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## SETTING THE SCENE

# EDUCATION AND TRAINING REQUIREMENTS IN THE REVISED EUROPEAN BASIC SAFETY STANDARDS DIRECTIVE

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## ABSTRACT

The European Commission is currently developing a modified European Basic Safety Standards Directive covering two major objectives: the consolidation of existing European Radiation Protection legislation, and the revision of the European Basic Safety Standards. The consolidation will merge the following five Directives into one single Directive: the Basic Safety Standards Directive, the Medical Exposures Directive, the Public Information Directive, the Outside Workers Directive, and the Directive on the Control of high-activity sealed radioactive sources and orphan sources.

The revision of the European Basic Safety Standards will take account of the latest recommendations by the International Commission on Radiological Protection (ICRP) and shall improve clarity of the requirements where appropriate. It is planned to introduce more binding requirements on natural radiation sources, on criteria for clearance, and on the cooperation between Member States for emergency planning and response, as well as a graded approach for regulatory control. One additional goal is to achieve greater harmonisation between the European BSS and the international BSS.

Following a recommendation from the Article 31 Group of Experts, the current draft of the modified BSS will highlight the importance of education and training by dedicating a specific title to radiation protection education, training and information. This title will include a general requirement on the Member States to ensure the establishment of an adequate legislative and administrative framework for providing appropriate radiation protection education, training and information. In addition, there will be specific requirements on training in the medical field, on information and training of workers in general, of workers potentially exposed to orphan sources, and to emergency workers.

The revised BSS directive will include requirements on the competence of a radiation protection expert (RPE) and of a radiation protection officer (RPO). The concept of a radiation protection expert will replace the current concept of a Qualified Expert (QE) which has been interpreted differently within Europe. These new requirements together with clearer definitions of the concepts RPE and RPO shall support harmonisation in Europe.

## 1. Legal basis

All competencies with regard to nuclear energy and radiation protection in the European Community are laid down in the Euratom Treaty (1957). Chapter III *Health and Safety* contains provisions which are directly applicable as primary legislation and offers the legal framework for the establishment of European Basic Safety Standards for the health protection of the general public and workers against the dangers arising from ionising radiation. The first basic safety standards date back to 1959, the latest version Council Directive 96/29/Euratom [1] was published in 1996. This principle piece of legislation has

been supplemented by additional binding instruments as well as by non-binding Commission Recommendations and Communications. According to Article 31 of the Euratom Treaty, these basic safety standards shall be worked out by the Commission after it has obtained the opinion of a group of public health experts, called Article 31 Group of Experts.

## 2. Revision of the Euratom Basic Safety Standards

The European Commission started a process to revise the existing European Basic Safety Standards Directive. At the same time, the Commission undertakes the simplification of its *acquis* of Community legislation by the codification of related acts or by recasting these. The development of modified basic safety standards will therefore comprise the revision of Directive 96/29/Euratom and at the same time the consolidation of existing European Radiation Protection legislation merging the following five Directives into one:

- the Basic Safety Standards Directive (96/29/Euratom) [1],
- the Medical Exposures Directive (97/43/Euratom) [2],
- the Public Information Directive (89/618/Euratom) [3],
- the Outside Workers Directive (90/641/Euratom) [4], and
- the Directive on the Control of high-activity sealed radioactive sources and orphan sources (HASS Directive 2003/122/Euratom) [5].

In addition, it is planned to cover the Commission Recommendation on the protection of the public against indoor radon exposure (90/143/Euratom) [6]. This consolidation will promote the coherence of definitions and requirements in all Directives and the association of specific and general requirements and should lead to a more effective legislation.

The revision of the EURATOM Basic Safety Standards will take account of the latest recommendations by the International Commission on Radiological Protection (ICRP), ICRP Publication 103 [7]. The principles of protection according to ICRP stay very much the same, and will therefore not necessarily require major changes in regulatory requirements, they offer, however, a much more coherent and understandable framework for radiation protection, introducing the concepts of planned, existing and emergency exposure situations, and highlighting the role of optimisation below suitable constraints and allowing for reference levels.

Further to accommodating the new philosophy of ICRP Publication 103, the new Basic Safety Standards will introduce more binding requirements on natural radiation sources, on criteria for exemption and clearance, and on the cooperation between Member States for emergency planning and response. The provisions for regulatory control of planned exposure situations foresee a graded approach commensurate to the magnitude and likelihood of exposures from a practice, and commensurate to the extent by which regulatory control may have an impact on reducing exposures or enhancing safety. Finally, the new BSS shall take account of recent scientific developments, such as the availability of new data on cataracts, and epidemiological findings on radon in dwellings.

In parallel to the revision of the European BSS, the International Atomic Energy Agency together with many other international organisations undertakes the revision of the *International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources* [8]. One objective in both revision processes is to achieve a greater harmonisation between the European BSS and the International BSS

The structure of the new Basic Safety Standards Directive was thoroughly revised, firstly to accommodate the incorporation of the other Directives as part of the recast process and secondly, to allow for the modifications proposed by ICRP. The overall structure of the new recast Directive is given in Table 1.

Preamble	
Title I	Subject matter and Scope
Title II	Definitions
Title III	System of Protection
Title IV	Responsibilities for regulatory control
Title V	Requirements for Radiation Protection Education, Training and Information
Title VI	Justification and Regulatory control of planned exposure situations
Title VII	Protection of Workers, Apprentices and Students
Title VIII	Protection of Patients and other individuals submitted to medical exposure
Title IX	Protection of Members of the Public
Title X	Protection of the Environment
Title XI	Final provisions

Tab 1: Overall structure of the new Euratom Basic Safety Standards

Following a recommendation from the Article 31 Group of Experts, the current draft of the modified BSS will highlight the importance of education and training by dedicating a specific title to requirements for radiation protection education, training and information.

### 3. Education and training in the revision process

In the field of education and training, the 1996 Basic Safety Standards Directive established general requirements for training, experience and recognition of qualified experts. In spite of clarifications given in the Communication concerning the implementation of Directive 96/29, based on different historically grown education and training systems and different interpretation of the definition of the *Qualified Expert*, Member States transposed and implemented education and training arrangements differently. The experience gathered since 1996 with transposition in national legislation (due by May 2000) and with operational implementation demonstrated a need for enhanced harmonisation. In 2002, a survey carried out on behalf of the European Commission on the situation of the radiation protection experts in the Member States identified some difficulties in the implementation of the concept of the *Qualified expert*. In fact different definitions and status of qualified experts were established in Member States and structure and scope of training and education vary within Europe. In 2006, the Commission initiated and financed the European Radiation Protection Training and Education Platform (EUTERP) with the main objective to remove obstacles for the mobility of radiation protection experts within the European Union through harmonisation of criteria and qualifications for and mutual recognition of such experts. During two workshops in 2007 and 2008, EUTERP discussed definitions, core competences and qualifications of the radiation protection expert which shall replace the concept of the qualified expert, and of the additional concept of a radiation protection officer. Clearer definitions and well defined core competences shall facilitate defining the education and training needs of a radiation protection expert and a radiation protection officer.

### 4. Definition and role of experts and services

In a more general Title IV on *Responsibilities for regulatory control*, the new BSS will define which experts and services are required for the establishment of an efficient radiation protection system. The introduction of precise definitions and of core competences of these experts and services shall facilitate the implementation of these concepts and contribute to enhanced harmonisation within Europe. The new BSS requires from Member States that adequate arrangements are in place to allow for the recognition of

- occupational health services,
- dosimetry services,
- radiation protection experts, and
- medical physics experts.

The occupational health services are meant to perform medical surveillance of workers with regard to their exposure to ionizing radiation and their fitness for the tasks assigned to them. The dosimetry services will assist in the individual monitoring of exposed workers by assessing internal and external doses and by establishing the recorded dose in cooperation with the undertaking and the occupational health service.

The Radiation protection expert shall give competent radiation protection advice on matters related to occupational exposure and public exposure. Within the healthcare environment, the Medical Physics Expert shall act or give specialist advice on matters relating to radiation physics applied to medical exposure. The Medical Physics Expert will in particular be responsible for patient dosimetry.

In addition to the above mentioned experts and services, the new BSS introduces the radiation protection officer as an additional concept. The radiation protection officer shall be designated by an undertaking to oversee the implementation of the radiation protection arrangements of the undertaking. The radiation protection officer needs to be competent in radiation protection matters relevant for a given type of practice. The decision to require the establishment of a radiation protection officer is left with the Member State. Arrangements for the recognition of the radiation protection officer are not required by the BSS.

In order to better define the role of the experts, the new BSS includes detailed requirements specifying the core competences of the radiation protection expert, the medical physics expert, and the radiation protection officer.

## **5. Requirements on Radiation Protection Education, training and information**

Following a recommendation from the Article 31 Group of Experts, the current draft of the modified BSS includes a specific Title V on *Requirements on Radiation Protection Education, training and information*. The objective is to highlight the importance of education and training and to consolidate education and training provisions from all radiation protection directives included in the recast.

Title V contains a requirement on Member States to ensure the establishment of an adequate legislative and administrative framework for providing appropriate radiation protection education, training and information to all individuals with specific competences in radiation protection. Education, training and retraining programmes shall allow for the recognition of radiation protection experts, medical physics experts, occupational health services, and dosimetry services. Title V maintains already existing (more detailed) requirements on information and training of

- exposed workers, apprentices and students,
- workers potentially exposed to orphan sources, and
- emergency workers.

From the Medical Directive [2], the requirements on education, information and training in the field of medical exposure remain. A newly introduced requirement concerns the establishment of mechanisms for the timely dissemination of information on lessons learned from significant events, such as accidents, incidents, near misses, as well as other information on new developments relevant to radiation protection in medical exposure.

## 6. Next steps

The Group of Experts under Article 31 of the EURATOM Treaty endeavours to finalise the text of the new Directive by Spring 2010. A lot of work remains but the prospects of achieving this goal are good. The text of the Experts and their Opinion will be the basis of a Commission proposal scheduled for 2010. Adoption of the Commission's proposal by the Council may take another few years and, taking into account the time granted for transposition into national legislation, it may not be before 2014 that the requirements become truly effective.

Meanwhile the Commission is closely following the revision of the international Basic Safety Standards. As a result of the decision making rules in the European Union, the EC has so far never formally co-sponsored the international Standards. It is now envisaged to do so, in the same way as for the document laying down the Safety Fundamentals [9]. The aim is to harmonise as far as possible the definitions and requirements, both reflecting the ICRP Recommendations. It should be emphasised, however, that the Euratom Basic Safety Standards and the international Standards will still look very different, on the one hand because the structures are not the same and neither is the amount of detail in existing legislation or requirements that needs to be incorporated; on the other hand because of the legally binding nature of the Euratom Basic Safety Standards, applicable to the 27 Member States of the European Union.

## 7. References

- [1] Council Directive 96/29/Euratom of 13 May 1996, laying down basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation (Official Journal L-159 of 29.06.1996, page 1).
- [2] Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure, and repealing Directive 84/466/EURATOM (Official Journal L-180 of 09.07.1997, page 22).
- [3] Council Directive 89/618/EURATOM of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency (Official Journal L-357 of 07.12.1989, page 31).
- [4] Council Directive 90/641/EURATOM of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas (Official Journal L-349 of 13.12.1990, page 21).
- [5] Council Directive 2003/122/EURATOM of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (Official Journal L346 of 31.12.2003).
- [6] Commission Recommendation 90/143/Euratom of 21 February 1990 on the protection of the public against indoor radon exposure (Official Journal L80 of 27.03.1990)
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# EDUCATION, TRAINING AND THE EURATOM FRAMEWORK PROGRAMME

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## ABSTRACT

The maintaining of knowledge implies education and training programmes that ensure not only the instruction of students and trainees but also the transfer of knowledge across generations. This is especially important for research in the Euratom field in the present context of nuclear renaissance.

DG-Research is responsible for the implementation of the Euratom Framework Programme on nuclear research and training. Through these activities, it is striving to promote the integration of national radiation protection research programmes in Europe, including education and training in radiation protection.

These education and training activities supported in the Euratom Programme are helping to establish top-quality teaching modules assembled into masters programmes or higher-level training packages jointly qualified and mutually recognised across the EU. This Euratom approach is entirely in line with the Bologna process.

This paper presents and discusses the various actions in education and training in radiation protection supported by DG- Research.

## 1. Introduction

Training is a provision of the Euratom Treaty<sup>1</sup> signed at Rome in 1957, chapter 1 article 4, committing the European Commission to facilitate nuclear research and training:

- "The Commission shall be responsible for promoting and facilitating nuclear research in the Member States and for complementing it by carrying out a Community research and training programme".

As was the case at the birth of Euratom, the transmission of knowledge is still imperative in the present context of the evolution of a long-term energy policy in the European Union (EU) and the role nuclear is playing in this policy.

The Directorate-General for Research, Directorate J (Euratom), Unit 2 (fission), implements an annual budget of about 50 Meuros for the scientific and financial support of European research, education and training in the field of nuclear safety and technology, radioactive waste management and radiation protection<sup>2</sup>.

An adequate level of expertise and human resources needs to be maintained in all areas of nuclear fission and radiation protection in Europe. Indeed, our current high level of nuclear safety and radiation protection is critically dependant on retaining and recruiting people with the necessary scientific competence and know-how. To guarantee the availability of suitably qualified researchers, engineers and technicians in the long-term, further development of scientific competence and human capacity is necessary. Coordination between educational institutions across the EU is pursued and the training and mobility of students and scientists facilitated.

The Euratom programme supports education and training activities to meet stakeholder needs in areas of reactor systems, radioactive waste management and radiation protection. This helps to provide attractive opportunities for young people wanting to enter the field. In particular, Euratom fission training schemes are organized in areas where gaps in training provision are perceived.

In the present paper and for the sake of clarity, education and training (E&T) are defined as follows:

- Education is a basic or life-long learning process which encompasses the need to maintain completeness and continuity of competences across generations, involving academic institutions as suppliers and students as customers in a knowledge-driven process;
- training is the learning of a particular skill required to deliver a particular outcome: it is about schooling activities other than regular academic education schemes and essentially an application-driven process, involving industry regulatory bodies as well as training organisations as suppliers, and professionals as customers.

The Euratom approach is naturally in line with the Bologna process<sup>3</sup> (ERASMUS). More specifically, its strategy for nuclear E&T is based on the following four objectives:

- MODULAR COURSES AND COMMON QUALIFICATION APPROACH ensuring top-quality for each module and the development of a coherent framework;
- ONE MUTUAL RECOGNITION SYSTEM ACROSS THE EUROPEAN UNION such as the European Credit Transfer and accumulation System of ERASMUS (ECTS);
- MOBILITY FOR TEACHERS AND STUDENTS ACROSS THE EU in order to broaden the circulation and exchange of ideas and knowledge in nuclear fission;
- FEEDBACK FROM "STAKEHOLDERS", BOTH PUBLIC AND PRIVATE, in order to involve future employers and improve the balance of supply and demand.

## **2. Euratom research, education and training activities**

The provisions of the Euratom treaty for education and training are implemented following 3 main directions<sup>4</sup>.

### **2.1 Imbedded training packages within research projects**

A significant part of the support for human resources, mobility and training are implemented by encouraging the embedding of this support within the Networks of Excellence, collaborative Projects and, where appropriate, other actions. The Commission recommends and monitors that 5% of the total project budget is dedicated to these activities. Projects in all areas have therefore developed a comprehensive 'training and (trans-national) mobility' package.

This includes:

- the development and delivery of training courses in the subject matter of the project;
- the exchange of research workers, aiming at improving synergies between private and public research organisations at international level.

Training courses are widely announced and open also to non-participating organisations, including, where appropriate, from 3<sup>rd</sup> countries as an element of international cooperation. A part of the research undertaken in the project is executed by researchers preparing a doctoral thesis or employed on a post-doctoral position. For those projects having recourse

to postgraduate students to perform research the budget dedicated to the transmission of knowledge merely exceeds the recommended threshold of 5%. The use of other funding instruments provided by national and international programmes (e.g. Erasmus Mundus of the Education, Audiovisual and Culture Executive Agency EACEA) is encouraged.

## **2.2 Euratom Fission Training Schemes (EFTS)**

In addition to the above embedded training and mobility activities, dedicated EFTS were engaged in 2008 and 2009 in areas where a shortage of skilled professionals was identified.

An EFTS is aimed at structuring research training and career development across the EU, targeting research workers at post-graduate or equivalent level, e.g. from doctoral students to senior visiting scientists. Its is a long term and ambitious programme, spread over many years and relying on the active participation and contribution of 'future employers', i.e. representatives of system suppliers, energy providers, safety authorities and TSOs, users of ionising radiation in medicine and industry, waste management agencies, etc. It encourages the involvement of young researchers, addresses life-long learning and career development of experienced researchers, maximises transfer of higher-level knowledge and technology with emphasis on multi-disciplinarity, trans-national and inter-sectoral mobility of trainees as well as trainers (e.g. industry-academia partnerships across the EU).

The EC intends to evaluate the training and mobility actions with the help of independent experts at the end of an EFTS period. EFTS should use a systematic approach to higher-level training (e.g. analysis, design, development, implementation and evaluation) and develop best practice guidelines on the basis of the lessons learned.

These EFTS are expected to help develop private-public partnerships recognised as international scientific references, through training schemes and/or doctoral schools, spread over many years and many countries.

They aim at:

- maximising the transfer of higher-level knowledge and technology, addressing young as well as experienced research workers, wherever a coordinated action at EU level will bring added value;
- increasing the attractiveness of nuclear research careers across the EU;
- strengthening links with other Community policies and training networks outside the EU.

## **2.3 Training, education and the Strategic Research Agendas (SRA)**

Research and training are also part of the SRA of SNE-TP (Sustainable Nuclear Energy Technology Platform)<sup>5</sup>, MELODI (Multidisciplinary European Low Dose Initiative)<sup>6</sup> and IGD-TP (Implementing Geological Disposal Technology Platform)<sup>7</sup>, and are cross-cutting activities of the SET-Plan (Community's Strategic Energy Technology Plan) and associated European Industrial Initiative in sustainable nuclear fission (generation-IV).

As far as radiation protection is concerned and in particular its backbone activity on low dose research, MELODI aims at the sustainable integration or European research on low radiation doses.

This is expected to be achieved through:

- bringing together the programmes of the various funding bodies and research organisations in Europe;
- establishing effective interfaces with stakeholders and the broader scientific and health community in Europe and beyond;

- ensuring the availability of key infrastructures;
- establishing an integrated approach for training and education, including knowledge management.

Expectations from this initiative are high and it may be seen as a model of integration of research and training in radiation protection.

### **3. Examples of imbedded projects, EFTS and SRA initiatives.**

#### **3.1 Examples of projects imbedding E&T and training PhD and post-doctorate students.**

CARDIORISK<sup>8</sup>: this 3.8 M€ project is performing radiobiological experiments to investigate the mechanisms involved in the radiation-induced mortality from cardiovascular and cerebrovascular diseases. In its first report to the Commission, this project launched in February 2008 indicates the organisation of a training course attended by 45 participants. Thirty percent of its workforce is composed of Ph.D. and post-doctorate students.

NOTE<sup>9</sup>: similarly to Cardiorisk but with a broader scope, this 12 M€ project investigates through experiments of radiobiology the mechanisms involved in Non Targeted Effects (NOTE) of ionising radiation which are the effects observed in biological tissues after irradiation of other parts of the organism than those in which the effect is observed. In other words, NOTE is studying the vectors of radiation effects requiring a deep understanding of the biological mechanisms. Since its start in September 2006 this project has organised 2 training courses on dedicated topics such as, for example, using mathematical models in radiation biology. Forty participants attended these courses. Together with short term student fellowships and travel grants to international conferences these courses represented 2.5% of the budget at the mid term of the project. In addition to this effort some research in NOTE is performed by PhD and post-doctorate students.

