa and Rossendorf including some titles of dissertation submitted for a diploma.
Some examples of assignment of the graduated engineers at the Nuclear Engineering and Analytics Rossendorf Inc. are added.

1. Introduction

In 1991, Saxony (state of Germany) launched a new project aimed at creating a fully integrated system of higher education on a tertiary educational level: BERUFSAKADEMIE / University of Cooperative Education. It took only a few years for the project in Saxony to develop this system of higher education with currently approximately 4,500 students in Saxony. Around 500 students are currently enrolled at the University of Cooperative Education in Riesa in the fields of Business Administration and Engineering. One kind of the academically qualified engineers (BA) is called engineer of radiation protection. The vocational training for this engineer has two learning places: the Universities of Cooperative Education Riesa (first two years) / Karlsruhe (last year) as the “center for academic course work”, and the company providing “the center for on-the-job training”. One of the last mentioned companies is the Nuclear Engineering and Analytics Rossendorf Inc.

The three years at the University of Cooperative Education are divided into two phases: Basic education and training cover the first two years and lead to a first job qualification. Each three months the students change between university and “on-the-job training”. The final qualification, for which almost all students aim, is achieved after a third year of more specialized studies and training. Up to the year 2007 this final qualification was the diploma. Now the bachelor degree is introduced.

A student enrolled at the University of Cooperative Education is both a student and an employee. Therefore, the University of Cooperative Education has two learning places: the University of Cooperative Education as the “center for academic course work”, and the company providing “the center for on-the-job training”. Each partner bears the cost of the learning center that it controls. Phases of course work (theory) - normally of 12 weeks duration in a term of six months - alternate with periods of on-the-job-training of equal duration.

The requirement for studying at the University of Cooperative Education is the German university entrance examination (“Abitur”). In addition, a contract defines the conditions of the traineeship. Signing a standard training contract is a necessary condition of enrolment.

2. History

In 1992 launched the project “University of Cooperative Education” at the Rossendorf Nuclear Engineering and Analytics Inc. (VKTA) in the field of the practice-integrated study phase of engineer of radiation protection. This project was started in association with the Rossendorf Research Center (FZR). Until 1995 the theoretical part of the study was only placed at the University of Cooperative Education in Karlsruhe. Since 1996 the University of Cooperative Education Riesa received responsibility for the first two years of the science-referred study phase as economical reasons (Riesa is close to Rossendorf). The last year is furthermore placed in Karlsruhe (this location is more specialised in radiation protection). Since 1992 the company Rossendorf Nuclear Engineering and Analytics Inc. provided fourteen students with an “on-the-job training”. All of them got there final qualification, for which almost all students aim.

3. Course contents

3.1 Theoretical phase

Radiation protection is an interdisciplinary, application-oriented science composed of different fields of activity.

Accordingly study contents are aligned with:
Natural sciences, information and communication techniques, general engineering sciences, consolidation subjects (specialising subjects) and business management and jurisprudence.

An overview to all subjects is contained in table 1.
Most of the subjects are included with practical trainings in laboratories.

Table 1: Overview about subjects of study (theoretical part)

Subjects of study	Number of hours per semester					
	1	2	3	4	5	6
Law (basic knowledge)	36					
Mathematics	60	48	48			
Physics	60	60				
Electrotechnology / Electronics	60					
Chemistry	60	60	72			
Informatics	36	36				
English (special)	36	36				
Apparatus and materials engineering (basic knowledge)		48	24			
Measurement and sensor technology		36	36			
Control engineering			36	48		
Project management and business economics			24	48		
Mechanical process engineering			72			
Thermal process engineering				72		
Instrumental analytics				60	60	
Quality and security management						96
Basics of Radiation Protection and Radiation medicine (Radiation measuring technique, medical basic knowledge)	36	60				
Radiology (Radiation medicine, radiation physics)			48	48	72	48
Radiation Protection				60		
Radiochemistry and Radio ecology					48	
Law of radiation protection					48	
Compulsory optional subjects					72	72

3.2 Practical phase

Table 2 shows the fields of activities of the practice-integrated study phase at Rossendorf. Column two contains the training-departments which are responsible for the training during the time interval which are placed in column three. You can see, there are two departments located outside from Rossendorf, i.e. we use the Dresden University of Technology, especially the Faculty of Medicine Carl Gustav Carus and the regulatory of Saxony for the education in medicine and in the field of authority.

Table 2: Overview above course contents (practical phase)

Subject of Study	responsible for this subject of study	Number of weeks for this subject
Introduction to nuclear large-scale installations (Rossendorf Research Reactor)	reactor department, VKTA	3 - 4
Environmental surveillance (meteorology, transport calculation, sample collection)	radiation protection department, VKTA	4
Waste management (transport, storage, treatment)	decommissioning and waste management department, VKTA	2 - 3
Incorporation monitoring (whole body counter, excretion analysis, dose assessments)	radiation protection department, VKTA	4
Clearance of low level radioactive materials for recycling or disposal	radiation protection department, VKTA	3

Measurement of activity and dose rate (room surveillance)	radiation protection department, VKTA	2
Apply for licence	conditions of Saxony	4 - 5
Treatment of liquid radioactive waste	decommissioning and waste management department, VKTA	3
Measurement of external exposures	radiation protection department	3
Activity measurement of filters and environmental samples	radiation protection department	2
Radiation protection in nuclear facilities, laboratories	decommissioning and waste management department	4
Shielding calculations	radiation protection department	2
Emergency management	radiation protection department	3

During the last three months the student prepares his bachelor degree.

Table 3 delivers an overview about all degree dissertations from 1995 to 2009.

Table 3: Overview about the dissertations submitted for a diploma in Rossendorf

Year	Title of degree dissertation submitted for diploma	Author	Report
1995	A computer aided expert system for interpretation of whole body counter results	Cordelia Hoinkis	VKTA report Nr. 29 Sept. 1995
1996	Preparation of Monte Carlo radiation transport program AMOS for simple shielding calculation	Sven Kowe	VKTA report Nr. 42 April 1997
1997	Investigation of usefulness of an in situ Gamma spectrometer for measuring gamma dose rate	Uwe Oehmichen	
1998	Quality assurance of contamination of persons and assessment of the influence of the contamination of the whole body counter result	Gregor Beger	
1999	Calculation of radiation dose for people of Rossendorf village using measured immission data	Sandra Reimann	
2000	Investigation of dependence of a Rossendorf whole body counter calibration to body mass and body length	Sven Jansen	VKTA report Nr. 67 March 2001
2001	Investigation of usefulness of a coincidence monitor for measurement the air activity concentration in a PET centre	Carina Reichelt	
2002	Examination of contamination pathways for contaminating the sediments of the Rossendorf river	Isabel Grahl	
2003	Experimental investigations of the nuclide specific estimation of Gamma dose rates by using a Gamma spectrometer without knowledge of depth distribution of activity	Anke Rietzschel	
2004	Introduction of quality assurance into the drum measuring device at Rossendorf department of decommission	Falk Tillner	VKTA report Nr. 78 Sept. 2004
2005	Continuos surveilance of the activity concentration of theRn-222- and Rn-220 daugther products at the low level underground laboratory “Felsenkeller” using a Ge-gamma ray spectrometer	Kathrin Behge	
2006	Investigation for the improvement of the efficiency of the Rossendorf whole body counter	Stefan Waurig	

2007	Computer aided analysis of LSC-beta-spectrum using reference spectra	Heike Mueller	
2009	Evaluation of the high resolution in-situ gamma spectrometry for clearance measurement of waste boxes	Jana Scheibke	
	Setup and commissioning of a few-channel spectrometer in pulsed radiation fields	Kerstin Brachvogel	

4. The graduate who has completed a course of radiation protection engineer at Rossendorf

Up to now eight graduated engineers got a job at Rossendorf. Because of the "on-the-job training" structure, the graduates are very acknowledged with the facilities at Rossendorf and no time-consuming period for establish an employee is necessary.
After get used to work fore same years as an engineer of radiation protection it is possible to work in positions in which one has great power and influence, for instance as production engineer at gathering station for radioactive waste of Saxony, at the Rossendorf research reactor or at the Rossendorf intermediate depot.

EDUCATION AND TRAINING IN RADIATION PROTECTION: THE INSTN EXPERIENCED APPROACH

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ABSTRACT

All domains using ionising radiations are concerned by a sustainable Education and Training (E&T) in Radiation Protection. In a context of both the increasing demand and decreasing number of radiation protection experts available in Europe, E&T is an essential aspect to enhance a radiation protection culture. Taking into account this background, the National Institute for Nuclear Science and Technology (INSTN) within the French Atomic Energy Commission (CEA) has proposed E&T courses to several groups of trainees concerned by Radiation Protection, since 1956.
These courses cover different levels of E&T in Radiation Protection (High school Diploma to post-graduate education and professional training)
The INSTN collaborates in ENETRAP II with other European partners to develop training standards and schemes to support the next EU BSS requirements.
This paper describes the most important Education and Training courses in radiation protection proposed by INSTN.

1. A few facts about the INSTN

As a part of the CEA (French Atomic Energy Commission), the National Institute for Nuclear Science and Technology (INSTN) is a higher education institution under the joint supervision of the Ministries in charge of higher Education and Industry. It was set up in 1956, when France decided to launch a nuclear programme, for providing engineers and researchers with high scientific and technological qualifications in all disciplines related to nuclear energy applications. The INSTN mission is to disseminate the CEA’s knowledge and know-how around the world. The INSTN headquarters are located at the Saclay CEA Centre (20 km South of Paris). Four branches are set up in the CEA’s centres at Grenoble, Cadarache, Marcoule and on the campus of Cherbourg-Octeville.

A few key figures of the INSTN can give an idea of the main contribution of the institute on education and training for nuclear science and technology: 120 in-house staff, 1,400 lecturers, teachers and experts, 8,000 trainees per year registered in vocational sessions (including 42% in RP), 700 students per year, 1,100 PhD students and 300 post-docs working in CEA's laboratories.
Several assets of the INSTN can be highlighted: a network of researchers and experts providing high-tech instruction, the ability to act as an interface between research bodies, universities and industry, the know-how and experience in teaching engineering and organising the adaptability for development in science and technology.

The INSTN is in charge of:

- National and European academic courses, for students, engineers and technicians, nuclear physicians, radiopharmacists and medical physicists;

- Vocational training sessions for professionals and PhD students of any origin and nationality;

- Training through research, which the institute coordinates; it also offers assistance and guidance to PhD students and post-doctoral researchers working in the CEA's laboratories. With a wealth of experience in international collaborations during the 70's, the INSTN is committed to European advancement and is helping to form partnerships and build up networks.

Its field of activities covers all the Education and Training in nuclear science and technology in particular in the radiation protection fields.

2. Radiation protection education and training

2.1 Training in radiation protection

Many training courses in radiation protection are implemented at INSTN for different kinds of professionals and for different levels of qualifications. We describe in this paper the most important training: Workers training in nuclear industry, radioactive material drivers, radiation protection Inspectors, Competent Person in Radiation Protection (PCR). The other training is described on the INSTN website: www-intn.cea.fr

2.1.1 Workers training in nuclear industry

In France, the radiation protection training for exposed workers (category A or B) entering supervised or controlled areas is mandatory and must be periodically updated, every 3 years as a minimum. Moreover, complementary training has to be followed by the industrial radiography workers to get a specific certificate. As regards the subcontractors in nuclear facilities, a specific training process is implemented.

Nuclear companies employing category A or B workers are responsible for the training of the employees, making the necessary arrangements in order to reach the required goal.

The French committee (CEFRI) is responsible for the certification of companies pertaining to the training and follow-up of workers under ionizing radiation The INSTN is one of the training providers certified.

Risk prevention training with different options has a training content adapted to three different sectors: Fuel cycle, nuclear power plants and research centres. The final objective for the participant is to react with the appropriate behaviour in real working situations. Two levels exist: Level 1 for the team worker and level 2 for the team supervisor. The Initial training cycle lasts 5 days with 2 days recycling, no later than 3 years after. For that kind of training, INSTN has developed 3 life-like workshops dedicated to the nuclear environment.

2.1.2 Radioactive material drivers

The European agreement on the international transport of dangerous materials by road (ADR) requires that all drivers of vehicles transporting radioactive materials attend an approved training course and pass a test. The INSTN is the only organism in France approved by the competent authority (Ministry of transport and Nuclear Safety Authority) for the training of drivers carrying radioactive materials by road.

The initial training for the drivers lasts five days with individual practical exercises and examinations. It is divided into, two parts, a basic course making drivers aware of hazards in the carriage of dangerous materials and a specialisation course for class 7, covering specific hazards related to ionizing radiation. The refresher training lasts three days and a half, and the drivers are obligated to take it every five years. The validity of the certificate is extended after the successful completion of the exam. The structure is the same as the initial training (basic and specialised courses).

There is also training for the safety adviser at the INSTN in competition with other training providers.

2.1.3 Radiation Protection Inspectors

The French Nuclear Safety Authority (ASN) supervises the safety and the Radiation Protection of workers (together with the ministry of labour), the public and patients. There are 429 in-house staff with a total of 232 inspectors from different academic background: engineers, medical doctor, pharmacist, lawyer. The inspectors are divided into two groups: 177 in nuclear safety and 84 in Radiation Protection. They control all the ionising radiation facilities in France. 700 inspections per year in nuclear safety and 700 inspections per year in RP in different fields (transportation, nuclear power plants, and Radiation Protection…) have performed.

To be operational, all inspectors train core curriculum about laws and regulations, which lasts 14 days.

The technical course on radiation protection (a mix of 15 theoretical and practical days) is only performed by the INSTN. The classical topics in radiation protection are taught (radioactivity, detection, dosimetry, biological effects…). Furthermore, specific modules on industrial and medical fields with internal ASN training is also performed: For refresher courses, each year, several short training (1 or 2 days), performed by ASN in-house experts for all the inspectors.

2.1.4 Competent Person in Radiation Protection (PCR)

In any installation where a radioactive source is located, the appointment of a “competent person in radiation protection (PCR)” is mandatory: it is the direct implementation of the European “qualified expert” fulfilling the requirements of the EURATOM Directive 96/29. The PCR is in relation with the radiation protection of the workers.

The PCR is appointed by the employer and may be external or internal to the enterprise, depending on the risk magnitude. Whatever the sector the PCR works in, the training must be organized in two modules. The first one is a five day theoretical module which runs with the three sectors (BNI Sector, Industry-research, Medical sector). This module must bear on the knowledge or the ionizing radiation and its biological effects, the radiation protection of the workers with the principles of protection against radiation and the regulation. This module is sanctioned by a written control of knowledge.

Then a practical module, specific to the sector and the option the attendee needs, must allow him to implement his theoretical knowledge to on the job situations. This module is sanctioned by an oral control of knowledge. This examination must verify the ability of the attendee to properly manipulate radiation detection apparatus, set up radiation protection principles and manage an incidental situation.

If the attendee succeeds in both theoretical and practical examinations, he is issued a certificate. Practising the duty of “PCR” in various sectors and options requires following and validating the corresponding adapted practical modules. A renewal of training is mandatory every 5 years.

Initial training is divided into two modules: the theoretical module lasts 4 to 5 days and the practical module lasts 3 to 5 days according to the sector. The refresher training lasts 4 to 5 days.

A ministerial order specifies the requirements on the trainers of PCR. The training of PCR must be carried out by a certified trainer. The trainer can get his certification from only two accredited organizations: either by the French Committee of certification of the Companies for the Training and the follow-up of the personnel working under Ionizing Radiation (CEFRI) or by the French Agency of Quality assurance (AFAQ).

Each country has its own organisation for RP training as regards the European qualified expert: e.g. PCR and Medical Radiation Physics Specialist” (MRPS) in France, RPA in the UK… In order to maintain a high level of knowledge and skills in radioprotection, to fight against the decline in expertise, to facilitate mutual recognition in workers, different European project programs (ENETRAP II, ENEN III, EUTERP) work on the elaboration of a European high-quality "reference standards" and good practices for education and training to enhance mobility of a "new" qualified expert. The term 'Qualified Expert' was misleading and, for the purposes of the next EU BSS, could be replaced by the more descriptive expression 'Radiation Protection Expert' (RPE) and should also include a definition of the Radiation Protection Officer (RPO), while further guidance could be provided in a Communication. The INSTN collaborates, within ENETRAP II under the 7th European Framework, with twelve other European partners to develop training standards and schemes to support these EU BSS requirements.

2.2 Education

2.2.1 Overview

At the national level, INSTN plays a pivotal role in all the level of Radiation Protection Education from high school graduate to engineer level. Four types of courses have been developed by INSTN, each corresponding to a category of personnel: i) first level of general training in Radiation Protection (PNR, eight weeks), ii) the Technician Diploma in Radiation Protection (BT, four months + one months of practical work), iii) the Advanced technician Diploma (BTS, six months + two months of practical work) and iv) the Master in Radiation Protection (six months + six months of practical work). Those highly specialized theoretical and practical courses, which are recognized by professionals and operators, are open to students, but also to employees willing to improve their professional qualification in the Radiation Protection field. In this paper, we will describe the master in Radiation Protection.

2.2.2 EMRP

INSTN has been involved in a Master's degree program since 1995. This former post-graduate educational course was transformed into a Master's degree in respect to Bologna declaration, in 2003. At that time, the only partnership was with the University Joseph Fourier (UJF) located in Grenoble.
A switch was set up with two more universities in order to create the European Master's degree in Radiation Protection, in 2006. It was one of the ENETRAP's outcomes (FP6). This new consortium of four universities concern three countries: France with INSTN and UJF, the Czech Republic with the Czech Technical University (CTU) in Praha and the UK with the UHI North Highland College in Thurso, Scotland.

The objectives of EMRP are firstly to build an integrated second year Master's degree course in Radiation Protection in order to meet the current and increasing needs for skilled personnel in sectors using ionizing radiation (industry, medicine, research). Secondly, to propose within this Academic course, a harmonized curriculum for Radiation Protection Expert (RPE/QE) to fulfil the requirements of the EURATOM Directive 96/29, thus favouring the mobility of experts across Europe.

The EMRP syllabus has two parts: the core curriculum and specific modules (figure 1).

	EMRP modules				
Core curriculum	1	Principles of nuclear and radiation Physics	7	Nuclear installation	Specific modules
	2	Detection and measurement methods and dosimetry	8	General Industry	
	3	Biological effect of radiation and Epidemiology	9	Medical applications	
	4	Legal and regulatory basis	10	Decommissioning and waste management	
	5	Occupational radiation protection	11	Non Ionising Radiation	
	6	Public and environment Radiation Protection	12	NORM	
			13	European Week	
			14	technical Visits	
			-	Internal Exposure: ENETRAP- EURADOS Module (elective suplementary module)	

Figure 1: EMRP syllabus

The organisation of EMRP allows each partner to deliver the core curriculum in the local language. They will develop and teach, in English, specific modules in their specialist area (at least, one location in English). A common selection procedure has to be implemented in each country. A minimum time period of 6 months (30 ECTS) has to be obtained in a foreign EU country in order to achieve the EMRP Diploma. To promote exchanges, the European week, is organized as an introduction seminar, each year at a different location, where all EMRP students from the different partner institutions will be registered together. The first one took place in Praha in January 2009.

More than two hundred students have been taught through this one year academic program for 15 years. They come from France, Algeria, Cameroon, China, Colombia, El Salvador, Gabon, Italy, Lebanon, Madagascar, Morocco, Niger and Tunisia.

74 professors and lectures are involved in the course. The steering committee is composed of 17 members. This full year represents 540 hours of lectures and practical work. The 6 months of on the job training period can be performed abroad. Three weeks for travel studies are highly appreciated. 100% of post-graduate students are employed.

Nevertheless, building this European Master's degree raises some difficulties. There is a large difference in tuition fees among partner institutions. It is necessary to find a unified definition of "joint diploma". The organisation of the required exchange period on a "one" year EMRP is difficult; maybe 2 years is required. A difference exists in radiation protection professional training and selection process among the partner countries. The running of a European course with needed exchanges is more expensive than domestic courses. Raising funds is critical to continue.

The Institute has been awarded the extended European University Charter 2007-2013 and, as stated in its Erasmus Policy Statement (EPS), it intends to strengthen and extend the undertaken actions by promoting the mobility of students.

3. Conclusion

INSTN is one of the major players in France in education and training on Radiation Protection fields. In addition, it implements high level educational programs in partnership with universities and engineering schools as well as professional training in the new fields explored by the CEA's research teams. At international level, INSTN organizes post-graduate courses in partner ship with supranational institutions as AIEA or European Commission.

NUCLEAR TRAINING CENTRE INVOLVEMENT IN RADIATION PROTECTION

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ABSTRACT

Applications of radiation sources have been developed in Romania mainly after the establishment of the Institute for Atomic Physics (IFA).

Professor Horia HULUBEI, the first IFA Director, realized from early beginning the necessity of a special education for radiation sources operators, even before the national regulation of the field. The first training programme, a post university training course on the utilization of isotopes and radiation sources, was initiated in 1960 by IFA and Physics and Mathematics Faculty.

In 1970 has been organized the Nuclear Training Centre (CPSDN) as specific unit with the purpose of post secondary training and post university specialization of personnel involved in nuclear practices.

CPSDN has provided, through its activity, a proper qualitative and quantitative support to the requirements of radiation sources users from all fields of activity such as industry, medicine, research, agriculture, army. Also, CPSDN developed the first specific training programmes for personnel involved in the nuclear power programme and research reactors.

According to present necessities, CPSDN is organizing standard training programmes envisaging the utilization of radiation sources under radiological safety conditions in specific applications, dedicated to special practices and responsibility. Topics and schedule are strictly connected to the applicants' aims, focusing on radiation protection in applications of sealed and unsealed sources, radiation generators, radiological safety in uranium and thorium mining and milling. Training curricula complies with the national regulatory requirements, each programme being certified by the regulatory body.

On request, CPSDN develops focused programmes for ionizing radiation special applications such as Postgraduate complex programme on Applications of Radio Isotopes and Nuclear Radiation Sources.

Involved in the nuclear field development, CPSDN has as permanent concern the continuous improvement of training services quality by diversifying the training offers and improving services performances. An important step towards the performance level of its own activity was the certification of CPSDN Quality Management System according to EN IS0 9001:2000, by TÜV HESSEN, through TÜV CERT in 2006.

Romanian accession to the European Union involves new challenges for nuclear education and training and, in this context, CPSDN is decided to become European competitive training provider for the nuclear field in radiological safety.

1. Brief History

Organized in 1970 as unit under State Committee for Nuclear Energy (CSEN), Nuclear Training Centre (CPSDN) took over the activities of training in nuclear field initiated by the Institute for Atomic Physics in cooperation with University of Mathematics and Physics from Bucharest (CUIR - post graduated education programme on the utilization of radioactive isotopes). Since then CPSDN has been developed many training forms dedicated to different applications, by categories of degrees of responsibilities in radiological safety assurance. Training programmes curricula have been permanently adjusted both to the technical

upgrading of the envisaged fields and to the growing regulatory requirements. During 1970 – 2008 CPSDN has contributed, through its activity, to the development of human resources competencies and expertise and to the implementation of research results of IFIN-HH and the other institutes from Magurele Platform. A short balance shows a number of over 750 training programmes and 18.500 graduates.
CPSDN organized, beside training programmes dedicated to users of radiological facilities, training of operators of VVER-S and TRIGA research reactors and training programmes for Cernavoda NPP Unit 1 operators.

2. Important Activities

The most important contributions for training of users consists, in terms of quantity, in programmes dedicated to operators for non destructive penetrating radiations examinations (qualification and authorization) and post graduated programme for all types of radiation sources, with several series per year.
Starting with 2006, CPSDN is organizing training forms for IFIN-HH personnel involved in the VVER-S research reactor decommissioning.
Training programmes structure has been permanently adapted to the evolution of regulations in the field. According to Romanian regulations in force, training programmes are organized on source types and practices.
Main training programmes which are organized several times per year are presented in Table 1.

TABLE 1

Standard Training Programmes	Schedule (No. of hours)
Radiation Protection on the Utilization of Measurement Systems with Radiation Sources	40
Radiation Protection on the Utilization of Radiological Facilities for Packages Control	30
Radiological Safety in Uranium and Thorium Mining and Milling	90
Radiation Protection in Radio Diagnostic Practice	30
Radiation Protection of Personnel and Patients in Nuclear Medicine	80
Radiological Safety on the Utilization of Radiation Open Sources	80
Radiological Safety on the Utilization of Radiation Sealed Sources	70
Applications of Radio Isotopes and Nuclear Radiation Sources	180
Radiological Safety on the Utilization of Sealed Sources /Open Sources/Radiation Generators. Knowledge Upgrading	30/40

For each programme, training level is adjusted to participants' knowledge level and responsibility.
A synthesis of activities developed during 2002 – 2008 (Table 2) demonstrates a continuous growing of CPSDN activities determined by the increasing of radiological equipment number in Romania though, during this period, CPSDN is no more the only training provider in the nuclear field.

TABLE 2

Year	2002	2003	2004	2005	2006	2007	2008
Number of programmes	12	15	21	23	27	31	31
Number of participants	293	231	372	397	647	716	719

Distribution of training programmes on sources types underlines an increasing of number of programmes for "Radiation Generators" (RG) field determined by important equipping in the field of public safe and security during last years (access control in protected objectives, custom control) and Roentgen diagnosis equipment updating in hospitals (Table 3).

TABLE 3

Source type	Number of training programmes			
	2005	**2006**	**2007**	**2008**
Sealed Sources	1	3	-	1
Nuclear Raw Material	2	1	1	1
Unsealed Sources	2	-	-	2
Radiation Generators, Sealed Sources	3	10	9	3
Sealed Sources, Unsealed Sources	4	3	-	1
Radiation Generators	11	7	17	14
Complex programme (Radiation Generators, Sealed Sources, Unsealed Sources)	-	2	4	8
Particles Accelerators	-	1	-	1

CPSDN is taking advantage of the opportunity of addressing to a large audience in order to promote nuclear physics and to present the achievements of IFIN-HH and other physics institutes researchers.
CPSDN facilitates trainees who are interested scientific visits in dedicated laboratories, access to IFIN-HH technical library, purchasing of “Physics Currier” and other specialty papers, such as: “Radiation Protection Currier” (Mircea Oncescu), “Nuclear Medicine Engineering” (Gheorghe Mateescu, Teddy Craciunescu), “Average and Excellence. Radiography of Science and Education in Romania” (Petre Frangopol), “Radionuclide. Radioactivity. Radiation Protection” (Petrica Sandru).
Also, CPSDN is organizing and participating as co-organizer in workshops such as: “Clinical dosimetry and limits of target volume in oncology radiotherapy (Bucharest, 9 – 10 March 2008), The First and The Second Symposium on “Secondary Standard Dosimetry” (2007, 2008), NUC INFO Days (2007, 2008, 2009), NUCLEAR PT 2008.
For the near future, CPSDN is decided to promote new education and informing methods in the nuclear field and other applied physics domains, edit educational materials (in Romanian/English languages) on main interest themes of radiation protection of population and environment.

2. Conclusions

CPSDN contribution to the development of human resources for the implementation of nuclear physics in Romania, during 1970 – 2008, consists in over 750 training programmes with over 18.500 participants.
Experience in covering a wide area of applications and quality of training programmes recommend CPSDN as important participant in the implementation of nuclear physics applications in Romania.
Through its continuous concern for improving training quality and based on an appreciated trainers team, CPSDN is ready to give a competitive answer to actual requirements for training and education of human resources from the field.
CPSDN is ready to share its experience to national and international partners for mutual benefit in order to improve and diversify its services.