ALPHA-RISK<sup>10</sup>: this 4.4 M€ project is currently ending with significant results on the risk arising from the exposure to radon. This gaseous natural radionuclide, emitter of alpha particles, is the major contributor to the average radiation dose to the European population from all sources. Alpha-risk will help to sustain the pending new European policy on radon. About 16% of Alpha-Risk workforce is composed of PhD and post-doctorate students.

MADEIRA<sup>11</sup> : (Minimizing Activities and Doses by Enhancing Image quality in Radiopharmaceutical Administration) this 3.7 M€ project started in January 2008 aims a reducing doses to patients thanks to improved image quality of new nuclear medicine techniques coupling the measurement of radiopharmaceutical uptake and computed tomography (PET and SPECT). It also is expected to increase the competitiveness of European manufacturers of these machines. Madeira organised so far one training course on radiation physics for nuclear medicine attended by 45 trainees. A similar one is planned for the end of November 2009 on radiation protection in nuclear medicine. In addition to this effort 60% of the research work in MADEIRA is performed by PhD and post-doctorate students.

#### **3.2 Three EFTS will be launched in 2009 and 2 are expected to be launched in 2010**

In chronological order, the EFTS already started or about to start are:

##### Education and training on Geological disposal of radioactive wastes (PETRUSII)<sup>12</sup>

PETRUS II started in January 2009, pursuing the overall objective to enable present and future professionals on radioactive waste management in Europe to follow a training

programme on geological disposal which would be widely recognized across Europe. In addressing the needs of the end-users, access to a combination of formal education, continuous learning and non-formal professional development will be offered and developed within the project.

#### European Network on Education and Training in Radiation Protection (ENETRAPII)

This project is the subject of a dedicated presentation in this seminar. It started on 1 March 2009 pursuing the overall objective to develop European high-quality "reference standards" and good practices for education and training in radiation protection (RP), specifically with respect to the radiation protection expert (RPE) and the radiation protection officer (RPO). These "standards" will reflect the needs of the RPE and the RPO in all sectors where ionising radiation is applied. The introduction of a radiation protection training passport as a mean to facilitate efficient and transparent European mutual recognition is another ultimate deliverable of this project.

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

#### The European Nuclear Education Network on Nuclear Engineering (ENEN III)

ENEN III started on 1 May 2009 for a period of three years. It associates 19 Partners from 12 EU countries and is coordinated by the ENEN association. The project covers the structuring, organisation, coordination and implementation of training schemes in cooperation with local, national and international training organisations, to provide training to professionals in nuclear organisations and their contractors or subcontractors. The training schemes provide a portfolio of courses, training sessions, seminars and workshops for continuous learning, for upgrading knowledge and developing skills in Nuclear Engineering.

In addition, two more are being negotiated and may be launched next year (NB following information is indicative only):

#### Cooperation in education In Nuclear Chemistry (CINCH)

The renaissance of nuclear power will require a significant increase of nuclear chemists. The project aims at coordinating education and training in nuclear chemistry in Europe. This EFTS expected to be launched in 2009-2010 will provide a common basis to the fragmented activities in this field and move the education and training in nuclear chemistry to a qualitatively new level. The main target group will be not only the doctoral students and research workers but also the students at the master level. Including these students into the system should increase attractiveness of the studies of nuclear chemistry and thus enlarge the source of highly qualified professionals for the future employers.

#### Training Schemes on Nuclear Safety Culture (TRANUSAFE)

Nuclear Safety Culture is a topic of paramount importance for all nuclear operators as well as for operators of installations dedicated to radiology and radiotherapy. It also involves regulators and their technical support organisations. The objective of this project is to design, develop and test relevant training schemes on Nuclear Safety Culture with a European dimension, based on a specific evaluation of the training needs. This will be applied to two groups of users: a group composed of actors of the nuclear industry and the other of users of radiation sources for industrial, medical or research purposes. The expected output is the recognition of good practices and behaviours related to the management of safety culture.

### 3.3 The SRA for radiation protection

Further to the reflections of the High Level and Expert Group (HLEG), whose activities were co-funded by the Euratom programme, European national regulatory bodies for radiation protection, or their technical support organisation (BfS, CEA, IRSN, ISS, STUK), set up the MELODI platform and are intending to progressively integrate their research programmes in the area of low dose. To support this initiative of European integration, the EC included a topic in the Euratom 2009 call for proposals to which a consortia made up of the above organisations, with other partners, successfully responded. The proposal, still under negotiation, foresees the creation of a network of excellence (NOE) for the Low Dose Research towards Multidisciplinary Integration (DOREMI). This NOE will include a strategy for European integration of education and training in radiation protection and in particular in the most critical field of radiation protection research in Europe, that of low dose multidisciplinary science.

The approach being elaborated would include Bologna-compliant courses of MSc, PhD, Post-doctoral programmes as well as focused shorter courses as required that would be accessible by undergraduate students.

The range of subjects covered would be broad and multi-disciplinary, rather than narrowly focused, and cover physics of radiation interactions with tissue, radiobiology - both low dose and high doses, basics in toxicology, epidemiology, probability and risk analysis, radiation risk – occupational, medical, public, and sociology of risk perception.

### Conclusion

In all scientific disciplines, education and training form an indivisible package with research. This complementary nature was understood by the promoters of the Euratom Treaty 50 years ago and is still imperative today. In particular, the Euratom 7th Framework Programme is promoting cross-fertilisation between research and training in all areas of the programme. Such actions are essential if the nuclear sector is to fulfil its role in addressing Europe's energy challenge.

Education and training in radiation protection has a wide societal impact, going beyond just energy issues. Indeed, all EU Member States, whether or not using nuclear energy, have to protect citizens from the harmful effects of ionising radiation in compliance with European directives. For both the owner/operator of a radiation source and the regulator, training and education in radiation protection can ensure of a high level of radiation safety in the future, in particular in medical applications. Harmonisation between Member States in this field is also a prerequisite in the area of radiation protection, and this includes guidance, practices, and education and training.

In addition to Euratom Fission Training Schemes, the main contribution of Euratom research to E&T is the imbedded training of Ph.D. and Post-doc students directly participating in FP projects.

Training will also be a key consideration within the strategic research agenda and the bottom-up integration of research and education in radiation protection in Europe pursued within the MELODI platform, and the Euratom FP can serve as a good example to be followed.

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# IRPA'S CONTRIBUTION TO E&T ACTIVITIES FOR RADIATION PROTECTION PROFESSIONALS

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## ABSTRACT

The International Radiation Protection Association (IRPA) promotes excellence in the practice of radiation protection through national and regional Associate Societies for radiation protection professionals. IRPA has recently prepared and E&T Plan structured around three main lines: the cooperation with international and regional organizations dealing with E&T in Radiation Protection; the internal stimulation of E&T by organizing discussion forums during IRPA Congresses; and the stimulation and support to the organization of E&T activities either by IRPA or by its Associate Societies. The main innovations are in the possibility of undertaking common activities by two or more Associate Societies; the promotion of E&T networks sharing language or regional proximity; and the emergence of activities to attract young generations to the profession.

## 1. Introduction

The International Radiation Protection Association (IRPA) is the international voice of the radiation protection profession. It promotes excellence in the practice of radiation protection through national and regional Associate Societies for radiation protection professionals by providing benchmarks of good practice and enhancing professional competence and networking.

One of the main strategic goals of IRPA is to promote excellence in radiation protection professionals. To reach that objective, IRPA has started the development of guidance documents for use by radiation protection professionals and Associate Societies. The first topic addressed has been stakeholder engagement and currently new guiding documents are being developed on radiation protection culture and on professional qualification.

Education and Training (E&T) is another key to reach professional excellence, and its essential role has been recognized since the beginning of IRPA. However, there is still a wide variation between different countries with regard to E&T methods as well as certification and recognition systems for radiation protection professionals and the desirable harmonization is still to come.

### 1.1 Radiation Protection Expert

The IRPA Executive Council (EC) has widely discussed on these issues and a position paper [1] was presented at a previous ETRAP Conference six years ago. Since then, an important milestone has been the recognition by the International Labour Organization of Radiation Protection Expert (RPE) within the International Standard Classification of Occupations (ISCO-08; 2263) [2]. RPE is included in the group of occupations covered by the definition of Environmental and occupational health and hygiene professionals.



The IRPA definition of RPE is very relevant in this context. According to IRPA, the RPE is a person:

having education and/or experience equivalent to a graduate or masters degree from an accredited college or university in radiation protection, radiation safety, biology, chemistry, engineering, physics or a closely related physical or biological science; and

who has acquired competence in radiation protection, by virtue of special studies, training and practical experience. Such special studies and training must have been sufficient in the above sciences to provide the understanding, ability and competency to

anticipate and recognize the interactions of radiation with matter and to understand the effects of radiation on people, animals and the environment;

evaluate, on the basis of training and experience and with the aid of quantitative measurement techniques, the magnitude of radiological factors in terms of their ability to impair human health and well-being and damage to the environment;

develop and implement, on the basis of training and experience, methods to prevent, eliminate, control, or reduce radiation exposure to workers, patients, the public and the environment.

In most countries the competence of radiation protection experts needs to be recognized by the competent authority in order for these professionals to be eligible to undertake certain defined radiation protection responsibilities. The process of recognition may involve formal certification, accreditation, registration, etc.

## **2. IRPA E&T Plan for 2008-20**

Given the differences existing between countries with regard to certification and accreditation and the nature of IRPA as association of national and regional professional societies, the IRPA EC is developing an E&T Plan that aims towards promoting, supporting, providing guidance and networking to the E&T activities organized by the Associate Societies individually or, preferably, in cooperation.

IRPA Societies are not universities and their E&T activities are not intended for an academic diploma but for professional enhancement. These activities generally focus on general Radiation Protection trends and/or on very specialized topics which cannot be covered by other organizations.

Taking these facts into account, the IRPA E&T Plan is structured around three main lines:

- The cooperation with international and regional organizations dealing with E&T in Radiation Protection;
- the internal stimulation of E&T by organizing discussion forums during IRPA Congresses; and
- the stimulation and support of E&T activities organized by the Associate Societies.

### **2.1 Cooperation with International and Regional Organizations**

IRPA is a main stakeholder representing the profession views on E&T needs in radiation protection for both basic levels and continuous professional enhancement. Consequently, IRPA is maintaining cooperation with the IAEA, the European Commission and the American Academy of Health Physics, amongst others.

IAEA is currently implementing a “Strategic Approach to Education and Training in Radiation and Waste Safety”, aimed at establishing sustainable education and training programmes in Member States [3]. In order to advise on policy development, the maintenance of the Agency’s training programme and the monitoring of the long term action plan, IAEA created in 2002 the “Steering Committee on Education and Training in Radiation Protection and Waste Safety” with nominated members representing regional, collaborating training centres, the European Union and Professional organizations (IRPA). As observer in the Steering Committee, IRPA is contributing to the implementation of the IAEA strategic plan on E&T by exchanging information on actual projects and developments with the Associate Societies.

Giving the great opportunity to interact with the main stakeholders on E&T, IRPA representatives are regularly attending the ETRAP (International Conference on Education and Training in Radiological Protection) Conference series, organized by the European Nuclear Society. This participation will hopefully continue in the next editions after ETRAP 2009.

In the European Union, the draft of the modified Basic Safety Standards Directive highlights the importance of education and training by dedicating a specific title to “requirements for radiation protection education, training and information” [4]. The European Radiation Protection Training and Education Platform (EUTERP) has been created with the main objective of removing obstacles for the mobility of radiation protection experts within the EU through harmonisation of criteria and qualifications for and mutual recognition of such experts. The ENETRAP II project (European Network on Education and Training in RAdiological Protection, FP7-EURATOM), which runs in 2009-2012 aims to develop European high-quality "reference standards" and good practices for E&T in radiation protection, specifically with respect to the RPE and the Radiation Protection Officer (RPO) [5]. These networks could have a clear role to recognize RPE from countries that do not have their own recognition system. IRPA has been collaborating in the past with these EU initiatives as observer, and contributed to the development of the definitions of RPE and RPO. Looking to the future, it would be good if IRPA could continue playing an advisory role. The European Associate Societies, which held annual informal meetings, can provide the EU networks with essential feedback from the professional perspective and IRPA can facilitate to establish the adequate mechanisms.

In the United States of America, the American Academy of Health Physics (AAHP) is an organization that advances the profession of Health Physics, encourages the highest standards of ethics and integrity in the practice of Health Physics, enhances communications among Certified Health Physicists (CHP) and provides a means for Active CHPs to participate in the certification program. The AAHP accredited the training activities (refresher courses and seminars) organized as part of the IRPA 12 international congress in 2008 and also assigned credits valid for recertification (continuing education programme) to the participants requesting them. This very positive experience is encouraging and IRPA will try to establish a memorandum of understanding with AAHP for a permanent collaboration.

## **2.2 Discussion forums at IRPA congresses.**

Over the last years it has proved very successful to organise an Associate Societies’ forum at all IRPA regional and international congresses. E&T is regularly scheduled to be one subject for discussion: this is a going on action.

The IRPA EC will check that these discussion meetings on E&T activities are maintained, either embedded or separated from the Associate Societies Forums, as a way to exchange experiences, promote the harmonization of the definition of RPE according to IRPA and encourage the organization of common and new E&T activities as well as to stimulate to an active participation in the actions proposed in the IRPA E&T Plan, which are described in the following paragraph.

### **2.3 Actions on E&T**

IRPA has already a long tradition in organizing Refresher courses at IRPA congresses. These are lectures by specialists in which updated information on a very precise topic is offered. The IRPA 12 Congress included 20 Refresher Courses, and also 3 Seminars in which different topics of a theme were addressed by a team of experts. The E&T Plan looks forward to maintain these activities and to reinforce them by, specifically:

- including Refresher Courses and Seminars within each IRPA Congress (already established in the guidance for IRPA congresses organization);
- implementing an evaluation and follow-up procedure for the Refresher Courses and Seminars, based on questionnaires to be fulfilled by the participants;
- exploring the live Internet transmission of the IRPA 13 Refresher Courses; and
- improving the post-congress accessibility at the IRPA website to texts and presentations from the Refresher Courses and Seminars (including those from IRPA Regional Congresses).

IRPA Associate Societies frequently organize specific training events, such as seminars, short courses and summer (or winter) schools on specialized topics. These activities are somehow unconnected, and there is an intention in the E&T Plan to promote good coordination. First of all, a questionnaire is going to be distributed to have a complete picture. Then, IRPA sponsoring would be granted to those activities which clear and openly look for professional enhancement within the IRPA family. Specific actions that should be undertaken by the organizing societies to get the “IRPA stamp” can be the following (from easier to harder implementation):

- Advertisement and promotion through IRPA and the Associate Societies.
- Availability of grants for young professionals to facilitate their participation (usually to young members of the organizing societies or from developing countries).
- Agreement to share and exchange teaching materials (by, for instance opening of internet spaces at the IRPA website).
- Webcast of lectures and courses previously recorded.
- Interactive participation via live Internet transmission in courses or seminars (“webinars”).

The IRPA E&T Plan also considers other actions, some of them innovative, to stimulate E&T activities at different levels, like the following:

- Promote the creation of “E&T networks” within IRPA, for instance by those societies sharing language (e.g. Latin-American societies together with Spain and Portugal) or belonging to the same region (e.g. European Radiation Protection Young Scientists Exchange Network, with pilot project for schools and universities with participation from OVS, FS, SFRP, NVS, NSRP and SRP), with dedicated spaces in the IRPA website.
- Encourage Associate Societies activities at national or regional scale to attract young generations to the profession: examples are emerging in some countries to engage pre-university and undergraduate students. Awards programmes to individual or collective work in schools or universities could be an effective way.
- Attract young professionals to IRPA Congresses by initiatives like the National and European Awards for young scientists (the IRPA European Societies will give a first award at the IRPA European Regional Congress in Helsinki in 2010).
- Provide backup and establish interaction with International Training Centres or the World Nuclear University.

### **3. Conclusions**

The IRPA E&T Plan 2008-2020 will continue the cooperation with international and regional organizations dealing with E&T in Radiation Protection where IRPA is representing the profession views. The continuous interaction between the Associate Societies to cooperate

in E&T will continue at different levels, in particular at the discussion forums organized during IRPA Congresses. The Plan also aims to stimulate and support the Associate Societies to organize coordinated activities; to share E&T resources; to create E&T networks sharing language or regional proximity; and to organize activities to attract young generations to the profession.

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# IAEA ACTIVITIES IN EDUCATION AND TRAINING IN RADIATION, TRANSPORT AND WASTE SAFETY: CURRENT STATUS AND FUTURE CHALLENGES

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## Abstract

IAEA's education and training activities related to radiation, transport and waste safety follow the resolutions of its General Conference. IAEA is currently implementing a 'Strategic Approach to Education and Training in Radiation and Waste Safety', aimed at establishing sustainable education and training programmes in Member States. This is being achieved through a range of activities that include, inter alia, educational and training courses, train-the-trainers workshops, distance learning, on-the-job training, specialized missions and a 'training tool kit' for Member States to evaluate their needs. All training materials are based on IAEA Safety Standards and are run in accordance with standard syllabi or as part of training packages that are approved by a steering committee.

The paper gives an overview of the mechanisms by which IAEA is enhancing education and training in radiation, transport and waste safety around the world. In addition to describing what has worked well, the paper will indicate what can be improved and what challenges lie ahead.

## Introduction

The statute of the International Atomic Energy Agency includes the establishment of, and provision for, the application of safety standards for protection of health, life and property against ionizing radiation. Education and training play a key role in facilitating the application of Safety Standards in IAEA Member States and for strengthening the global radiation safety regime. The education and training activities of IAEA follow the resolutions of the General Conferences and reflect IAEA Safety Standards and guidance [1,2,3]. A "Strategic Approach to Education and Training in Radiation and Waste Safety" (Strategy on Education and Training) was endorsed by the IAEA General Conference in resolution GC(45)/RES/10C in 2001 [4] and aimed to establish sustainable education and training programmes in Member States by 2010. A steering committee advises the IAEA secretariat on the implementation of this strategic plan. The various IAEA mechanisms and activities that are associated with implementation of the strategic plan are described below.

## Regional Training Centres

Within the strategic plan, regional training centres (RTCs) play a crucial role in the development of competence at the regional level, and their establishment in all regions is a considered to be a key success. IAEA post graduate education courses in radiation protection and the safety of sources (PGEC), specialized courses and train-the-trainer events have all been run at the regional training centres. The PGEC, in particular, is considered to be a fundamental element in building a strong radiation protection infrastructure within Member States. Overall, the RTC's provide an active interface between IAEA and its Member States and they significantly contribute to helping States to apply the IAEA Safety Standards in all regions.

In order to facilitate networking between IAEA regional training centres, an Inter Centre Network (ICN) was developed, with the objective to:

- facilitate communication and exchange of information between the centres and between the IAEA and the centres;
- disseminate lecture material through the ICN website;
- promote e-learning programmes;
- provide feedback from participants and lecturers on training material to the Steering Committee;
- harmonize training centre management.

Although good in concept, the ICN has not been well utilized due both to technical difficulties with the IT platform and a relatively small group of users. Recognizing that the concept is still valid, ways to improve the network will be considered.

## **IAEA Training Activities in Radiation Protection**

### ***Post-Graduate Educational Course (PGEC)***

The post-graduate educational course (PGEC) in radiation protection and safety of radiation sources is a comprehensive and multidisciplinary programme with theoretical and practical training. It is aimed to educate and train young professionals, especially regulators, who may in later years become senior managers. The PGEC is hosted by IAEA Regional Training Centres (RTCs) in Africa (English and French), Europe (English and Russian), Latin America (Spanish), Asia (Arabic and English). The course is supported by IAEA and is run in line with the IAEA Standard Syllabus [5]. Every year over 100 participants benefit from this post graduate course.

Presenter's material in the form of PowerPoint slides have been developed in line with the standard syllabus and are provided to the RTCs. This ensures that the information provided to the students is based on IAEA Safety Standards and this facilitates a harmonized approach. Data from the RTCs shows an increasing trend in the use of local lecturers and less reliance on IAEA. This is taken to be a good indicator that the self-sustainability of the RTC's is improving.

Feedback from the students indicates that the content of the syllabus may, in some areas, need to be better balanced as some modules contain a lot of detail to be covered in the allocated time. This matter will be taken into consideration when the syllabus is next reviewed. The PGEC includes an element of project work and feedback shows that this is very beneficial to the students and many continue with their projects when they return home.

Other steps being taken to improve the PGEC include sharing good practices and lessons learned among the regional training centres and the preparation of a 'model' quality manual for RTCs.

### ***Specialized Training Courses (STCs) & Workshops***

Short duration specialized training courses are run for one or two weeks in IAEA Member States. They are aimed at participants who already have relevant work experience. Workshops provide participants with the opportunity for in-depth training and exchange of information. Topics covered by such courses and workshops are wide ranging and include, for example, the regulatory framework, occupational protection (external and internal), patient protection (diagnostic radiology, radiotherapy and nuclear medicine), radioactive waste management, transport of radioactive materials,

safety of radioactive sources and safety in industrial applications. The courses are regularly organized at the national and regional level for different target audiences, such as for regulators or radiographers. Each year around 25 such regional training events are organized in various Member States. The training materials have been translated into most official IAEA languages. An ongoing issue has been with respect to the validation of training material prior to being made available for routine use. In practice, the process has been slow and a more efficient process is currently being established.

### ***Training material for Radiation Protection Officers***

The Radiation Protection Officer, according to the International Basic Safety Standards, is an individual technically competent in radiation protection matters relevant for a given type of practice who is designated by a registrant or licensee to oversee the application of the relevant requirements of the IAEA Safety Standards. That being the case, it was considered appropriate to increase emphasis on the development of training material for Radiation Protection Officers (RPO), this also being a significant element with regard to the successful implementation of the IAEA strategic plan. The course is divided into compulsory 'core' modules supported by supplementary modules that are specific to the practice (e.g.: industrial radiography).

### ***Other Training Mechanisms***

#### *On the Job Training*

The objective of on-the-job training (OJT) is to provide individuals with practical experience in a chosen area for a longer duration under the direct supervision of experienced professionals. The duration of the OJT is dictated by the training theme, varying from 1- 3 months. The added value is the opportunity to work in well-developed centers and to learn from peers. The successful completion of PGEC, STC and OJT provides a solid basis for radiation protection professionals.

#### *Distance Learning (DL)*

IAEA successfully concluded a 'Distance Learning' project in Radiation Protection in the Asia and the Pacific region. The participating countries were Australia (coordinator), Korea, Indonesia, Mongolia, Thailand, The Philippines and New Zealand. This learning method was used both nationally and internationally. Distance learning complements the classroom training and was found to be useful where only small number of people need training or where target population is scattered or live far from national training centers. Distance learning is also good tool for refresher training or as pre-training to prepare an individual to attend a training course. The learning material developed for the distance learning is now being used for providing pre-training for PGEC participants. The objective is to harmonize the level of knowledge in radiation protection of all the PGEC participants coming from different educational backgrounds and with varying levels of experience. The selected participants receive the pre-training material in their home country to prepare themselves for the long duration PGEC. This material has been translated to Arabic, Russian and Spanish. Consideration is being given to converting this material from CD format to a web-based system.

#### *Training the Trainers (TTT)*

This training modality is mainly aimed at developing communication skills with a view to building a core of national trainers in radiation protection. The training syllabus includes presentational and communication skills, organization of training events and includes practical exercises. In the TTT training course the participants are familiarized with IAEA developed training material so that it can be used effectively in future training

courses. The TTT training course is designed to be interactive with presentations by the participants. More than 10 such train-the-trainers workshops for radiation protection in medical and industrial applications have been run at the national and regional levels. In addition, the module has been made included on the PGEC. Future work in this area will involve how to evaluate the on-going effectiveness of the potential trainers.

### **National strategy for building competence in radiation protection**

To ensure a comprehensive approach to building competence in radiation protection, States may wish to consider developing a national strategy. Such a strategy can be considered to consist of 4 interlinked phases, where the outcome of one phase is the starting point for the next phase, with the loop being closed by evaluation and feedback, as shown in Fig 1.:

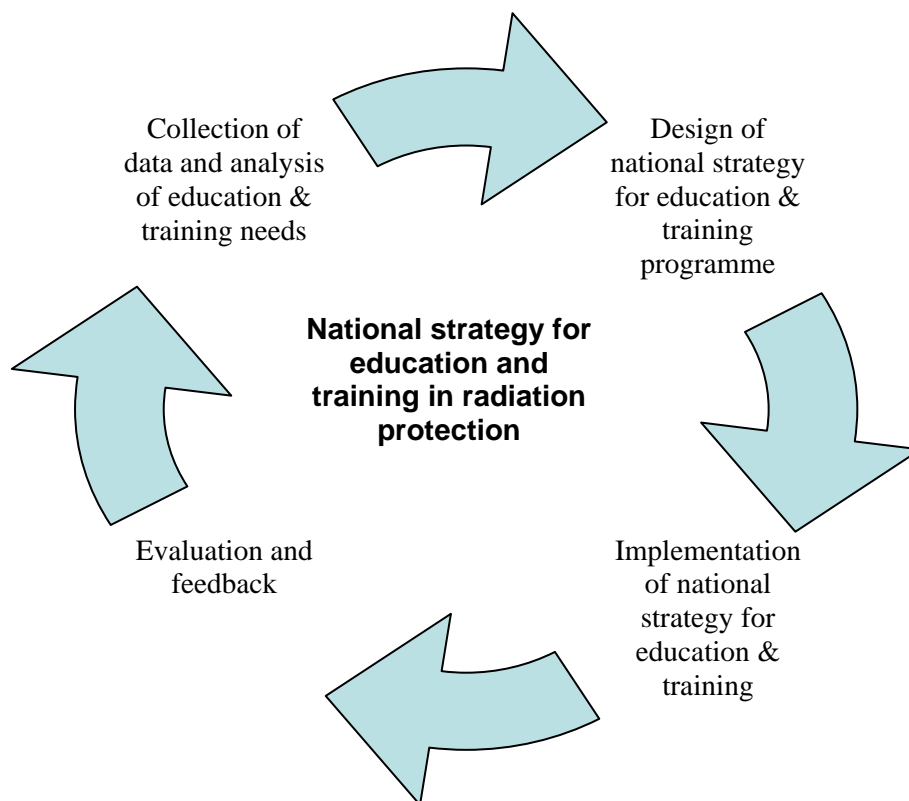


Fig 1. Four phases to establish and maintain a national strategy.

The first step is to collect and analyze information about the current and foreseeable situation for a range of areas, inter alia, regulatory requirements and regulatory infrastructure for education and training in radiation protection, and data on types and numbers of radiation sources and information about the number of adequately trained personnel (including workers, radiation protection officers, staff of the regulatory body, and qualified experts). The output of the analysis should show the identified needs regarding the number of people that need education and training in the various fields of radiation protection. This analysis will enable the national strategy to be designed to meet those needs, for example by identifying the need to increase the number or expertise of training providers. Evaluation and feedback from implementing the plan will help to ensure that strategy remains effective.

IAEA is in the process of developing a 'Training Tool Kit', based on IAEA Safety Standards and training material, to specifically help its Member States to develop such a national strategy. IAEA also offer an Education and Training Appraisal (EduTA) mission to Member



States, with the objective of reviewing the national status of provisions for education and training in radiation protection.

### **The Future**

Considerable work has been undertaken in pursuance of the strategic aims for strengthening education and training in radiation protection and the safety of sources, and considerable progress has been made, especially at the regional level. Future work will focus on strengthening education and training at the national level, with the regional training centres playing a key role. The ultimate effectiveness will depend upon the commitment of Member States to develop their own national strategy and sustainable training programmes in radiation protection and safety of sources. By working together more progress can be made towards the realization of a harmonized approach for education and training. These steps are essential ingredients for maintaining high standards of radiation protection and the safety of sources worldwide.

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# **CURRENT STATUS IN E&T IN RADIOLOGICAL PROTECTION**

# RADIATION AND WASTE SAFETY TRAINING: TOWARD SUSTAINABILITY AND SELF-RELIANCE – A MALAYSIAN EXPERIENCE

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## ABSTRACT

The growing trend and increasing use of ionizing radiation in various economic activities demand effective radiation safety practices and regulatory control. In this respect, Education and Training (E&T) plays a vital role and as a tool in capacity building and molding personnel with suitable technical competency and good safety habits towards achieving continuous safety and quality improvement in organization.

Various types of training were developed, designed and introduced into the market by Malaysian Nuclear Agency (Nuclear Malaysia) to meet different needs of customers taking into consideration product susceptibility and customer behavior in order to gain endorsement and market acceptance hence ensures product sustainability. In this context, training modalities have been carefully planned starting from product design and marketing to the adoption of synergetic approach in teaching and learning activities to provoke interest and acceptance. Attractive training packages that are customer-centric, relevant products and market-driven training modules have been successfully introduced to address the market needs resulting in sustainable training programmes. Together with incentives offered, it serves as a catalyst to stimulate participants' interest in term of benefits derived: financial, professional and personal gains.

This paper examined critically the experience of Nuclear Malaysia in executing radiation and waste safety training for the improvement of safety performance and quality in an organization contributing to product sustainability and self-reliance. The training programme had been implemented in accordance with the needs of organizations apart from fulfilling regulatory requirements as well as towards achieving the National visions for knowledge generation, wealth creation and societal well-being.

## 1. Introduction

The success of an entity is normally linked to the capability of its workforce in executing the assigned job functions. They are movers and catalysts contributing to the effectiveness and efficiency that spur organizational growth and achieve set targets and objectives. The introduction of Atomic Energy Licensing Act in 1984 marked the new dawn of national nuclear technology development in Malaysia. The Act governs all activities related to radiation technology so that they are carried out in accordance with standard and stipulated procedures. Malaysian industries recognized the importance and usefulness of nuclear technology for development and upgrading quality but take cognizance that nuclear technology has its downsides and controversial if not handle properly. In view of this, the government had initiated measures and implement strategies towards regulating the use of the technology to ensure safety and security; and activities using nuclear materials follow the national and international standard practices.

The functions of promotion and technology development are under the purview of Malaysian Nuclear Agency (Nuclear Malaysia), while the aspects of monitoring and regulation are under auspices of Malaysian Atomic Energy Licensing Board (AELB). Even though both organizations are under the same Ministry, the separation of power is critical to avoid conflict of interest and assuring activities are carried out with high integrity and in ethical manner.

## 2. The Landscape of Radiation Training in Malaysia

The dire need for effective and encompassing radiation training in Malaysia arises due to the widespread utilization of radiation technology in various economic sectors. There are intense demands for radiation training as a result of high safety awareness among the users as well as strict monitoring and inspection by the authority especially the AELB.

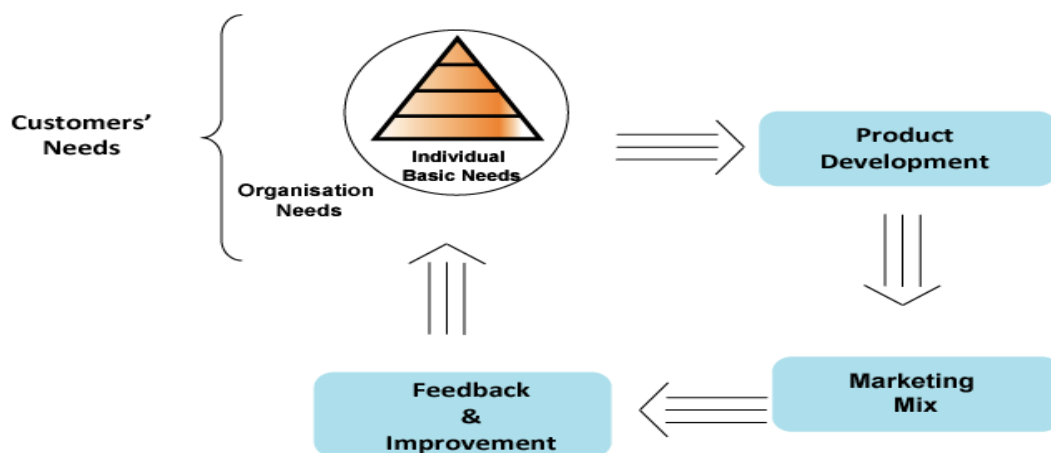
Nuclear Malaysia is the first and premier agency in the country that organized training for industries and other stake-holders. The main challenges facing the agency include **firstly**, to enhance the capacity of human capital to reach a performance level where nuclear technology activities can be operated in an efficient, effective and ethical manners; and **secondly**, to achieve income target of 30% of the operational budget with ultimate goal towards self reliance. The Training Centre is one of the major contributors in Nuclear Malaysia to meet this target.

As such, it is necessary to urgently address those needs to improve performance and to position training activities for better growth and profit. Recently there are numbers of players making entry into the market offering training in radiation and waste safety. Majority of these players were the products and spin-offs from the Nuclear Malaysia's training activities.

## 3. Sustainability – It's About Demand

The quest for the marketable products and quality training at an affordable cost to attract customers requires well-thought strategies and thorough planning. We are well aware that customers normally select training program that meet their specifications, offers convenience and provides solution to their problems. Hence, sustainable training products were developed and designed taking account customers' perspective without neglecting 4Ps' marketing mix. Garnering customers' attention in a volatile marketplace and make them commit to attend training programme is an uphill battle especially in the period of economic downturn.

Nuclear Malaysia approaches/strategies to capture customers' attention and penetrate new market include the followings: Firstly, Promoting the culture of creativity and products innovation to complement the traditional approach of business; Secondly, Organizational philosophy of 'Customers are the King' and 'Customers run your businesses'; Thirdly, the understanding of customer behaviors; and Fourthly, adaptation of the Maslow's theory of the Hierarchy of Needs. Customer-centric training was designed to maintain competitiveness and acquire customers' endorsement, recognition and acceptance (Fig. 1).

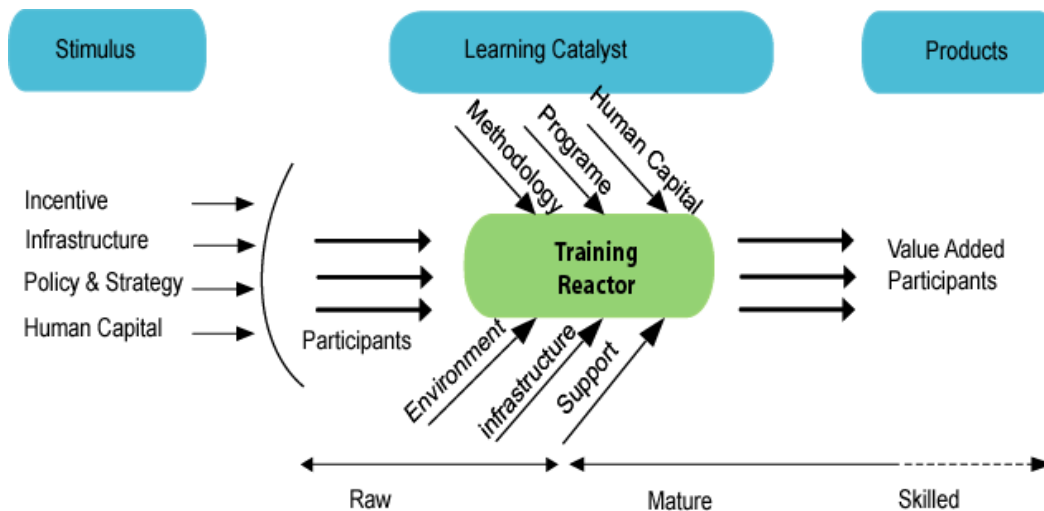


**Fig. 1 Customer-Centric Training Cycle to Ensure Sustainability**

To ensure the success of training programmes/products, Nuclear Malaysia performed periodic market survey to gauge customers' satisfaction improvement of infrastructure such

as classrooms and laboratories that are necessary to fulfill customers' requirement and satisfaction.

Our experience shows, the 'pull and push' factor has been the decisive factor determining the success of training products developed (Fig. 2). Customer concerned or individual benefits such as 'What is it at me (WIIAM)' and 'What is it for me (WIIFM)' are also taken into consideration.



**Fig. 2 The 'Pull and Push' Factors for Attractive Products and Sustainability**

#### 4. Approach using Stimulus Package

Malaysian government is very committed in human capital development. The stimulus package introduced recently by the government to assist economic recovery and minimize the impact of economic downturn had also included element of training. Nuclear Malaysia had benefitted from this package via provision of training through a programme called 'Training & Placement'. They are trainings for X-ray operators, non-destructive testing (NDT) personnel and Radiation Protection Officer. Under this package personnel undergoing the courses are fully paid by the Government and received allowances. Qualified and certified persons after attending the course shall easily be absorbed into the market. Companies/individuals participating in the training programme also gained some benefits in the form of tax rebates, financial rewards and professional enhancement.

In a volatile and competitive marketplace, every player had to embark with strategic approach to win customers' confidence and product endorsement. Wider customer acceptance of our training products are among others due to the vigorous and focused marketing initiatives and attractive products; right pricing strategies; listening to and satisfying the customers; and adoption of logos, pathos and ethos concept into business model.

Some of our products – Training for 'Radiation Protection for Officer', 'Industrial Radiography' and 'Medical X-ray Operator' – have gained the status of 'Iconic Products' and generates considerable amount of revenues.

In order to become a market leader in the business of training, the support of strong leadership is a pre-requisite. Strong leadership provides direction and makes available resources for the Training Centre to run efficiently and effectively.

The Training Centre has recently been diversified into 'soft-skill' training programmes not really related to our core business of radiation, but corresponds to the job functions. They are management courses (Human Resource Development, Communication, Quality and Productivity, Research management, Research Methodology etc.) for personnel involved in

scientific fields. Such activities enable us to venture and capture new markets thus widen our earning base.

## **5. Reaching the Customers**

Nuclear Malaysia's training products had been successful in capturing its target customers especially personnel at supervisory level of industrial sectors: manufacturing, oil and gas etc; and medicals. However, market segment for the masses involved at operational level are largely untapped. These segments comprise front-line workers which made up of personnel from the Military, Custom and Excise, Fire and Rescue etc, could become the future potential source of revenues.

Nuclear Malaysia in the quest to maintain status quo; and penetrate and break ground into the largely untapped and potentially lucrative market employs the following strategies:

### **5.1 Cross Border Training**

Apart from regular training at our premise, the programmes have also been conducted in selected growth areas that have been proven productive. Through this marketing approach, the cost has been substantially reduced besides having the advantages of tailored-made programme. The mechanism employed included Regional based training, In-company training and smart partnership. Nuclear Malaysia is also taking strides to internationalize its activities especially the Middle East and ASEAN Countries. This exercise had already been fruitful as shown by demand in Kuwait and Brunei Darussalam.