TWENTY YEARS OF RADIOLOGICAL PROTECTION TRAINING AT DUBLIN UNIVERSITY

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ABSTRACT

A description is given of the training workshop in radiological protection held in Trinity College, University of Dublin every year for the last twenty years, and its development during this period. The workshop originally consisted of three lectures on radiation detection, dosimetry and regulation. It now includes presentations by both internal and external speakers on principles of radiation production, dosimetry and detection, unsealed radionuclides, external radiation including X-rays, university radiation safety rules and procedures, and national radiation safety legislation and its enforcement. There are also problem solving workshops together with laboratory sessions on protection procedures, radiation hazards, spills, decontamination and emergency procedures, contamination monitoring and incident management. The workshop has proved to be valuable for both research students and academic staff. In 1989 it attracted 50 delegates from a university totalling 8,000 students; it now has an attendance of up to 70, the university having nearly doubled in size.

1. Trinity College Dublin

The University of Dublin (or Trinity College Dublin, as it is usually called) was founded in 1592. The study and use of ionising radiation in Trinity College can be traced back by over a century from the present day to the pioneering work of the Trinity geophysicist John Joly. As early as 1907 he investigated pleochroic haloes created by the alpha-particle tracks from small radioactive inclusions in geological minerals (1). By 1914 he had developed a method for extracting radium and using it, or more usually the radon emanating from it, in $>$ 1 GBq quantities placed in hollow needles for insertion into cancerous tumours for radiotherapy treatment (2).

Later on, among other work in College, E. T. S. Walton worked in the 1950s on accelerator development. This was after his return to Trinity from the Cavendish laboratory, Cambridge. There in 1932, urged on by Rutherford, Walton and John Cockcroft had split the atomic nucleus (3). For this achievement the two shared the 1951 Nobel prize for Physics.

In 1962, Trinity installed an early caesium-137 gamma irradiator for work in plant genetics. However, despite the overall increase in work with ionising radiation, no formal training in radiological protection was given for many years in Trinity College, or indeed anywhere else in Ireland. From the 1950s onwards (and presumably earlier as well) new users in College of sources of ionising radiation were instead informally briefed for about an hour on an individual basis as the need arose. By the middle of the 1980s information sessions were also being held which were aimed mainly at biochemists using unsealed sources (4).

2. The early development of radiological protection in Ireland

Before the 1970s a national dosimetry service for Ireland was offered in association with St Luke's Hospital, Dublin. This hospital was founded in 1954 specifically for the radiotherapy of cancer.

In 1971, Trinity College appointed its first Radiological Protection Officer (R.P.O.). This was at his own instigation, and it was the first such appointment made at any Irish university.

This predated any state organisation for radiological protection. Such an institution gradually evolved from only 1973 onwards, when the Nuclear Energy Board was established. This was eventually superseded in 1992 by the present Radiological Protection Institute of Ireland.

Concurrent with these developments, national legislation was introduced in 1977 and again in 1991 to regulate the use of sources of ionising radiation (5), (6).

Nevertheless, the number of training courses available within Ireland remained, and still remains, small. However, instruction in radiological protection was one of the duties of the R.P.O. officially laid down by College in 1987. By then, there was a wide range of work in College involving the study and use of ionising radiation. (A much more recent example is our own work on the gamma radioactivity of building materials in Ireland (7).)

It was in this context that the current formal arrangement of annual training workshops in radiological protection was launched in the College twenty years ago this year.

3. The first workshop

In October 1989 the new R.P.O. at the time (E.C.F.) arranged the College's first formal training workshop in radiological protection. At that time the College had grown to just over 8,000 students. A significant number of these in the physical and especially the biological sciences were using both sealed and unsealed sources of radiation. There were also those working in the College's teaching hospitals. Although they sometimes participated in the workshops they were subject to separate administrative arrangements for radiological protection.

The first workshop attracted an attendance of about 50. Most delegates were research students, but 12 academic and technical staff members were also present. It lasted just three hours, and contained presentations on

(a) Radiation production, detection and dosimetry
(b) Radiation protection and the biologist
(c) The role of the Nuclear Energy Board.

The standard pattern was established that presentations were always given by members of the College staff except for topics like (c), which (in this case) was given by an officer of the Nuclear Energy Board.

Demonstrations were shown of different radiation monitors in operation, radiation shielding etc. There were also videos on radiological protection, produced by Sheffield University Television, and on the handling of unsealed radioisotopes, produced by Amersham laboratories. A valuable principle, established at this first workshop, was to have a senior person such as the Science Faculty Dean introduce the workshop

4. Early developments

By popular demand the training workshop was repeated three months later at the beginning of 1990. Thereafter, workshops were held annually in the autumn. In 1991 the workshop was extended to a full day, and included a fourth presentation on the development of the principles of radiological protection.

In that year there was also for the first time a session in which delegates were required to solve simple numerical problems on basic nuclear principles, half-lives, activities, the inverse square law, dose rates etc. Inevitably, what was trivial for some was a major challenge for others. The underlying pedagogy was (and is) to make delegates think for themselves and talk with one another for an hour or so about radiological protection. The session has never been thought of as an examination.

Also at this workshop, a few delegates were present from a separate institution outside Trinity College. After a time this development tended to be restricted; despite some extremely positive feedback from the outsiders, it was found that in general workshops ran more smoothly when attendance was confined to those towards whom the College had actual responsibility for their radiological protection.

In a separate development Trinity College participated in 1993 in a series of collaborative radiological protection training workshops involving University College, Dublin, the Autonomous University of Barcelona, and an Irish industrial firm using a large gamma irradiator. This was supported by the ‘COMETT’ European Community technological training programme for universities and industry.

During this period workshops for College attracted an attendance each year of between 30 and 40. In 1996 the workshop was expanded to include laboratory-based practical demonstrations of the safe handling of unsealed sources.

5. Workshops since 2000

By 2000 each workshop was attracting up to 70 delegates. This reflected the major expansion in research activity in College at the time, and also in student numbers, which, by 2009, reached nearly 16,000. As a result of feedback from course participants, the new R.P.O. (E.M.D.) decided to extend the workshop to one-and-a-half days’ length, and at one stage to even two days, in order to include, in particular, more practical laboratory sessions.

New presentations have been added on internal and external hazards including X-ray diffraction systems, and on national and College legislation and regulations. There are also the new practical sessions on radiation, spills, contamination monitoring and decontamination, emergency procedures, and incident management. Certificates of attendance are also now presented to the delegates. As in the past, copies of the presentations and ancillary material are also given out.

6. Current workshop structure

The first day of the workshop currently consists of the following activities:

(a) Radiation production, detection and dosimetry – 90 minutes
(b) Protection from external radiation and the safe use of X-rays – 45 minutes
(c) College radiation safety rules and procedures – 45 minutes

(d) Introduction to problem solving techniques – 75 minutes
(e) Practical session (i): Practical protection from radiation in a laboratory situation – 75 minutes.

On the second day the workshop normally runs in only the morning, and contains the following:

(f) The safe use of unsealed radioisotopes – 45 minutes
(g) Radiation safety legislation and enforcement – 45 minutes
(h) Practical sessions: (ii) Hazards (iii) Emergency procedures (iv) Contamination monitoring (v) Incident management – total of 105 minutes.

7. The EU context

The training workshop content has been changed over the years to reflect changes in recommendations that were periodically put forward by the International Commission on Radiological Protection based on the best available scientific data. The recommendations of ICRP 60 of 1990 (8) were implemented into European law through the introduction of an EU Council Directive (96/29 Euratom of 13 May 1996) (9). This directive sets out the basic safety standards for the health protection of workers and the general public against the dangers of ionising radiation, and is known as the European Basic Safety Standards Directive.

The 1996 directive differs from earlier versions in many respects, including the introduction of special provisions concerning exposure to natural radiation sources and new lower radiation dose limits for members of the public, exposed workers and pregnant employees. This EU directive was implemented by national legislation in Ireland in May 2000, by the introduction of a statutory instrument entitled S.I. No.125 of 2000 'Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000' (Govt. Publications Office, 2000) (10). Many changes were made to the workshop content at this time to reflect the principles of this new legislation.

All EU countries now have national legislation that implements the same basic principles and radiation dose limits as those outlined in the European Basic Standards Directive. Consequently, the workshop core content is appropriate for course participants whether they work in Ireland or in another EU country. In 2007 the ICRP approved new recommendations (10), which will inevitably lead to Ireland's national legislation with regard to radiological protection being updated in the future. It is not expected, however, that this will lead to many changes in the workshop content, as the basic principles in these ICRP recommendations remain unchanged and the current radiation dose limits are not affected.

8. Conclusions

Our experience over the years has amply demonstrated to us the worth and value of running training workshops in radiological protection 'in-house' to the members of a large institution like Trinity College. We intend to continue developing these workshops as the need arises.

9. Acknowledgements

We wish to thank Professor Ian McAulay (the first College R.P.O. at Trinity College Dublin) for his invaluable support and advice in the development of these workshops, and for his critical review of this paper.

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Education and Training in Radiological Protection and Safety in Portugal: Collaboration between a University (IST) and a Research Centre (ITN)

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ABSTRACT
Radioactive sources and materials, particle accelerators and nuclear technologies are used in Portugal mainly in medicine, industry, agriculture, research and more recently for security applications.
This paper reports on collaborative education and training activities, on going since 2004, between the Nuclear and Technological Institute (ITN, a research centre) and the Technical University of Lisbon (IST) to develop higher education and training programmes for various target receptors. Two education and training programmes are analysed: a "pre-Bologna" Master Degree on Radiological Protection and Safety carried out between 2004 and 2005 and two Post-Graduation Diploma (2 semesters, circa 60 ECTS) on "Radiological Protection and Safety", in place since 2006. Only preliminary conclusions are discussed in this paper but the experience has already shown the superior benefits of collaborations between Portuguese Universities and research centers in terms of radiological protection training and education for a wider audience.

Introduction
The uses of ionizing radiations in Portugal have increased significantly in recent years with the new demands for licensing of practices, facilities and imports of sealed and open sources to be used in a wider range of applications both in the health, industrial and R&E sectors.
The degree of awareness that has been growing in recent years shows that competent and skilful professionals must be educated and trained to respond not only to the everyday needs but also to increasingly more complex scenario, from routine to emergency situations from dealing with radioactive and/or radiation sources. Reported accident consequences (radiological accidents, radiological and nuclear threats arising from the utilization of radiological dispersal devices and from malevolent acts, etc.) have shown the need to invest in education and training on radiation protection and related topics such as radioactive waste management. Many authors [Stornik, K., IAEA Bulletin, 1984, 1] have been calling the attention for the need of an integrated approach to education and training in both radiological protection and nuclear safety that should not forget the fundamental importance of the multidisciplinary fields involved: chemistry, physics, biology, medicine, geology, computational methods, risk analysis, sociology and communication. And this awareness has also been the core of many international organizations and National Governments' concerns and legislation.
Despite last years' undeniable progresses, Portugal is still far from the ideal ratios in terms of radiotherapy installations (6 units per one-million inhabitants) and the lack in human resources needed to operate these facilities and to continuously be trained in order to be able to operate new and more sophisticated equipment that has been introduced in the market, is even a more complicated issue.
The Portuguese legal framework on radiation protection, based on the transposition of the 96/29 and 97/43 EURATOM Directives to the national legislative framework requires the arrangement for relevant training to be given to exposed workers, apprentices and students. Decree-Law 227/2008 establishes the legal framework concerning professional qualifications in the field of radiological protection. Therefore, Radiation Protection Experts (RPE), Radiation Protection Officers (RPO) and also Operators are new designations of experts and technical responsible personnel for carrying out radiation protection tasks in radiological activities and practices.

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However, the fact that the regulatory competences on radiological protection and safety are spread out through a number of different competent authorities and not assigned to a unique independent regulatory body/authority, has in many ways delayed the practical application of the professional qualifications established in the legislation.

The relevance of professional training and the urgent need to attract young people to all fields related to the applications of ionising radiation in the medical, industrial and research areas, have been the central motivation for the collaboration that has started in 2004 between the Nuclear and Technological Institute (ITN, a research centre from the Portuguese Ministry of Science, Technology and Higher Education), through its Radiological Protection and Safety Unit (UPSR) and the Department of Physics of the Technical University of Lisbon (IST).

Main Objectives of the Higher Education Programmes

The main objectives have been to develop higher education and training programmes to prepare experts and researchers to complement the resolution of many not yet solved issues in various areas of radiological protection in Portugal such as:

- To evaluate the populations' exposure to ionizing radiation from medical and industrial applications
- To study the efficacy of the planning treatment systems in Radiotherapy and to better understand the secondary effects of the ionizing radiation applications through cytogenetic studies and biological dosimetry for both exposed workers and patients
- To clarify the need and benefits of implementing radiation detection methods for individual and areas' monitoring.
- To help people, mainly in the medical sector but also in the industry and in the research fields, to understand and apply legal obligations in the national legislation resulting from EU Directives and international recommendations with the objective to implement good practices through practical protocols.
- To introduce general concepts about environmental radioactivity in order to clarify differences between natural radioactivity and the presence of artificial radionuclide in the environment.
- To help people to understand the concept of radioactive waste resulting from the uses of radioactive materials in the medical, industrial, agricultural, research and teaching areas.
- To advise and train all users of radioactive sources, mainly the waste management scheme, that can result in the loss of the sources with all the possible negative effects.
- To give not only a wider panoramic of all the benefits of the application of ionising radiations but also the consequences of malpractices as result of ignorance or misunderstand of basic concepts and the steps needed to implement in case of radiological emergencies
- To introduce people to basic concepts such as nuclear safety, nuclear emergencies and nuclear wastes in order to increase and complement their knowledge in an area common in many EU Countries and whose effects go beyond borders.

Two education programmes have been enforced: a "pre-Bologna" Master Degree on Radiological Protection and Safety carried out between 2004 and 2005 and two Post-Graduation Diploma (2 semesters, circa 60 ECTS) on "Radiological Protection and Safety", in place since 2006, targeting medical and industrial professionals, final Degree and Post-graduate students from different degrees such as Physics, Engineering, Chemistry, Biochemistry, Geology and Health Physics disciplines. The courses programme includes introduction to nuclear physics, fundamentals of safety and radiation protection, dosimetry, environment radioactivity and radioactive waste management, radiation shielding, Monte Carlo applications and biological effects of radiation, amongst others. Differences in the programmes' contents are basically dependent on the background of the target audience.

Candidates Profile

For both Master Degrees and DFA, candidates can apply with a minimum classification of 14 out of 20 points obtained either from a Degree or from the Bolonha's second cycle, in the following areas:

- Physics, Physics Engineering, Technological Physic Engineering
- Biology, Biomedical Engineering, Medicine
- Chemistry, Technological Chemistry, Biochemistry
- Chemical Engineering, Biological Engineering
- Radiological Sciences from Higher Educational Institutes (Radiotherapy, Radiology, Nuclear Medicine)

Only in exceptional cases, such as the ones showing already a wider professional experience and knowledge, admissions are accepted with final classifications below 14 or from degrees in areas not above specified (ex: Civil and Mining Engineering, Law and International Relations).

Curricular Structure

For both the Master Degree on Radiological Protection and Safety (4 semesters, circa 120 ECTS) and the two Post-Graduation Diploma, DFA[2], (2 semesters, circa 60 ECTS) in "Radiological Protection and Safety", basic programmes' contents were, in many ways, similar but the Master Degree had the obligation of presenting a thesis fact that does not exist in the DFA. The fundamental structure of the DFA actually in place is organized in a system of credits (~ 120 ECTS) and the study plan comprehends harmonization disciplines to complement the basic formation of the candidates (H), technological and technical specialized disciplines related to the core of the learning objectives that are compulsory (T) and optional disciplines (O) that will be chosen following discussion between the Master or DFA Coordination Team and the candidate having in mind his/her profile and professional interests. Table 1 shows the post-graduation credits associated to each discipline for all semesters.

Table 1 – DFA' s disciplines and associated credits (in ECTS)

1st Semester	Credits (ECTS) (T+P+L+Proj)		Curricular Unit
Elements of Physics and Nuclear Reactions	(3T+1.5P)	6	T
Radiological Protection and Safety	(3T+1.5P)	6	T
Nuclear Experimental Techniques	(2P+4L)	6	T
Introduction to Monte Carlo	(2T+3L)	6	T
Biochemistry and Molecular Biology	(3T+1.5L)	6	H

2nd Semester	Credits (ECTS) (T+P+L+Proj)		Curricular Unit
Biological Effects of Radiation	(3T+1.5P)	6	T
Introduction to Dosimetry	(3T+1.5P)	6	T
Shielding Design and Assessment	(1T+3Proj)	6	T
Environmental Radioactivity and Radioactive Waste Management	(2T+2P+1L)	6	T

Preliminary Findings and Discussion

Preliminary findings have shown that most students having no basic knowledge in radiations and physics find quite hard to understanding the basic radiological protection and safety concepts. This problem is only partially absent in professionals already dealing with practices involving uses of radioactive and radiation sources in workplaces (medicine and industry) where this knowledge existed and was passed on to actual professionals. This process tends to be quite rare as most senior people working in the field have retired and curricula of high schools and universities do

[2] DFA stands for "Diploma de Formação Avançada" (Advanced Training Diploma)

not consider these subjects as fundamental ones. One of the subjects that most interested students, mainly those who are professionals, is the application of the legislation (topics such as licensing, authorization for practices, exemption values, import/export of sources, discharge values, dose criteria for each practice, etc.).

An insufficient knowledge of basic mathematics makes quite difficult the comprehension of more detailed approaches, mainly the development and the application of equations often found in the legislation (dosimetry, shielding design and assessment of installations, radioactive waste discharges, etc.). Disciplines such as Monte Carlo simulation have shown that in the beginning students take a very defensive approach to the subject due to difficulties in dealing with computer simulation programmes, software programming and data analysis. Students perceive environmental radioactivity as an added value to the knowledge acquired and tend to related it to what they read in the media, mainly accidents such as Chernobyl or the uranium radwastes but not yet as something that should be seen as fully integrated in the broad area of radiological protection. Radioactive waste management has shown to be an important subject for students working in nuclear medicine and in the industry but more in terms of individual protection that incorporated in a wider radiological programme. Many students have also shown the existent misconceptions between radioactive and nuclear waste and, in many cases, due to wrong information collected from the media.

The discipline of biological effects of radiation is usually seen in a very positive way but the results have shown that lack of fundamentals in biology, chemistry and biochemistry. In such cases as well as in radiological protection and safety, radiological monitoring of suspected contaminated areas and/or people, the reduced or even the non-existence of practical classes due to logistic problems, is one of the negative culprits of the training and educational schemes being developed up to now.

The still ongoing experience has also shown that people, regardless their actual professional status, are eager to gain more knowledge in areas having a social impact such as nuclear power, radioactive waste management, protection of the environment and biological effects of radiation although, sometimes, and due to the lack of formal educational that should have been provided much earlier in life, tend to misunderstand very distinct concepts such as nuclear and radiological accidents/incidents, the effects of having smoke detectors at home containing a radioactive material that should be treated as radioactive waste, the dangers of wrong manipulation of sealed sources in the industry.

It has also been shown that professionals, already working for some years in their respective fields, do not feel very enthusiastic in attending training courses to recycle or refresh their knowledge or learn new skills.

Data collected up to now about expectations concerning the ongoing educational programmes are still very inconsistent due to the professional and academic heterogeneity of the target people and the difficulty in having them expressing openly their true feelings about the subjects involved.

It seems clear that post-graduation courses in these areas are fundamental to proceed but more detailed discussion should be given to the content of the disciplines accordingly to the candidate's characteristics and objectives and that is imperative that current university curricula should include the basics in radiological protection and safety. Also the implementation of Summer Schools between the Portuguese Universities, Classical and Technical, and the Public Institutes should be a factor to take into account in the future.

The authors feel that this is the right time to establishing a task force at high level, to further pursue the identification of the needs and the resolution of the problems encountered in the above described collaboration between IST and ITN (but extensively to all establishments that are interested in cooperating), with the objective to setup a national educational and training strategy to further develop competences in radiological protection and nuclear safety.

SOGIN
RADIOLOGICAL PROTECTION AND NUCLEAR SAFETY SCHOOL EXPERIENCE AND PROSPECTS

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ABSTRACT

SOGIN is a joint-stock company owned by the Ministry of Economy and Finance. It was established in November 1999 to implement the decommissioning of nuclear installations in Italy. Due to the numerous technical and cultural diversities found in its sites, SOGIN has set itself the objective of standardizing the management of the radiation protection of its workers and the population. This requires a precise series of actions for guidance, coordination, and control. With this in mind, in February 2008, SOGIN set up its Radiation Protection and Nuclear Safety School. So far courses have been held for 590 participants for a total of 17,000 man hours in participation and 1,800 man hours in teaching. The results obtained to date are considered positive.

1. Introduction

SOGIN is joint-stock company owned by the Ministry of Economy and Finance. It was established in November 1999 to implement the decommissioning of Italian Nuclear Power Plants (Caorso, Trino, Latina, Garigliano). Furthermore, from 2003, SOGIN has been given the task of decommissioning a nuclear fuel production plant (Bosco Marengo) and three fuel-cycle plants (Casaccia, Trisaia, Saluggia).

Plant	Reactor type	Power MWe	Final shutdown	end decommissioning
Garigliano	BWR	150	1978	2019
Latina	GCR	200	1986	2019
Caorso	BWR	860	1986	2019
Trino V.	PWR	260	1987	2013

Plant	Facility Type	end decommissioning
EUREX – Saluggia	nuclear fuel reprocessing	2019
FN - Bosco Marengo	nuclear fuel production	2009
IPU – Casaccia	research on nuclear fuel elements	2018
OPEC – Casaccia	research and analysis on post-radiation nuclear fuel elements	2018
ITREC – Trisaia	Fuel reprocessing and production (thorium-uranium cycle)	2019

The total cost of decommissioning is expected to be 5.200 million Euro.

Currently, 680 employees work in SOGIN.
SOGIN plants are very different from one another with diverse technical, cultural, organizational, and professional contexts. To face this situation, the company has set itself the goal of standardizing, where possible, the safety conditions for workers and population, aiming at establishing a coordinated way of operating, in accordance with recommended quality standards. This requires a clear act of guidance, coordination and control.
In this context, on 5 February 2008, SOGIN established the "Radiological Protection and Nuclear Safety School" at Caorso NPP. At present, the school formally falls under Human Resources Management employing staff working in different fields within SOGIN.

This presentation describes:

- tasks allocated to the School
- courses provided in 2009
- results
- areas of expected improvement

2. School tasks

The tasks of the School are:

- Developing, diffusing and consolidating the culture of Radiation Protection and Nuclear Safety in SOGIN.
- Promoting uniform and appropriate behavior in every SOGIN site.
- Contributing to the maintenance and to the improvement of security conditions on the sites.
- Representing the Company in the international nuclear field and in the Italian academic world.
- Establishing a reference point for Italian companies working in the nuclear field.

The courses are for both in-house and external customers.

3. Courses provided in 2009

Basic Courses:

- Radiation Protection for qualified personnel (5 weeks)
- Radiation Protection and Safety for new employees (2 weeks)
- Individual protection devices Management (2 days)

Specialized courses:

- General nuclear safety from design to testing (1 week)
- Management of radioactive materials and radiological characterization of the plant (7 days)
- Assessment of Environmental Impact for normal conditions radioactive releases (1 week)
- Assessment for Environmental Impact for emergency radioactive releases (1 week)
- Internal Dosimetry (1 week)
- External Dosimetry (1 week)
- Total Quality - N° 4 modules (8 months.) Contract management and supervision of works on construction sites
- Security Analysis (1 week)
- Nuclear Safety Culture (2.5 days).
- Methods of calculation and assessment of external dose by numerical codes_(1 week).
- Radiation protection Italian regulations (D.lgs. D. 230/95) and safety at work Italian regulations (D.Lgs 81/08) (1 day)
- Nuclear regulations (2 days).
- Follow-up of 2008 courses (RAD1 and RAD2 - Almera - Culture Safety & Security Analysis)

For each course, a person has been appointed to be responsible for the guidance, coordination, and selection of teachers. The people in charge are SOGIN experts in the field of Radiation Protection and Nuclear Safety while the teachers, who are experts in the various subjects, can be either from inside or outside SOGIN. For each course, a record card is prepared with course objectives, potential participants, and programs. The programs include classroom exercises using computational codes, laboratory demonstrations, and visits to the plant. A final test to evaluate the degree of learning and a questionnaire on the satisfaction of learners close every course.

4. The people present at the courses

The courses of the School are for:

- site personnel:
  - Site Managers: Project Manager - Plant Manager - Project Engineering - Field Manager
  - Head of Chemistry and Health Physics Divisions

- Heads of Operation - Maintenance – C.F.S. - Q.A Divisions
- Staff in possession of certificates or licenses to conduct Plant
- Employees and workers of Exercise - Maintenance - Chemistry and Health Physics Divisions

- headquarters staff:
  - Engineering Staff
  - Human Resources
  - Contracts Office
  - Legal Office
  - Markets & Business Development
  - Administration Office
  - Operations Planning

5. Results

Activities balance 2008 – 1st half of 2009, forecast 2009

		Activities balance 2008	Activities balance 1st half for 2009	Forecast 2009
Courses	n.	17	20	30
Participants	n.	229	261	300
Participants x hours	man x hours	12.000	7.209	10.000
Teachers	n.	15	17	20
Teaching	hours	1.000	810	1.000
Satisfaction participant		83%	83%	
Average mark final test		7/10	8/10	

Beyond the numbers, we would like to underline the following:

- the enthusiasm and commitment of learners, teachers, and organizers;
- the notions and the criteria learnt during a course can be the basis for the harmonious development of skills and professionalism;
- the development of skills and expertise is achieved not only through training but also with the full involvement of resources in planning and executing activities;
- the development, deployment, consolidation, and uniformity of nuclear culture in society is of particular importance as many contractors are generally employed.

6. Improvement areas

In-house customers

The results in terms of participation and learning of SOGIN staff can be further improved through:

- the full involvement of all offices involved in defining the training of its personnel;
- the establishment of an agreed program;
- the establishment of incentives and rewards for learners and their managers and teachers, according to the results obtained.

Maintenance of skills

Given that the development of skills and expertise is achieved not only through training but also with the full and proper involvement of resources in planning, executive, and managerial activities, in this area the School can give its specific contribution through the follow - up and recycling of 'Operational Experience'.

External customers

Sogin's Service Communication no. 65/2008 gives the school the following tasks:

- align training of radiation protection and nuclear safety to European and international experiences;
- represent the company in the international nuclear industry and in the Italian academic world;
- provide qualified technical reference for Italian companies involved in the radiological, nuclear, and local contexts.

In order for the tasks listed above to be developed effectively and consistently, the organization, marketing, and logistical aspects will also be handled by the School, thus making it a key reference point for the Company while also coordinating teaching activities with external customers.

Organizational actions

The organizational structure of the School is being improved by means of :

- a better integration into the Company;
- the inclusion of School activities according to the Company's Quality Assurance System;
- the appointment of appropriate experts for the continuous updating of the courses, recycling of operational experience, maintaining relations with universities and foreign operators.