### **5.2 Consortia**

This innovative marketing model is a derivative version of in-company training programme designed for a small group of companies that provide the benefit of customized programme based on cost sharing principles. This opportunity is well suited for the Small and Medium Industries (SMI) that lack the financial resources to organize the course on individual basis.

### **5.3 Dual Location Approach**

Realizing customers' limited resources, shortage of capable trainers and lack of facilities, the 'tailor-made' training is conducted at two different locations capitalizing on the strength of respective organizations and training modality. Practical part of training for instance is conducted at Nuclear Malaysia while the theoretical section is in the customers' premise. Customers comprise mostly the SMI/ small companies offering them the benefit of cost reduction and larger number of staff could be trained on-site compared if it is conducted elsewhere.

### **5.4 Incentives**

Customers are always seeking for some kind of investment return in a short term, i.e., in the form of incentives – financial, professional and personal gain, from the Government or private finance initiatives. The authorities in Malaysia had given due recognition for training programmes that we conducted. The gains that customers received includes training rebates, double tax deduction, certificates of professional achievement and qualified practice, and personal gain.

### **5.4 Quality Management System (QMS)**

Quality Management System is a useful marketing tool to instill customers' confidence in products and delivery system. It also provides assurance for efficient, effective and ethical service. The centre has been awarded the latest version of QMS ISO9001:2008, indicating our commitment for quality which promises continuous improvement in teaching-learning, training materials and facilities, and trainers.

## 5.5 Tuition on Demand

In line with global trend and extensive use of information and communication technology, on-line training programme was designed with the concept almost similar to 'pay as you learn' 'Anywhere, Anytime', in which customers learn at their own pace, sit for the examination, and get certified from their premises.

## 6. Challenges and Moving Forward

Like any other business, there is a need for performance appraisal at every stage of the planning process for training programme with the aim of improving quality and bottom-line. Commitment to the endeavor of education and training (E&T) is a primary driver toward increased level of performance and productivity. In the planning of training model, there is an urgent need for us to balance between maintaining financial stability while focusing on strategic objectives (e.g. imparting knowledge to participants) that would preserve our market leadership in radiation E&T.

Any decision to introduce new products should also be based on market needs and pragmatic approaches, rather than intangible criteria and dogma such as feeling, sentiment and emotion. More notable '*Iconic Products*' should be created to generate and sustain customer interest and recognition. Clearly, we are facing the challenge of incorporating sustainability objectives into business approaches and operating models, i.e., to understand how to establish a meaningful, well-developed strategy and business model that have significant impact on customers.

## 7. Conclusion

Sustainability of training products depends on the market acceptance, endorsement and recognition by stakeholders. Nuclear Malaysia devised some strategies to face the current turbulent environment and competitive marketplace to make the training programme sustainable and self-reliance. The approaches include attractive products packaging; pragmatic marketing strategies; attractive incentives for customers; and effective and efficient delivery system.

In future, Nuclear Malaysia will be introducing 'Customer Royalty Programme' and 'Franchising' to stave off competition and create 'Win-Win' situation with our customers. In order to realize the vision of making Nuclear Malaysia's Training Centre as regional and global player, we need to work on consolidating the leadership position; aggressive marketing; continuous improvement as stipulated in our QMS management system; and nurturing the culture of discipline, dedication and determination workforce.

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# RADIATION PROTECTION TRAINING PROGRAM AT THE EU JOINT RESEARCH CENTRE IN ISPRA, ITALY

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## ABSTRACT

Training in Radiation Protection in the Joint Research Centre (JRC) of the European Commission, in Ispra, is addressed to Exposed Workers, Radiation Protection Technicians, Emergency Squads and Non-Exposed Workers.

After a major reorganisation of the Radiation Protection Sector, training methods and schemes have also been reorganized, developing new generic and specific training actions for internal and external Workers, aimed at harmonizing different background education and different Radiation Protection practices among Workers of different nationalities.

For the year 2009, the training programmed at JRC-ISPRA has involved almost 400 workers, and has covered most of the needs of the Centre.

Basic Radiation Protection classroom training, specific Controlled Area on-the-job trainings, emergency management and preparedness, radioactive transports, alpha risks and glove-box handling procedures are some of the training actions successfully organised by the Radiation Protection Sector in 2009.

## 1. Introduction

### 1.1 Nuclear activities in JRC-ISPRA

The European Commission's Joint Research Centre (JRC) is a Directorate-General of the European Commission, providing independent scientific and technological support for EU policy-making.

JRC-ISPRA has been founded in 1958, after the Treaty of Rome, in order to foster research on nuclear applications and technologies: its mission and roles evolved, throughout the years, and the nuclear research is now only a limited part of its activities.

The Ispra Site, the third biggest Commission site after Brussels and Luxembourg, covers an area of 167 hectares, and has 36 km of roads and 6 km perimeter fencing. There are about 250 buildings hosting some 1.800 staff plus, typically, 500 staff of external companies and up to 200 daily visitors.

The Site also hosts some nuclear facilities awaiting decommissioning (two research reactors, hot cells, radioactive liquids treatment station, etc.), some facilities in the decommissioning process (radiochemistry laboratory, etc.), some waste management facilities in operation (solid waste station, new radioactive liquids treatment station, characterisation facilities, decontamination facility, etc.), and some research facility in operation (Cyclotron Laboratory, Performance Laboratory (PERLA), PUNITA Laboratory, SETRAC, etc.).

Nuclear activities in JRC-ISPRA, although heavily reduced after 1987, when a referendum stopped all power plants (and all major nuclear activities) in Italy, have been expanded since 1999, with the adoption of the “*Nuclear Decommissioning and Waste Management Programme*”, a process which will span over a few decades.

JRC-ISPRA is committed to progressively reduce its nuclear liabilities, releasing from regulatory control all classified areas which were subject to nuclear activities in the past, and



eventually assigning them to conventional research activities, without any radiological constraint.

## 1.2 Radiation Protection in JRC-ISPRA

JRC-ISPRA accounts for 21 nuclear licences, 14 Controlled Zones and 12 main Surveilled Zones. The number of Exposed Workers operating in JRC-ISPRA is around 180 internal staff and around 180-200 external staff (depending on specific projects), employed by 25-30 external Companies. A minor number of Non-Exposed Workers (30 in 2006, 34 in 2007, 77 in 2008) operate in Controlled Areas, being specifically authorized for limited-time working activities presenting no radiological risk.

Internal JRC Personnel operates under JRC Qualified Expert (QE) control: the QE is also responsible, among many other duties according to Italian Law [1], for Exposed Workers' classification, their monitoring (either for external and internal doses), and the effectiveness of the global radiological protection programme in force under his/her competence.

Outside Workers (according to [2] and [1]), are classified and operate under the surveillance of their Company's QE, who usually collaborates with JRC-ISPRA's QE in order to implement the most suitable Radiation Protection programme in the JRC.

Radiation Protection (RP) assistance is a task assigned, for all JRC-ISPRA nuclear activities, to the **Nuclear Decommissioning Unit's "Radiation Protection Sector"**, to which the JRC's QE belongs: some 15 RP internal Technicians manage JRC-ISPRA's 26 classified areas, and coordinate RP assistance given by some other 25 external RP Technicians, who operate under a JRC-ISPRA Framework Contract for RP Assistance.

The Sector is also responsible for the operation of four internal Laboratories: the External Dosimetry Laboratory, the Whole Body Count Laboratory, the Nuclear Instruments' Calibration (accredited) Laboratory, the Electronics Laboratory.

Operational Radiation Protection activities in JRC-ISPRA are mainly structured over three pillars:

1. Support to safe custody of those facilities awaiting the decommissioning process
2. Support and assistance in the management of radioactive waste
3. Support to operating facilities

## 2. Training for JRC-ISPRA specific needs

### 2.1 Training Internal Exposed Workers

JRC-ISPRA, as License-Holder, is responsible, according to Italian applicable nuclear legislation [1], for education and training (about radiological risks) of its Internal Workers [6].

JRC-ISPRA has been a relevant Training Centre on Radiation and Radiation Protection, in the past ("*Ispra Courses*"), and delivered high-level training to Professionals and Scientists.

Today, current RP training has been tailored to JRC-ISPRA's needs, that is to face future huge decommissioning works, in the context of a Country in which all major industrial nuclear activities are suspended since 22 years. Indeed, while Italy has developed since long time a clear legal framework for the profession of Qualified Expert, there is no such framework for RP Technicians (in the industrial domain), nor any officially recognized training scheme. This implies that License Holders should develop their internal RP training programmes, in order to compensate for the absence of an official national training (or education) certification.

Basic RP training is therefore administered to JRC Exposed Workers, followed by specific courses on radiological risks on JRC-ISPRA's facilities, and advanced training on dosimetry, transports, HASS, and other more advanced topics.

Wherever necessary, in order to tackle highly specific risks for which JRC-ISPRA does not possess anymore adequate competences (as alpha works in glove-boxes, during the year 2009), selected JRC Personnel is asked to follow external training sessions, and subsequent internal informative training sessions are then organized in the Centre.

## **2.2 Training External Exposed Workers**

JRC-ISPRA is also responsible, according to Italian Law [1], for specific information and training of External Workers (operating in the Centre) about radiological risks in its facilities.

Specific training on radiological risks on JRC-ISPRA's facilities is therefore administered to External Exposed Workers: this means showing detailed radiological status (doses, contaminations, peculiarities) of each one of JRC-ISPRA's facilities, and implies the existence of an updated system of recording of dose and contamination maps throughout the JRC-ISPRA.

## **2.3 Training Exposed Workers for harmonization**

A significant turnover among Staff is experienced in JRC-ISPRA in these last years: while this surely represents an opportunity, opening exciting possibilities of knowledge exchange between Workers -and therefore of improvement-, it also corresponds to an issue, regarding proper training on correct behaviour in Controlled Areas and JRC shared and approved work practices.

The issue is two-fold: continuous Personnel's turnover implies devoting Personnel for continuous training and, on the other hand, harmonization within, e.g., RP assistance practices -during experimental work, during RP assistance, or during decommissioning and waste management operations- is essential.

Individuals normally tend to operate according to their previous work experience and practice, usually gained in other countries, with different regulations and rules, which may significantly differ from the ones in force in Italy<sup>1</sup>. Harmonization is therefore needed, especially among RP Technicians, who check and supervise all radiological risks.

Specific training sessions are therefore devoted to the diffusion of good practices (in the use of radiation sources, for example, or in workplace monitoring, or in laboratory set-up and management, etc.) among Workers.

## **2.4 Training Non-Exposed Workers**

Many JRC-ISPRA internal and external workers (around 1800 people) are classified as NON-Exposed Workers, and are actually not exposed to any radiological risk during their work activities in the JRC (Scientific, Technical and Administrative Personnel operating outside classified areas).

However, since a few years, an urgent need for more comprehensive information to Non-Exposed Workers clearly emerged: specific divulgation sessions, aimed at helping Workers to better understand the risks to which they are exposed (or not exposed) to, at their workplace, have been successfully organized.

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<sup>1</sup> A significant example, in this regard, is the use of specific radiation hazard zone signals. While in many Countries (France, Spain, etc.), the use of coloured trefoils is standardised, as an additional indication of dose and contamination levels –and forms, therefore, part of the radiological culture of Exposed Workers-, those symbols are not allowed in the Italian regulation, resulting in many non-Italian Workers being at first confused and asking either for clarification or for their introduction in JRC-ISPRA!

## 2.5 Training new Radiation Protection Technicians

Newcomers usually need to be trained on Radiation Protection: some RP assistance services require deep knowledge of JRC-ISPRA's facilities and interfaces, therefore on-the-job training has been successfully applied.

Individual training passports are prepared, specifically tailored to the candidates' previous experience and skills, in order to familiarize them with places, practices, risks.

Tutoring by a more experienced Colleague is the standard practice in training new RP Technicians in JRC-ISPRA.

## 2.6 Training Radiation Protection Technicians on radiation software

A few radiation software packages are currently being used in the Radiation Protection Sector for RP purposes: these include a JRC-ISPRA-customised specific version of SAFE AIR<sup>®</sup> [4] (for contamination release and dose to the public evaluations, in accidental conditions); MICROSIELD<sup>®</sup>, for many different dose rate calculations; IMBA PROFESSIONAL PLUS<sup>®</sup>, for internal dosimetry evaluations.

Specific training on the use of these codes, addressed to selected RP Technicians, is necessary and regularly performed.

## 2.7 Training Radiation Protection Technicians on technical procedures

RP Technicians, and mostly those belonging to the External Companies offering their services to JRC-ISPRA, need to be continuously trained on specific work instructions in force in JRC-ISPRA.

Specific training sessions for RP Technicians, either classroom-based and on-the-job, are organized, with the scope of reviewing basic procedures most encountered in practice (smear test sampling, dose and contamination mapping, incident reports, clearance of material, entry/exit from controlled zones, assignment of EPDs, etc.).

## 2.8 Training Radiation Protection Technicians on radiation instruments

Many contamination meters and dose rate meters (with a plethora of external probes) are being used in JRC-ISPRA by RP Technicians<sup>2</sup>.

This variety of instruments represents a major issue, either in terms of training to the newcomers, and of continuous training to permanent RP Technicians. Moreover, training RP Technicians, due to their daily assistance tasks to other Workers, is difficult to organize and to perform.

A specific training session on the use of one (or more) instrument(s) is repeated every week for one month, in order to facilitate the participation of the majority of RP Technicians (the subject changes every month): closure sessions at the end of the year (*rattrapage*) are also programmed.

## 2.9 Training Emergency Squads

Emergency Squads are available 24/7 in JRC-ISPRA: they are composed of permanent JRC Fire Brigade Staff and a variable number of voluntary JRC Staff, working on a shift basis every day. The Emergency Squads are required by Law, due to JRC-ISPRA Nuclear

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<sup>2</sup> Personal dose-meters, electronic personal dosimeters, air samplers, smear test measuring equipment, neutron monitors, neutron dose-meters, direct air contamination monitors, tritium monitors, bubblers, portable gamma spectrometry devices, laboratory NaI and HPGe detectors, and some hundreds of ambient monitors are available and are currently used in daily RP assistance

Licenses, and intervene in Controlled Areas in case of incidents of any nature. Moreover, they are also assigned the duty of radiation monitoring and sampling around the Site during a nuclear emergency.

Emergency, due to the nature of the Site, which is dispersed over a vast territory and over a big number of buildings, is locally managed by specifically trained JRC Staff (Building Delegates), who act as a link between the Emergency Director and the Staff during an emergency, and locally coordinate actions on Staff gathered at assembly points, including evacuation to a safe place, if necessary.

Continuous training to Emergency Squads, Building Delegates and Emergency Directors is also provided, on a quarterly basis.

### **3. Training effectiveness evaluation and feedback**

The evaluation of the effectiveness of a training action is part of its execution: a database of questions and answers has been collectively developed within the Sector, and is used to generate set of questions (different for each session and for each course) to be submitted to the candidates. Evaluation is usually directly communicated to candidates and significant questions/answers are publicly discussed.

Feedback from the Candidates is requested and appreciated, and is treated *via* the existing system at the European Commission (SYSLOG TRAINING evaluation).

Very interesting suggestions have come from candidates in the years, especially concerning on-the-job training and the balance between theory and practice during the courses.

In 2009, a mock-up glove-box, equipped with ventilation and filtration, to be used in training Personnel for work activities with alpha risks, has been put in operation, and candidates have been successfully trained in operations (glove changes, insertion/extraction of material, emergencies, etc.) of this kind.

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# **RADIATION PROTECTION TRAINING IN LOVIISA NPP, LEGISLATIVE GUIDANCE AND DEVELOPMENT OF TRAINING PROCESS**

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## **ABSTRACT**

Radiation protection training has been the framework for site induction training throughout the history of Loviisa NPP. Legislation and regulations have set requirements for the content of radiation protection training but also the development in safety culture and aspiration to improve the prerequisites for good working conditions have motivated ameliorating the training process. This paper will give an overview to the regulatory requirements for radiation protection training in Finland and on the other hand, a survey to the development of the training process in Loviisa NPP. By 2009, the process has shaped into a sound form but some tools that would improve the training results are still to be studied and applied into action. Future changes in human resources due to change of generation and possible new plant installation projects will keep the training process in progress. Implementation of radiation protection and -safety training into covering the project management and contractor chains in designing will be a challenge.

## **1. Introduction**

From the beginning of the production of nuclear energy in Finland, the nuclear safety guides (YVL guides) of Radiation and Nuclear Safety Authority (STUK) have directed the development of radiation protection training given by nuclear energy operators. YVL guides set requirements for training when the first Finnish nuclear power station unit was pressed into service. As times have progressed, requirements for training have changed and affected to the areas of focus in the ensemble of contractor and staff training at Loviisa NPP.

In addition to regulatory requirements, the ambition to develop the safety culture has directed the plant to pay increasingly attention to training. On the other hand, the whole industry is facing change of generation when experienced experts are retiring and young employees beginning their working careers. These factors have challenged Loviisa NPP to strengthen its training processes

In this paper, the most important milestones of YVL guides and other national regulation that have affected to training will be viewed. Furthermore, the starting point and development of training through the history of Loviisa NPP will be briefly presented. Moreover, present training process of contractor or staff member arriving into the plant will be described. Finally, the future challenges and possibilities will be discussed

## **2. Regulatory requirements for radiation protection training in Finland**

The Industrial Safety Act [1, 2] has from the mid-1950's given general requirements for employers to give sufficient training in regard to working environment circumstances, right working procedures and possible health risks related to work. It treats training in a general level, not paying attention to a certain industry or work.

The nuclear safety guides (YVL guides), instead, have guided the development of radiation protection training throughout the history of the plant operation. In 1981, guide YVL 7.9, *Radiation Protection of workers at nuclear facilities* [3] gave requirements for the radiation

protection training about the topics that were expected to educate to the workers. The content was expected to include at least the applicable parts of radiation legislation and regulations, fundamentals of radiation and radiation risk.

The first revision of YVL 7.9 [4] required from the beginning of 1993 emphasized the significance of an examination in which the workers were required to show their understanding of the radiation protection aspects. On the other hand, offering a deeper level of radiation protection training to workers whose work affects particularly to the radiation protection objectives was highlighted.

The approach in the second revision of YVL 7.9 [5], published 2002, is enlarged to make radiation protection training to provide workers with preconditions to act consistently if unpredictable situations occur at the workplace. It encourages in using mock-up facilities in training for personnel who work in demanding workplaces as regards radiation or contamination circumstances. Also highlighting worker's own responsibility in taking care of him/her own and other person's radiation safety is emphasized. Approving site induction trainings given in other Finnish and Swedish nuclear power plants was made possible.

Requirements for training and qualification of plant staff is described in YVL 1.7 [6]. It defines general demands for site induction training, for basic, further and recapitulative education for plant staff and administrative

### **3. Training process in Loviisa NPP**

#### **3.1 History of radiation protection training**

Radiation protection training was begun in late 1970's when the first unit of Loviisa NPP was pressed into service. Radiation protection training was the framework of site induction training; other fields of education were deepened later. Material consisted of hand-written and -drawn overhead projector slides and it was trained by radiation protection personnel.

In 1980's, the training methods were similar to the ones in the previous decade but an examination where learning was shown after the lecture was introduced. Visualization was based upon transparencies and film slides.

1990's were the decade of relatively strong development in site induction training. In addition to radiation protection matters, more attention was paid to industrial safety and general procedures on site. The first VHS training film was introduced. Each training session was divided into radiation protection and industrial safety section. The first of these was held by radiation protection personnel and the latter by training organization which by then had concentrated on training operators.

In mid-1990's co-operation between two Finnish nuclear power companies began in site induction training. First radiation protection training video was a product of co-operation between the two power companies. Site induction training material and content was formed into consistent form at both sites.

In the beginning of the new millennium, the co-operation was enlarged to cover all nuclear power companies in Finland and Sweden. Training methods and exams were standardized as far as practicable and site induction training performed in any Finnish or Swedish nuclear power plant was approved at other sites. In Finland, co-operation in producing training videos and DVDs was continued. Means offered by digital technology has applied in visualizing e.g. radiation and contamination in training DVDs.

Within the three decades of producing nuclear energy in Finland, training processes have been modified due to changing regulations, working culture, and developing technical means. The most important milestones in regulations and in radiation protection training are presented in Figure 1.

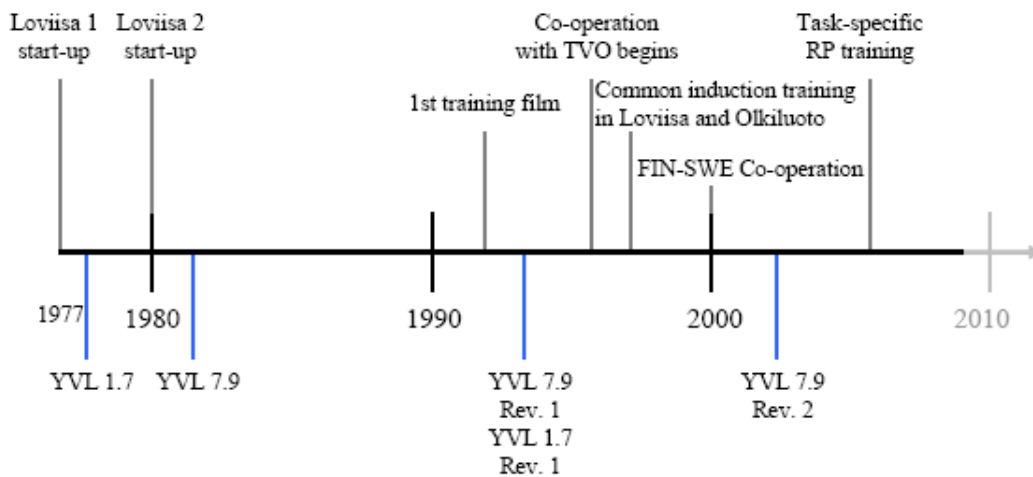


Figure 1. The most important milestones and requirements in radiation protection training.

### 3.2 Current training process in Loviisa NPP

During the last three years the site induction training has continued in its Nordic form but in addition, more and more attention has been paid in offering new employees and contractors site- and task-specific training including industrial safety training, education on plant working procedures and radiation protection. The training process for a worker arriving to Loviisa NPP is outlined in Figure 2.

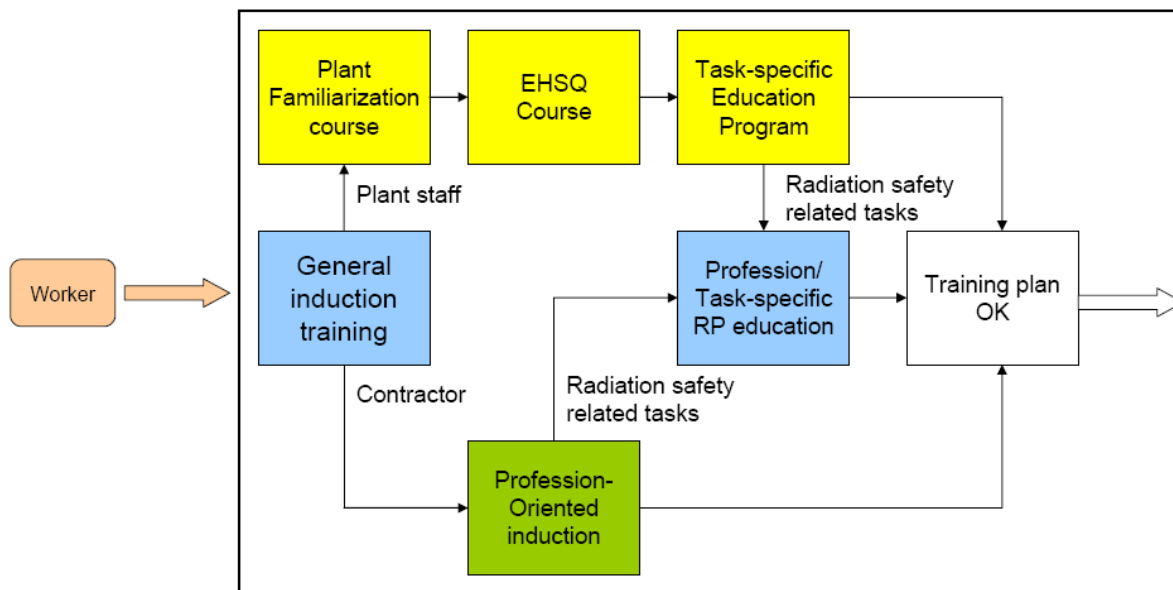


Figure 2. Training process in Loviisa NPP.

General radiation protection training is offered first in the general site induction training. The approach in this is in offering the worker a sufficient knowledge in order to operating correctly in radiologically controlled area. A basic knowledge on radiation, dose, health effects, dosimetry, means for minimizing doses and controlling radioactive contamination is given. Learning is tested with an examination in the end of the training session.

For a plant staff member, a personal training program is established in where the task-specific requirements are set for knowledge in different professional fields. Each plant member goes through plant familiarization course and EHSQ course. Both of these are roughly one-week courses. In EHSQ course, one day is reserved for radiation protection training. Viewpoint in the course is on the other hand, linking the topics learnt in General induction training more closely to the plant RP actions and on the other hand, illustrating the

most general radiation protection procedures in guided workshops. These can include measurement tasks with small radioactive sources, demonstrating different shielding materials, effect of distance etc.

If the work affects particularly to the radiation protection objectives, the person is guided to profession- or task-specific radiation protection training. The objective is to give sufficient knowledge on what radiation and contamination is, how it builds up, how does it affect to a human, how the risks can be minimized, which are the most essential radiation sources in the plant regarding to the specific occupational group and what are the correct actions if unpredictable situations occur at the workplace.

For a contractor, the training procedure is somewhat simplified compared to what it is to a plant staff member. However, the most significant elements of the EHSQ and plant familiarization course topics are discussed in profession-oriented induction lead by the foreperson or contact person of the contractor. Again, if the task has a clear relation in radiation safety objectives, the person attends to an advanced RP training with a relevant work group. Somewhat the same content is discussed as for plant staff members but the weight is more on radiological circumstances at the working area, radiation protection procedures in the specific job and actions in possible unpredictable situations.

#### 4. Future challenges and opportunities

As if the radiation protection training has taken steps forward within the last few years, there are still some challengers that will have to be surpassed. One of them is managing radiation safety as a process in designing and realizing of plant modification projects and maintenance. Figure 3 illustrates this.

Traditionally the focus in e.g. plant modifications has been in following them through cost-efficiently, maximizing the plant safety and efficiency. Focus in radiation protection training has been in offering the employees an adequate level of knowledge about radiation and radiation protection means in tasks they are expected to perform in the plant.

Good training for employees does not appear to be enough to ensure the long-term realization of radiation protection targets if the knowledge of the project management and designers is not sufficient in radiation safety issues. Good implementation of work does not correct deficiencies in design and project management: Mistakes in these cause unnecessary exposure to radiation during the installation, operation, maintenance and decommissioning of the system. As a time scale, this can mean a time period of years or even decades.

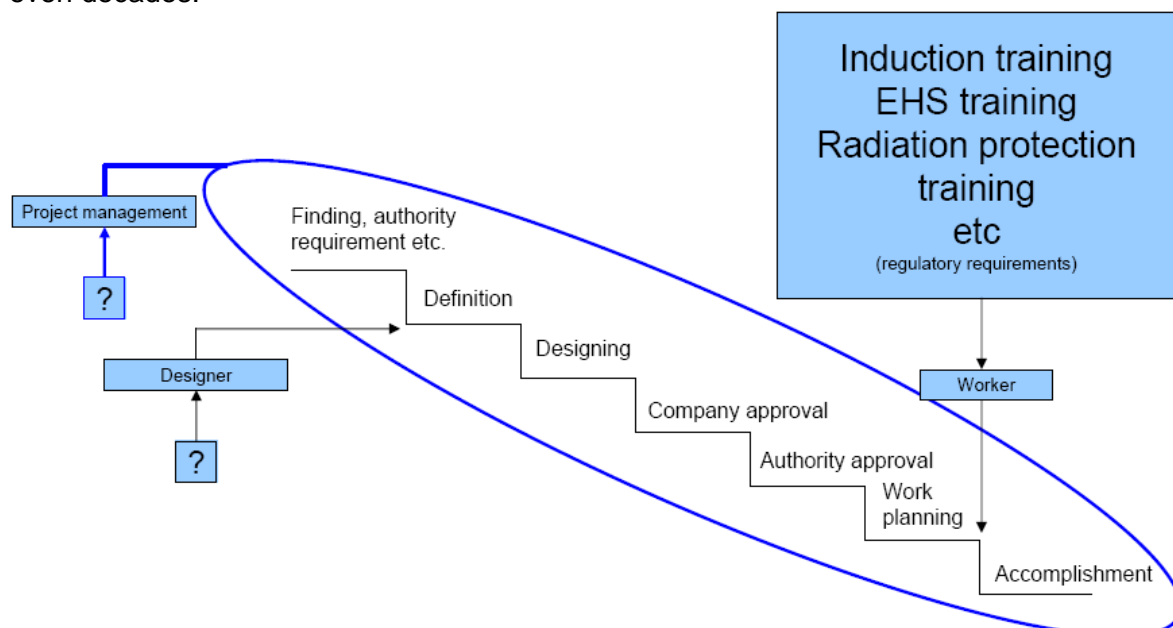


Figure 3. Radiation protection training in different project phases.



Best results in long-term radiation safety management would be achieved by concentrating in offering enough radiation safety training for people who make decisions about system layouts, modification schedules, component selection etc., naturally together with ensuring good radiation protection knowledge for plant workers and contractors. Steps have been taken into this direction in Fortum Company.

But there are still lots to be done even better in the current approach of radiation protection training in Loviisa power plant. Mock-up facilities where the practices of radiologically controlled area could be demonstrated and practiced have been discussed. This would improve the possibilities for practicing use of protective equipment and contamination monitors, decontamination methods etc.

Other field that can offer development is using modern training tools that information technology offers. Computer aided and internet-based training has not been exploited efficiently in Loviisa so far. Instructor-conducted training shall not be entirely closed down but computer aided training might be used for learning foreknowledge and on the other hand, for recapitulation training where already learned information needs to be summoned up.

Nuclear power producing companies in Finland are in the middle of change of generation. During the past and following few years, tens of per cent of plant staff will be replaced by incomers due to retirement of the most experienced workers. This will continue the pressure for strengthening the training processes in the following years.

Finland will be in a situation where choices are soon made whether new nuclear installations will be built or not. If the decision will be positive, demand for facilities and training personnel will increase. Along this there will be a need and room for further developing methods for improving the results of radiation protection training.

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# DEVELOPMENT IN TRAINING DELIVERY

# **DISTANCE TEACHING - AN EXPERIENCE FROM PETRUS (EDUCATION IN GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTES)**

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## **ABSTRACT**

One of the key objectives of the PETRUS initiative dedicated to the Education and Training in geological disposal is to investigate how distance teaching techniques can be used to deliver courses, and how the use of such technology impacts students' perception of learning.

This paper presents the outcomes of tests carried out by four PETRUS partner universities to evaluate the performances of the "face to face remote teaching methodology". Four teaching sessions have been organised with the participation of a representative sample of Master's degree students. A questionnaire filled at the end of each session allows getting perspective from students' willingness to be involved in this new learning process.

The paper also addresses problems linked with the technical quality and reliability of this technology and proposes a set of recommendations to overcome the challenges associated with shifting from the conventional pedagogical model to an online teaching and learning paradigm.

### **1. Introduction**

Renewing and reinforcing competences in the field of geological disposal of radioactive waste are the overall goals of the PETRUS group which considers the development of the academic education as a key instrument. Producing professionals that can address diverse issues related to the radioactive waste disposal requires a unified effort at European level since the very large diversity of the job profiles in this field is constrained by the very small size of the radioactive waste community which has been estimated in all less than 4000 specialists. As the demands for new recruitments are rather modest, generating the right number of graduates necessitate an innovative approach. The main idea is to develop a common educational programme at the European level by sharing the best academic resources and pedagogic materials available in each university. A cost-effective way to succeed in this challenge is to make use of the synchronous 2-way audio and visual Internet capability for broadcasting live lectures at multiple distance sites.

The works undertaken by the PETRUS group to experiment this teaching method that we call "face to face remote teaching" are presented hereafter. These works encompass technical activities for implementing the system as well as four pedagogic tests with the participation of

a representative sample of Master degree students in Geosciences which allows getting perspective on the performance and relevance of the teaching methodology.

## 2. Technical materials

Our experiment corresponds to the model defined in literature as *Virtual classroom*. Virtual classrooms have been located at UPM in Madrid (ES), TUC in Clausthal (DE), UTC in Prague (CZ) and INPL in Nancy (FR). In all of these locations the classrooms are equipped with broadcasting material that can function in synchronous way. Electronic communication between sites is enabled by high-speed transmission lines.

Prior to broadcast lectures, two high-performance commercial multipoint Room-based videoconferencing systems (i.e. Adobe Acrobat Connect Professional and Marratech) and their associated software have been tested in order to choose the best product regarding the quality of the audio and video transmitted/received signals. In particular the resolution of the compressed interactive video has been examined through the quality of the PowerPoint presentations (PPT) received at the distant classrooms. As a conclusion of these tests, the individual quality of the both products has been judged as insufficient to fulfil the whole expected performances.

To overcome this problem, the technical staffs proposed a new solution consisting in the use of two server stations, one for managing the video and audio transmission through the Adobe Acrobat system, the other one for managing the whiteboard and Power Point presentations using Marratech system. The diagram below presents the simplified connection scheme.

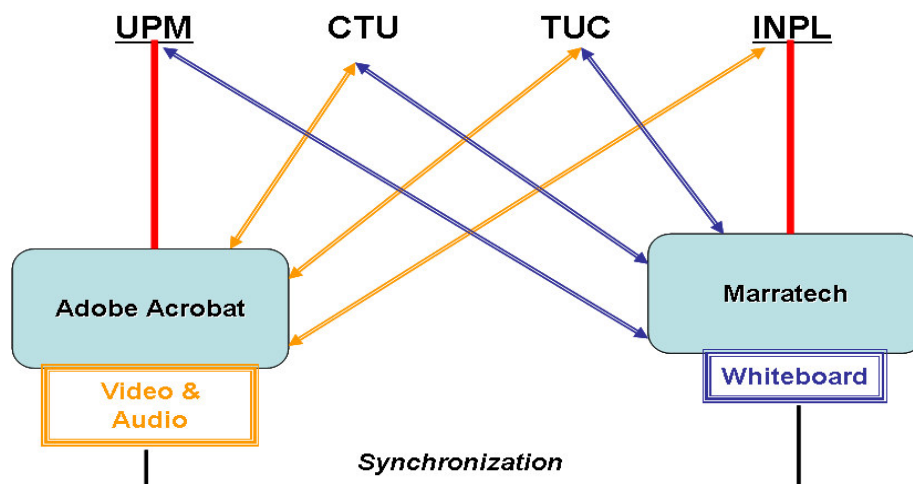


Fig.1: Simplified connection scheme

Thanks to this combination high quality sound and image have been obtained in all virtual classrooms.

At each lecture podium, the teacher has at his disposal a control panel, a computer, a document camera and a digital whiteboard. Each classroom is equipped with video cameras, television monitors, and microphones. The control panel allows the professor and/or technician to adjust the video cameras, mute or un-mute the local microphones, and alternate images from the computer, document camera and digital whiteboard. The video cameras can be adjusted to focus on different areas of the classroom or to zoom in on the professor or students. Television monitor located in the distant classroom allows viewing the professor as well as the other connected distant classrooms in incrustation mode, while the large screen enables viewing interactive images like the PPT presentations. There is also a television monitor in front of the lecture podium that enables the professor to viewing students at the distant sites. As an example, the figure below shows the INPL classroom reception equipment.

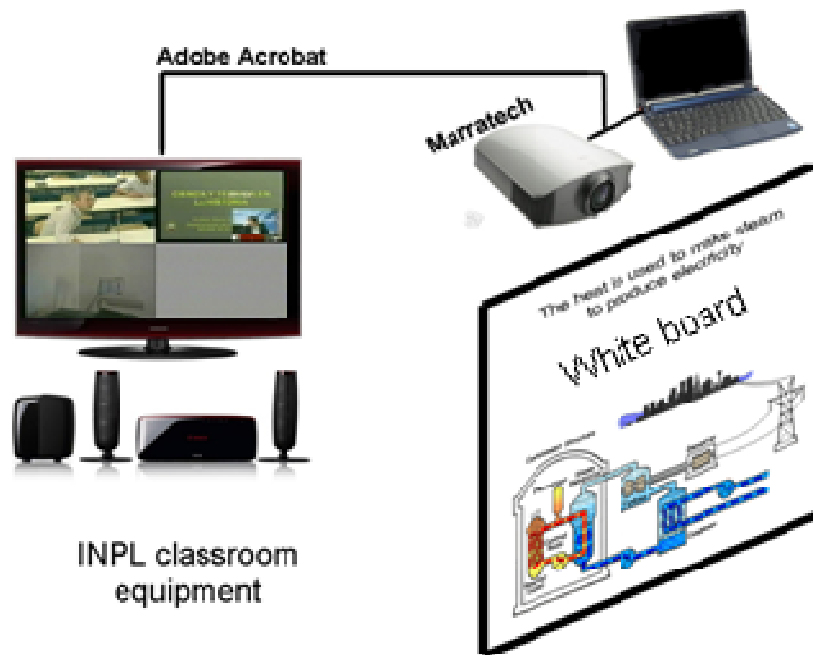


Fig.2: Reception equipment at INPL

One important issue regarding the use of such technology is the security of the data transmitted. We have adopted the end-to-end encryption ensuring security for the entire net meeting including voice, video and documents.

### 3. Pedagogical tests

Four teaching sessions have been organised; each one designed and led by one of the participant university. Lectures have been taught in English, each one lasting roughly an hour. In total, 37 students have followed the lectures. No major technical problem has been found during the transmissions except random link disconnections with one of the three distant classrooms during the first test. This problem has been solved before starting the second session by improving the material performance (i.e. increasing memory and processor speed).

Measuring how the students behave when confronted with the remote teaching methodology has been the main objective of these tests. All the students have been asked to give feedback on the lectures that they attend by filling a questionnaire. The goal was to get perspective from each individual student in his own experience rather than a collective opinion. The questionnaire containing 30 questions was distributed at the end of each session. In order to avoid any emotional or group reaction, students have been requested to complete the questionnaire at home and the results were collected two or three days after the end of the session.