Marketing and Business Development

In order to increase the marketing and business activities, the following are determinant:

- a system to manage clear and timely reports with corporations (private and public) involved with activities of the school;
- an ad hoc team that promotes, monitors, and coordinates all relations with the public concerning the school and supports actions already underway;
- a new policy of prices.

A TOOLKIT FOR RADIATION DOSE ASSESSMENTS

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ABSTRACT

Regulations regarding radiation protection require that safety assessments are supported by numerical calculations of doses incurred by workers and the population, both for the operational lifetime and for the long term evolution of the facility. Many institutions and companies develop calculation tools targeted towards specific applications, such as radiological characterisation of effluents and waste, assessment of doses incurred by workers due to occupational exposure, leaching of radionuclides from a long term disposal facility of radioactive waste, etc. Tractebel Engineering has developed a toolkit to suggest the best suited tools for the assessment of any facility and for any development phase. By constantly following up on the international developments of calculation codes and tools, as well as regulations and standards, Tractebel Engineering is able to respond to the needs in radiation dose assessment appropriately. This paper presents the status of the toolkit, including the tools currently mastered by Tractebel Engineering.

1. Introduction

Many different processes can result in the exposure of humans to ionising radiation or radioactive substances. The role of radiation protection is to assess at all times this exposure, in order to establish the required means of protection. A vast landscape of commercially or freely available calculation codes exists, each one of them targeted towards a specific field of application. Tractebel's RDA (Radiation Dose Assessment) toolkit provides a roadmap, to guide radiation protection agents towards the best suitable calculation codes at hand.

Figure 1 illustrates the different processes that can occur due to nuclear activities. The risks associated to these processes can be (external) irradiation and external/internal contamination of nuclear operators and or members of the population.

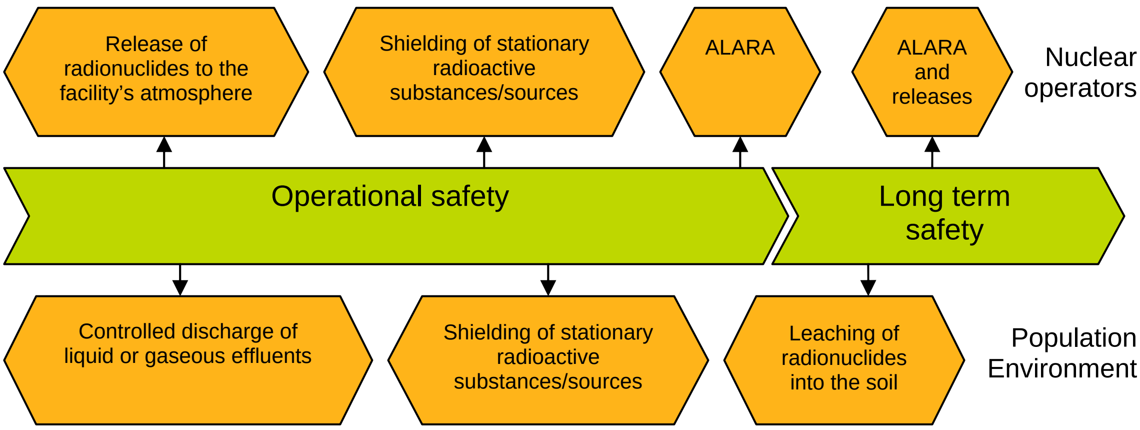

Figure 1 – Processes that occur due to nuclear activities

2. The RDA Toolkit

A multitude of calculation codes and tools exists, each one of them targeted towards a specific application. Without proper guidance, selecting the adequate code is often difficult. As a consequence, a lot of time is wasted during the exploration of the available calculation codes and tools.

The objective of the RDA (radiation dose assessment) toolkit is to identify all the irradiation and contamination risks involved in nuclear operations and to guide the user towards the codes that can perform the required dose rate calculations. The development of the RDA toolkit is based on experience built up during the execution of different projects.

As illustrated in Figure 1, the following processes can occur due to nuclear activities:

- Controlled discharge of liquid and gaseous effluents, leading to irradiation, internal and external contamination risks for the population and the environment;
- Release of radionuclides into the facility's atmosphere, leading to irradiation and internal contamination risks for nuclear operators;
- Shielding of stationary radioactive materials, in order to limit irradiation risks, both for nuclear operators and members of the population;
- The ALARA approach to protect the nuclear operators;
- Leaching of radionuclides into the soil, leading to irradiation, internal and external contamination risks for the population and the environment in the long term.

Table 1 gives a non exhaustive overview of codes currently used by Tractebel Engineering for radiation protection calculations.

	Operational safety				Long term safety
	Controlled discharge of liquid and gaseous effluents	Release of radionuclides into the facility atmosphere	Shielding of stationary radioactive materials	ALARA	Leaching of radionuclides into the soil
Irradiation risk for operators	NA	RESRAD BUILD	MicroShield® MCNP	VISIPLAN	NA
Contamination risk for operators	NA	RESRAD BUILD	NA	NA	NA
Irradiation risk for population	FRAMES GENII	NA	MicroShield® MCNP SKY3PC SKYDOSE	NA	RESRAD OFFSITE
Contamination risk for population and environment	FRAMES GENII	NA	NA	NA	RESRAD OFFSITE

Table 1 – Calculation tools envisaged for the risks and groups

The RDA toolkit features all these codes and suggests the best suitable codes for the required dose assessments. The calculation codes and tools have been developed by different organisations. Some of them are freely available, others are commercial products.

Tractebel Engineering closely follows up on the international development of codes and tools, in order to keep the RDA toolkit in line with the required standards.

3. A collection of radiation dose calculation codes

This section provides a description of the codes used for radiation protection calculations by Tractebel Engineering. Tractebel Engineering constantly follows up on these codes and new codes in development in order to keep the RDA toolkit up to date.

3.1 Shielding and skyshine calculations

3.1.1 MCNP(X)

MCNP(X) [1] is a Monte Carlo N-particle simulation tool, developed by Los Alamos National Laboratory, to perform neutron, photon, electron or coupled particle transport calculations. It models interaction between particles and matter and tracks nearly all particles at nearly all energies. MCNP(X) is a versatile and easy to use tool because of its multitude of features, such as a collection of sources and geometries, as well as its extensive collection of cross-section data.

Based on the Monte Carlo method, MCNP(X) is an efficient and accurate code, but the downside is that it is very calculation intensive, it requires high-performance calculation machines and it requires very accurate input data. For basic calculations, conservative estimates or screening purposes, it is often advisable to resort to other, more intuitive, codes that highlight a specific aspect or process.

3.1.2 MicroShield®

MicroShield® [2] is a comprehensive assessment tool, marketed by Grove Software Inc., to perform photon/gamma ray shielding and dose assessment calculations. It is widely used, among others for designing radiation shields, estimating source strengths from radiation measurements and education.

It is based on the point kernel method, applied to 16 relatively simple geometries. In addition to the source, up to 10 shields can be defined using simple or composite materials. Six dose points can be defined for one run. The photon spectrum is created either as radionuclides or as energies, and photon energies can be grouped according to different grouping methods, including user defined. Uncollided and buildup results are calculated simultaneously.

3.1.3 SKYSHINE III

SKYSHINE III [3] has been developed by Radiation Research Associated Inc. to evaluate the effects of a building structure on the neutron and gamma dose rate at a given position outside a building housing several point-isotropic sources. It is used to evaluate the shielding performance of the engineered walls, the effect of reflection and attenuation of the walls and scattering in the air.

The SKYSHINE III program considers a rectangular structure enclosed by 4 walls and a roof, each consisting of up to 9 segments. The Monte Carlo method is used to generate different events, the consequences of which are estimated by means of interpolation of data from validated lookup tables.

3.1.4 SKYDOSE

SKYDOSE [4] is part of an air scattering package developed by Kansas State University. The package is completed with SKYNEUT, MCSKY and the SKYDATA library. SKYDOSE is used to assess the impact of a point isotropic gamma source in an engineered structure on the dose rate at different positions on an axis that connects the structure with a distant point.

The SKYDOSE program is based on the integral line-beam method for the evaluation of the air scattering of the gamma rays/photons. The geometrical structures considered can be either a vertical cone (silo geometry), a rectangular building or an infinite wall. In addition to the building geometry, an overhead shield can be introduced into the model.

3.2 Leaching and diffusion of radionuclides

The RESRAD family of codes has been developed by Argonne National Laboratory for the Environment Protection Agency. It consists of a number of codes that have proven to be useful for radiation protection purposes. The original RESRAD program, on which the RESRAD family of codes was based, served the EPA to investigate remediation of contaminated land. The RESRAD codes implement simplified models based on homogeneous media of simple geometry, allowing numerical equilibrium calculations for the boundaries between different media. Two of these codes are described here.

3.2.1 RESRAD OFFSITE

RESRAD OFFSITE [5] presents a model of the whole path from contamination of soil to humans living near the contaminated land. By appropriately defining the contamination and the surrounding layers of soil, this model can also be used for near surface disposal facilities.

RESRAD OFFSITE models the different transport processes that bring the radionuclides closer to humans, as well as radioactive decay human factors and biological effects. The water path includes transport processes such as precipitation, infiltration, leaching, dilution in ground water and root uptake by plants. The air path on the other hand consists of processes such as top soil mixing, resuspension in air and deposition on the ground. Human factors are mainly present as consumption rates (for internal contamination through ingestion), breathing rate (for internal contamination through inhalation) and time spent outdoors (for external irradiation).

The results of RESRAD OFFSITE can be retrieved for all media, for all selected radionuclides and for all pathways. These results can then provide a guide for the user to further improve the safety of the system.

3.2.2 RESRAD BUILD

RESRAD BUILD [6] is, like RESRAD OFFSITE, based on the original RESRAD program and models the pathway from a radioactive source to humans. In this case, both the radioactive source and the persons are positioned inside a building. The principal pathway considered by RESRAD BUILD is the air pathway. The transport processes considered are the air flows between the rooms of the building under investigation.

3.3 Modelling of controlled discharges: FRAMES/GENII

FRAMES (Framework for Risk Analysis in Multimedia Environment Systems) is an open architecture, object oriented platform that helps the user to design a conceptual site model that is based on real processes and interactions. The most appropriate models can then be assigned to these processes and interactions, and finally the data can be introduced for the site or facility to be studied.

Different codes can be linked to the FRAMES platform. GENII [7], developed by Pacific Northwest National Laboratory, is such a code, consisting of independent but interrelated modules:

- Four atmospheric models;
- One surface water model;
- Three environmental accumulation models;
- One exposure module;
- One dose/risk module.

The modules are menu driven user interfaces, dose factor libraries and environmental dosimetry programmes.

3.4 ALARA

3.4.1 VISIPLAN

VISIPLAN [8] is an ALARA tool, developed by the SCK•CEN. It is based on a 3 dimensional model of a building or facility, in which external exposure to fixed radioactive sources is assessed. The VISIPLAN software enables:

- To plot the dose map of the areas of interest;
- To derive the individual doses associated to specific interventions, i.e. in function of the trajectories and the stay duration (task duration) of the operators at specific locations;
- To derive the corresponding collective doses;
- To compare the individual and collective doses associated to different scenarios, i.e. to different intervention procedures;
- To carry out sensitivity calculations associated to different source terms due, for instance, to the decontamination, the installation of shielding,…

To facilitate the modelling of complex geometries, Tractebel Engineering has developed the VISIMODELLER program, that translates CAD Microstation files into the VISIPLAN input format.

3.4.2 QAD

QAD (version QAD-CGGP) is an alternative code used by Tractebel Engineering to perform 3 dimensional dose rate calculations in complex geometries, e.g. the ALARA studies for the replacement of the steam generators at the nuclear power units Doel1 and Doel2 (Belgium).

4. Conclusions

Many different processes can result in the exposure of humans to ionizing radiation or radioactive substances. The role of radiation protection is to assess at all times this exposure, in order to establish the required means of protection. A vast landscape of calculation codes exists, each one of them targeted towards a specific field of application.

Tractebel Engineering's RDA Toolkit provides a roadmap, to guide radiation protection agents towards the best suitable calculation codes at hand. In order to keep the RDA Toolkit up to date, Tractebel Engineering closely follows the international development of radiation dose assessment tools and programmes.

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RADIOPROTECTION TRAINING FOR OCCUPATIONALLY WORKERS IN NUCLEAR FUEL PLANT

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ABSTRACT

Nuclear Fuel Plant (FCN) is a fuel fabrication facility that produces fuel bundles CANDU-6 type for CANDU nuclear power plant. All nuclear activities in the facility are based on natural and depleted uranium, presented in bulk and itemized form (open and sealed radioactive sources).
The industrial safety and security, health of workers, radiological safety, personal dosimetry, decontamination, hygienization, environmental control, nuclear safeguards control, fire extinguishing, emergency and physical protection belong by Nuclear Safety Department (DNS).
Education and training in radioprotection part of *Safety Culture* in plant are done in this department Laboratory of Radioprotection and Dosimetric Personnel. The training is performed for initial instruction, refreshing or reinstruction for all employees both category A and B of exposure and for radiation external workers. For periodical radioprotection and the radiation workers are training annually in purpose to obtain level 1 permit following a radioprotection specific procedure. The radioprotection course is coordinated by radioprotection officer (RPO). It is followed by an examination, category A separated by category B. The biography is from nuclear Romanian legislation, specific activity with natural and depleted uranium open and sealed radiation sources. A group of 16 employees owned / who is in possession of level 2 permit issued by Romanian regulatory body CNCAN performed the training of FCN radiation workers in the domains: nuclear raw material, open and sealed sources, radiological installation, radioactive wastes, radioactive material transportation, individual end collective monitoring, external and internal effective doses, procedures for radioprotection an dosimetric measurement equipment. Software is in place for random election of questions and registering and keeping evidence of permit level 1 for all FCN employees.

Key words: fuel fabrication, natural and depleted uranium, raw nuclear material, open and sealed sources, category A and B of exposure.

1. Introduction

Nuclear Fuel Plant (FCN) is a subsidiary of National Society NUCLEARELECTRICA SA. FCN is a facility for manufacturing of the nuclear fuel bundles CANDU type with 37 elements, based on *natural uranium* (0.711% U-235) and *depleted uranium* (a small quantity with 0.25% U-235 and 0.52% U-235). The annual production is about 10,000 fuel bundles CANDU type that means about 200 tons of natural uranium in UO2. The depleted uranium is processing in campaigns only at the starting of a new unit of Cernavoda Nuclear Power Plant. The personnel working in FCN is about 420 people, and the activity is continuous.

2. International and National Framework

The European vision on the Education and Training fields is based on the Lisbon Treat strategy. According to this strategy, Europe should become "the most competitive and dynamic knowledge based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" by 2010. The Romanian vision on the Education and Training fields starts, as well, from the Lisbon strategy but includes some specific aspects.

The integration of Romania in European Union means the integration for education and training systems, especially on nuclear field that will bring together all aspects of Romanian education and training in nuclear engineering, nuclear safety, radiological protection and other nuclear disciplines. The Nuclear National Programme (PNN) presents the Romanian expertise and vision in the field of training, education and formation of human resources necessary for safety operation of nuclear facilities and creating a *safety culture* to the radiation workers.

The recognition system in place in Romania consists in an authorization (work permit) granted by CNCAN, or in case of workers, by the owner of the authorization and it is based on examination.

The obligation of the authorization holders for using in the deploying of the practices involving ionizing radiation sources only the personnel who have a proper work permit is required by the Law no. 111/1996 [1].The authorizations as requested by the law are granted by CNCAN (Romanian Regulatory Body) only if the applicant is able to prove the professional qualification of his personnel, their knowledge related to regulations on radioprotection and safety. The responsibility for ensuring the training of the personnel belongs to authorization holders. CNCAN elaborated a set of norms for developing and implementing the European requirements for training and education. The applicable norms for FCN are presented in reference [3] and give the framework for release the work permits.

The work permits are classified on three levels (level 1 for RPW, level 2 for RPO and level 3 for QE and MPhE). The definitions, competences and responsibilities for RPEs, MPhEs, RPOs and RPWs are established in the specific regulations [3]. The radiological safety courses are requested by [2]. The training courses organised by the owners for RPEs and RPOs must be approved by CNCAN.

Romanian definitions for RPE and RPO are very similar with the EU proposed definitions and the responsibilities for RPE and RPO are established by Romanian legislation in force. As a consequence, it is appreciated that the proposed guide and definitions for RPE and RPO will not have major effects on the current Romanian E&T and recognition system.

3. Education and training of employees in FCN

3.1 General instruction and verification

FCN has issued yearly a document titled: *Programme for instruction and training in FCN*, including the following main domains:

1. Radiological Safety/Radioprotection – done initially and annually. After this instruction and exam the work permits for radiation field, level 1 is issued by FCN for each employee;
2. Labour Safety – done initially and annually
3. Environmental Protection – done initially and annually
4. Emergency Situations – done initially and annually
5. Classified Information – done annually

3.2 Radiological safety in FCN

From radiological point of view FCN is divided in two areas: **Supervised Area (ZS)** and **Controlled Area (ZC).** All the FCN employees are categorised like **Occupationally Exposed Personnel/ Radiation Workers (**RW) following the international classification and recognition [2]. Functions and Responsibilities of RW are from specific literature, transferred in [2] and [3] and taken by FCN in [4] and [5]. RW that are working in controlled areas are in category A. The rest of employees are in category B.

3.3 FCN Radioprotection Training Department

The activity for radiological safety surveying and monitoring is organised in DSN which has also the mission to train the FCN personnel to continuously improve their individual performance and to eliminate human errors that could adversely affect nuclear and public safety.

Training, education and examination of employees for all the domains that involved *safety*, *security and safeguards* are performed in DSN. The required qualification is a combination of theoretical and practical knowledge and the minimum period of work experience depends on the risk level associated to practice, type of practice and theoretical background, classifying of exposure A or B [3]. The requirements regarding the necessary topics and durations are provided in specific regulations [3].

3.4 Documents

Education and training activities are explicitly stated in FCN assuring *nuclear safety mission* and passing to the *safety culture concept.* The plant has been taking care of training in the field of radiation protection and dosimetry of ionising radiation since several years. In the recent years, FCN has been more and more engaged in harmonisation actions, both by elaborating radioprotection procedures, and by organizing training courses and exercises. Therefore, efforts are particularly made to provide to the employers under training with updated standardized methodologies or with agreed procedures, when international and national standards are not available.

The framework of education and training are presented in *Radiological Safety Manual* [4] and the procedure CN-RP-62 - *Trainings on radiological safety and issuing of working permit level 1 for FCN personnel* [5]. There are many others procedures that are related to education and training in radioprotection with specific activities or included in Radioprotection Procedures set.

4. Education, training, recognising of personnel for radiological safety in FCN

4.1 Radioprotection Officer – RPO

According to the Romanian legislation the RPO is the person who is responsible to ensure compliance with the regulations in controlled and supervised areas and shall obtain a work permit level 2 granted by CNCAN based on an examination.

In the Romanian legislation is stated that for each **controlled/supervised area** at least one RPO shall be nominated for ensuring that work with radiation is carried out in accordance with the requirements of any specified procedures or local rules.

A number of 16 FCN employees were certified by CNCAN for possessing the permit level 2 for working in the nuclear field for different domains. Part of them is classified like RPO and they are nominated on FCN authorizations. The title in FCN is *Responsible with Radiological Safety (RSR)* for the following domains:

- **Nuclear Raw Material – Fuel Elements Fabrication**
- **Unsealed Radioactive Sources – Other applications with URS**
- **Sealed Radioactive Sources – Other applications with SRS**
- **Radiological installation – X-generators**
- **Radioactive Material Transportation Non-fissile material**

The RPO certificate is valid for 5 years and then must be renewed.

4.2 Refresher Courses - contributions to improve the E&T activities

FCN carries out education and training activities in radiation protection in the frame of courses organized by several other institutions [2]. These activities are less oriented to provide knowledge on standardized methodologies or to develop harmonised education programmes, as they have to comply with the specific objectives of the organizers of the courses.

The last refresher course was organized in March 2008 with the participation of 13 persons involved in FCN in radiological safety/radioprotection (RPO, managers). Lectures were given in courses organised by the Institute for Physics and Nuclear Engineering “Horia Hulubei” (IFIN-HH) National Center for Nuclear Training (CNPSDN).

The course theme was ***„Radiological safety in fabrication of CANDU nuclear fuel***” and was approved by CNCAN by Approval no 33/2008. At the end of the course the participants have passed an exam with questions from the syllabus (Romanian legislation in the nuclear

field; Measurement and Dosimetry Units; Biological effects of the ionising radiation; Working with uranium. Effect of radon; Unsealed and Sealed Radioactive Sources; Radioactive Wastes Management).
The duration of recycled course is 5 days, one time at 5 years [2]. At the end of the course an examination following the domains mentioned. The verification test has 60 questions.
After graduation of the refresher course the persons were examined by CNCAN for obtaining the work permit level 2 on the domains mentioned in section 4.1.

4.3 Radiation protection technicians

The Laboratory for Radioprotection and Personal Dosimetry (LRDP) is belonging to DSN and is responsible for measurements of individual doses, measurements of work-place doses, contamination monitoring, radiological monitoring, personnel training and examination, issuing the work permit level 1.
The Radioprotection Technicians in FCN are employees with many years stage in production, possessing work permit level 1 but have more ability and competence in order to: advise the employer; operate laboratories for the calibration of survey monitors, individual monitoring of internal contamination (whole body counters, alpha, gamma), personal monitoring for external exposure (thermo-luminescence dosimetry services) and radon concentration evaluation; assure the radiological environmental surveillance; perform computing activities of support (e.g. numerical calculation, formulas, tables, assessments), provide support to fulfil the law obligation for FCN, qualification of measurement techniques and methodologies) standards development, harmonization of dose evaluation procedures.

4.4 Radiation Worker

1. General

The only responsibility held by the radiation worker is to work in a safe manner with respect to his own safety and to his colleagues. This implies a degree of basic competence. “Working safely” means respect of relevant radiation safety procedures.
There is a wide range of radiation safety training available for the radiation worker but in FCN there are three: training the managers of compartments, training category A of exposure and training the exposure B. Typically duration is 1 or 2 days. Usually, all courses follow a similar format, which is a mixture of classroom presentations combined with an element of practical work if the employees are radioprotection technicians.

2. Ability, competence and suitability

An effective radiation worker is one in which the individuals are competent in the roles that they undertake. In practice, what an employer requires (and this may or may not be a regulatory requirement) is that an individual is competent in the role or function that he is required to undertake and is suitable for appointment in that role.

3. Requirements for training and education of RW and recognition

The specific duties of the RW depend on the nature of the practice and have to be established by local rules and procedures. The responsibilities of the RW are defined in the current Romanian legislation [3]. Provide all personnel working in radiological controlled areas on FCN with adequate information on RP rules, the logic behind them and their implementation. Instruct beginners on how to manage risks in radiological controlled areas.
According to the regulations, the RW have to respect the local rules and radioprotection procedures, are subordinated to the radioprotection technicians and RPO and have to report any abnormal situation or malfunction which could affect the safety, any incident and to participate by their established roles in emergency situations.
a) Education: Usually high school degree is required.
b) Training: The licensee is responsible to provide for the RW basic knowledge and understanding of radiation properties, interaction, detection and biological effects, good knowledge of the local rules and the operational radiation protection methods, work instructions and the safety features of the devices, on the job training under the supervision of a radioprotection officer or radiation protection supervisor.

c) Recognition: The recognition of the RW consists in a *work permit* issued by the licensee based on an examination. For this purpose at the beginning of each year there are performed several steps as required by [3], [4] and [5].

1. Course Thematic and Radioprotection Course are sent by mail to all FCN compartment managers and persons responsible with radiological safety on authorization level 2 owner (RPO and manager compartments)
2. There is training for compartment managers and persons responsible separately by category A and B
3. The compartment managers and persons responsible are training the professional exposed personnel
4. The exams consist in a test with 40 questions with multiple choices shared upon the radiological exposed category A and B. The duration of exam is one hour

5. FCN training and examination by computer (TEC)

TEC Application for FCN

The FCN intention is to implement in the near future the Training and Examination by Computer (TEC) like a complete and modern system which offers a variety of teaching, learning and examination to personnel.

The **first stage** (I) is to provide access to users which want self-teaching and verifying the knowledge. The radioprotection course is posted on the FCN intranet and any person who wishes to widen his/her area of knowledge (category A or B of exposure and radioprotection technicians). The interest persons can uses the FCN intranet with questions about radiological safety. The intranet course is structured on 10 objectives (nuclear legislation, biological effects of radiation, uranium and their compounds, work-places radiological monitoring, individual radiological monitoring, radioactive waste management, radiological areas control, warning of protective equipment, warning of respirators, radiological emergencies)

The **second stage (II)** will be in the future to connect the data base for radiological questions from intranet specific data given the specialised option (exposure A or B, sealed or open sources, radioprotection technicians).

The **third stage (III)** is the evaluation and testing of knowledge. The evaluation test is made by 40 items (questions) from the objectives with different participation which will differs from year to year.

TEC is a very useful tool scalable and interchangeable and in continuous improvement and offers an enjoyable training/teaching/learning/examination experience for the users.

6. Conclusions

1. Radiation Workers

Knowledge, competency and suitability are key individual factors for persons working with radiation and there is a danger that training events concentrate just on knowledge provision, while competency and suitability are not addressed. Radiation workers at all levels need to be competent to work safely, and competence can be assessed, either as part of a training event or as part of a certification process. Suitability, however, cannot be achieved just by attendance at a training course.

2. Trainers

Employers and those responsible for training development and course design fully understand the concepts of competency and suitability. The trainers can provide a level of knowledge and develop a basic level of competency, but it is up to the employer to assess the adequacy of both and make judgements on the suitability of an employee for a role he is to be given

3. Harmonised approaches to education and training

The education to standardised methodologies and the harmonisation of the training path is one of the management traits of the education and training activities in FCN, in respect to other national centres (universities, hospitals, public and private institutions, professional associations) providing courses and training in radiation protection

4. On the base of this experience gained in the field of NUCLEAR RAW MATERIAL (MPN) FCN can participate to the ENETRAP project or other projects which can contribute to the improvement of training activities in radioprotection in FCN.
5. e-learning
The training and examination of employees by computer with management of courses and questions on INTRANET is the next step of Radioprotection and Education and Training in FCN. The main features of the system are the following: publishing of interactive courses materials online and testing and examination online.

7. References

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4 FCN Radiological Safety Manual, edition 5 2009;
5 CN-RP-62 - Training on radiological safety and issuing of permit level 1 for FCN personnel
6 BSS – IAEA Basic Safety Standards
7 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 Ionizing radiation

EDUCATION IN RADIATION PROTECTION SPECIFICALLY FOR INTERVENTIONISTS: EXPERIENCE FROM CANARY ISLANDS.

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ABSTRACT

The obligatory nature of the instruction Directive 97/43/EURATOM has given place to the need to realize courses training for interventional profesional. The specific necessary formation(training) to be employed at interventionism has created the need of the formation and training in radiological protection in highly qualified professionals. Classes of theory and practice were necessary to cover all the areas of knowledge of the European guide 116 of Radiation Protection. The experience allowed to analyze the knowledge and the measures nowadays available as well as the necessary ones so much for the protection of the professionals as of the patients. The analysis of survey satisfaction of the professional pupils has allowed recognize the right result that has been his implantantion. In fact, the answers given to the acceptation survey were very good too 87,5%.