Several questions required a written comment. These questions help to confirm or to correct the score ticked off by the student for an almost similar question which appears somewhere else in the questionnaire. For instance, the written comment on “What did you learn from the lecture?” restrains the weight of the “learning outcomes” score that may range from 1 (learned nothing) to 6 (learned a lot). The evaluation was completed by several individual interviews few weeks after the end of the lectures.

The results presented below are obtained from the analysis of the total number of responses received, irrespective of sessions. Answers are grouped in four categories: i) Learning outcomes ii) Efficiency of the remote teaching method iii) Quality perceived and iv) Teacher performances.

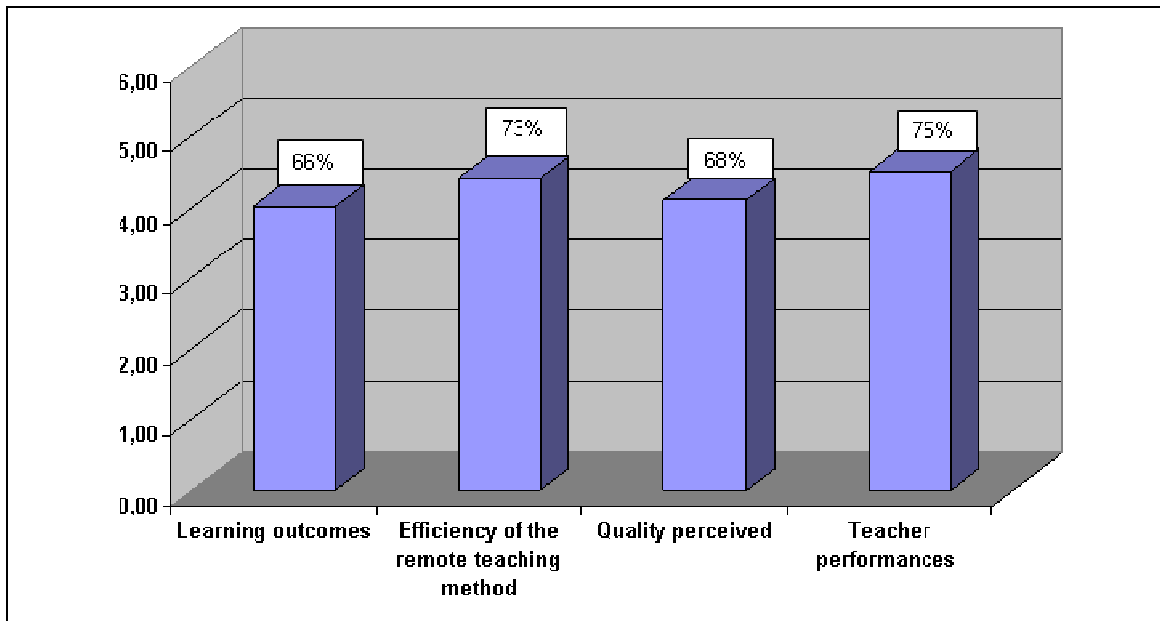


Fig.3: Statistical results of the pedagogical tests

Although global results are rather positive, the assessment has been deepened by performing more detailed analysis of the students' feedback based on the potential difficulties reported in the literature relative to virtual classrooms.

#### 4. Detailed analysis

Problems encountered by distant teaching users have been reported by several authors [1, 2, 3]. However, most of the difficulties pointed out by these authors, notably concerning the following items, have not been observed during our tests:

- **Lack of students' willingness to participate in class.** This difficulty is often reported as a consequence of the depersonalization of the distant professor and the fact that students can not see the teachers in "live." In our case the novelty of the concept was probably the reason for the high degree of students' participation. Indeed they have not previous experience with the remote instruction and therefore this new method has inspired some curiosity in them. On the other hand the involvement was based on the voluntary participation thus only motivated students have followed the tests.
- **Language barrier.** Within Europe, there is growing evidence that English has become the biggest scientific lingua franca. However, no matter how much students are competent in English, there is always a certain level of difficulties associated with the use of no native language in the learning process. In our case, English was not the native language, neither of students, nor of professors. Paradoxically, this situation has better focused the students' attention since they had to make additional effort for following the lecture and understanding different English accents.
- **Students' anxieties** when they have to interact with the distance professor and when they see themselves projected onto a large screen. In our case this was to a great extent mitigated by the presence of local professors (and technical staff) in the distant classrooms:

Despite of the above differences with the cases reported in the literature, the analysis of the students' feedback has drawn our attention to several points that need serious improvement; some of them include modifying teaching strategies and revising the content and the design of the lectures.

- Compared with the "standard" teaching method, the amount and quality of interactions between the professor and (distant) students but also among different

virtual class rooms must be increased in order to strengthen the collaborative learning environment.

- Advance preparation of the technical materials (i.e. establishment and tests of the electronic connections) is a matter of great importance. Impoverishment of the image quality during a lecture or even unexpected delay in audio transmission would be a source of frustration for both teacher and students.
- Students must receive a paper copy of the lectures (texts and power point presentations) before the delivery of the courses. By providing pedagogic materials to students in advance, the students' fear of missing information is alleviated. This is particularly important when the lectures are not taught in the students' working language.
- Finally, the most important difficulty concerns students' attention spans and their concentration for long period of time. Indeed, several surveys (e.g. [4]) have shown a drastic drop of the "attention curve", typically after 15 minutes, when an individual watches a screen passively (fig. 4). Thereby, it is important to avoid too long monolithic lectures and manage periodic short discussion breaks.

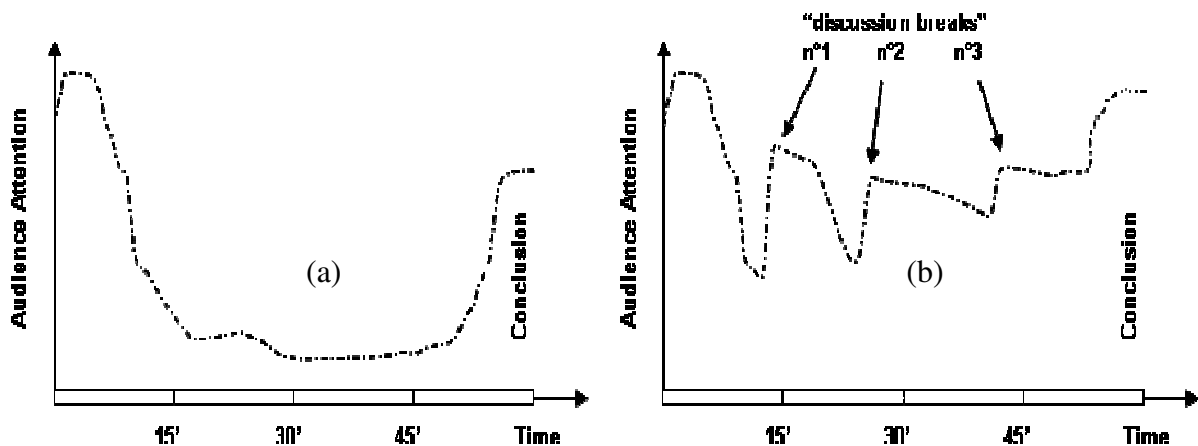


Fig.4 Typical attention of the audience pays to a lecture: a) monolithic presentation b) improvement by introducing discussion breaks.

## 5. Conclusion

The "face to face remote teaching" tests conducted in the frame of the PETRUS initiative with the involvement of four European universities have shown rather positive results related to the pedagogical process that encourages further developments and improvements. Technical problems have been easily mastered resulting in high quality audio and video transmission better than initially expected. The analysis of the students' feedback allowed collecting several elements for better fitting the teaching practice to the virtual classroom requirements.

However, this experience has also put to the fore an unforeseen difficulty at the organisation level. Indeed, finding common dates for running the tests have been by far the major obstacle since internal organisation of the academic year (teaching plans and timeframes, period of holidays ...) are very different in the four universities. This could be a real cause of concern when the organisation of common courses encompassing several tens of lectures is targeted.

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### **Acknowledgement**

The authors would like to express their gratitude to the European Commission for its support to the PETRUS project.



# DEVELOPMENT OF A $\gamma$ -RAY SPECTROSCOPY SYSTEM USING CsI(Tl)-PIN DIODE DETECTOR FOR EDUCATIONAL PURPOSES

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## ABSTRACT

At the Korean Atomic Energy Research Institute (KAERI), a prototype  $\gamma$ -ray spectroscopy system was developed and fabricated that is rugged, compact, reliable and relatively inexpensive. Laboratory evaluation shows its resolution and efficiency are good, and it is safe to operate and easy to use, making it quite suitable for educational purposes at secondary-school level and beyond. The system consists of a CsI(Tl)-PIN diode detector, integrated electronics, and a multi-channel-analyzer. The capability of the system was checked using Cs-137 and Co-60 sources. Resolutions are 7.9% and 4.9%, respectively, for the 660- and 1,332- keV lines, and the efficiency is sufficient to accumulate a quality spectrum in a few minutes by using weak, encapsulated commercial sources. The results obtained from the  $\gamma$ -ray spectroscopy system show this system is eminently suitable for educational purposes.

## 1. Introduction

Radiation is all around us, and its applications in our daily lives are common and wide spread. Yet public awareness of this fact is lacking, especially to students at elementary-level and up. A simple demonstration of radiation to the youngsters would go a long way to promoting wider awareness.

Better perception and understanding of nuclear radiation by the public is even more necessary now than before, especially with wide spread use of radiation in such practical applications as medicine, pharmaceutical, appliances, etc.

Among the nuclear radiation, perhaps the public is most familiar with  $\gamma$ -ray (and x-ray), and hands-on experiments involving this form of radiation at schools, elementary and up, would be an effective way to broaden the public awareness. Quality  $\gamma$ -ray detection systems are not cheap nor simple and safe to operate by a layman; they are generally fragile and require high voltage or cooling. A simpler, cheaper, and safer  $\gamma$ -ray detector would be a boon to disseminating nuclear knowledge.

We at KAERI developed a  $\gamma$ -ray spectroscopy system that can be readily deployed for the above mentioned demonstration. R. M. Anjos, et al,[1] earlier pointed out the role a simple  $\gamma$ -ray detector can play in education.

## 2. Materials and methods

### 2.1. CsI(Tl)/PIN diode detector[2]

CsI(Tl)-PIN diode detectors were fabricated for the application in various radiation fields by Kim H.S. et al.[2]. The density of the CsI(Tl) scintillator is  $4.51\text{g/cm}^3$  and hardness is 2Mohs. Although the crystal is slightly hygroscopic, no special packaging is necessary. A CsI(Tl) ingot was cut into  $10\text{ (W)} \times 10\text{ (L)} \times 20\text{ (H)}\text{ mm}^3$  using a diamond string saw and optically coupled to the same size,  $10\text{mm}^2$ , PIN diode (Hamamatsu 3590-08). The maximum emission spectrum of CsI(Tl) scintillator, 550nm, overlaps well with Si absorption spectrum resulting in high quantum efficiency. Optical grease and PTFE tapes were used to assemble the CsI(Tl) scintillator. Fig. 1 shows the detectors.

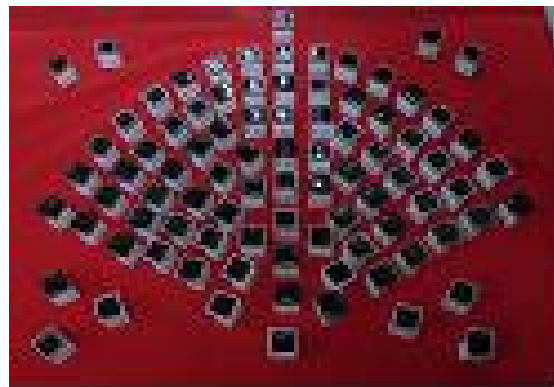


Fig. 1. CsI(Tl)/PIN diode detectors

### 2.2. Design of the $\gamma$ -ray detector system

Fig. 2 shows the components of the system. Owing to the use of PIN diode, rather than photo tube, we were able to mount the whole system in a small metal chassis.

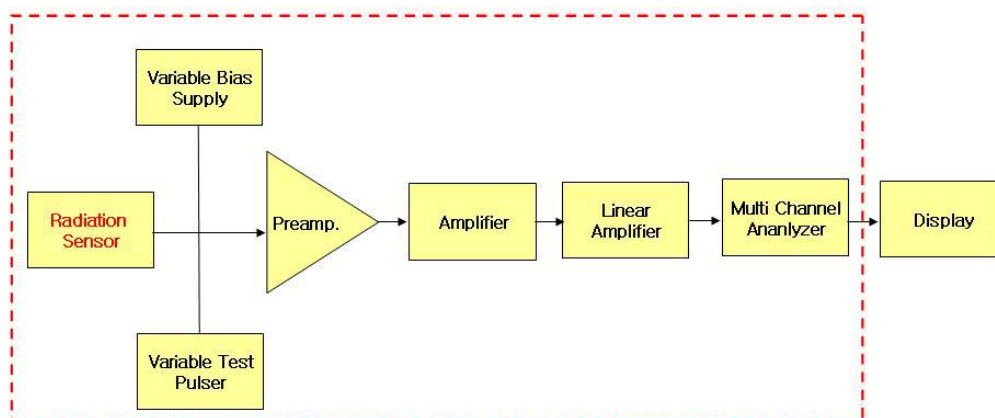


Fig. 2. Component layout of the spectroscopy system

### 2.3. Fabrication of the prototype of the $\gamma$ -ray spectroscopy system

Fig 3 shows a working prototype of the system consisting of a CsI(Tl)-PIN diode detector, integrated electronics, and a multi-channel-analyzer. The detector is rugged and quite compact, as is the rest. The chassis lid opens easily, and this makes accessibility to the components quite simple.

A Cremat CR-110 and CR-200 hybrid chips were used as preamplifier and shaping amplifier and an Amptek ADMCA is used as MCA. Fig. 3(a) shows the chassis with the lid closed and open. The diagram of of the pulse amplification chain is displayed on the chassis lid for teaching.



Fig. 3. Prototype of the spectroscopy system with the lid open and closed

### 3. Results and Discussion

The energy spectra were measured using Cs-137 and Co-60 sources. They are shown in Fig 4. The energy resolutions for 660 and 1,330keV were 7.9% and 4.9%, respectively. The noise contribution to the resolution is considerable, and as a result, the relative resolution is worse for the lower energy peak. The efficiencies are sufficient to accumulate a quality spectrum in a few minutes using weak, encapsulated commercial sources.  $\gamma$ -ray energy was calibrated using three lines from these sources.

A calibrated detector system was used to illustrate how characteristic  $\gamma$  rays are used to identify specific isotopes to the science teachers at the training courses, and then the technique was used to identify materials, mostly very heavy metals, probably from the surface glaze, present in a piece of pottery to the delight of the audience. Fig. 5 shows the spectrum of a pottery piece measured by the developed  $\gamma$  spectroscopy system. The radiation from the pottery sample was counted for 20 minutes. Apparently, there are significant peaks of the heavy metals in the pottery piece in the spectrum.

The ruggedness, simplicity and safety in operation, inexpensiveness, and convenient portability makes the present spectrometer suitable for such routine measurements as i) ambient background radiation observation, ii) monitoring the intensity of selected radioactivity iii)  $\gamma$ -ray attenuation in absorbers and similar  $\gamma$ -ray singles experiments. The new system can replace Geiger-Muller counters in many traditional basic experiments for example. With the pulse-height selectivity the new system brings, these experiments can be done not only more easily and safely but also with more detail and provide higher quality data.

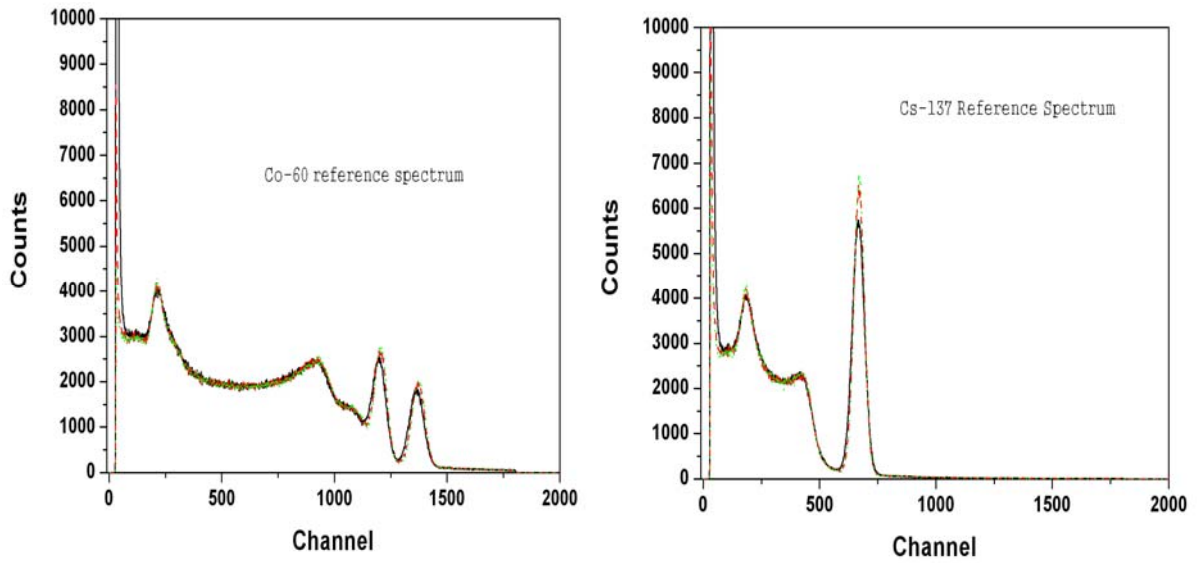


Fig. 4 Co-60 spectrum (right), Cs-137 spectrum (left)

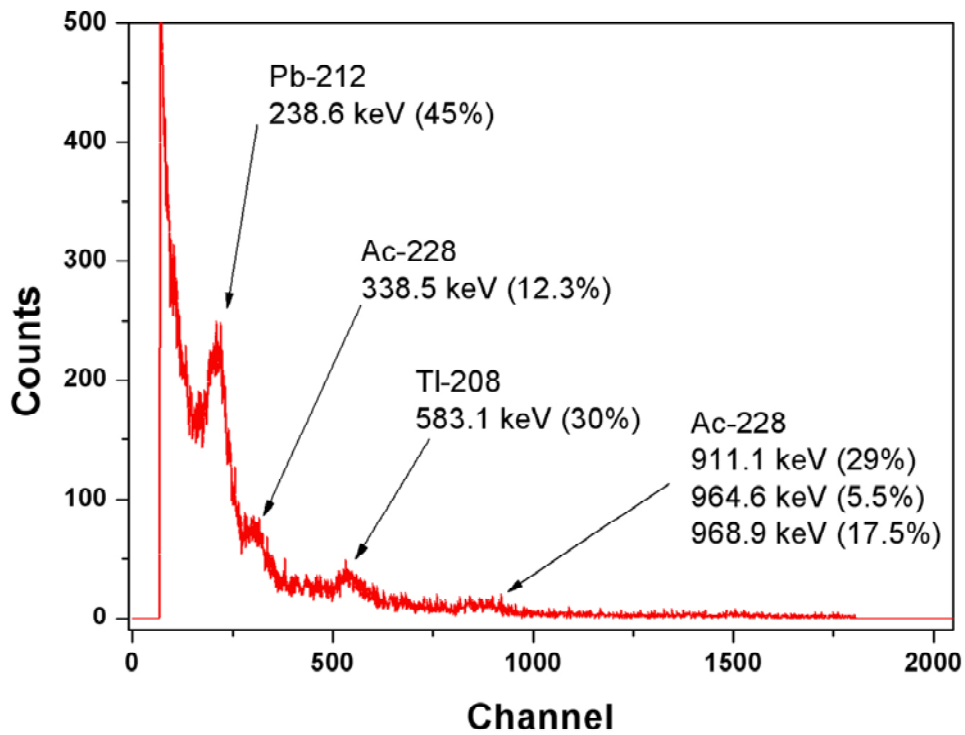


Fig. 5. Spectrum of a pottery piece

#### **4. Conclusions**

The  $\gamma$ -ray spectroscopy system that is rugged, compact, reliable, and relatively inexpensive has been developed, fabricated and tested.

Measured resolution is 4.9% at 1,332 keV, 7.9% at 660 keV, respectively. The efficiency is sufficient to accumulate quality spectrum in few minutes using weak, encapsulated sources. This results measured from the prototype show that its resolution and efficiency are good, making it quite suitable for educational purposes at secondary school level and beyond. The  $\gamma$ -ray spectrum measurements using this system may be very useful at school experiments, especially the simple application to the pottery.

We expect to manufacture a detector system based on this prototype with high hopes that they would be widely adopted for education and even for more sophisticated and higher level investigations.

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# **FIFTY-YEAR EXPERIENCE OF NUCLEAR&RADIATION EDUCATION AT NuTEC/JAEA - MAINLY ON RADIATION BASIC COURSE AND NEW DISTANCE LEARNING SYSTEM -**

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## **ABSTRACT**

Human resources development (HRD) in the nuclear and radiation field is one of the main missions of Japan Atomic Energy Agency (JAEA). Nuclear Education and Technology Center (NuTEC) of JAEA has been playing a main role for HRD through 50 years of its history in Japan. NuTEC has developed and conducted a variety of training courses to meet the domestic and international needs to educate useful and competent human resources in the nuclear and radiation field. Among these training courses, Radiation Basic Course was inaugurated in 1958 as the first and principal course at NuTEC, and is still continued, sending more than 8,000 human resources, many of whom became experts and kept influential in the nuclear/radiation field of Japan. This training course has been putting emphasis on experiments, in addition to lectures, using radioisotopes and many kinds of advanced nuclear/radiation apparatuses and facilities. Recently, we have started a new distance learning system named Japan Nuclear Education Network (JNEN) for the nuclear/radiation education, connecting several Japanese universities through multi-directional, simultaneous communication Internet lines. The above two topics are mainly discussed, along with overall introduction of the education and trainings having been conducted at NuTEC/JAEA, referring also to its future plans.

## **1. Introduction**

### **1.1 History of JAEA and NuTEC**

Japan Atomic Energy Agency (JAEA) was established in 2005 by integrating two precedent organizations, that is; Japan Atomic Energy Research Institute (JAERI), and Japan Nuclear Cycle Development Institute (JNC). JAERI was founded in 1956 as a center for basic research on nuclear science and technology. JNC also dates back to 1956 for its first precedent organization, Nuclear Fuel Corporation, which reorganized in 1967 into Power Reactor and Nuclear Fuel Development Corporation (PNC), then into JNC in 1998. JAEA has a variety of R&D subjects such as basic physics, chemistry and biology, utilization of radioisotopes and radiations, nuclear safety, nuclear fuel cycle, nuclear fusion, neutron science, accelerator science and rad-waste management.

Nuclear Education and Technology Center (NuTEC) was originally founded in Tokyo as the Radioisotope School (RS) in 1957. Then in 1958 Nuclear Reactor Training Center (NRTC) was independently founded at Tokai site for the education mainly for nuclear reactor operators. The two centers were organisationally unified in 1975 though operated separately at the two sites. In 2002 RS moved to Tokai site, then in 2005, together with the establishment of JAEA, the two centers were unified into NuTEC.

The Radiation Basic Course was held as the first training course of NuTEC in 1958. It was originally a 4-week course with a maximum capacity of 32 participants, held 7-8 times a year in the beginning years, conducted with eminent teachers and instructors in the nuclear field of Japan at that time. In 1958 the first international training course on radioisotopes and

radiations was held in cooperation with UNESCO, followed by another international training course in cooperation with IAEA in 1959..

## 1.2 HRD activities at NuTEC

NuTEC/JAEA has been playing a pivotal role in Japan for human resources development (HRD) in the nuclear and radiation field through 50 years of its history and still today. In its history, NuTEC has developed and conducted a variety of training courses to meet the domestic and international requirements to educate useful and competent human resources in the nuclear and radiation field. The total number of the graduates from these training courses has increased gradually through its history as shown in Fig.1, up to over 100,000 domestic trainees until today, in addition to about 3000 international trainees.

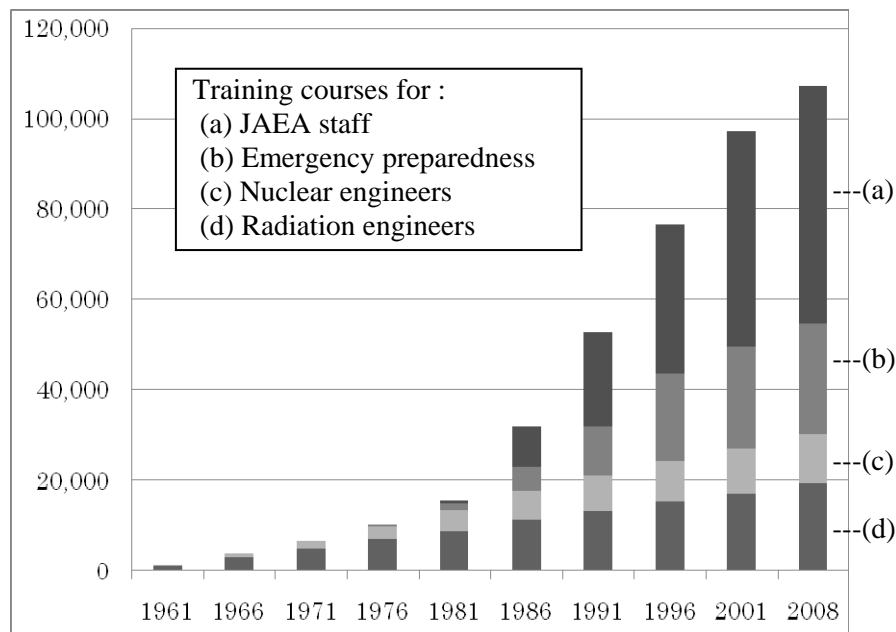


Fig. 1: Increase of the total number of trainees in the NuTEC domestic training courses

There have been many kinds of training courses, some of which still exists such as the Radiation Basic Course, while some of which were terminated such as, for example, Radiation Chemistry Course or Autoradiography Course.

Currently the HRD activity at NuTEC/JAEA can be classified into three categories, that is; 1) education and training for domestic nuclear engineers and scientists, 2) collaboration with universities, and 3) international cooperation.

The training courses in the category 1) are listed in Table 1. We also have training courses for JAEA staff in addition to the courses listed there. The Radiation Basic Course is the first one conducted at NuTEC (RS) in 1958. Except for several courses which are given only by lectures, most of the training courses of NuTEC put emphasis on the laboratory experiments and exercises using well-equipped and advanced facilities of JAEA, including research reactors and accelerators such as JRR-4. Many courses include in the curricula technical visits to advanced large facilities of JAEA such as TANDEM, JT-60 and J-PARC. A variety of subjects are possible in the training curricula because of holding a variety of experienced and leading-edge researchers in the nuclear and radiation fields in JAEA.

Table 1: Training courses at NuTEC for domestic nuclear engineers and scientists

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**Training Courses for Radioisotope and Radiation Engineers**

1. Radiation Basic Course (15 days, once/year)
2. Radiation Safety Management Course (14 days, once/year)
3. Radiation Protection Basic Course (4 weeks, once/year)
4. 1<sup>st</sup> Class Radiation Protection Supervisor Course (5 days, 8 times/year)
5. 3<sup>rd</sup> Class Radiation Protection Supervisor Course (2 days, 3 times/year), since JFY. 2006
6. 1<sup>st</sup> Class Working Environment Expert Course (3 days, 2 times/year), until JFY. 2008

**Training Courses for Nuclear Reactor Engineers**

1. Nuclear Beginners Course (4 weeks, once/year)
  2. Reactor Engineering Course (6 months, once/year)
  3. Introductory Neutron Experiment Course (3 days, once/year)
- 

In the category 2), we cooperate in the nuclear and radiation education with domestic universities based on the collaboration agreements. Especially, NuTEC/JAEA has a close cooperation with the nuclear professional school of the University of Tokyo, which is located close to JAEA Tokai Research Center. As of 2009, JAEA, through NuTEC, has collaboration agreements with 17 universities, mainly of graduate school. In the fiscal year 2009 JAEA despatched totally 53 visiting professors to the universities/college and accepted 16 students allowing them to conduct their research works using JAEA facilities. NuTEC/JAEA has also supported universities in the nuclear/radiation education based on the Nuclear Human Resources Development Program sponsored by MEXT and METI (the Ministry of Education, Culture, Sports, Science and Technology, and the Ministry of Economy, Trade and Industry) of the Japanese government.

As the international cooperation, in the category 3), there are such activities as; training for Asian countries, international cooperation under the scheme of FNCA (Forum for Nuclear Cooperation in Asia) and IAEA, and cooperation with ENEN (European Nuclear Education Network) and CEA/INSTN.

## **2. Radiation Basic Course**

Since 1958, Radiation Basic Course has been continuously conducted over a half century for the nuclear/radiation scientists and engineers to offer basic knowledge and skills in handling and studying radioisotopes and radiations safely and effectively. This course has reached the 283<sup>rd</sup> in 2009, sending about 8,300 graduates so far. Although we have Radiation Protection Basic Course as listed in Table 1, the Radiation Basic Course has also played a role to provide nuclear/radiation engineers and scientists with safe and protective handling skills for radiation and radioisotopes through its long history since the dawn of nuclear age of Japan.

As listed in Table 2, the curriculum of this course consists of lectures, exercises, experiments and others. The lectures effectively and concisely cover the basic fields of radiation, with some application subjects given by the specialists of these fields. It is noted that the exercises and experiments occupy more than half of the curriculum. This is because we believe and have tried to offer the opportunity to have direct experience of handling actual radioisotopes and of operating basic and/or advanced apparatuses such as gamma-ray spectrometers and liquid scintillation counters.

This training course provides the trainees with sufficient knowledge and skills to take the Radiation Protection Supervisor licence (1<sup>st</sup> class) of Japan.

Among all the training courses at NuTEC/JAEA, the Radiation Basic Course has continuously provided the trainee with useful and valuable opportunity to learn the basics of radiation and



radioisotope. We will further continue this training course, with some necessary modifications to meet the new demands of the future.

Table 2: Curriculum of the radiation basic course

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<b>Lecture (totally 29 units)</b>
1. Nuclear Physics (3 units)
2. Interaction of Radiation with Matter (2)
3. Radiochemistry (3)
4. Radiation Chemistry (2)
5. Radiation Biology (3)
6. Radiation Measurement (3)
7. Measurement of Radiation Dose (1)
8. Gamma-ray Spectrometry (1)
9. Liquid Scintillation Counting (1)
10. Safe Handling of Radiation and Radioisotopes (1)
11. Control of Radiation Exposure (2)
12. Radiation Monitoring (1)
13. Decontamination and Waste Management (1)
14. Application of Radioisotope and Radiation to Agriculture and Biology (1)
15. Application of Radioisotope and Radiation to Medicine (1)
16. Application of Radioisotope and Radiation to Industry and Environmental Study (1)
17. Radiation Protection Law (2)
<b>Exercise (totally 7 units)</b>
1. Physics (1)
2. Chemistry (1)
3. Biology (1)
4. Law (1)
5. Radiation Monitoring Techniques (2)
6. General (1)
<b>Experiment (totally 32 units)</b>
1. Guidance of Safe Handling of Unsealed Radioisotopes (1)
2. Radiation Dose Measurement (3)
3. Gamma-ray Spectrometry (5)
4. Liquid Scintillation Counting (5)
5. Compton Scattering (3)
6. Milking with $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ Generator (5)
7. Neutron Activation Analysis (5)
8. Radiation Monitoring (5)
<b>Others (totally 4 units)</b>
1. Orientation (2)
2. Technical Tour (2)

---

(70 min/unit)

### 3. Japan Nuclear Education Network (JNEN)

JAEA has collaboration agreements with domestic universities, totally with 17 universities and colleges in 2009. These are basically the bilateral cooperation between a university/college and JAEA.

In addition to the above-mentioned agreements, JAEA and three universities launched a new multi-directional distance learning system for the nuclear/radiation education in 2007, named the Japan Nuclear Education Network (JNEN) [2]. The concept of JNEN is a multi-directional education system connecting the remote sites of the participating universities and JAEA through Internet. Many kinds of lectures are available through the system at real time. There

are two semesters for JNEN. These two semesters are for 1); radiation-related subjects and for 2); rad-waste management subjects, consisting of 15 lectures each. JNEN was expanded to include 6 universities in 2009, that is; Tokyo Institute of Technology, Fukui University, Kanazawa University, Okayama University, Ibaraki University, and Osaka University, in addition to JAEA. The conceptual structure of JNEN is illustrated in Fig. 2.

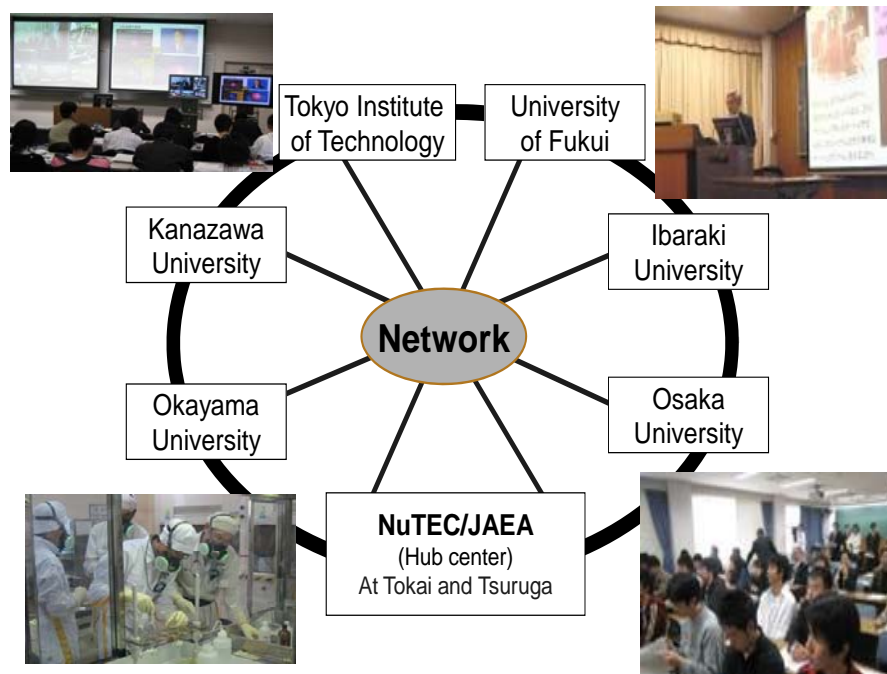


Fig. 2: Illustration of JNEN system

Through JNEN, students of a university can take lectures of the professors belonging to other universities. The professors and students of various universities can make Q&A and discussions on the topic of interest through wide monitors multi-directionally on the real time. The students can also review the lessons by the e-learning system after the lectures.

In addition to the lectures, some experimental courses, for one week or less, are organized in the summer and/or winter vacation season on the handling of nuclear materials, radioisotopes and glove boxes, using JAEA facilities such as Nuclear Fuel Cycle Engineering Laboratories.

We plan to expand this network to some more universities of Japan, as well as with foreign universities, possibly in collaboration with ENEN, in the future.

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# EDUCATION AND TRAINING NETWORKS

# ENETRAP II 7FP: DEVELOPMENT OF E&T SCHEMES FOR RADIATION PROTECTION EXPERTS AND OFFICERS

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## ABSTRACT

This paper focuses on the current 7<sup>th</sup> framework programme ENETRAP II, which aims at developing reference standards and good practices for education and training programmes for radiation protection experts and officers, reflecting the needs of these professionals in all sectors where ionising radiation is applied. The introduction of a radiation protection training passport as a mean to facilitate efficient and transparent European mutual recognition of these professionals is another ultimate deliverable of this project. It is envisaged that the outcome of ENETRAP II will be instrumental for the cooperation between regulators, training providers and customers (nuclear industry, research, non-nuclear industry, etc.) in reaching harmonisation of the requirements for, and the education and training of, radiation protection experts and officers within Europe, and will stimulate building competence and career development in radiation protection to meet the demands of the future.

## 1. Introduction

Radiation protection (RP) is a major challenge in the industrial applications of ionising radiation, both nuclear and non-nuclear, as well as in other areas such as the medical and research area. As is the case with all nuclear expertise, there is a trend of a decreasing number of experts in radiation protection due to various reasons. On the other hand, current activities in the nuclear domain are expanding: the nuclear industry faces a so-called "renaissance", high-tech medical examinations based on ionising radiation are increasingly used, and research and non-nuclear industry also make use of a vast number of applications of radioactivity.

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

Today's challenge involves measures to make the work in radiation protection more attractive for young people and to provide attractive career opportunities, and the support of young students and professionals in their need to gain and maintain high level RP knowledge. This can be reached by the development and implementation of a high-quality European standard for initial education and continuous professional development for radiation protection experts (RPEs) and radiation protection officers (RPOs), and a methodology for mutual recognition of

these professionals on the basis of available EU instruments, such as the European qualification framework (EQF) and/or the directive 2005/36/EC.

## **2. State of the art**

### **2.1 European Directive and first answers to training needs**

For European Union Member States, requirements related to radiation protection training are described in Council Directive "96/29/EURATOM" of 13 May 1996. It lays down basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation (OJ L-159 of 29/06/96). Communication 98/C 133/03 (OJ L-133 of 30/04/98) from the Commission concerning the implementation of the above Council Directive 96/29/EURATOM describes a European syllabus for the training requirements for the recognition of "qualified experts" in radiation protection.

A revision of Council Directive 96/29/EURATOM is currently being prepared. The results of the 6FP ENETRAP project contribute, via the EUTERP Platform, to the advice submitted to the European Commission and the Group of Experts according to art 31 of the EURATOM Treaty, who are preparing the revision of this Directive. The outcome of the project may also lead to a new guidance document to replace Communication 98/C 133/03.

At national level, in answer to the European legal requirements of the 96/29/EURATOM Council Directive, almost all European countries provide in an E&T programme in RP. Unfortunately, nowadays, a wide variety in national approaches is observed and used terminologies are very different. This situation is most unfavourable since it does not facilitate the development of a common European RP and safety culture, and it worsens the mobility of RP professionals throughout Europe.

### **2.2 ENETRAP 6FP**

First approaches to harmonisation of E&T activities in Europe were undertaken in the 6<sup>th</sup> framework project ENETRAP [1]. This project was a coordination action under support of the EC, contract number FI6O-516529. It started in April 2005 and was finalised in December 2007.

Within the framework of ENETRAP, a detailed study of the current European E&T programmes, regulations and skill recognitions was made. From the analysis of the results received from almost all European Member States, a proposal for harmonised programmes for both education and training in RP was put forward.