In the framework of the Spanish Official Order SCO/3276/2007 from Ministry of Health and Consume (SMHC), which was published in the State Official Journal (BOE) at 13th November 2007, a Radiation Protection course have been developed in Canary Islands to medical doctors who makes interventional procedures. That order contains some rules concerning Radiation Protection education given by European Directive 97/43/EURATOM. In particular has been fixed for specialists who makes interventional procedures, one second level in radiation protection directed specifically to interventionist practices should be achieve.

Since 13 November 2008 is compulsory for these specialists to have a certificate attesting to having completed a training course of 16-20 teaching hours.

The Canary Society of Medical Physics (SOCAFIM), which is a chapter of Spanish Society of Medical Physics (SEFM), has developed one of such course. SOCAFIM sought and succeeded in obtaining sponsorship form the Canary Islands Government in order to make the Course in both more populated islands of archipelago: Tenerife and Gran Canaria were most interventional procedures are made. Furthermore, a negotiation with the 4 high hospitals of the islands was made to assure place at Radiology and Cardiology Departments for the practical sessions of the course. Thanks to this activity, one group of specialists in Medical Physics together with 2 medical doctors was constituted to act as teachers in the course. The program was made following European Guide 116 of Radiation Protection. Didactical material for some classes was get from Dep. of Medical Physics, Complutense University, Madrid.

Complete information about the possible development of the course was made and sent to SMHC to achieve the regulatory permission. This include program, places for the course, teachers, theoretical number of hours and practical number of hours. Meanwhile a compromise to give an exam to students to know their level of knowledge and skills was acquired.

fig.1 Limited groups of practices in Interventional rooms

Fig.2 Analysis of different conditions of work

The total attendance, both in Tenerife and Las Palmas, was 53 students, which means about 70% of the lists given by Directors of Hospitals and Clinics of Canary Islands to the health authority as medical doctors who were working carrying out interventionist's activities in the Archipelago. In total, every student received 16 hours of theoretical classes, 2 hours of seminaries and 2 hours of practical activities Fig.1 & 2 . Finally, an exam with 50 test questions multiple choice was made. All students have obtained a very good result. The answers given to the acceptation survey were very good too 87,5%.

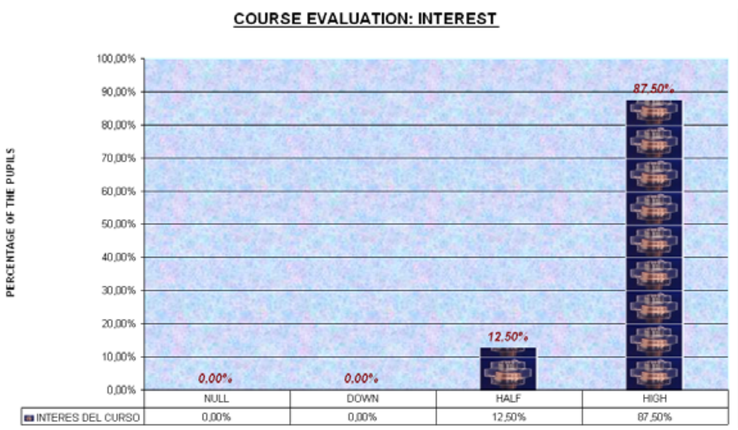

Fig. 3 Results of the course evaluation

Bibliography:

Spanish Official Order SCO/3276/2007
European Directive 97/43/EURATOM
European Guide 116 of Radiation Protection.
Didactical material; Dep. of Medical Physics, Complutense University, Madrid.

COMPUTER BASED RADIOLOGICAL PROTECTION COURSE FOR WORKERS IN THE HEALTH CARE SECTOR

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ABSTRACT

Radiological protection aspects in the health care sector are a primary concern with respect to worker safety due to the very different radiation sources, kind of occupational activities and large number of people usually 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 radiological protection course for all I.R. workers of the National Health Service within the Tuscany region. The main challenge of the project is to provide the basic safety information in such a complex field, where people with very different education levels and duties work together (i.e. in a radiological interventional room). The goal of the project is to fulfil the specific educational requirements of Directive 96/29/EURATOM as introduced in the Italian law.

1. Introduction

According to EC regulation, all persons whose work may be associated with ionising radiation risk must be adequately trained. This training must ensure that workers 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.
Radiological protection (RP) aspects in the health care sector are a primary concern with respect to worker safety due to the very different radiation sources, kind of occupational activities and large number of people usually 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 within the Tuscany region. The course is also open to contractors' personnel as complementary information in addition to the RP training they must receive from their employers.
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 (i.e. in a radiological interventional room).
In Fig. 1, the distribution of Tuscany region health care professional exposed to I.R. is shown. In the *"Others"* group , physicists, biologists, biological lab technicians, cleaning staff are included. 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.

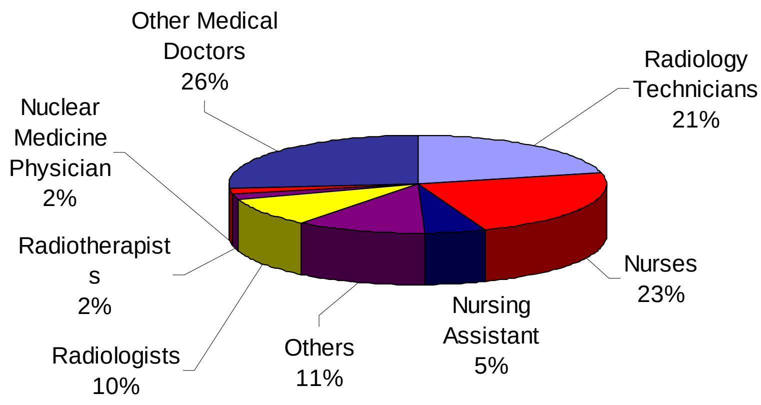

Fig 1. Professional distribution of ionising radiation exposed workers in health care sectors in the Tuscany region, Italy.

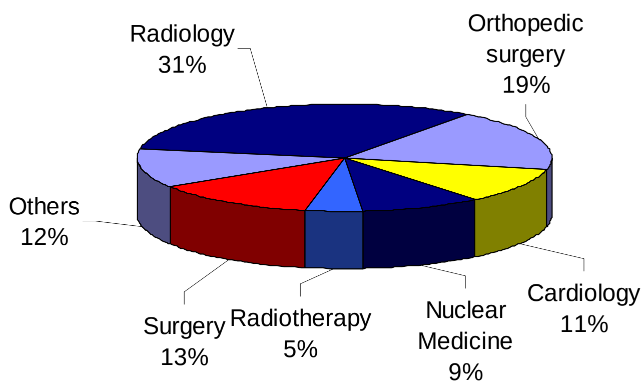

Fig 2. Exposed workers distribution between health care activities in the Tuscany region.

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 habitants.

2. Course content

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 radiological 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 lower educational level and no-background in the field of physics, radioprotection and current legislation concerning the exposure to ionising radiation. In this section, each sub-section contains information on how to act and a list of FAQs and related answers. In the latter case, the target group are hospital auxiliary staff, workers belonging to external service providers (i.e. cleaning services) and workers from external firms.

The main aspects of safety procedures, definitions, health hazards, are stressed through a series of numerical examples, pictures and warning text boxes spread out in each chapter.
A summary of the course content, divided in chapters and sections, is reported in Table 1.
Each section includes a multiple choice test, a glossary and a bibliography.
The entire radiological protection course corresponds to 150 web pages, and it is estimated to require 30 hours of study in order to proficiently acquire the basic knowledge and to be able to correctly answer the test questions. A learning time of 13 hours is estimated for not experts workers, who are required to read only the dedicated section *"Radiation protection for not experts"*.

3. Course development and delivery

The course is designed as a computer based course, and a web site interface was chosen as user interface so to take advantage of the flexibility, in terms of information retrieving, information and document storage capability and eventually future upgrading.
The projects is developed with an open source content management system (Joomla!™), and in a first stage the course will be distributed cost free as interactive CD-ROM to all NHS hospitals in Tuscany.
The main features of the interactive CD are:

- web site interface
- course organized in ten chapters (see Table 1), section and sub-sections
- a total amount of 140 subsection, each corresponding to a web page
- updated national radiation safety regulations
- about 150 multiple choice tests covering all aspects of RP
- a searchable glossary of RP terms
- possibility for user to download PDF files with lessons, multiple choice tests, glossary, complementary material such as national radiation safety regulations

In a second phase the course can be easily translated and published as a Web Based Training to make it accessible to a larger number of workers, possibly outside the Tuscany region, and eventually on an e-learning platform. In the latter case the course could be inserted in each hospital Continuing Medical Education program.

4. Additional learning e-tools

The web based course takes advantage of the web based interface in order to provide additional learning tools:

- a detailed, searchable glossary of radioprotection terms and definitions
- 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 regulations concerning exposure to ionising radiation
- links to external web sites of major international radiation protection committees and agencies
- bibliographic notes and links
- links to curiosities related to radiation exposure (i.e. Cosmic rays..)

Section	Sub-section
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 radiological 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 radiological protection	4.1. The radiological 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 radiological protection principles 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. 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 waste
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. Hazard Assessment (External exposure, Contamination and internal exposure) 9.2. Radiation safety measures 9.3. Local rules and operational procedures 9.4. Decontamination procedures 9.5. Handling of radioactive waste
10.Radiation protection for not 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 (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

Tab 1: Radioprotection course content.

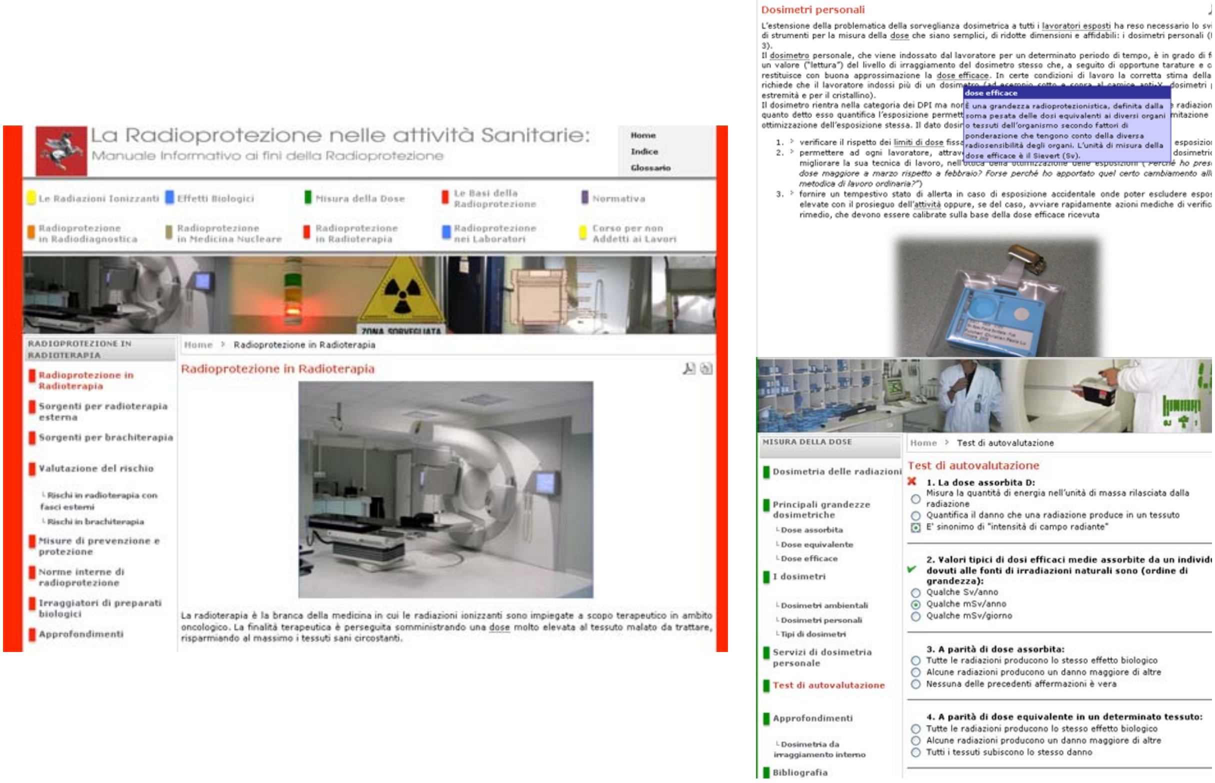

Fig.3. Web based course interface. On the right an example of interactive glossary (up-right) and multiple choice test (down-right).

5. Conclusions

A computer based radiological 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 radiological 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 lower educational level and no-background in the field of physics, radioprotection and current legislation concerning the exposure to ionising radiation. The course is designed as a web site interface and will be delivered by CD-ROM format to 6000 workers, and in a second stage will likely be available on an e-learning platform.

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DOSE MAPPING AROUND THE INDUSTRIAL RADIATION DEVICE USING THE MCNPX CODE

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ABSTRACT

The use of radiological instrumentation on industrial scenario, namely involving radiography and gammagraphy devices, raises a number of radiological protection and safety challenges. For good practices concerning their operation it is essential a good formation and training of the workers using these types of devices. The quality of this apprenticeship depends on the efficiency of these learning and training actions namely of the quality of the material available to the trainers. This material should be adequate and have a direct relationship with the specific radiological instrumentation.

In order to provide the appropriate material for the formation and training actions of the workers the characterization of the radiation fields around the radiation devices, namely its dose mapping and the ray tracing, was achieved using Monte Carlo simulations. The corresponding pictures can be seen as an important tool for the apprenticeship of the workers and also for the formation and education of the staff (all levels) who works on industry using these radiation devices.

Keywords: Dose mapping; Monte Carlo; MCNPX; Formation and training; Industrial scenario.

Introduction

The use of radiological instrumentation namely radiography and gammagraphy devices, on an industrial scenario raises a number of radiological protection and safety challenges. The assessment of the benefits versus risks of its utilization must be always present. Worldwide, this type of equipment continues to be used many times without a true alternative. So, it is necessary to continue to teach and training the workers operating with these kind of equipment and to improve the effectiveness of the training actions. The efficiency of apprenticeship process depends on the quality of the material available to the trainers, namely if this material is adequate and has a direct relationship with the instrumentation to be studied. In order to provide the appropriateness and specific material the characterization of the radiation fields around the radiological instrumentation, namely its dose mapping and ray tracing were achieved using Monte Carlo simulations.

In Portugal exists near 400 moisture gauges, density gauges and moisture and density gauges, near 150 level gauges, 30 thickness and weight gauges, near 73 gammagraphy devices and around 220 industrial radiography equipments[1]. These equipment could be grouped, from the point of view of radiological safety, in 3 items: *(i)* the

[1] Data provided by the Directorate General of Health (DGS).

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radiation devices which have relatively small doses but are used extensively (for ex. moisture and density gauges); *(ii)* the radiation devices which provide high doses (gammagraphy and industrial radiography) and *(iii)* the radiation devices which could originate doses lower than the gammagraphy but higher than the moisture gauges (for example, level gauges). The performed work has studied one device pertaining of each item. In this contribution are presented results concerning two kinds of equipments: the level gauge and a gammagraphy device. The characterization of the radiation field around the radiation devices, namely its dose mapping using Monte Carlo simulations, has been done. The quantity determined by Monte Carlo is the photon flux and the ambient dose equivalent, *H*(10).* The ray tracing of some particular region of the device are also shown.

Material and Methods

The equipment studied was a level gauge, with a ^{60}Co source (2.05 x 10^{9} Bq), and one irradiation device used in gammagraphy, with a ^{192}Ir source (1.51 x 10^{12} Bq). In order to validate the Monte Carlo simulations and the used methodology, experimental measures were taken when possible. That was the case for the level gauge.

On Figure 1a), obtained with Sabrina [2], is illustrated the level gauge with the irradiation component in red and the structure (in grey) made of stainless steel with the thickness of 0.010 m and lined with refractory bricks with the thickness of 0.258 m. The four positions, marked in the figure as green circles, correspond to the positions where experimental and simulation data have be determined, position (1) is at 1m of the source container, position (2) is in contact with the container, position (3) is at the opposite side, in contact with the structure and position (4) is at 1m of the structure. The shielding of the source is made of lead. The Figure 1b) represents the piece to be radiographed, a U-shaped tube with 17 cm thickness of steel. The warehouse where the gammagraphy took place is represented in green with walls of concrete having 30 cm thickness. The Figure 1c) represents a top view of this piece in the room.

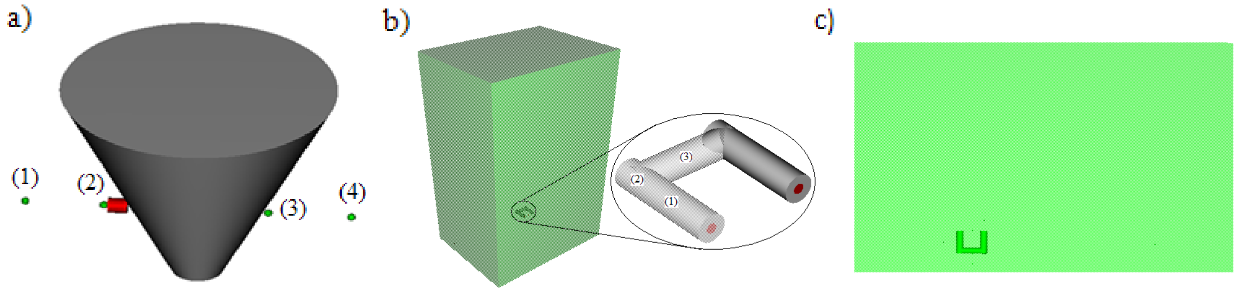

Fig 1 a) – Level gauge and stainless steel structure; **b)** – Piece to be radiographed.; **c)** – Geometry used in gammagraphy: top view

For the particular case of level gauge, experimental data was taken in the quantity absorbed dose. For the gammagraphy scenario, due to the high dose in the irradiation room, it was not possible to take measures and so only simulation data is available.

In Monte Carlo simulations F6 tallies were used with appropriate coefficients [1]. For the level gauge, coefficients flux to kerma (*Φ/K*) was used. For the gammagraphy analysis coefficients flux to *H*(10)* were used (*Φ/ H*(10)*. The dose mapping was obtained using MCNPX mesh tallies.

The different scenarios witnessed were described in the program Sabrina in order to visualize the photons trajectories of every situation (the ray tracing).

Results and discussion

On Table 1 are shown the experimental and simulated results concerning the level gauge. There is a good agreement between experimental and simulated absorbed dose values.

Position	Experimental (µGy/h)	MCNP (µGy/h)
1	3.0 ± 0,2	3
2	125.0 ± 8,8	129
3	3.0 ± 0,2	3
4	1.0 ± 0,1	1

Tab 1- Absorbed dose around the structure obtained with a Babyline 31 and MCNPX

Two of the planes defining the mesh tally, provided by MCNPX, limit the space containing the irradiation system. The obtained dose mapping of *H*(10)* is illustrated in Figure 2.

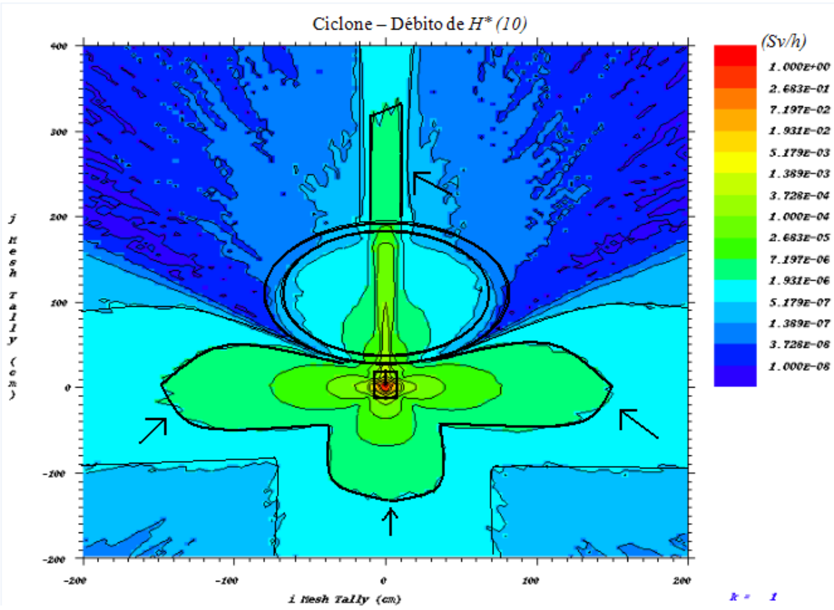

Fig 2 – Dose mapping around the level gauge

The circles represent the structure being irradiated. The source container is shown as a rectangle with a collimator inside, a line inside the rectangle in the figure. It is visible the effect of the collimator, enabling values of *H*(10)* of few µSv/h to reach the other side of the structure. Besides this effect, it is also important to emphasize the scattering effect of the structure. It is important to note the fast transition of three orders of magnitude for the *H*(10)* value in a short distance around the structure.

The black lines appointed by arrows are a controlled zone defined accordingly to the ICRP 103 dose limits. A supervised area is illustrated by thinner lines. According these values, the identification of a controlled area around the container as well as on the opposite side of the structure being irradiated is recommended.

Thanks to Sabrina it is possible to obtain images where the particles tracks are actually visible, as well as their energies and different interactions with matter [2]. An image of the particles tracks for the level gauge mentioned so far is illustrated in Figure 3. The energies mentioned are in MeV.

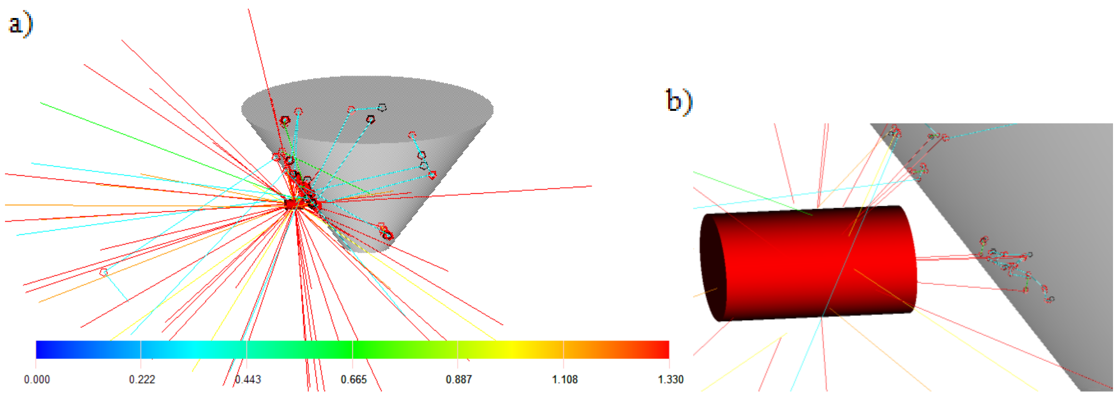

Fig 3a) – Ray tracing of a level gauge; **b)** details of source container.

The different interactions that occur in this level gauge are demonstrated with circles. The red (dark) circle corresponds to the Compton scattering (photoelectric absorption). It is possible to conclude that the predominant photons have energies around 1.25 MeV, the mean energy of ^{60}Co [3], and that some of these reach the other side of the structure. The photons with lower energies, due to Compton scattering, are in both inside of the structure and around the container, but they don´t get to reach the other side of the structure.

The second studied case is one application of the gammagraphy technique. The ^{192}Ir source was considered in three different positions. In this contribution results corresponding position 2 (see Fig. 1b) is shown. The corresponding dose mapping is shown in Figure 4.

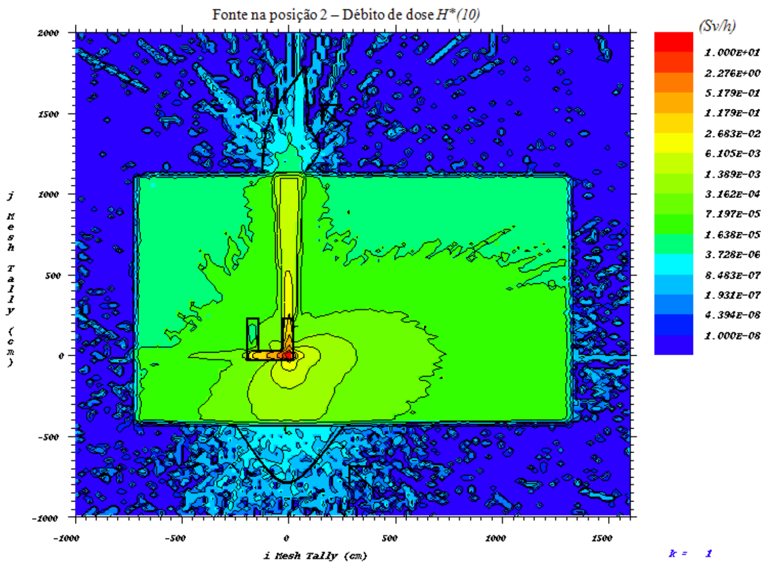

Fig 4 – Dose mapping during a gammagraphy

A pronounced collimation originated by the tube itself can be observed. This collimation originates that the areas outside of the warehouse right in front and rear of the radio graphed tube have dose rates comparables to some values found inside the irradiation room (one ten of µSv/h) . It would be necessary the implementation of a controlled zone outside of the warehouse in the direction in front and in rear of the tube. These controlled areas are designed in Figure 4 accordingly to ICRP 103 dose limits.

In Figure 5 the ray tracing obtained with Sabrina is illustrated for the source position previously defined from the front and rear of the warehouse (considering the front where the tube is turned to).

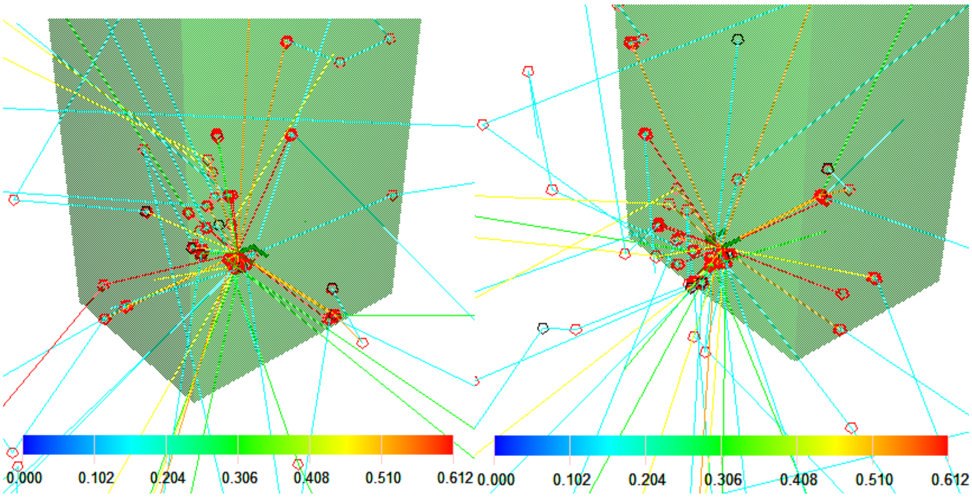

Fig 6 – Ray tracing of gammagraphy (frontal and rear view)

In these images only the particles that leave the warehouse were illustrated. Once again the main interactions are Compton scattering and photoelectric absorption, illustrated with red and black circles, respectively. This type of information complement the information of the mesh tallies allowing the technician working with these devices to have a general picture of the photons, its favorite paths and the dose originated by them.

Conclusion

With the dose mapping achieved around the instrumentation, it is possible to focus the attention to particular zones where the dose assumes higher values becoming easier to the workers to understand which areas they should to avoid. The trainers will also be able to achieve a better understanding of the physical aspects that occur, what is happening to the photons, where they are absorbed and scattered.

In conclusion, the results of this work can provide important tools helping the trainers to be well prepared to learn and to promote formation and training actions with a specific and appropriate material.

References

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[3] http://nucleardata.nuclear.lu.se/ (22/07/09)

RADIATION PROTECTION COURSES FOR TECHNICAL APPLICATIONS IN GERMANY - AN OVERVIEW

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ABSTRACT

Radiation protection in Germany is ensured by employees trained as radiation protection officers (Strahlenschutzbeauftragte) according to the decree about protection against harms caused by ionizing radiation (Strahlenschutzverordnung – StrlSchV) and according to the decree about protection against harms caused by X-rays (Röntgenverordnung – RöV). To get the certificate as a radiation protection officer, these employees have to participate in a training course on radiation protection according to the corresponding expert knowledge directives in radiation protection (Fachkunde-Richtlinien). For technical applications not only radiation protection officers but also employees that offer businesslike services like repairing and testing of X-ray tubes must also participate successfully in such a training course.

This paper overviews the different fields of work that need education and training in radiation protection according to the corresponding technical expert knowledge directives in radiation protection in Germany and tries to illustrate the different kinds of radiation protection courses for technical applications.

1. Introduction

The question, how to harmonize the education and training in radiation protection in Europe, has been the task of different efforts for some years. EUTERP, the European Training and Education in Radiation Protection Platform, has developed two different definitions for functions that shall ensure radiation protection [1]:

- **RPE (Radiation Protection Expert):** Persons having the knowledge, training and experience needed to give radiation protection advice in order to ensure effective protection of individuals, whose capacity to act as a radiation expert for specific practices - under discussion - is recognized by the competent authorities.

- **RPO (Radiation Protection Officer)**: 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 requirements of the standards.

In Germany radiation protection is ensured by a large set of different types of members of the radiation protection staff, the so called “Strahlenschutzbeauftragte” (SSB). Although the discussed and proposed definitions of a RPO and RPE do not fit properly into the German radiation protection system, in most cases a SSB is comparable to a RPO. In contrast to the recommendations worked out by EUTERP [1] concerning the definition of a RPO, each SSB has to be recognized by the competent national authorities. In practice there are many different kinds of SSBs depending on the kind of source of radiation (radioactive source, an accelerator-system or a X-ray facility) and on the potential risk of the respective application. However, in some cases, high specialized SSBs could also be accepted as RPE.

In Germany three conditions have to be fulfilled in principle according to the “Decree about protection against the harms caused by ionizing radiation (Strahlenschutzverordnung – StrlSchV)” [2] and the “Decree about the protection against harms caused by X-rays

(Röntgenverordnung - RöV)" [3] to achieve the Expert Knowledge (so called "Fachkunde im Strahlenschutz"):

- The employee must have sufficient practical experience in radiation protection achieved by on-the-job-training.
- The employee must have a sufficient professional education.
- The employee must attend a course in radiation protection and pass the final examination.

A valid certificate of the Expert Knowledge is required to be allowed to work as an SSB.

For technical applications these general requirements are specified in two different Expert Knowledge Directives: The "Technical Expert Knowledge Directive concerning the handling of X-ray tubes" [4] and the "Technical Expert Knowledge Directive concerning the handling of radioactive (sealed and open) sources and the radiation protection necessary for all kinds of accelerator systems" [5].

In practice, different applications of radioactive sources or X-ray tubes do, of course, show a large variety according to the risk. Therefore, different practical experience (depending on the professional education) and different radiation protection courses are required for different applications. That leads altogether to 37 different kinds of Expert Knowledge Groups for technical applications – leading to 37 different kinds of SSBs. This paper describes the differences and similarities between these Expert Knowledge Groups. It does not deal with the organization of radiation protection concerning medical applications, nuclear facilities and veterinary medicine.

2. The organization and responsibilities of radiation protection in Germany

In Germany, the employer has to organize all necessary radiation protection arrangements. To ensure the correct realization of these radiation protection arrangements, including the administrative duties, the employer must make sure that a sufficient number of SSBs is installed. All SSBs must be recognized by the respective competent national authority.

The SSB takes responsibility for radiation protection concerning his in-plant authority. On the other hand, in most cases, he must exercise his responsibilities as a SSB in addition to his actual tasks. He is also in most cases not a specialized expert in radiation protection and needs therefore – depending on his professional education and on the potential risk of the application – sufficient practical experience and additionally a training course in radiation protection as mentioned above.

There are, of course, exemptions (e. g. nuclear power plants, large accelerator systems), but at least for most of the technical applications the role of an SSB is described more properly by the definition of a RPO than by the current definition of a RPE (see above).

It is important to underline that a SSB does not only advise the employer in radiation protection arrangements but also takes responsibility for those duties in radiation protection that are assigned by the employer. Consequently, the radiation protection courses for different technical applications, which have to be attended to get the necessary qualification (Expert Knowledge), must ensure that each single person becomes educated as well as possible – depending on his previous knowledge. That might explain the large number of different radiation protection courses in Germany, which is confusing at first view.

This German system of radiation protection assures the actual presence of a competent person (related to his specific work) within a couple of minutes – an advantage in comparison to an RPE that might be more educated, but is possibly too far away from the place of urgent action.

3. The Technical Expert Knowledge Directive concerning the handling of sealed and open radioactive sources and accelerator systems

Technical applications concerning the handling of sealed and open radioactive sources and accelerator systems are divided into 20 different Expert Knowledge Groups (so called “Fachkundegruppen”) [5].
The most important Expert Knowledge Groups are shown in Table 1.

Depending on the potential risk and on the educational level, between 0 and 24 months of experience is mandatory. In addition, as mentioned above, the person must successfully have taken part in a radiation protection course. When both qualifications are achieved (practical experience and successful attention of a suitable radiation protection course), the certificate for Expert Knowledge can be obtained, which is obligatory on being appointed SSB.

In 2004 radiation protection courses for different qualification levels have been put into a new modular structure. That allows constructive attendance of different modules. This structure is shown in Figure 1. The duration of these radiation protection courses varies between two and at maximum ten days.

After the Expert Knowledge is obtained, the employee can be appointed officially as SSB and the competent national authority has to be informed about this appointment. Additionally, a refresher course must be attended every fifth year.

Name	Description
S1.1, S1.2, S1.3 and S2.1	Handling of non-portable sealed radioactive sources with low activity
S2.2	Handling of sealed radioactive sources with low activity
S2.3	Handling of sealed radioactive sources with high activity
S3.1	Application in technical radiography (field worker)
S3.2	Application in technical radiography (overall responsibility for radiation protection)
S4.1	Handling of open radioactive sources with low activity
S4.2	Handling of open radioactive sources with high activity
S 5	Course for employees, working in external facilities
S6.2	Use of smaller accelerator systems with low power
S6.3	Repairing and technical service of accelerator systems
S6.4	Use of larger accelerator systems with high power
S7.1	Use of radioactive sources in public schools (teacher)

Table 1: The most important different Expert Knowledge Groups

(Radioactive sources or accelerator systems)

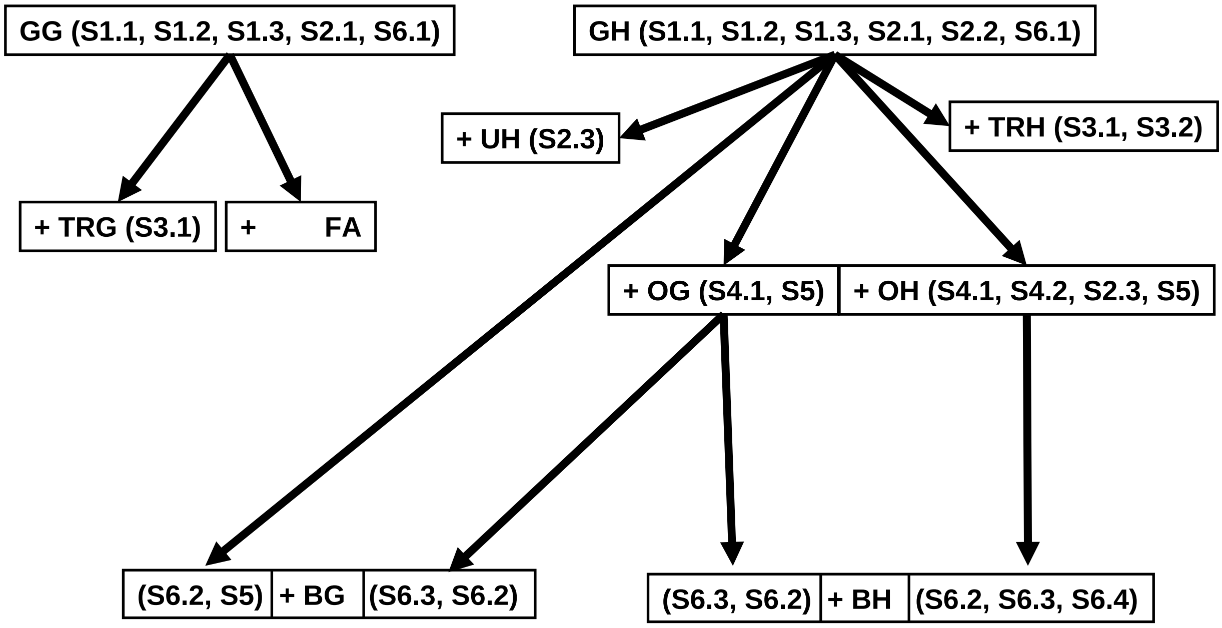

Figure 1: Modular structure of radiation protection courses. This structure allows combining different modules to obtain a required qualification.

4. The Technical Expert Knowledge Directive concerning the handling of X-ray tubes

Similar to the "Technical Expert Knowledge Directive concerning the handling of radioactive sources and accelerator systems" [5] the "Technical Expert Knowledge Directive concerning the handling of X-ray tubes" [4] defines different Expert Knowledge Groups – again depending on the potential risk (higher or lower dose-rates, portable or non-portable X-ray tubes) and on the educational level. The most important Expert Knowledge Groups are shown in Table 2.

Name	Description
R1.1	Applications in non-destructive materials testing (overall responsibility for radiation protection)
R1.2	Applications in non-destructive materials testing (field worker)
R2	X-ray diffraction and –microstructure analysis
R3	Applications of X-ray tubes with inherent protection and/or use of devices with unwanted X-rays (Störstrahler)
R4	Use of X-ray facilities in public schools (teacher)
R5	Inspecting, testing, servicing and repairing of technical X-ray facilities
R6	Inspecting, testing, servicing and repairing of medical X-ray facilities
R8	Handling of electron accelerators
R9	Expert Knowledge Group for radiation protection experts (Sachverständige)

Table 2: The most important different Expert Knowledge Groups
(X-ray tubes and devices with unwanted X-rays)

Again, depending on the level of education and on the potential risk, between 0 and 24 months of practical experience is mandatory. After obtaining the certificate on Expert

Knowledge by the competent national authority, a quinquennial refresher course must be attended as well.

5. Conclusion

For technical applications a diversity of 37 different Knowledge Groups has been established for the German radiation protection system, which is based on SSBs. In most cases, a SSB would rather correspond to a RPO than to a RPE. Altogether, the experience with the German radiation protection system is positive. There have not been many accidents and the personal effective doses are small: In 2007 more than 80 % of all occupationally exposed persons have received an effective dose below the detection limit of their personal dosimeters, and less than 0,4 % received an effective dose above 6 mSv [6].

In Europe there are various efforts to harmonize the system of Education and Training in Radiation Protection, starting with several projects under the topic Education and Training of the 6th Framework Programme of the European Commission. IAEA has developed programs in radiation protection to establish a sustainable education in their member states and, in addition to that, IRPA has pointed out that Education and Training is a key factor in establishing effective national radiation protection programmes. EUTERP again acts as a platform to support networking, is able to work as an advisory body for the European Commission in education and training issues and helps to establish a high standard in radiation protection in all European countries. Without any doubt there is a need for harmonization and mutual recognition for different applications – it will be interesting to see, in which way harmonization in Education and Training concerning radiation protection will influence the existing national education systems.

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INTEGRATION OF RADIATION PROTECTION IN THE SKILLSLAB PROGRAM OF RADIOGRAPHERS

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ABSTRACT

However radiation protection education of radiographers at the department of medical imaging of Hogeschool-Universiteit Brussels consists of a theoretical part on physics, equipment and techniques and a practical training in the in-house skills-labs, the trainers aim at a better integration of radiation protection techniques and dose optimisation in the daily routine of the radiographer. Protection of the patient and dose optimisation should be a reflex while examining a patient. To obtain this attitude, the authors propose an integrated skills-lab model for both diagnostic radiographic techniques and RP optimisation starting in the first year of the professional education program.

Background

Radiation protection of the patient during medical procedures is of high importance. Recent publications show that the annual dose per caput ranges from 0,5 to 1,9 mSv/year (1). It is estimated that In Belgium the exposure increases by 3%/year. This increase is mainly due to an increase of CT examinations (2).

Radiographers have an important role in the protection of the patient against radiation. As the ISSRT declares: “Radiographers… are in a key position regarding radiation protection of the patient, public and other staff members. It is their responsibility to ensure that the amount of radiation delivered to acquire high quality diagnostic images is kept as low as reasonable achievable…” (3). In diagnostic radiology there is a strong relation between the radiation dose and the quality of the image. This counts as well in x-ray radiography as in nuclear medicine. Radiation protection should never compromise the diagnostic power of the examination. Training in radiation protection cannot be separated from training in radiographic techniques.

Training of radiographers is relatively recent in Belgium. The first professional education program started in 1998 in Brussels. At the moment there are four schools that offer a programme for radiographers. And since 1998 about 350 students graduated in the field. At the same time this implies that the majority of workers at departments of radiology and nuclear medicine are not trained professionals, in general they are nurses. From 2002 Belgian law obliges all workers that manipulate sources of radiation in the medical field to obtain a certificate in radiation protection, this implies a training of minimal 50 hours, not a professional training as proposed by the EC (4).

For the education of radiographers this situation has some practical consequences. The main drawback is that the situation in hospitals were students have to perform their internships is not optimal and often not even sub-optimal, with respect to the use of radiographic and radiation protection techniques. For this reason the department of medical imaging of the Hogeschool-Universiteit Brussel (HUB) invested heavily in a skills-lab infrastructure for the in-house practical training of the students. The practical skill-lab training prepares the students for the internships were they experience the clinical situation. The skills-lab cannot replace the internships.

Aim

The optimization of the integration of radiation protection training in the skills-lab environment.

Medical imaging students at the HUB are trained in patient positioning and parameter settings of X-ray equipment during practical sessions in the skills-labs of the school. Students also work on dosimetry, radiation protection and image quality during practical exercises. But there is only little integration between the ‘medical’ and ‘technical’ sessions. The authors believe that in the Belgian context, where students after there graduation start in a non-optimal environment, the knowledge of optimization and patient protection can fade away if these aspects are not integrated in the process of patient positioning and examination performance.
The method proposed in this text is not implemented yet. The project is still under construction and will be implemented in the academic year 2010-2011.

Method

The integration is sought after two levels:

- The integration of the dosimetry and radiation protection exercises in the sessions on positioning and examination procedures.
- A better and uniform training of the teaching staff on the topics of radiation protection and dose optimization.

Changes in the curriculum

Table 1 shows the topic related to practical work and radiation protection during the first year of the bachelor course in medical imaging as it is taught today (the changes are not yet implemented).

Topic	Credits	Hours	Modality
Basic Imaging	6		
Radiographic positioning		28	Theory
Radiographic positioning		20	Practical work
Technology	5		
		28	Theory
		14	Practical work
Radiation	4		
Radiation Physics		16	Theory
Radiation Protection		6	Theory
Internship	5	134	Practical work

Table 1: Practical work and radiation protection related topic in the first year’s curriculum

As we can see there is no practical work on radiation protection in the first year of the course. There is an introduction in radiation protection aimed at personal protection during the internship. The radiation protection of the patient is taught in the second year. When the curriculum was developed it was considered that the first year students did not actually participate in the practical work during their first internship. However, it is now experienced that first years students end up teaching positioning techniques to the local workers at the departments during their internships. Therefore the subject patient protection is addressed during the courses on radiographic positioning in the first year, but not systematic. This project is aimed to improve this situation. A method is proposed to include the topic radiation protection of the patient in the practical training in radiographic positioning, without increasing the load of the programme. To achieve this, the following steps are taken:

- The main factors in radiation protection at plain projection radiography are explained in a self-study course. Students can use this course as a reference tool. Exercises and case studies are placed at the school internet site.
- Radiation protection is addressed systematically during the practical sessions radiographic positioning. While explaining a radiographic procedure, the crucial aspects of patient safety are discussed: what is the general patient dose, is their need for shielding, what are the optimal parameters, what with the grid?

These questions are systematically included in the training contents. The different aspects: dose, scattered radiation, beam parameters, are only addressed when the students have the necessary theoretical background. This implies a well-coordinated schedule of the topics.

Table 2 show a preliminary program for a new curriculum.

Topic	Credits	Hours	Modality
Basic Imaging	7		
Radiographic positioning		28	Theory
Radiographic positioning		22	Practical work
Radiation Protection		8	Self study
Technology	5		
		28	Theory
		14	Practical work
Radiation	3		
Radiation Physics		16	Theory
Internship	5	134	Practical work

Table 2: Practical work and radiation protection related topic as proposed for a new curriculum

Train the trainers

The department of medical imaging started the academic year 2009-2010 with 85 students in the first year. To organize a well-scheduled practical training in radiography for such a group is not an easy task. The skills-lab facilities of the school consist of four X-ray rooms and a gamma camera. So four groups in parallel can have their practical training in radiographic positioning. Six lecturers are involved in these lessons. To guarantee that the information to the students is consistent, these lecturers get an in-house refresher course in radiation protection and the way it should be included in the new curriculum. The physicists attached to the department give the classes. The content of this training is as practical as possible, it includes dose measurements and demonstrations of scattered radiation to show the use and misuse of shielding material and other protection measures. During the training all the topics that are discussed with the students are addressed. There will be a schedule in print on what topics have to be discussed in what lesson.

Discussion and conclusion

The authors think there is a close relation between the radiographic technique used and the exposure to the patient during diagnostic radiographic procedures. Radiation protection training of radiographers should therefore be closely related to the training of radiographic techniques. Radiation protection training with little of no regards to the practical implementation during daily routine is not very efficient. Refresher courses for radiographers should therefore also be closely linked to the practical implementation of RP techniques.

The proposed project will involve a certain amount of work: writing of the reference course, setting up a training web site, developing the training program for the lecturers, organising the training content for the first year program. However, once the system is set up it will not take more work then the current curriculum and the authors are convinced the efficiency of the training program will be increased.

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How "do's" and "don'ts" can be of significant importance in radiation protection

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The risk for deterministic effects on patients can be a potential problem in interventional radiology, and especially when the procedures are performed outside a Radiology department. Cardiology departments often perform advanced interventional procedures, but the competence and attitudes towards radiation protection can sometimes be absent. The International Atomic Energy Agency has recently highlighted the importance of radiation protection and competence in interventional Cardiology, and has also arranged several courses and produced training material for radiation protection in cardiology [1]. The Norwegian Radiation Protection Authority (NRPA) was contacted by a Cardiology department with a request for assistance. The department performed bi-ventricular pacemaker (BVP) implants, which is a technically complicated treatment for patients with severe heart insufficiency. The department had recognized a suspicious radiation burn on a patient, three weeks after a BVP procedure. The particular patient had undergone two BVP implants and the lesion was the size of a palm. The lesion was situated on the back of the patient and was recognized as radiation dermatitis.

Material and method

The NRPA prepared sets of termoluminicens detectors (TLD), each containing 10 TLD's. The TLD's in each set was arranged in a star pattern for covering a large area of the patients back. Dose measurements were performed on eight subsequent patients and they were afterwards read at the NRPA laboratory. After the eight initial dose measurements, a site audit was performed at the Cardiological department. Characteristics for the equipment were registered and the working technique and general skills in radiation protection during a BVP procedure was observed. A short meeting, with educational guidance in radiation protection related to the working technique, was held with the participating staff after the procedure. After this, new sets of TLD's were distributed and dose measurements were performed on six new patients, for evaluation of the guidance given at the educational meeting.

Results

The average maximum entrance surface dose (MESD) for the first eight patients was 5.3 Gy, ranging from 2.03 to 13.14 Gy and the fluoroscopy time varied from 18.1 to 101 minutes, with an average of 47.8 minutes (table 1).

Patient	Fluoroscopy time [min.]	MESD [Gy]
1	27,0	3,64
2	77,3	4,42
3	18,1	3,03
4	60,4	2,03
5	24,2	3,03
6	22,4	9,12
7	101,0	13,14
8	52,2	4,23
Average	47,8	5,33

Tab 1: Maximum entrance surface dose and fluoroscopy time for the first eight patients.

The X-ray equipment was a Siemens Multiscope (1989) with an image intensifier with a 40 cm diameter. The equipment was intended for abdominal angiography and not suited for coronary procedures, due to the large image intensifier. During the procedures there was mainly used magnification technique with 28 cm diameter image intensifier entrance field. The equipment did not have options for pulsed fluoroscopy or last-image hold. However there was a possibility for extra filtering of the X-ray beam, but this option was not used. There was no dose measuring device connected to the equipment. The dose rate was not adjusted by the cardiologists to the actual image quality needs during the different steps of the procedure and the audit gave an impression that it was an over-use of fluoroscopy. During the image acquisitions, the acquisitions were started at the same time as the contrast injector started. This results in unnecessary radiation, because the acquisition starts a few seconds before the contrast medium reaches the heart.

During the meeting after the audit procedure the following "*Do's"* and "*Don'ts" were given*:

- *Don't* over-use the fluoroscopy.
- *Do* adjust the image quality to the actual needs during the different steps in the procedure.
- *Don't* start the image acquisition before the contrast medium has reached the heart.

The TLD measurements the following week, for six patients, showed a significant skin dose reduction with an average MESD of 0.44 Gy, ranging from 0.24 to 0.75, which is less than 10 % of the previous average (table 2). The average fluoroscopy time was also reduced from 47.8 to 23.7 minutes.

Patient	Fluoroscopy time [min.]	MESD [Gy]
9	32,0	0,28
10	19,5	0,68
11	18,9	0,35
12	47,0	0,75
13	13,7	0,24
14	11,0	0,36
Average	23,7	0,44

Tab 2: Maximum entrance surface dose and fluoroscopy time for six patients after the site audit and the educational meeting after the procedure.

Discussion and conclusion

The initial eight measured patient doses were all above the threshold for deterministic effects. The threshold for an early transient erythema is about 2 Gy and the patient with the highest dose, which was 13.1 Gy, was above the threshold for severe effects like dermal atrophy and telangiectasis [2]. After the audit and the educational meeting, where the three "*Do's"* and "*Don'ts"* were given, all the six monitored patients were far below the threshold for deterministic effects. The 50 % reduction in fluoroscopy time gave a significant contribution to the decrease in skin dose. Additional significant factors to the decrease in skin dose were to start the image acquisition when the contrast media reaches the heart and to adjust the image quality to the actual needs during the different steps in the BVP procedure. In some of the moments in the procedure there are low requirements for good image quality, but when the 0.3 mm pacemaker wire is implanted, there is a need for very good image quality. This case shows that a few very basic advices can give significant results in dose reduction, especially if the user has no competence in radiation protection. The measured high doses initially motivated also probably to change of attitudes towards radiation protection of the patients. To fully optimize the procedure, with respect to patient doses, much more effort has to be put in the education of the operator. On a routine inspection on the hospital, four years after the incident, there were revealed that the Cardiology department had implemented dose monitoring of all patients and developed a system for follow-up of patients who receive doses above two Gy.

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TRAINING ON RADIOLOGICAL PROTECTION: USING A COMPLEX SIMULATION SYSTEM AS AN EDUCATIONAL TOOL

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ABSTRACT

This paper describes how a complex simulation system can be used as an educational tool besides the normal operational use. In the first part of the paper the ABR-KFUe simulation system is introduced and the underlying redesigned software architecture of this system is presented. Clients can be connected to this system via a unified XML interface. This enables the development of clients for various use cases ranging from education and training to alarm situations.
In the second part of the paper a training example is presented. The example uses the simulation system described in the first part. It is shown that this system can be used for different user groups and contexts other than normal operation, e.g. for training or teaching lessons.

1. Introduction

In the domain of nuclear engineering, complex simulation systems are used to give answers on several physical aspects. In Germany, the regulation authorities use simulation systems which calculate the release, the airborne transportation, and the deposition of radioactive nuclides. In Baden-Württemberg and Rheinland-Pfalz, a remote monitoring system called KFUe is used for the 24/7 distance observation of nuclear power plants which includes such a simulation system (called ABR-KFUe) to calculate the dose in the surrounding of a nuclear power plant in case of an accident.

The atmospheric dispersion of released radioactive substances and the resulting radiation exposure of the population can be divided into three simulation steps. In the first step a three-dimensional wind field is calculated based on measured or prognostic values. Thereafter, the dispersion model calculates the spread of radioactive material by advection in that wind field taking turbulent diffusion into account. Finally, the radiation exposure doses for adults and infants are calculated and visualized.

To be able to interpret the results of such simulation calculations and to assist the decision makers to draw the right conclusions, regular training sessions have to be performed. The aim of these training sessions is twofold: firstly, to train the users in using the system and secondly, its use in the scope of defined training accident scenarios where the authorities and power plant operators work together. Also, calculations can be performed to answer specific questions during normal operations. The third context where the system will be used in is during lessons and exercises with students.

The usage of such simulation systems in different contexts demands a very flexible system architecture. On the one hand, the system must be used in case of an accident where the emergency situation does not permit the acquisition of detailed user input. On the other hand, the system must be able to adopt the input parameters and workflows according to a scenario which can be used during lessons and exercises.

2. The ABR-KFUe system

The currently used operational ABR-KFUe [1] simulation system automates every step of the nuclear disaster prevention process. But the focus when developing this mature system was on dealing with alarm situations. Therefore the system lacks in usability if it is used for education and training purposes.

The next generation of the ABR-KFUe simulation system has a completely redesigned underlying architecture which improves the system performance, the maintainability, and the training abilities. This new architecture [2] is based on a hierarchy of autonomous resources which are represented as a layered pyramid (fig. 1). Resource providers can be different software tools, databases, or powerful computers, depending on the types of resources. Figure 1 also shows the layered hourglass software architecture supporting the abstract resource oriented model. Each layer corresponds to a resource provider and can run on different machines.

Objects that are instantiated at different levels in the stack are actual resources, e.g. components, programs, scripts, etc. The waist of the hourglass is composed of three layers:

- The Session layer - Host of the client session resource; at this level the user role policy is applied and the corresponding simulation resources are advertised and controlled
- The Simulation layer - Host of the simulation resource which, in case of the ABR-KFUe system, corresponds to a complete end to end propagation calculation; a simulation resource manages the execution of all the underlying scientific workflows
- The Workflow layer - Host of the workflow resource that manages the execution of the underlying operational modules.

The fat top of the hourglass is represented by the different remote clients using the simulation framework through a thin adaptation layer, if necessary. The fat bottom is represented by the different employable job execution technologies.

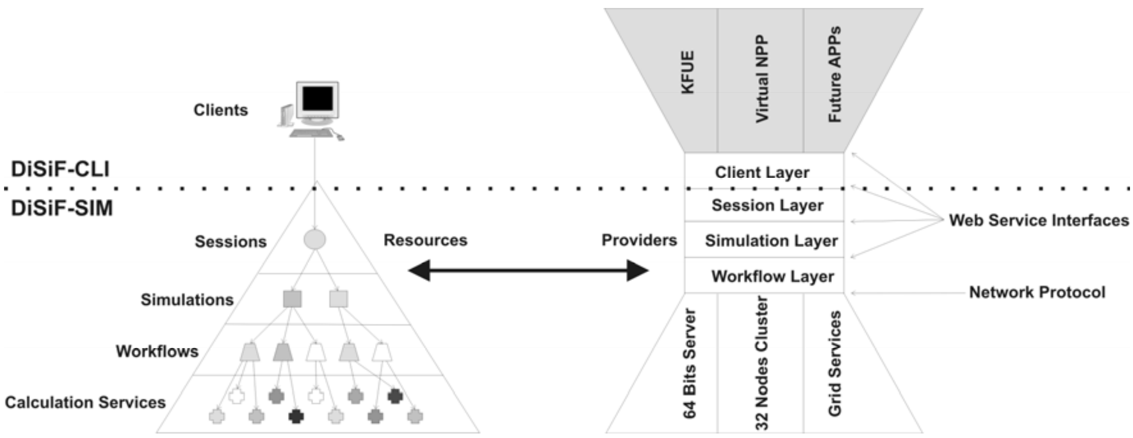

Fig. 1: Next generation ABR-KFUe system architecture [3]

The client layer allows for different types of clients to connect to the simulation system via a unified XML interface (Fig. 2). Through this unified interface it becomes easy to develop and apply clients which represent the different contexts the system is used ranging from education and training to alarm situations.

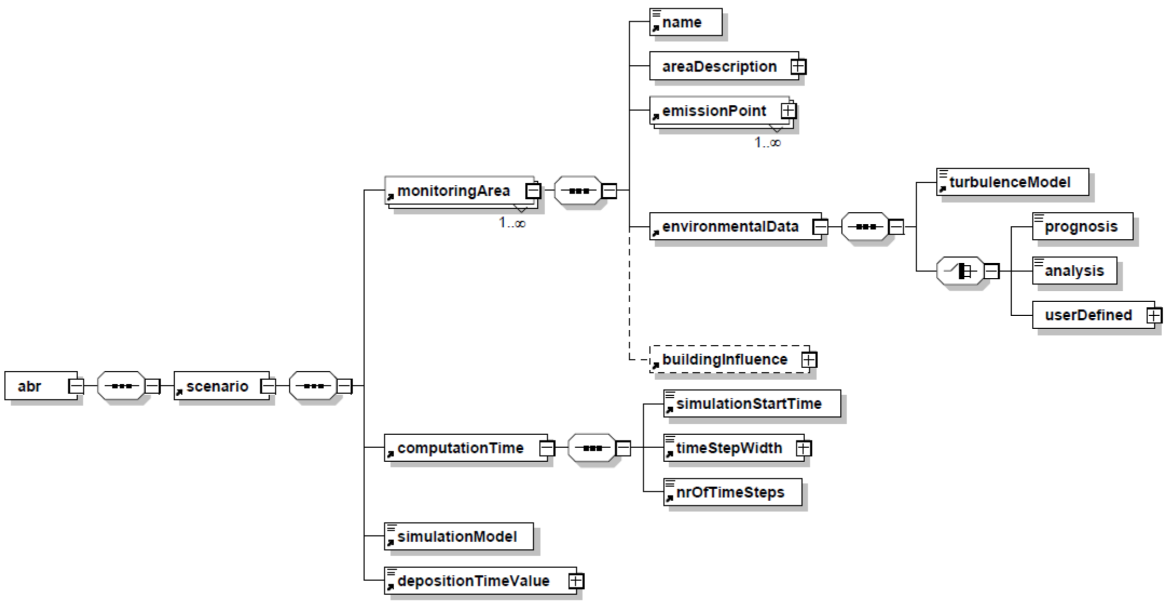

Fig. 2: Unified XML client interface

3. Education and Training

In the domain of knowledge management the distinction between explicit and tacit knowledge is one of the most common differentiations. Hereby, the greatest challenge is represented by the transfer of explicit linguistically expressible knowledge into tacit knowledge (i.e. practical skills and the ability to carry out certain tasks).

In order to demonstrate the potential applications which can support the knowledge transfer, it is useful to have a look at the different groups of users. Following this principle, there are system support experts, experienced users and newbies who are to become acquainted with the system. To give an example a specific parameter has been chosen to perform simulation calculations: the diffusion category (table 1). The diffusion category describes the turbulence and form of the plume and depends mainly on the wind speed and air temperature.

	Day with insolation			Night	
Surface wind speed (ms^{-1})	Strong	Moderate	Slight	Overcast or ≥ 4/8 Low cloud	≤ 3/8 cloud
2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-d	D	D	D
6	C	D	D	D	D

Table 1: Guidelines for determining Pasquill-Gifford [4] stability classes (diffusion categories)

The Expert. A complex system like ABR-KFUe calls for regular maintenance and inspection. Thus, for example in sensitivity tests (i.e. calculations where one parameter is varied and the others are kept constant) valuable insights about the impact of certain parameters upon the results can be obtained.

The regular User. For "usual" calculations the input of the diffusion category is not required since this parameter is provided by the Weather Forecast Centre for prognosis values or by KFUe measurement stations for analysis values. Nevertheless, a thorough understanding of the impact of various diffusion categories can aid users in the evaluation of the outcome of a calculation, the assessment of the situation.

The Newby. Of special interest are the possibilities for new users of the ABR-KFUe System to gain experience from sensitivity studies. In particular, the use of already reckoned simulations and their diverse prerequisites can significantly support the rapid and extensive training. The output format of the ABR-KFUe can be effortlessly visualised with VisIt [5] an open-source software package. For instance, it allows comparative animations of dispersion calculations with different diffusion categories and thus for an intuitive access to their effects. Another example is the straightforward conversion of the results in spreadsheet tables and the possibility of generating different statistically meaningful graphical representations of these results, e.g. bar charts to reflect the histogram of the different values for the received radiation dose in a given area.

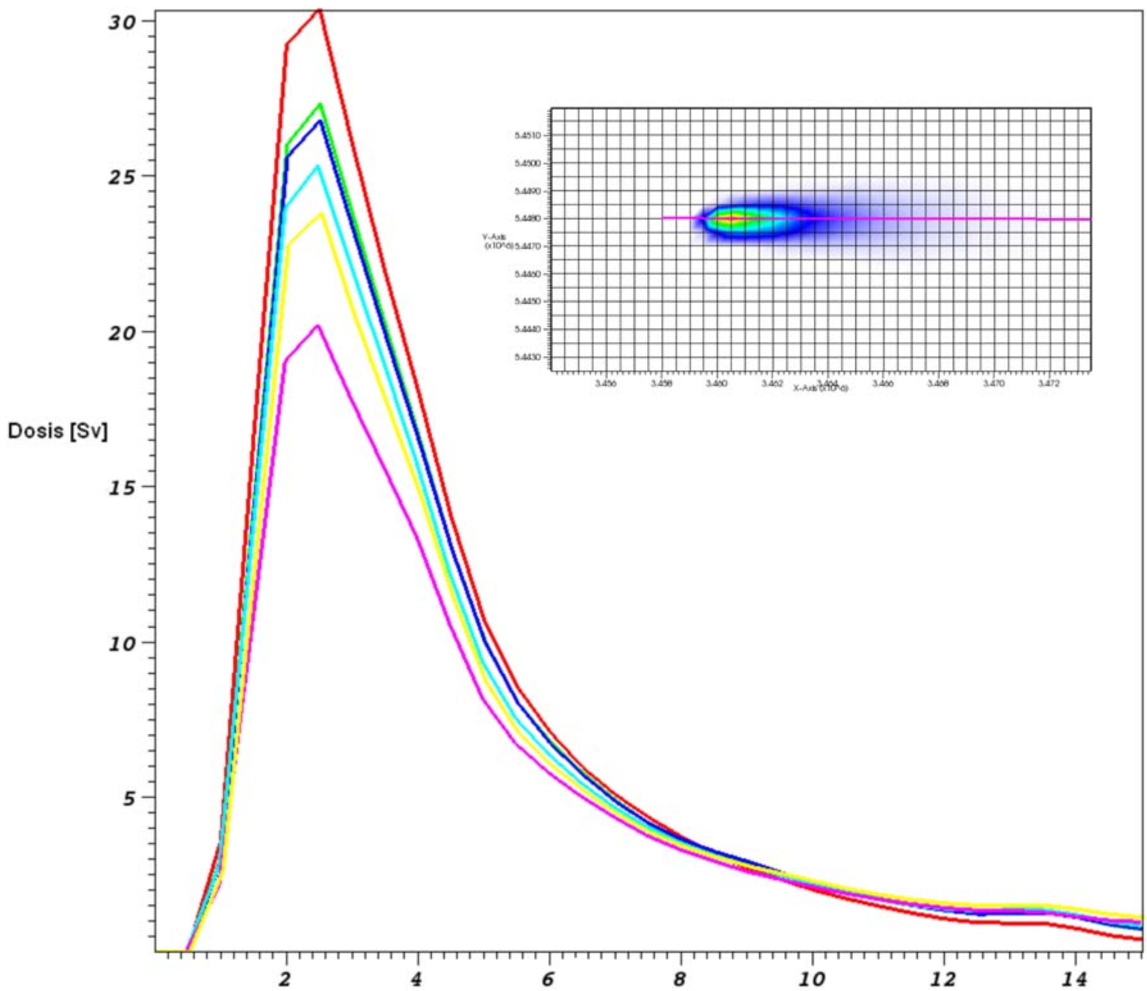

Fig: 3: Effect of diffusion categories A through F on the ground-level radiation exposure

Fig. 3 shows the cut through the ground level radiation exposure and the level of contamination from different calculations using the diffusion categories A to F. For these calculations the same meteorological conditions, e.g. wind speed (2 m/s) and direction (270 degrees) have been used. The aim of these calculations was to show the impact of the different diffusion categories concerning the maximum dose level and the location two hours after a full release of radioactive particles (release category FK3). In this case category A (as the most turbulent one) leads in our calculations to the maximum dose value while category F (as the most stable one) leads to the minimum value.

4. Conclusions

The main goal of this work was to develop a highly configurable simulation system for the domain of nuclear engineering. The system is capable of fulfilling the needs of three categories of users: regular users, domain experts, and students. Different client applications can be tailored in such a way that much of the complexity of the system can be hidden behind this unified client interface. This enables the system to be used during lessons and exercises. At present, the design phase has been completed and the implementation phase has begun. Our preliminary results suggest that at this pace the system will be able to enter its final production phase within one year.

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FULLY ADAPTED RADIATION PROTECTION TRAINING FOR THE DISMANTLING OF THE BN MOX PLANT IN DESSEL, BELGIUM.

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ABSTRACT

To dismantle the Belgonucleaire MOX plant in Dessel, Belgium, ECS has developed a specific training programme. That consists of a basic education and a specific education, ‘cold’ and ‘warm’, under supervision of a mentor. During the programme there are several points of evaluation that make it possible to change the programme, if necessary. Changes to the programme can easily be made, because of the presence of the ‘boxschool’ on-site with its modular training facilities. It has proven to be a very efficient way of education which leads to higher radiation protection safety. In the following paper the global approach of selection is described, as well as the training programme, ‘boxschool’ and certification.

1. Introduction

BELGONUCLEAIRE (in short “BN”) has been operating the Dessel plant from the mid-80’s at industrial scale. In this period, over 35 metric tons of plutonium (HM) has been processed into almost 100 reloads of MOX fuel for commercial west-european light water reactors. In late 2005, the decision was made to stop the production because the shortage of the MOX fuel market remaining accessible to BN.

The license to dismantle the BN MOX plant has been granted by the Belgian safety authorities in February 2008 and the first dismantling operations started in March 2009.

In order to decommission the facility in a safe way, an integrated team was formed with three contractors, each one with specific experience in nuclear activities. European Control Services (in short “ECS”) has been entitled by BN to provide radiation protection agents (to be integrated in the team already existing at BN) and a nuclear training programme for every operational agent from the contractors acting in the dismantling project (nuclear operator, radiation protection agent, …).

This training programme is an important stage in the dismantling project, because of the fact that people with experience in MOX facilities and its specific risks (alpha) as well as in glove box dismantling cannot be found easily and on the other way in order to harmonize different working cultures and to increase the safety level of the dismantling works.

European Control Services was founded in 1990 and is a member of GDF Suez Energy Services. ECS has a large experience in all kind of training facilities (nuclear and non-nuclear) as well as in radiation protection.

This paper describes in detail the selection, training and certification of the radiation protection agents concerned in the dismantling project of the BN MOW facility. Radiation aspects in the training of nuclear operators are also briefly described.

2. Boxschool

For the dismantling of the BN plant a special training school was developed, named 'boxschool'. The aim of this boxschool is to enable a simulation of a controlled area without any real nuclear risk. This makes it possible to train radiation protection agents and nuclear operators who have a very limited nuclear experience. Secondly, the boxschool makes it possible to test and to simulate new techniques developed during the dismantling.

The boxschool is fully equipped with glove boxes under operational (cold) conditions, ventilation system, glove tents, dismantling equipment ... . The school is installed in a cold workshop at the MOX plant itself.

In the figure beneath you can see the organisation of the boxschool with the different training areas.

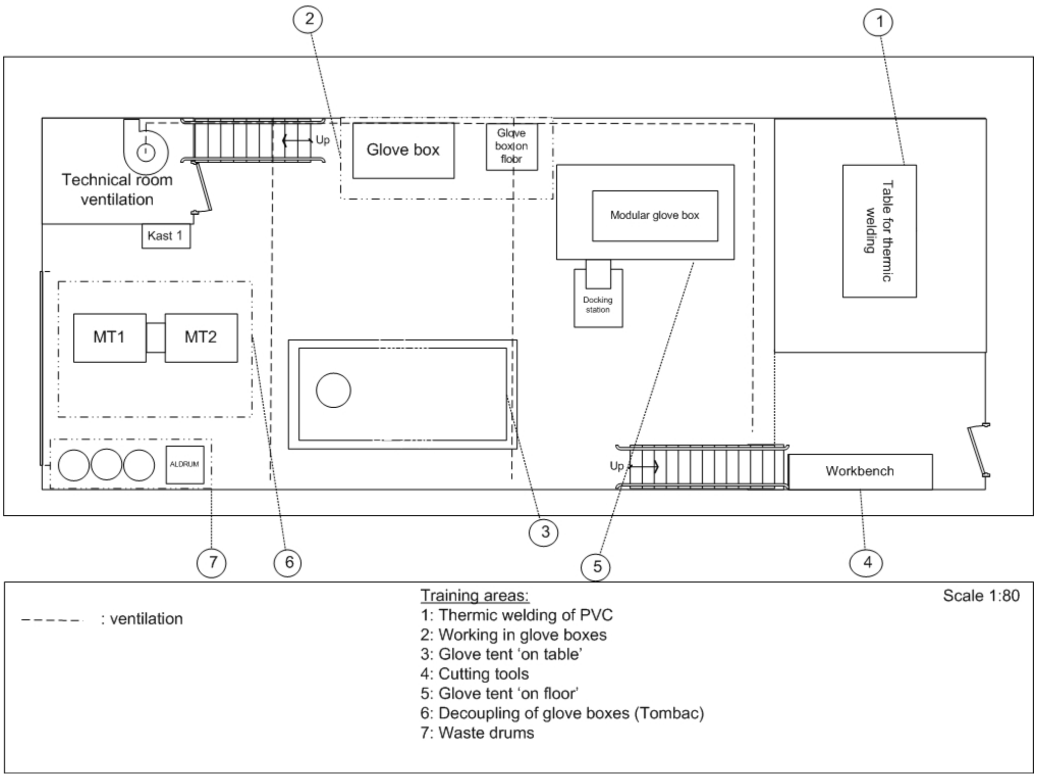

Fig 1. Organisation and implanting of the boxschool

3. Radiation protection agent

3.1 Basic education

In order to be selected as a radiation protection agent, the agent has to fulfil several criteria, such as a technical education, safety advisor level 2, 5 years professional experience and 1 year of experience as a radiation protection agent or 1 year of nuclear experience. Therefore all the radiation protection agents were recruited one year before the start of the project in order to gain nuclear experience at various nuclear facilities in Belgium.

During that year the radiation protection agent has to follow different trainings, mainly in classic safety matter, like: fire prevention and control, first aid, scaffolding supervision …Two nuclear training are also scheduled: nuclear safety culture and an intensive course of radiation protection.

If the agent is successful in all these trainings (including examination and certification by skilled agents of BN), he can continue his education to become a radiation protection agent in the BN MOX dismantling project.

3.2 Specific education

This training programme consist of two steps, which take place on-site:

- ‘cold education’: to provide a cold education (outside of the controlled area) the boxschool described above was developed. All the tasks of radiation protection as well as general tasks are simulated.
- ‘warm education’: during the warm education, the agent will apply the skill set learned in the ‘cold education’.

Both educations are under supervision of several mentors. One for the cold education and two for the warm education.

Note: the procedure of mentorship is taken over from BN. A mentor takes care of a new employee and trains him on-the-job. This was perfectly possible when BN was in production and there were a lot of experienced employees to act as mentor. In the new organisation of the dismantling project, the number of new people outreaches largely the number of experienced people. Therefore it is practically impossible to rely only on mentorship.

In the figure beneath you can see the different stages in the training programme.

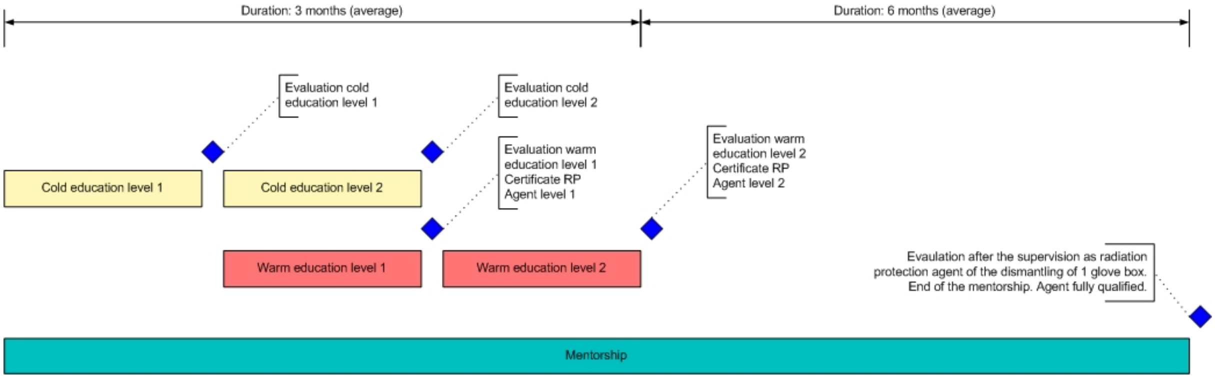

Fig 2. Different stages in the training programme

You can see that during the training programme there are several points of evaluation. Each certificate sanctions the training session and is a prerequisite to continue the programme. There are two levels in cold education (see 3.2.1) that are followed by two levels in warm education. Cold and warm education will take three months on average. The mentorship overlaps the whole training programme and continues for an average of 6 months after cold and warm education. Changes to the programme can easily be made, because of the presence of the boxschool on-site with its modular training facilities. Every real situation in the controlled area can be put into a simulated scene in the school. That makes it possible to learn and improve skills in a safe manner, leading to an enormous improvement regarding safety in the controlled area. The school stays open for every agent who wants to check his skills and relearn or improve them.

3.2.1 Cold education

In the table underneath, you find the training programme and the two different levels of the cold education.

LEVEL 1	**GENERAL**	
		Presentation of the training programme
		LTC *("List of Tasks and Checks")*
		DASAO
	SAFETY TRAININGS	
		Access to the facility
		Access to the controlled area
		Fire prevention and fighting (in glove boxes)
		Criticality
	WORKING IN GLOVE BOXES	
		Working in glove boxes
		Use of a full face mask
		Glove controls
		Thermic welding
		Glove replacement
		Bag-in & Bag-out technology
		Decontamination
	DISASSEMBLING TECHNIQUES	
		Use of tools for disassembling
	CUTTING TOOLS	
		Use of cutting tools
	WASTE TREATMENT	
		Waste classification
		Sorting and recognizing of waste
		Waste packaging
		Optimisation of the filling of waste drums
		Assembling and testing of waste drums
		Coupling and decoupling of waste drums
	TRANSPORT/TRANSFERT	
		Transport of waste packages
		Transport of a glove box
	SPECIFIC RADIATION PROTECTION 1	
		Interventions on primary confinement
		Control of surface and air contamination
		Control and maintenance of measuring equipment
		Shielding
		Principles of people decontamination
LEVEL 2	**GLOVE TENT**	
		Mounting and dismounting of a glove tent
		Making of penetrations
		Use of docking station
		Tightness testing of a glove tent
		Maintenance of a glove tent
		Use of shielding
		Use of balancers
	DiSCOUPLING OF GLOVE BOXES	
		Decontamination
		Knowledge of different types of coupling
		Confinement's keeping
		Discoupling
	SPECIFIC RADIATION PROTECTION 2	
		Replacement of a glove box panel
		Special interventions with higher alpha risk
		Decontamination of contaminated personnel
		Principles of glove box transport

Tab 1: Training programme cold education

3.2.2 Warm education

The dismantling project of the BN MOX facility is based on written working instructions and procedures. For every subproject an engineering team develops an LTC. An LTC is a list of tasks and checks. It describes the working procedure and has to be followed during the subproject. A subproject can be the testing of a tent, disassembling of a structure, dismantling of a glove box, …

It has been chosen to combine the warm education with a 'training LTC' for two reasons:

1. Every agent or operator learns to work with a LTC;
2. Quality system is guaranteed because every work in the controlled area requires a LTC.

In the training programme two LTCs were developed. A first one to evaluate level 1 and a second one to evaluate level 2.

3.3 Mentorship

During the training programme of a radiation protection agent, there are three mentors: one for the cold education and two for the warm education. In that way the final evaluation is based on the comments, advise and skills of different people in order to improve the quality of the training programme.

3.4 Result analysis

Due to the fact that non of the radiation protection agents has not yet reached its final evaluation point (completion foreseen end of November 2009), a final result analysis can not be made yet. The modular training programme has however proven his efficiency. The different evaluation points and the flexibility of the training school, make it possible to react immediately if failures in certain trainings arrive. Trainers and mentors can spend extra time to an individual case if necessary and the boxschool makes it possible to train individually. This is a big advantage knowing that, even without failure, the skills of agents don't improve at the same pace.

4. Nuclear operator

In order to improve radiation protection safety at all levels, every nuclear operator also receives the radiation protection aspects specifically for his task. To improve radiation protection behaviour, its warm education is followed by a radiation protection agent who is still monitored This has a double advantage: radiation protection of the nuclear operators is improved and the monitored radiation protection agent can improve his skills and learns how to supervise the radiation protection safety.

5. Conclusion

Final results are not yet available, but the training programme, started in February 2009, has proven his efficiency until so far. It concerned 9 radiation protection agents and 65 nucelar operators. Up to now, 84 % of the trainees passed his evaluation and certification by BN at level 2. The existence of numerous evaluation points, the separation of cold and warm educations, the follow-up by a LTC, the modular boxschool and the mentorship approach lead to an improvement in radiation protection safety during the dismantling project. The general approach of this training programme can easily be adapted for other dismantling or decommissioning projects. At the end of this training programme a debriefing meeting will be held to evaluate the programme and further improvement points could be determined.

TRAINING FOR REGULATION OR REGULATION FOR TRAINING?

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ABSTRACT

We describe how CIPRSN developed the training of a small group of people with competencies in regulatory tasks in radiation protection and nuclear safety. The future need of specialized educational and training programs dedicated to regulatory issues is emphasized and the necessity of an independent regulatory body is discussed in this context.

1. The problem

The Independent Commission for Radiological Protection and Nuclear Safety (CIPRSN) was created in 2005 [1] to provide the national regulatory system with the capacity for independent observation. It has two main objectives: to analyze the Portuguese infrastructure in the field and to propose improvements to the existing legal framework and enforcement measures. Another key task was to support the Portuguese Government in solving the infringement procedures resulting from the incomplete transposition of European Directive 96/29/EURATOM. However, the CIPRSN faced the problem of the scarcity of available experts in Portugal.
In recent years, few efforts were made by the governmental authorities to recruit and train students in specific legal and technical aspects of regulation and inspection in radiation protection. Partially, this is the result of regulatory competencies being distributed among many governmental authorities where radiation protection is only a small part of their attributions. This hinders the concentration of human resources needed to make the population aware of these issues, attract students and support educational programs. Some national Universities have courses at post-graduate levels in Medical Physics and, more recently, one in Radiation Protection (at the Technical University of Lisbon). However these are not aimed at the development of competencies in regulatory and inspection tasks. The circular problem facing the development of an efficient national regulatory system can be stated as follows: *a proper regulatory system requires a body of people with different degrees of expertise in licensing and inspection procedures, but how can a training program of experts be developed without an efficient regulatory system?* (See Figure 1).

2. Breaking the circle

CIPRSN has no licensing and inspection competencies, but, within its attributed tasks, it is trying to break this circle by establishing a small group of people with regulatory competencies in radiation protection and nuclear safety. To recruit people, CIPRSN resorted to individual grants funded by the Portuguese Foundation for Science and Technology. Two legal advisers and two physicists were recruited to build a team coordinated by an official seconded from the European Commission. The training of this people has been largely interdisciplinary, as the result of the exchange of knowledge from their different backgrounds. The tasks that CIPRSN had to deal with during its operation served as training case studies, together with the participation in workshops and conferences. Collaboration with the Radiation Protection Group at CERN was also established for training in the licensing of complex installations.

The main works developed so far, comprise:

- Contribution to the solution of infringements procedures;
- Consolidation of the Portuguese legislation relating to radiation protection and nuclear safety;
- Self-assessment of the Portuguese regulatory infrastructure;
- Collaboration in the assessment of the radiological risk of the MedAustron project;
- Development of guidelines and licensing procedures for PET cyclotrons;
- Studies about possible improvements of the regulatory structure (proposal of an independent regulatory body);
- Creation of a database of international and European laws, guidelines and recommendations;
- Participation and communications in national and international workshops and conferences;
- Visits to national public and private entities dealing with ionizing radiation;
- Meetings with national regulators;
- Development of the contents for a webpage.

In the last two years these tasks provided a sound knowledge in regulatory issues for this small group of people.

3. How to move forward?

It is well known that regulation in radiation protection and nuclear safety requires a high level of expertise and specialization in areas like medicine, nuclear and non-nuclear industry, research, protection of the environment, waste management, national and international transport and emergencies, as well as in non-proliferation and nuclear security issues. Such a small group of people can hardly deal with all those areas, moreover taking into account that the number of installations to be regulated and inspected is increasing drastically specially in areas like medicine. At this point it is essential to recruit more people and integrate them in educational programs oriented to the specific areas of regulation mentioned above. This, however, can not be attained in the same framework of education that served for the training of the initial group.

A more formal educational scheme can only be developed and sustained within an existing body with established competencies in regulation, inspection and training. This body should be independent from governmental authorities, establish international partnerships with recognized agencies and possess an autonomous budget to develop such educational programs. Such a body does not exist in Portugal, a situation that is not in conformity with the requirements of the Convention on Nuclear Safety (CNS) [2] and the new European Directive 2009/71/EURATOM.

The CNS, in Article 8 (1), states that each country must *establish or designate a regulatory body provided with adequate authority, competence and financial and human resources to fulfil its responsibilities* and, in Article 11(2) of the same convention, that it also must *ensure sufficient numbers of qualified staff with appropriate education, training and retraining*. The same obligation has now been included in the European Directive 2009/71/EURATOM [3]. Article 5 states that Member States *shall establish and maintain a competent regulatory authority* and that to this authority *shall be given the human and financial resources required to fulfil its obligations*.

Thus, the establishment of a regulatory and independent authority with competent staff and appropriate education and training programs, apart of being a recognized necessity by many users or stakeholders of ionizing radiation in Portugal, is also a legal obligation.

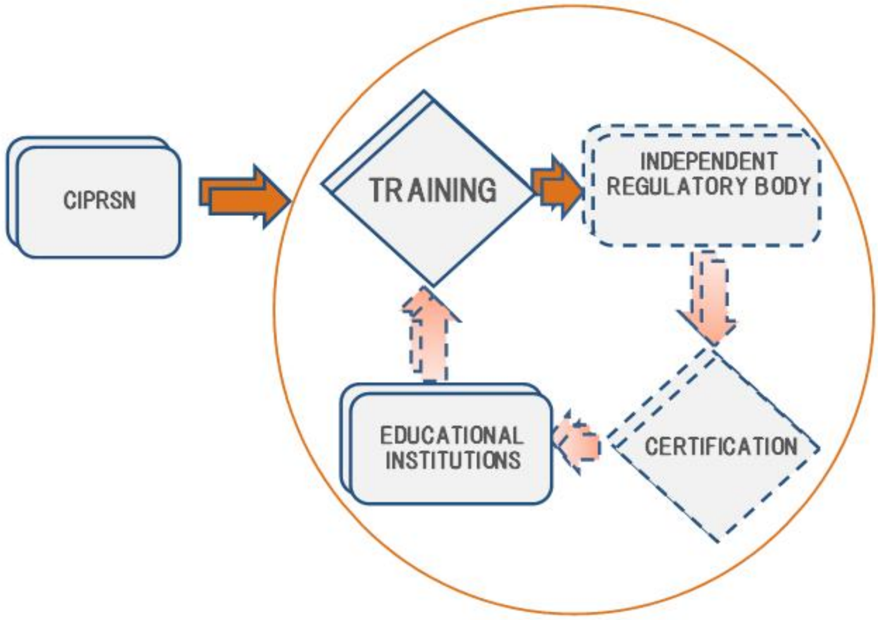

Figure 1 The circular problem facing the development of an efficient national regulatory system: *a proper regulatory system requires a body of people with different degrees of expertise in licensing and inspection procedures, but how can a training program of experts be developed without an efficient regulatory system?* CIPRSN is trying to break this circle.

4. Summary and conclusion

CIPRSN has developed an educational and training scheme in regulation for a small group of students. This group developed the necessary and essential legal and technical competencies in order to be prepared to constitute a core of a future independent regulatory authority with qualified staff dedicated to radiation protection and nuclear safety issues. As part of its duties, such an authority would be able to promote educational and training programs in the areas of expertise needed for an efficient regulation. However, such a regulatory authority does not exist in Portugal, although it is a recognized necessity and, furthermore, it is required by international obligations. An urgent political decision is needed in this matter, otherwise the efforts of CIPRSN to break the vicious cycle of scarcity of human resources needed for the establishment of an efficient system of independent regulation will have been in vain.

References

[1] Portuguese Decree-Law 139/2005 of 17 August 2005, Diário da República I – Série-A
[2] INFCIRC/449/1994, Information Circular of the International atomic Energy Agency IAEA of 5 July 1994
[3] Council Directive establishing a Community framework for the nuclear safety of nuclear installations, of 23 June 2009

LESSONS LEARNED ABOUT COMMUNICATION TO THE PUBLIC AFTER AN INCIDENT IN A NUCLEAR POWER PLANT

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ABSTRACT

The purpose of this study is to describe the lessons learned in the process of communication to the public, carried out after an incident at a Spanish nuclear facility.
After the incident, various groups of visitors of the Plant demanded a study to evaluate its dosimetric consequences. The news media generated in the affected people a sense of misinformation, as well as cast doubt on the results of the measures.
Parties involved felt the need to complement the dosimetric measurements with previous talks to clarify the incident, its consequences, and the measurement process that was going to be performed. The purpose was to provide a means of direct and close communication between the public and experts.
At the end there was a general feeling of calm and confidence in the process executed and people appreciated the treatment and the information received.

1. Introduction

The purpose of this study is to describe the lessons learned in the process of communication and information to members of the public, carried out after an incident at a Spanish nuclear facility.

1.2 Background

After an incident occurred at a nuclear facility, various groups of the general public who had visited the Nuclear Power Plant after the incident, demanded a study to evaluate its dosimetric consequences. The news media, as well as the opinion of different sectors of society in relation to the incident, generated in the affected people a sense of misinformation, which made them question the information received so far.

When incidents like this occur, people that do not have the necessary training are vulnerable to all the messages they receive, and this vulnerability increases when individuals themselves or people close to them feel to be directly affected by the incident. The fear of the unknown and the lack of simple and close information make it very difficult to assimilate certain incidents to the public. This fear, fed by rumours and misinformation, has a strong influence on trust and credibility.

The messages that the public receive, analyzed from ignorance, create a distorted perception of reality, producing mistrust and anxiety among the receivers.

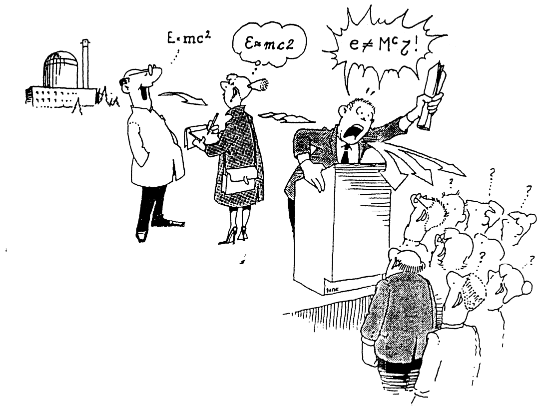

Fig 1. Same information, different message

The vocabulary specific to Radiation Protection is mostly unfamiliar to the general public: Radioactivity, millicuries, activity, Becquerel, Level 1 on the INES scale, whole body counter, radioactive contamination, etc, are concepts not easily understood by unspecialized people that appear daily in the media.

Due to this distrust, the involved parties in the contamination counting process: the installation itself, the Dosimetry Service of Tecnatom and the Regulator; felt the need to supplement these measurements with preliminary talks to assist those affected to clarify the incident, its consequences and the measurement process to be performed.

Firstly, anyone giving the talks should know the audience, understand their concerns, be identified with their mood, and make them feel understood and be empathetic.

Starting from this point, this person should design the communication strategy and define the message establishing a consistent argument. Not only should this person have great knowledge of the subject to be treated, but also be trained to face the public.

Taking into account the characteristics of the young audience, (totally unfamiliar to the incident and extremely influenced by the media and their families) special attention was paid to the use of appropriate means: all the talks dealt with the topics in a simple way, using images, metaphors, avoiding technicalities where possible, etc, to achieve that the message reaches the public in an understandable manner.

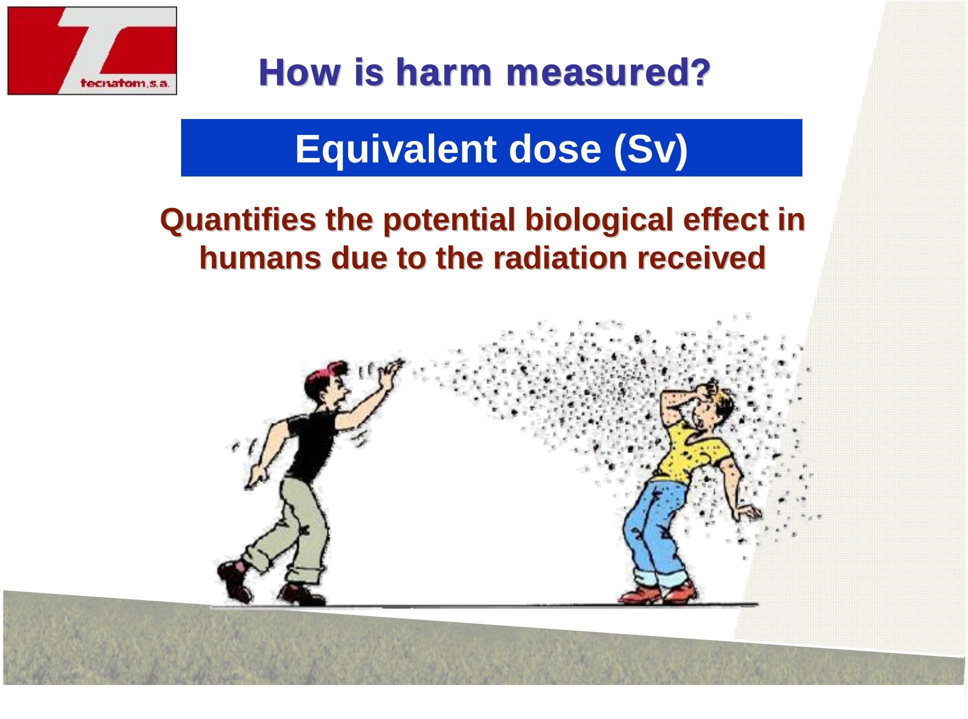

Fig 2. Equivalent dose

On the other hand, it was very important to get the involvement of trainers to transmit to the public a message of confidence and tranquillity. Taking into account the characteristics of the groups it was necessary to search for young, close and dynamic communicators, conveying a perfect knowledge of the situation that could easily connect with them.

The idea was that the message received by different groups, contributed to give a clear, complete and truthful vision about what had happened. The purpose of the talks was not to teach a class, but to provide a direct and up-close communication between the public and the experts, in which the listeners could take part in questions and answers to satisfy all their concerns and thus form their own opinion.

Fig 3. Communication between public and experts

Not only during the lectures, but also at the end of them, the audience was encouraged to talk to the speakers and ask about any doubts they had, so that the group could acquire a full and seamless knowledge.

The communication process should be an interactive process, which takes into account "the other", to understand his doubts and fears, anticipating his concerns. From this point of view, the demand of information that the public requested aimed to get clarification on the incident and the possible health effects associated.

Talks were given by experts in Radiation Protection, Dosimetry and Operation and were divided into blocks as follows:

- Chronological explanation of the incident. Facility staff, based on information available to date, detailed the order of events and measures that had been and were being taken to assess the radiological consequences of the incident to both staff and members of the public.

- Basics of Radiation Protection. Explanation of what is radioactivity, types of radiation, natural and artificial sources, basic units, radiation applications, etc. The Dosimetry Service of Tecnatom gave a brief talk which tried to make the group understand the meaning of those concepts that were appearing in the media during those days, to make it easier to understand and analyze.

- Description of the measuring equipment that would be used and measurement process. Because of the doubts raised by reports in some media about the veracity of the measures that were undertaken, workers of the Dosimetry Service of Tecnatom explained the experience of that service, the operating principles of the equipment to be used, steps in the measurement process and the procedure for outcomes.

- Following the talks, the measurements were conducted individually, and people again were encouraged to clarify the concerns that arose about the process and its results. It should be noted that most of the questions they asked, were mainly based on reports in the media in the days before the meeting.

1.3 Conclusions

The Dosimetry Service of Tecnatom can not make a work of prior information to the public before such events become news, and must deal with them once released by the media, when a sense of anxiety and fear over the possible consequences of what happened is generated.

After this experience with successful results, it is considered that on future situations, the basic standards to be used for effective communication, to attain a sense of security and confidence in the task of the technicians that take the measurements, are as follows:

Empathy: public understanding. Not everyone has the same knowledge about the events that occur. In communication, the most important is the "other ". Whom I speak: What information does he have? What does he feel? What does he demand? Is my message well prepared? Do I make myself understood?

Planning: It is important to know the audience you are going to speak to, and prepare the ssesion according to their characteristics and needs. Whenever possible, all that is possible.

Transparency: The truth and timely information create an image of transparency. Trust is obtained with the truth, and this confidence is crucial for a perception of risk in line with reality.

At the end of the counts, both families and young people involved had a less pessimistic idea than before, ending the sessions with a general feeling of greater calm and confidence in the process performed and the results of the measures. People appreciated the treatment received and the information provided, and encouraged the experts to continue in this line of action in similar situations.

The Actual State of Physics Teachers' Cognition on the Concept of Radiation in Korea

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ABSTRACT

Students obtain most of concepts through textbooks, and above all teaching-learning activity between teachers and students. Accordingly, if science teachers have the misconception, it will affect directly on students' scientific concept. As the result of this study, there were found many problems in teachers' cognition on the concepts of nuclear radiation. Because 12th grade's physics II is classified into the optional subject in 7th curriculum, teachers have a few chance to teach it , and also have difficulties in teaching it because of preparing the entrance examination of the university. Surely, the concept of radiation must be educated correctly because of presenting in 'Environment' unit of 10th grade's Science Textbook. Finally, this result can help science teachers to teach these difficult concepts more correctly. In addition, this can also be useful for the in-service retraining program.

I. Introduction

Because there is a possibility that traditional concepts obtained and maintained by students through daily life and school education give absolute influences on learning a new concept to reinforce the traditional concept or induce a wrong concept as a new concept, the necessity for investigating preconception possessed by the students prior to concept learning is being emphasized. Traditional studies have indicated inaccuracy of concept description, diagram, and graphs used in school education as sources of the wrong concept (Seung-Il Choi et al, 1987; Dong-Sik Kook, 2003).

Generalizing and analyzing the results of studies performed on the students' preconception, sources that their conceptions for a scientific concept originates in can be classified into experiences on nature, daily life experiences, language life, and school education in broad meaning. At this point, the sources of student's misconceptions obtained through school education can be subdivided further into ‘teaching material used in science learning’, ‘personal concept of teacher on specific scientific concept' and combination of language through science class. (Seung-Jae Park, Heui-Hyeong Cho, 1999).

Although students learn contents of science via textbook sometimes, in most case they obtain the concept through teaching and learning activity between teacher and student. Accordingly, when a science teacher has a wrong concept, this gives a direct effect on student's concept acquisition (Jae-Sul Kwon, Beom-Gi Kim, 1993). In other words, a capable teacher as well as a good textbook and an excellent student is an essential factor in school education. Even though good curriculum, school education environment, and textbooks were prepared, these would be delivered, used, and applied to students by and through teachers, so the excellence of teacher is considered as an absolute factor in school education.

When a science concept possessed by science teachers is not scientific, the results of instruction conducted by these teachers will not only distort further or reinforce the student's preconception, but also provide sources inducing another misconception for a new concept.
In the 7th national curriculum, as the Physics II is an advanced elective curriculum to be learned after completing the Physics I, even a physics teacher often has insufficient teaching experience on the concept of radiation in current situation that a lot of students avoid the Physics II. Especially, as it is treated in the last chapter in the 12th Grade, its lesson often is not performed properly because of preparation for the College Scholastic Ability Test and the class preparation of teachers is often careless.

Preceding researches concerned with radiation includes Seong-Gu Heo (1979) and Kyeong-Heui Chio (2003), however all of them are studies related on teaching or only a test using the radiation unit for surveying awareness of high school girls in terms of STS. And there are scarcely studies on the concept of radiation itself or the physics teacher’s awareness on radiation concept.

Therefore, this study aims to identify the concepts to be noted when teachers teach and provide reference materials to be considered in teaching and writing textbooks.

II. Research Methods

This study intends to provide materials for effective teaching of conception through survey conceptions possessed by the teacher, considering that the conception of teacher gives an absolute effect on forming of the students' scientific conception. Accordingly, preconceptions of teachers were surveyed through a questionnaire. Points considered in preparing a questionnaire is to check up if a responder knows the concept accurately by making him/her explain his/her own opinion on the reason as well as to select an answer in an objective test. The questionnaire comprised 2 patterns of a basic concept and an advanced concept, each of which was composed of 4 elements. As 4 elements of 6 questions in the basic concept, there were 'comprehension of terms', 'radiation units', 'radiation types', and 'development of radiation', and as 4 elements of 5 questions in the advanced concept, 'features of radiation', "radiation decay', "hazards of radiation', "application of radiation" (Table 1). Contents of the questions used in this research were included in the Appendix.

As subjects of this study, survey results obtained from 126 science teachers who participated in the teacher training were analyzed. While there may be some restriction in interpreting these results in general because the number of responders is small and some middle school teachers are included, it is considered that the analysis results of this study may provide significant data to teaching physics even though they don't have enough experience on teaching radiation.

The quantitative analysis was focused on the objective multiple-choice test, and the validity, meaning, or interpretation of the analysis results were based on the subjective descriptions prepared directly by the teachers.

Type	Element	No. of question	Form
Basic Concept	Understanding of terms	2	Descriptive type
	Radiation units	1	Multiple choice type
	Kinds of radiation	2	Multiple choice type Descriptive type
	Generation of radiation	1	Multiple choice type
High Concept	Properties of radiation	1	Descriptive type
	Radioactive decay	2	Multiple choice type Descriptive type
	Radiation damage	1	Descriptive type
	Applications of radiation	1	Descriptive type

Ⅲ. **Results and Discussion**

This study intends to provide materials for effective teaching of conception through survey conceptions possessed by the teacher, considering that the conception of teacher gives an absolute effect on forming of the students' scientific conception. Accordingly, the responders were made explain their own opinion for questions in the questionnaire. Teachers responded the questionnaire were 126 science teachers who participated in the teacher training. Among them, teachers with less than 5 years of career were 54.5% and teachers with over 5 years of career, so it was found that most teachers had less than 5 years of career. However, it was found that the teachers possessing an experience to teach radiation concept was only 76.2% of total responders, this indicated indirectly that there would be a lot of difficulties in teaching the radiation concept in future.

The questions of questionnaire were divided into the basic and the advanced concept, and each concept comprises 4 elements. Total questions were 11. The survey results against teachers by the elements of each concept were as follow.

1. Basic Concept

(1) Comprehension of Terms

The most basic terms for teaching the chapter of atom and atomic nucleus are 'radiation' and 'radioactivity'. In textbooks, the radiation is explained as 'an energy emitted from atomic decay' and the radioactivity is expressed as 'a feature of an atom emitting radiation'.

Among the responders, it was found that the teachers who answered both the 2 concepts the most closely to the expression of textbook were only 18.3%, the teachers who answered only one of the 2 concepts correctly were 48%, and the teachers who answered none of the concepts correctly were 81.7%. When it is considered that the 'radiation' and 'radioactivity' are the most basic concept, it is suggested that there are a lot of problems.

In case of 'half-life', it is expressed in the textbook as "time taken for the number of atomic nucleus of radioactive to be reduced to 1/2 of the initial number'. In questions of the questionnaire, the closest answer to the expression of textbook was ① and ② also can be regarded as a correct answer, considering that mass of a radioactive substance is proportionate to radiation level. The results of teachers' answer on 'half-life' are shown in Fig. 1.

In case of the term on ‘half-life’, 79.4% of the teachers selected ① and ② as a correct answer. From this, it was suggested that most teachers had correct concept on it.

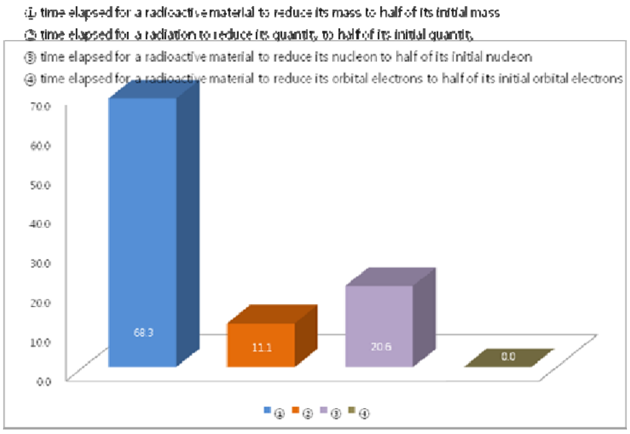

Fig. 1. Response result for understanding of terms 'half-life'

(2) Decay of Radiation

The question on where the radiation originate is the most natural question on learning the radiation and also may be regarded as a basic concept as much. It is described in the textbook that the radiation is emitted changing from an unstable atomic nucleus to stable nucleus.

In general, the radiation is emitted from a radioactive isotope, which refers to have same atomic number, but to have different number of nucleon. Namely, the case that the number of positron or neutron in an atomic nucleus is distributed ideally may be considered to correspond to this. In this case, the atomic nucleus is in unstable state and emits radiation for going to stable state. Accordingly, it is suggested that the closest answer to contents of textbook and the above description is ③ in this question. The result of answers on ‘development of radiation’ is shown in Fig. 2. As shown in this figure, the number of teachers who selected the correct answer, ③, was no more than 39.7% of total. Compared with this, the number of them who answered that ‘the radiation exists always and does not originate from anywhere’ was no less than 11.9% and it was found that as many as 11.1% of the teachers misconceived that a phenomenon occurring in an atom (No. ②) develops in the atomic nucleus.

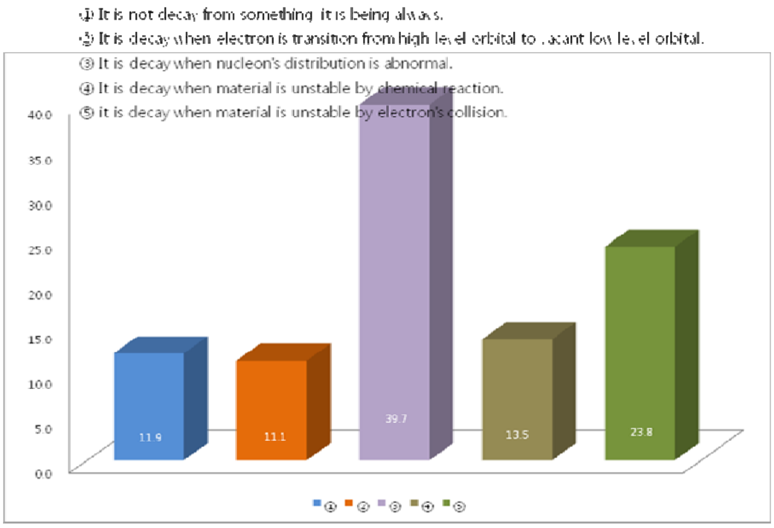

Fig. 2. Response result for 'decay of radiation'

2. Advanced Concept

(1) Features of Radiation

In the textbook, movement of radiation in an electric field is described that the alpha ray gets curved toward negative (-) pole, the beta ray gets curved toward positive (+) pole, and the gamma ray go straight without curving. These are because the alpha ray has positive (+) charge, the beta ray has negative (-) charge, and the gamma ray has no charge. As the concept of radiation' movement was a question to ask a concrete feature of radiation, it was classified into an advanced concept. However, it was the most basic feature among various features of the radiation what charge the radiation has, so most of the teachers selected a correct answer. But, it was found that as many as 35.2% of total teachers didn't know basic features of the radiation properly, answering incorrectly including that the gamma ray get curved toward a specific side.

(2) Hazards of Radiation

Although the concept of hazards of radiation on human body is rather important in daily life than other concepts, it is not at all described in the textbook. In the textbook, a concept on penetration force of radiation was introduced. The penetrating force is the largest in neutron and gamma ray and the weakest in alpha ray. However, the penetrating force and the hazard are different each other. Namely, it is a gross fault to consider that a substance with strong penetrating force has great effect on human body. On the contrary, it may be considered that the substance with strong penetrating force can pass through thicker material due to lower interaction with other material. I

Therefore, the radiation with the greatest effect on human body is alpha ray and gamma ray gives the smallest effect. It shows directly opposite result to the penetrating force. In actual fact, the number of teacher who selected a correct answer for this question was only 4% of total. Most of them answered that the gamma ray with the strongest penetrating force is the most harmful to human body. It may be considered that the concept is not treated properly as much and there is a tendency to manage it carelessly, confusing with the concept of penetrating force. Taking it into account to have a close relation with human life, it is suggested that it must be treated prudently.

(3) Application of Radiation

Application areas of radiation introduced in the textbook may be divided into medial, industrial, and engineering area. In the medical area, radiation therapy including cancer therapy is most often introduced, a nuclear power plant in the industrial area, and a nondestructive testing in the engineering area were given for an instance most frequently.

In the questionnaire on the application of radiation, it was intended to estimate whether the responders knew the contents of each application area well and it was investigated how broad they understood on the contents of whole area rather than the numbers listing the application contents of each area. In results of the survey, the number of teachers who answered more than one contents correctly in all the three areas was merely 10% and no less than 24% of them did not described any area properly. As a whole, there is nothing but to consider that understanding on the application area of radiation is insufficient.

3. Assessment of physics teacher’s awareness state

Based on the above survey results, the actual awareness state of teachers on the radiation concept was assessed. Quantitative analysis of the survey for assessment was performed mainly through an objective multiple-choice test and validity, meaning, or interpretation of the analysis results were based on the contents described directly by the teachers. The answers close to the concept expression described in the textbook were recognized as correct answers against the survey questions. The awareness level of teachers by concepts on the radiation was divided into 'very good', ‘good’, ‘normal’, and ‘insufficient; on the basis of correct answer percentage for the survey answers and its standards was shown in below Table 2.

Right answer rate	90% over	80% over	70% over	70% below
Level	very good	good	usual	insufficiency

In the results of assessment on the actual awareness state on radiation of teachers, it was found that ‘very good’ was 1, ‘good’ was 3, normal is 1, and ‘insufficient’ was 6 (Table 3).

Type	Concept	Level
Basic concept	Radiation, Radioactivity	insufficiency
	Half-life	good
	Radiation units	insufficiency
	Kinds of radiation	good
	Natural radiation	good
	Generation of radiation	insufficiency
High concept	Properties of radiation	usual
	Radioactive decay	insufficiency
	After radioactive decay	very good
	Radiation damage	insufficiency
	Applications of radiation	insufficiency

Ⅳ. Conclusion and Suggestion

This study investigated the concept on the radiation possessed by teachers, considering that the concept of teachers gives absolute effects on scientific concept formation of students. The subjects of this survey were 126 science teachers who participated in the teacher training. While a problem that the subject group was restricted might be pointed out, it seems that the results of this study can provide many suggestions to teaching-learning method on the concept of radiation on the account that all of them have less than 5 year career from appointment.

The results of actual awareness state on the concept of radiation of teachers that ‘insufficient’ was resulted in 6 seems to have a lot of problems when it is considered that they are teachers specialized in the physics, while it is taken account that they have relative short career and have scarce experience of teaching the concept of radiation. Taking the actual state of education into account that the radiation concept is introduced in the last chapter in physics II on 12^{th} grade and great portion of time must be invested to prepare the College Scholastic Ability Test, it may be understood to some degree, but it is classified clearly into the concept to be taught in the 7^{th} national curriculum, so it seems that the teachers must have a correct concept on it. Furthermore, the concept of radiation is introduced not only in the 12^{th} grade but also the ‘Environment’ chapter in Common Science in the 10^{th} grade, so the accurate concept on it should have been obtained.

To solve these problems, there may be methods such as assisting formation of correct scientific concept through various re-training programs for teachers, but as all the deficient concepts can not be established through training, it seems that the teachers must give efforts to obtain exact concept by themselves through the most rapid and effective way.

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SAFETY CULTURE AND RADIATION PROTECTION AT IPOC

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ABSTRACT

The IPOCFG, E.P.E., in Coimbra (IPOC), is one of the three oncology centres in Portugal, traditionally the reference sites for cancer patients. IPOC was a pioneer institution in Portugal in what concerns a radiation protection policy in a hospital environment. A general policy for Radiation Protection and Safety was approved by the hospital administration in 2005, including the nomination of one RP Adviser and four RP Supervisors for the main ionizing radiation areas as well as the attributed functions, competencies and responsibilities. The global radiation protection program developed at the institution includes as a structural basis a strong educational and training component.
The implemented safety culture includes also an internal incident report system based on the European ROSIS (Radiation Oncology Safety Information System) project.
To give an overview of the global radiation protection program developed at the IPOC with special incidence on the education and training issues is the aim of this paper.

1. Introduction

In October 2002 IPOC was the first Portuguese hospital integrating in its professional body a medical physicist exclusively dedicated to radiation protection and safety. Since then many steps have been taken in order to implement a coherent safety culture throughout the hospital with main influence in the three ionizing radiation areas – Radiotherapy, Nuclear Medicine and Radiology.
A general policy for Radiation Protection and Safety was approved by the hospital administration in 2005, including the nomination of one Radiation Protection Adviser (RPA) and four Radiation Protection Supervisors (RPS) as well as the attributed functions, competencies and responsibilities. This general policy has recently been revised and converted into a main policy document integrated in the Health Quality System Manual of the hospital.
The global radiation protection program developed at the institution includes as a structural basis a strong educational and training component. Radiation Protection Courses organized in coordination with the hospital Education Centre have been offered to radiation oncologists, radiation therapy and diagnostic technologists and nurses, since 2001. Also short training sessions are organized for dedicated professionals whenever a new technique is available either in radiotherapy or nuclear medicine. The radiotherapy emergency plans in the linear accelerators and in the HDR brachytherapy unit are regularly trained with all professionals involved in the radiological practices.
The implemented safety culture includes also an internal incident report system based on the European ROSIS (Radiation Oncology Safety Information System) project. Apart from a more traditional preventive approach based on assuring the compliance with regulatory requirements, the developed procedure of reporting accidents, incidents and near misses contribute quite effectively for working with awareness and alertness and thus minimizing the risk of accidental exposures.

2. Radiation protection program

Some examples of the main arrangements that have been made at IPOC to guarantee the radiation protection and safety of the radiation sources, the radiation protection of the exposed workers, the patients during medical exposures and the general public are described in the following.

2.1 Radiation protection and safety of the radiation sources

A radiation protection study was carried out for each of the twenty three radiological installations at IPOC that involved both radiation shielding evaluations and radiation monitoring in order to obtain the necessary legal licence of each practice.

The radiation areas have been classified in controlled or supervised areas in accordance with the levels of exposure. Warning radiation symbols and appropriate labels have been displayed at the entrance to restrict the access to the radiation areas.

The more relevant documents relative to radiation protection and safety that are specific for each of the Radiotherapy, Nuclear Medicine and Radiology departments have been brought together in a single binder which is easily accessible for the staff. Every radiation worker needs to read those documents before starting working in that department. For the other departments, written procedures have been displayed within the controlled areas that describe appropriate working instructions concerning the radiological risk of the operations involved.

The use of unsealed sources in Nuclear Medicine is associated with the risk of contamination, for instance of the floors and the worktop surfaces. It is then necessary to carry out a workplace monitoring of the contamination in the areas with higher activity. In some of the workplaces like the radiopharmaceuticals administration room, the patient toilets, the post administration patient waiting area, the radiopharmacy and the radioisotope storage and waste handling room, the contamination monitoring is carried out daily. In the two radionuclide therapy patient rooms it is carried out after each patient release.

Emergency procedures in Radiotherapy have been written describing actions to be taken in the case of an emergency situation (malfunction of equipment), to minimize exposure to healthcare personnel while maximizing safety of the patient.

Emergency procedures are being implemented for the Nuclear Medicine therapy patients. Also for the blood irradiator of the Imunohemotherapy Department a specific emergency plan was developed. The coordination with the global emergency plan of the hospital is being established for each radiological practice.

To guarantee the security of the radioactive sources used in brachytherapy (I-125 seeds) and in nuclear medicine (Tc-generators), a record is kept of every source movement since the receipt of sources until the use on patients, storage and disposal of unused sources.

2.2 Radiation protection of the exposed workers

IPOC has a total number of 176 exposed workers working in twelve different departments. Individual monitoring of the external exposure of the workers is implemented providing different types of dosimeters according to the types of exposure (whole body, ring, bracelet and abdominal dosimeter). The management of the individual dosimetry is based on an integrated approach for the whole institution and involves the selection of the approved dosimetry service, the choice of the suitable type of dosimeter, the period of the exchange of dosimeters and the proper use of the dosimeters. Local rules for the proper use of the personal dosimeters have been approved by the hospital administration in 2000. Every exposed worker that uses a personal dosimeter should have read this document and must sign a statement confirming awareness. According to the national regulations, the personal dosimetry history record should be made available to the worker upon request. A personal dose database has been implemented from the dose values reported by the approved dosimetry service. This database is monthly updated for all the radiation workers of the institution.

For the maintenance of a safe working environment, a recording and reporting sheet has been implemented by the Risk Management Commission (RMC) of the hospital. This form is available in each radiation facility. All relevant information related to a radiation accident must be recorded and reported to the RMC. As a member of the RMC, the RPA is in charge of conducting a formal investigation about the causes of the event and must report to the RMC the recommendations for preventing the recurrence of similar events. The RPA also must report to the competent authority whenever the individual dose exceeds the legal dose limits.

2.3 Radiation protection of the patients

The Medical Physics Department has the responsibility to setup a quality assurance program to protect patients from unnecessary irradiation. The QA program has been developed for Radiotherapy for almost two decades, including acceptance tests, commissioning and periodic quality control tests both for external beam therapy and brachytherapy.
Following the purchase of a complete set of testing equipment, a quality control program for Radiology is now being set up for the x-ray units of this department .
Part of the QA program in Radiology consists also on the assessment of representative doses to patients in radiodiagnostic exams. Moreover, according to the Portuguese legislation, the hospital administrator should assure the compliance of the patient radiation dose with the European Diagnostic Reference Levels (DRL) where available. In the framework of a master's degree thesis developed in 2005, the patient dose has been assessed for conventional radiology, mammography and CT examinations at IPOC. Local DRL's for CT examinations were recently established by extending the patient dose assessment to the three CT units of the hospital.
Moreover, according to the legal requirements, the patient dose information should be available to the referring physician. A dose information form has been developed for six of the existing radiodiagnostic facilities with the relevant information of patient exposure in the specific facility, the compliance with the European DRL and the patient dose in a way easily understood by prescribers and patients. The dose information sheets are posted in the respective x-ray rooms for the easy access of the patient and staff.
Finally, as also a crucial part of the QA program in Radiology, the optimization of patient doses versus image quality has already been started. A preliminary work in digital mammography aimed to assess image quality using the image quality criteria of the European guidelines. It was a very interesting work as it put the radiologist and the physicist working together.
Using different softwares that allow the estimation of the fetal dose due to the medical exposure of a pregnant patient, it is possible to assess the radiation risk to the foetus with the knowledge of the stage of the pregnancy when the exposure occurred. This risk assessment is included in the RPA attributed responsibilities.

2.4 Radiation protection of the members of the public

The diagnostic procedure in Nuclear Medicine consists in the administration of the radiopharmaceutical and imaging the patient. Then the patient uptake is assessed from the patient dose rate measurement at 1 m and the patient is released without restrictions when the corresponding activity is down to 740 MBq according to the legal requirements.
In the cases of radionuclide therapy patients in Nuclear Medicine and patients with radioactive implants in Brachytherapy, instructions for patient release have been written to minimize the exposure of the members of the family and for the general public.
The use of unsealed sources for patient diagnostic and therapy in Nuclear Medicine generate a lot of radioactive waste that is monitored after its production and stored in a proper room. According to the national regulations, it can be disposed via the hospital waste treatment system when the corresponding activity of each item is less than 3.7 kBq.
In the same way, all the contaminated effluents produced in the higher activity areas of the Nuclear Medicine Department are collected in proper delay tanks. The release into the sewer

system of any tank is made when the activity is below the limit value stated in the national legal requirements.

3. Education and training initiatives

Training in general and specific training in radiation protection are widely recognised as one of the basic components of optimisation programmes for medical exposures. General recommendations for training programmes in radiation protection are provided by international organizations like IAEA, including lists of topics for diagnostic radiology, interventional radiology, radiotherapy and nuclear medicine [1-3].

All staff with responsibility for medical exposures needs training in radiation protection.

The Medical Physics Department of IPOC had always taken part in continuing programs of education and training for staff in subjects related to radiation protection and safety and to quality control of procedures and equipment. Medical physicists at IPOC support the technical aspects of new techniques and investigate which procedures are required for their adoption.

To educate staff about safety and radiological protection matters, instructing and providing continual training of staff in such topics as radiation protection magnitudes, definitions of controlled and supervised areas, establishing and promoting a safety culture and the concept of defence in depth are assumed as one of the defined responsibilities of the Medical Physics Department.

Within this rational, different education and training initiatives have been carried out in cooperation with the Centre of Permanent Professional Development at IPOC. We can mention some of these:

- Regular courses on “Physics for Radiotherapy Physicians Residents”(56 hours each), since 1996;
- I Course on Radiation Protection (24h), Nov. 2001
- II Course on Radiation Protection, Oct – Dec. 2007, with four modules:
    - Fundamentals of radiation protection (16h)
    - Radiation Protection in Radiology (14h)
    - Radiation Protection in Nuclear Medicine (14h)
    - Radiation Protection in Radiotherapy (14h)
- Seminar on “Prostate brachytherapy permanent implants” for all involved professionals, followed by specific training for nurses concerning patient care for permanent I-125 seed prostate implants – July 2004
- Regular sessions on “Radiation Protection at the hospital” for different professionals in Nuclear Medicine, Radiology and Occupational Health Service

Emergency procedures have been implemented for the three linear accelerators and the HDR brachytherapy unit in the Radiotherapy Department. They are trained once a year by all personnel involved in each radiological practice and records of the trainings are kept.

The RPA collaborate with the Risk Management Commission in the writing of the radiation protection aspects of the “Basic Manual of Health and Safety of the IPOC” that is made available to all new employees. Moreover the “Manual of Integration in Radiation Protection at IPOC” is mandatory reading for all new radiation workers. These documents are supposed to be a valuable tool and an effective aid to training in RP as they cover topics like sources, risks and effects of radiation; classification of radiation areas; personnel monitoring and health surveillance; basics of radiation protection and safety.

4. Incident reporting system

Reporting of incidents, near misses and accidents at all radiation treatment step level is one of the preventive measures that can be taken to avoid accidental exposures.

The European ROSIS (Radiation Oncology Safety Information System) project is a voluntary web-based safety information database for Radiotherapy. Incidents and corrective actions are shared over the Internet by staff in radiotherapy clinics. The main objectives are: to be an open web-based system for shared information, creating safety awareness; to enable clinics to review safety issues before accidental exposure occurs and to enable identification of safety critical steps [4].

The radiotherapy Department of IPOC became an “active department” within the ROSIS project in December 2003. A coordinator group was formed including a physicist, a radiation oncologist and a technologist. The motivation of all department professionals was based on “safety” and “quality improvement” rather than “error” approaching. A report form based on the ROSIS Incident Form was developed and approved to facilitate the reporting process. The forms are available at each department site (treatment units, simulator, clinical dosimetry, mould room, clinical offices, etc.). During 2004 the Incident Forms of the ROSIS on-line database have been filled up, after translation on a monthly-basis [5]. Presently they are monthly collected and analysed in order to search for more common errors or near misses. The feedback process has the aim of implementing a general practice of continuous quality improvement. It is of benefit to know the errors and their characteristics (frequency and consequence) in order to address them properly. To improve the safety in radiotherapy means minimizing the occurrence of errors, finding errors before they are causing harm and minimizing the harm caused.

The six years process of incident reporting has been a very successful methodology of preventing accidents. Till know, an average of 94 incidents have been reported annually. 72% of all reported cases were near misses not affecting the patient treatment. Thirty cases in the six years period had consequences for the particular patient. Most of them have been detected in the first few fractions of treatment and could be compensated.

The “lessons learned” become more direct and explicit. A general culture of safety awareness was created which helps to educate the staff on the causes and effects of the incident and to establish procedures to prevent the occurrence of similar incidents.

A periodic evaluation is the motor for keeping the process of reporting on. The general evaluation meetings are crucial for the professionals’ motivation.

Reporting incidents stimulates awareness, improves self-confidence and after all it is a question of training.

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Safeguards course in the framework of BNEN
(Belgian Nuclear higher Education Network)

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Abstract

In the framework of BNEN, the Belgian Nuclear Higher Education Network, elective and/or advanced courses are offered to the students additional to the standard curriculum. This master after master is open for students that hold a university degree in engineering or equivalent.
In December 2008 an advanced course was given at the Belgian Nuclear Research Centre SCK•CEN to BNEN students, complemented with professionals from the European Institute of Reference Materials and Methods in Geel and SCK•CEN in Mol, Belgium.
The advanced course dealt with safeguards (nuclear materials control), and covered all important areas of safeguards ranging from basic nuclear theory over nuclear measurement techniques for nuclear material control to (inter)national legislation on non-proliferation.
The course was developed in the framework of the ESARDA Working Group on Training and Knowledge Management. ESARDA is the European SAfeguards Research and Development Association.

A similar course was given in March 2009, but focused on a public of social scientists with no particular technical/engineering background. This course had a broader reference to radiation protection, while dealing with nuclear physics on a more elementary level.

1. Introduction

1.1. History of the ESARDA Working Group on Training & Knowledge Management

The forerunner of the ESARDA Working Group on Training & Knowledge Management (TKM WG) was established beginning 2004 as the ad hoc Working Group on Modules of Courses by the ESARDA Steering Committee. The traditional focus of academic nuclear engineering courses was (and still is) the front-end of the nuclear fuel cycle and reactor safety. Security and non-proliferation aspects are dealt with in a limited way or not at all. At the end of their study nuclear engineers may well not have heard at all of non-proliferation aspects of nuclear energy, which is felt as a lack of the current curriculum for nuclear engineers by the safeguards community. Indeed, some of them will be confronted in their career with the verification activities on nuclear materials by international organizations. In addition to this, a significant loss of safeguards experience is expected for the next decade due to the retirement of many experienced safeguards experts. Without the coming into business of new, young professionals this will pose serious problems for the safeguards community, and even the nuclear community in general.

In 2005 a first ESARDA safeguards course was given on the premises of the Joint Research Centre of Ispra, Italy, under the auspices of the ESARDA TKM WG [1]. It was attended by 20 participants from various backgrounds and institutes. Students of the Belgian Nuclear

Higher Education Network BNEN could acquire 2 ECTS (European Credit Transfer System) points for attending the course and writing a small essay on a relevant topic.
With the financial support of JRC Ispra the course was continued annually with growing success. In 2007 the TKM WG published a syllabus for the standard part of the course [2]. This was required by the European Nuclear Education Network (ENEN) to allocate 3 ECTS points to the course.

From 2008 the course attracts so many students that a numerus clausus of 60 students per year had to be established. At the same time it was decided to start a limited version of the ESARDA course with the safeguards essentials at the Belgian Nuclear Research Centre SCK•CEN in Mol, Belgium. This course was a topical course in the curriculum of BNEN and 2 ECTS points were allocated to students that successfully wrote an essay.
The present aim of the ESARDA TKM WG is to establish the sustainability of the taken initiatives and to support initiatives taken in other European countries.

1.2. Aims of the ESARDA safeguards course

The ESARDA TKM WG defined several goals for the safeguards course:

- high-quality course on academic level
- sustainability
- geographical spread

The academic quality of the course was the main focus of the ESARDA TKM WG in the first years of its existence. This quality was established by inviting a large number of outstanding safeguards specialists for lecturing specific parts of the course. Additionally the ENEN network required a written syllabus and an examination of the acquired knowledge of the participants in order to allocate 3 ECTS points to those participants that successfully passed the examinations.

The technically oriented Working Groups of ESARDA have contributed significantly to the syllabus by writing the chapters on their respective specialization, like Containment & Surveillance, Destructive and Non-Destructive Analysis and other verification regimes.

In view of the present success of the course, sustainability may not yet be a concern. The course provided by JRC Ispra is subsidised by the EC-JRC so that there is no subscription fee and students are provided housing during the course. As long as the subsidies will be available, students will be attracted by the curriculum and lecturers of the Ispra course.

The Mol course has been started since there was a demand from BNEN to provide BNEN students a safeguards course that was more concise and could be more easily attended by all students. The curriculum is limited to the essentials of safeguards and the lectures are given by local safeguards specialists from SCK•CEN and JRC Geel. It profits from the existence of the syllabus developed by ESARDA.
The course fits perfectly to obtain the other goals of the TKM WG. Due to its low costs the sustainability is assured since only limited contributions are required from participants, while with a second safeguards course there is start to spread the safeguards course geographically. The course takes two full days, and there are no practical exercises, and no exams.

In the framework of ESARDA further initiatives are taken to set up safeguards courses in other European countries. For countries like the UK and Sweden with a larger nuclear infrastructure, separate, local courses can be established. In Sweden parts of the safeguards course are already lectured at the universities of Uppsala and Stockholm. Smaller countries can participate in the already existing courses.

2. Content of the Mol safeguards course

2.1. Introduction

The course intends to provide a specialised overview of all the elements needed to understand the basic principles of Safeguards, and the verifications that take place within the framework of the Treaty on the Non-proliferation of Nuclear Weapons

2.2. Basics of Nuclear Physics

A repetition of basic concepts of nuclear physics was considered mandatory, because part of the students had a background in sociology, and part of them had engineering background, but needed some refreshment. The course contained concepts of atomic and nuclear structure, radioactivity, nuclear stability and the nuclide chart, natural radioactivity and fission, the chain reaction, but oriented towards the safeguards relevant nuclear materials.

2.3. Nuclear Fuel Cycle

To better position the safeguards activities, a good view of the fuel cycle is a must. An overview was given of the different phases of the fuel cycle: mining, milling, conversion, enrichment, fuel fabrication (uranium and mixed-oxides), reactor operation, reprocessing, waste, final disposal. The fuel cycle from front end to back end was considered in a rather comprehensive way, to allow the link with the IAEA safeguards criteria (part 2.7), that vary along the fuel cycle item under inspection.

2.4. International Treaties

Safeguards originates from the Treaty on the Non-proliferation of Nuclear Weapons (or briefly, the Non-proliferation Treaty – NPT). To better situate the NPT, a comprehensive overview of international treaties was given, including those that are related to disarmament. A historical overview of (non) proliferation and disarmament efforts was considered the obvious approach.
The various treaties discussed were of the following categories:

- Weapons of Mass Destruction (Space treaty, Sea Bed treaty, Moon treaty);
- Nuclear Weapons (South pole treaty, Partial Test Ban Treaty (PTBT), Tlatelolco treaty, Non-proliferation treaty, SALT I, SALT II, Rarotonga treaty, INF, START, SORT, CTBT, Bangkok treaty, Pelindaba treaty);
- Chemical/Biological Weapons (Genève Protocol, Convention Biological Weapons (CBW), Convention Chemical Weapons (CWC);
- Conventional Weapons (Conventional Forces in Europe, Convention Inhuman weapons;
- Ballistic Missiles (Treaty Antiballistic Missiles, Missile Technology Control Regime (MTCR);
- The Euratom treaty.

2.5. The general safeguards picture

This part of the course dealt with Safeguards principles, Safeguards approaches, Case studies in (non-)proliferation.

In the sub-part on Safeguards principles, the objective (political and technical) and limitations of safeguards are explored.
Safeguards principles for declared material were clarified, such as starting point of safeguards, safeguards measurement techniques (in general), some definitions (material categories, significant quantity, timeliness goal, detection probabilities), nuclear material accountancy, containment and surveillance (C/S) and its evaluation, diversion strategies, types of inspection, standards of accountancy.
Safeguards principles for undeclared activities were discussed to highlight the new elements originating from the Additional Protocol.

The sub-part on Safeguards approaches contains a historical overview of the different approaches existing since the start of the IAEA, as described in INFCIRC/26, -/66, -/153, -/193, evolving from bilateral agreements on specific installations, towards full scope safeguards in the States that signed the NPT (since 1970). The safeguards agreements with the UK (INFCIRC/263) and France (INFCIRC/290) were highlighted as well. The Additional Protocol (INFCIRC/540) was developed after the discovery of an undeclared weapon programme in Iraq, and was explained in detail.

In the sub-part on Case studies in (non-)proliferation, specific attention was given to actual problematic cases: North Korea, South Africa, Libya, Pakistan, India, Israel, Iraq, Iran.

2.6. Techniques

Different topics were dealt with, that were treated in various sub-sections.

2.6.1. Nuclear Material Accountancy

The sub-section on Nuclear Material Accountancy explained Nuclear Material Accountancy as the basis of safeguards, the verification of the Nuclear Material Balance, as a main Nuclear Material Verification activity, and statistical techniques used, such as the determination of the sampling plan during inspection, and the analysis of the inspection results

2.6.2. C/S

The sub-section on C/S contained the legal basis of C/S, some application examples, the underlying safeguards requirements, digital C/S systems, current C/S equipment, C/S in the context of integrated safeguards, and current R & D projects and needs.

2.6.3. NDA

The sub-section on Non Destructive Analysis (NDA) dealt with nuclear techniques and other instruments for measuring other physical properties. The aim of the topic was to give a flavour on how a single measurement, or a combination of, can contribute for the inspector to make independent conclusions in his verification activities. Going to technical details is a necessity, and is partly supported by the nuclear physics course. The recommended NDA methods are also part of the IAEA safeguards criteria, as discussed in 2.7.
The nuclear related NDA deals with Gamma-Ray Instruments and Neutron Instruments, with details on the detectors and associated electronics, and methodology.
The non-nuclear related NDA deals with weighing and load-cells, ultrasonic thickness gauge, Cerenkov glow measurement devices, with details on the physical principles and methodology.
Performance was considered in detail, as well as the different types of NDA Instruments, Equipment authorization for inspection use in the IAEA, and Equipment information.

2.6.4. DA

The sub-section on DA dealt with the currently applied techniques, such as Thermal Ionization Mass Spectrometry (TIMS), Isotope Dilution Mass Spectrometry, Inductively Coupled Plasma Mass Spectrometry (ICP-MS), alpha Spectrometry, Hybrid K-Edge, Compucea, which were described in detail.

Attention was paid to Quality Control, with specifically method validation and instrument calibration, traceability and comparability of measurement results, uncertainty of measurement results, external performance evaluation, document/data control and deployment of a quality system.

In this context, the role of isotopic certified reference materials (CRMs) was highlighted.

Particle analysis proved to be very powerful tool for detection of undeclared activities, considering that the highest sensitivity, accuracy and precision are required for answering specific questions.

2.6.5. AP methods

The sub-section on AP methods showed briefly the particular inspection techniques inflicted by the Additional Protocol: Open source information, satellite monitoring, environmental sampling (swipes, wide-area sampling and monitoring).

The link was made to safeguards inspection techniques in general, with DA methods in particular, and the complementarities were highlighted.

2.7. Verification measurement tables

The structure of the IAEA Safeguards Criteria was explained: the 12 chapters corresponding to the different fuel cycle plants, the content per chapter, with the similarities and differences, and the annexes (abbreviations and definitions, list of instruments, specific provisions for a PIV of a PIT, definitions of acceptable C/S and requirements for re-measurement and re-verification of material under C/S, special criteria for Difficult-to-Access fuel items, timeliness component of inspection goal, procedures for sampling plans, values of detection probability to be used for planning verification measures, confirmation of the absence of borrowing of nuclear material, zone approach, alternative procedures for interim inspections for timely detection at LWRs without MOX fuel, alternative inspection procedures for DNLEU conversion and fuel fabrication plants, alternative procedures for the use of remote monitoring).

The verification measurement tables were explained for the LWR and the RRCA.

2.8. Import/export control

Export controls on nuclear materials exist since the entering into force of the Treaty on the Non-proliferation of Nuclear Weapons (NPT). An extension to dual-use items was activated after the first Gulf war, and the detection of an undeclared weapons oriented programme in Iraq. This module explains in a historic context the various treaties related to exports: Zangger Committee, Nuclear Suppliers Group (London Club), Australia Group (for chemical goods),
Wassenaar Arrangement (Export control in the framework of NPT, MTCR, CWC, Conventional Arms).

The link was made to the Additional Protocol, that goes for extended authority in the verification activities.

2.9. Physical protection

Physical protection was explained as complementary to safeguards verification activities, in the sense that it is a first step in protecting sensitive goods from diversion or theft.

The Convention on Physical Protection of Nuclear Materials (INFCIRC/274 Rev 1) was explained; with its standards of physical protection for international shipments of nuclear materials, the cooperation in the recovery and protection of stolen nuclear material, and the international cooperation in the exchange of physical protection information.

2.10. Design Information

A special chapter was devoted to Design Information, regarded as "information concerning nuclear material subject to safeguards under the agreement and the features of facilities relevant to safeguarding such material", as it is considered vital for effective Safeguards.

This information is used by the IAEA to establish the facility safeguards approach, to determine material balance areas (MBAs) and select key measurement points and other strategic points, to develop the design information verification plan (DIVP), and to establish the essential equipment list (EEL).
Revisions to design information are made if there are modifications or changes in operating conditions and/or equipment design, and other changes which may affect the application of safeguards by the IAEA, throughout the facility's life cycle.

2.11. IAEA Member State Support Programmes

A short overview was given of the IAEA Member State Support Programmes, their way of working, the projects involved, and some details about the Belgian and European Support Programmes, as an example.

3. Conclusions

The Mol safeguards course was a success with 20 participants. Four out of the six BNEN students have written an essay to obtain 2 ECTS points. One other participant requested a similar course for his institute, more focused on political scientists.

The course required a relatively low budget that can be easily covered by participants.

Contacts have been taken with several ESARDA representatives to support the establishment of a course in other countries (UK) or to give students the occasion to follow the course in Mol (e.g. Lithuania, EC DG-TREN Luxembourg, etc.).

4. References

[1] K. van der Meer, G. Maenhout, G. Stein, "The ESARDA safeguards course: a state-of-the-art", 27th Esarda Annual Symposium on Safeguards and Nuclear Material Management, Meeting London 2005.

[2] G. Janssens-Maenhout (editor), "Nuclear Safeguards and Non-Proliferation – Course Syllabus", ESARDA publication 2008, electronic version at http://esarda2.jrc.it/internal_activities/WC-MC/Web-Courses/index.html.

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