A universities Consortium was set up that developed a European Master in radiological protection [2], which is currently running. The EMRP started in September 2008. The four partners in this project are:

- University Joseph Fourier, Grenoble, France (EMRP project leader);
- North Highland College, Thurso, Scotland – UK;
- Czech Technical University, Prague, Czech Republic;
- Institut National des Sciences et Techniques Nucléaires, Gif-sur-Yvette, France.

Next to this, a training scheme was put forward. Based on a modular approach, it puts forward a general common basis, and a series of specialised modules on occupational radiation protection in different installations where ionising radiation is applied (nuclear power plants and fuel cycle industry, the medical sector, non-nuclear industry, research laboratories, waste and disposal sites, etc...). The "theoretical" programme is extended by a period of on-the-job training (OJT) and the possibility to follow (parts of) several modules via e-learning is implemented.

The results of the ENETRAP 6FP project were transferred to the EUTERP Platform. The ENETRAP 6FP Consortium also contacted expert networks who are willing to "foster" the chapters dealing with their specific competences, such as the ALARA network and EURADOS.

### **2.3 EUTERP**

The results of ENETRAP 6FP was submitted to the EUTERP Platform [3]. This Platform addresses all stakeholders of RP training and has amongst its member's representatives from regulatory bodies, training providers, research centres, medical physicists, professional societies, international organisations and international projects. It started in 2006 and was supported by EC DG TREN for three years. One of the tasks of this Platform is to advise on a revision of the definition of the qualified expert. Another task is to seek international agreement on the requirements and qualifications for the RPE and RPO, in order to remove barriers for mobility of these professionals within the European Union. Currently, the coordinator NRG (The Netherlands) is taking actions to transform the EUTERP Platform into a legal entity, in order to achieve a sustainable network.

### **3. ENETRAP II 7FP**

Determined to build further on the achievements of 6 FP ENETRAP, most ENETRAP partners participate in 7FP ENETRAP II [4]. The overall objective of this project is to develop and implement European high-quality "reference standards" and good practices for E&T in RP, specifically with respect to the RPE and the RPO. These "standards" will reflect the needs of the RPE and the RPO in all sectors where ionising radiation is applied (nuclear industry, medical sector, research, non-nuclear industry). The introduction of a radiation protection training passport as a mean to facilitate efficient and transparent European mutual recognition is another ultimate deliverable of this project.

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

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

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

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

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

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

Specific objectives of the ENETRAP II project are to:

- develop the European radiation protection training scheme (ERPTS) for RPE training;
- develop a European reference standard for RPO training;
- develop and apply a mechanism for the evaluation of training material, courses and providers;
- establish a recognised and sustainable ERPTS "quality label" for training events;
- create a database of training events and training providers (including OJT) conforming to the agreed ERPTS;
- bring together national initiatives to attract early-stage radiation protection researchers on a European level;
- develop some course material examples, including modern tools such as e-learning;
- develop a system for monitoring the effectiveness of the ERPTS;
- organise pilot sessions of specific modules of the ERPTS and monitor the effectiveness according to the developed system;
- development of a European passport for CPD in RP.

A steering committee, consisting of representatives of all ENETRAP II partners, will be established to oversee and coordinate the progress of the project. The steering committee will set up and report to an advisory board, which at its turn will also give feed back and guidance to the steering committee. The composition of the advisory board should be such that all relevant stakeholders, with respect to the stated aim of the project, are represented, i.e. regulatory authorities, international organisations, professional organisations, training providers, research institutes, end-users from nuclear industry, medicine and non-nuclear industry, etc. The advisory board should advise about the best balance between supply and needs of training, thereby ensuring stable feedback mechanisms to the steering committee. This advisory board should also prepare the terms of reference for a top-level steering task group mandated by the high authorities of Europe with the objective of defining an overall policy and strategy.

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

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

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

All these activities are carried out in the work packages defined here under.

- WP1 Co-ordination of the project
- WP2 Define requirements and methodology for recognition of RPEs

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

ENETRAP II 7FP will be realised by 12 partners, each having relevant experience in policy support regarding E&T projects on radiation protection. It concerns SCK•CEN (Belgium), CEA-INSTN (France), Forschungszentrum Karlsruhe, Centre for Advanced Technological and Environmental Training FZK-FTU (Germany), Federal Office for Radiation Protection BfS (Germany), the Italian National Agency for New Technology, Energy and Environment ENEA (Italy), NRG (The Netherlands), CIEMAT (Spain), Health Protection Agency HPA (UK), the ENEN Association (France), the Nuclear and Technological Institute ITN (Portugal), the Budapest University of Technology and Economics BME (Hungary), and University Politehnica of Bucharest (Romania). Staff members of the different partners who play a key role in this project, have also proven to be highly involved with E&T matters, on national and international levels, and are member of several E&T networks. Connections to international organisations such as the IAEA, EUTERP, IRPA, etc are guaranteed. The presence of the ENEN Association within the Consortium, taking the role of work package leader of the important WP9, ensures the close collaboration of the different European networks, ultimately facilitating a European network dealing with both education and training activities in the nuclear field such as nuclear engineering, radiation protection and other nuclear areas. With the implementation of the advisory board, where amongst others EUTERP will be represented, the major part of all future employers, regulators and training providers is connected to this project.

#### **4. Conclusions**

Based on the outcome of the ENETRAP 6FP, ENETRAP II 7 FP aims at contributing further to the European harmonisation of E&T of radiation protection professionals. With the introduction of a modular European reference training scheme and European recognition methodologies, key issues will be delivered for the development and implementation of mutual recognition system of RPEs. In this way ENETRAP II meets the EC requirements to rely on the principles of modularity of courses and common qualification criteria, a common mutual recognition system, and the facilitation of teacher, student and worker mobility across the EU. ENETRAP II will structure research on radiation protection training capacity in all sectors where ionising radiation is applied. End users and specifically regulatory authorities are represented through foreseen participation in the advisory board which will advise about the best balance between supply and needs, thereby ensuring stable feed back mechanisms. The tasks defined in this project maximise the transfer of high-level radiation protection knowledge and technology, addressing young as well as experienced radiation protection workers. In this context, the proposed project will thus contribute to meeting the objectives of the EURATOM 2008 work programme.

#### **5. References**



- [1] [www.sckcen.be/enetrapp](http://www.sckcen.be/enetrapp)
- [2] L. Musilek, J. Balosso, P. Livolsi and M. Mennie, The European Master's Degree in Radiation Protection (EMRP), proceedings of the SEFI2008 conference, <http://www-ice.upc.es/butlleti2/juliol2009/sefi/>, ISBN : 978-2-87352-001-4, July 2009
- [3] [www.euterp.eu](http://www.euterp.eu)
- [4] [www.sckcen.be/enetrapp2](http://www.sckcen.be/enetrapp2)

## **Acknowledgement**

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# THE ROLE OF EFOMP IN THE EDUCATION AND TRAINING OF MEDICAL PHYSICISTS AND HEALTH PROFESSIONALS IN RADIATION PROTECTION THROUGH NATIONAL AND INTERNATIONAL NETWORKS

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## ABSTRACT

The European Federation of Organisations for Medical Physics (EFOMP) affiliates almost forty - National Member Organisations (NMOs) and one of its main objectives is the harmonisation and synchronisation of national education and training schemes in the field of medical physics including radiation protection. EFOMP has presented various recommendations and guidelines on this in the form of Policy Statements taking into consideration Euratom Directives 96/29 and 97/43. The EFOMP policies also include regular training as a requisite for Continuing Professional Development (CPD). One of the most recent Policy statements is No. 12 which deals directly with education and training. This paper outlines a number of the activities through which EFOMP promotes Learning and Education in Europe. This could serve as a model to stimulate education and training in general radiation protection including areas outside of medicine.

## 1. Introduction

The European Federation of Organisations for Medical Physics - EFOMP was set up in 1980 in London [1]. Among its aims and objectives are the harmonisation and synchronisation of national education and training schemes in the field of medical physics. EFOMP achieves its objectives through, amongst other, the production of guidelines for education, training and accreditation programs. One of its most recent Policy Statement is No. 12 [2] which describes the present status of Medical Physics education and training in Europe. This Policy Statement takes into consideration European Union Directives relevant to education and training. Before describing in detail the specific activities of EFOMP with respect to Training and Education it is useful to outline the educational pathways to become a Qualified Medical Physicist (QMP) and subsequently a Specialist Medical Physicist (SMP). With respect to Radiation Protection in the medical field, the SMP qualification is often considered to be equivalent to the Expert in Radiation Physics as described in EU Directive 96/29/Euratom. Figure 1 shows the pathway in some detail.

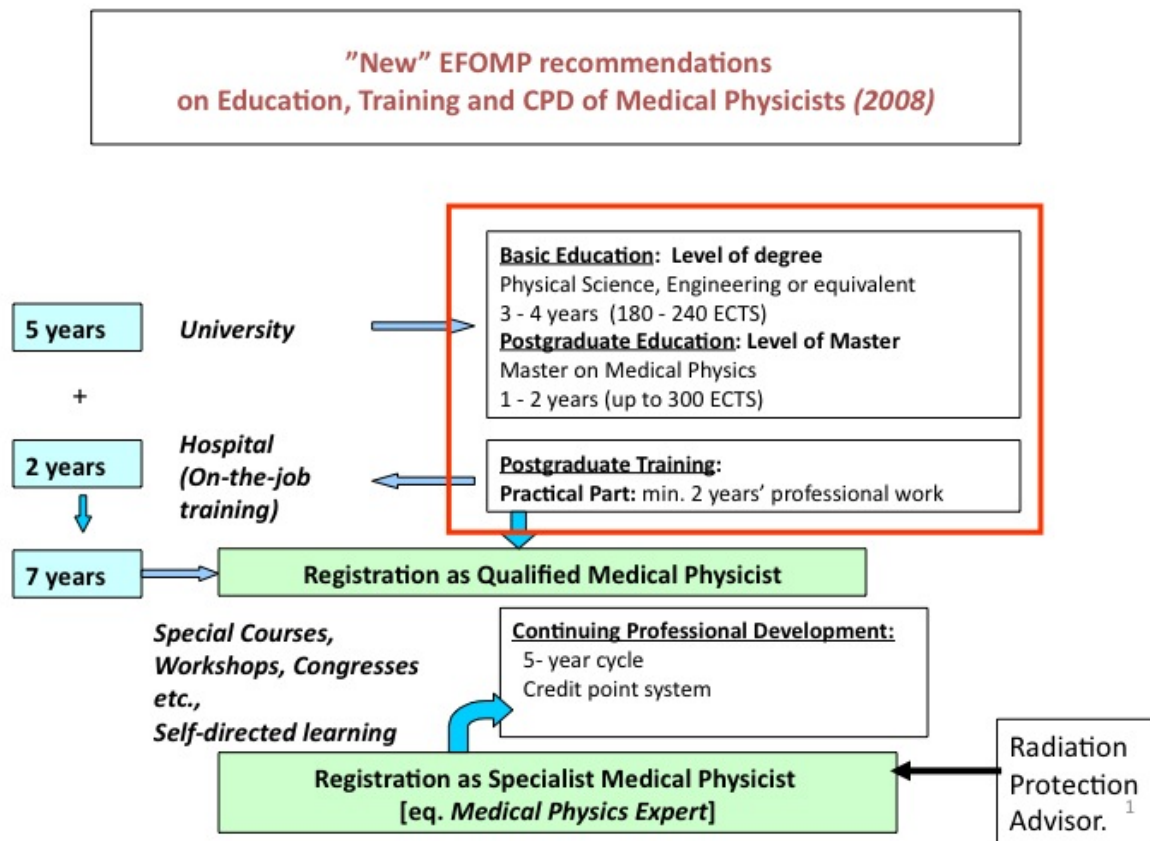


Figure 1. Educational pathway for medical physicists (EFOMP Policy Document 12)

Following a basic undergraduate degree in Physics or a degree in which physics is a major component, it is now generally accepted that a one year Medical Physics subject specialization is required. EFOMP recommends that this is done through a M.Sc. in Medical Physics and one of the activities which EFOMP is involved in is a “tuning process” of MSc programs across Europe. This will be described further below. After acquiring the MSc (which deals with the theoretical knowledge to work as a medical physicist) an individual now has to acquire practical training. The nature of this training varies widely across Europe and the development of standards on this is another activity EFOMP is planning to be involved in. An essential component of professionalism is Continuous Professional Development - CPD. This is also a critical component in the transition of QMP to MPE. EFOMP has spent considerable effort developing a standardized method to score this. Finally, EFOMP has initiated the development of an European Network of Schools of Medical Physics. Finally, the European School of Medical Physics – ESMP, is a long standing EFOMP activity, in partnership with the European Scientific Institute – ESI, in providing a forum for the Education and Training of

1. RPA : Radiation Protection Advisor : generally considered to be equivalent to Expert in Radiophysics (EU Directive 96/29/Euratom)

young Medical Physicists [3].

Medical Physicists also play a critical part in the education of other health professionals in radiation protection. A brief outline of work carried out in this under the auspices of EFOMP will be outlined. Knowledge of Radiation Protection forms an important component in all of the above activities, as will be elaborated in the following sections.

## **2. Tuning of Post-Graduate Degrees**

The Bologna declaration was signed in June 1999 with as aim the facilitation of mobility of students, professionals and researchers in Europe [3] The implication of the EFOMP requirements for medical physics training to include a MSc program strongly suggests that a convergence of such degrees should occur across Europe in line with the stated goals of Bologna. The implementation of this convergence is through a “Tuning process”. This is a methodology to “re-design, develop, implement and evaluate study programmes for each of the Bologna cycles” [4]. It is important to note that ‘Tuning’ *does not mean uniformity*. “The name Tuning is chosen to reflect the idea that universities do not and should not look for uniformity in their degree programs or any sort of unified, prescriptive or definitive European curricula but simply look for points of reference, convergence and common understanding” [4] This means that Tuning promotes ‘points of reference’ (which are essential for a system of easily comparable, compatible and transparent degrees) *whilst encouraging diversity in curricular delivery methods and learning paths according to the principle of autonomy and local culture and conditions*. For the medical physics profession a fundamental ‘points of reference’ is the sets of learning outcomes for the Masters in Medical Physics. A second point would be the learning outcomes for clinical skills obtained at the end of the clinical training period. These learning outcomes should be stated in terms of an inventory representing the minimum set and level of competencies that a student should be acquired.

Tuning is a university driven project. Groups of EU universities would be the drivers for determining the learning outcome student competences (including level of competence). This has to be done in consultation with future employers, recent graduates and professional organizations (e.g., EFOMP and EFOMP National Member Organizations) to ensure relevance to society and employability of graduates. Competencies refer to learner knowledge and understanding, interpersonal, intellectual and practical skills, ethical values and attitudes. Tuning recognizes two types of competences: Generic (means transferable across disciplines) and Subject Specific (applicable to a particular discipline). Generic competences can be split in three : instrumental competences (cognitive abilities, methodological abilities, technological abilities and linguistic abilities), interpersonal competences (individual abilities like social skills (social interaction and co-operation) and systemic competences (abilities and skills concerning whole systems, combination of understanding, sensibility and knowledge, prior acquisition of instrumental and interpersonal competences required). The competencies which have been identified include a considerable and significant component related to radiation protection. This includes standard areas such as ionising and non-ionising Radiation and its control, radiation protection legislation, use of equipment, Quality Assurance and safety. Specific areas such as Radiotherapy, Diagnostic Radiology and Nuclear

medicine are part of it but also generic areas such as the ability to be able to communicate orally and in writing with both experts in the field and non-experts and a demonstrable respect for diversity and multicultural awareness [*ibid*]. The outcome of the process will be a set of teaching and training syllabi for use throughout Europe which will ensure compatibility of education standards thus ensuring mobility. Finally, Radiation Protection is but one aspect of Health, Safety and Risk management in the hospital environment. EFOMP is of the opinion that medical physicists by virtue of their training and experience are well positioned to advise hospital staff and management on health and safety issues. To provide a minimum standard of education as part of the tuning process, EFOMP recommends that formal Risk and Safety training is part of the curriculum of the education of medical physicists. This will of course immediately be applicable to radiation protection in the health care environment. Table 1 shows an example of such a course as provided in the School of Medical Physics and Engineering of the Department of Applied Physics in Eindhoven University of Technology in the Netherlands. (<http://www.smpee.tue.nl/>).

### **3. Clinical Training**

Inherent in the educational and training pathway envisaged by EFOMP (fig. 1) is the requirement for training in clinical skills. Currently most countries in Europe have a training component in the educational pathways for their medical physicists. However, this training is far from uniform ranging from relatively unstructured “on the job” training to very structured, competency based programs. The process to develop guidelines for the development of a minimum set of clinical skills which need to be acquired will proceed along the same process as the Tuning process described above. The main difference will now be that clinical skill training by its nature occurs in a clinical setting and that representatives of hospital and health care providers need to be involved in the tuning process. Clinical skills of course include considerable aspects of radiation protection. Measurement and calculations of patient dose, shielding surveys, dealing with isotope spills etc. form all an inherent part of the “tuned training program”. Another aspect which is an integral part of any training program is the assessment of the trainee. It is not clear what form this assessment process will take as different models are currently employed in Europe. Assessment could be along the lines of the UK training program : ([www.ipem.ac.uk/docimages/2440.pdf](http://www.ipem.ac.uk/docimages/2440.pdf)) or, alternatively, similar to that operated in North America through the CAMPEP organization ([www.campep.org](http://www.campep.org)) However, other assessment procedures may also be considered. A complicating factor is of course the fact that in an increasing number of countries in Europe, Medical Physics is now a profession protected under national legislation. The regulatory environment applies particularly to the training component of the MP education as the taught component tends to come under University Regulations and is hence amenable to the Tuning process. This development of standards related to the clinical training has just been initiated by EFOMP and it is anticipated that this process will take several years before completion.

**Basic knowledge**

- \* Basic principles of safety and human failures
- \* Risk analysis skills
- \* Risk identification and estimation
- \* Incident analysis, accident analysis
- \* Work processes and design: analysis skills
- \* Electrical safety
- \* Safety care and management tools for a learning organization

**Practical training**

- \* Risk analyses.
- \* Discussion of safety with (medical) colleagues.
- \* Practical application of risk analysis skills in the own institute, resulting in a report.

**Learning Outcomes**

- \* The trainee knows what safety is.
- \* The trainee knows what risk analyses are.
- \* The trainee knows how to relate safety and risk analyses to his daily activities.
- \* The trainee has attention for his own professional safety attitude and that of other medical professionals.
- \* The trainee knows different risk analysis methods and their (dis)advantages.
- \* The trainee knows which risk analysis methods apply to the clinical environment.
- \* The trainee knows the PRISMA method, often applied by the inspection of health care.
- \* The trainee is able to judge which risk analysis method applies to a distinct situation and is able to consider a detailed risk analysis or a pragmatic approach.
- \* The trainee knows what a safety management system (SMS) is and is able to apply SMS to medical technology.
- \* The trainee is capable of adequately applying insights from the course to a concrete medical physics subject.

**Table 1.** Example of Risk and Safety Management course as provided in the School of Medical Physics and Engineering of the Department of Applied Physics in Eindhoven University of Technology in the Netherlands. Course equivalence is 6 ECTS (<http://www.smpee.tue.nl/>).

#### 4. Continuous Professional Development

Continuous Professional Development (CPD) is a critical component of the development of any professional and medical physics is not different. EFOMP has been and continues to be, very active in this area and has published a number of policy statements for CPD schemes. In addition it has established a system to recognise medical physics registration schemes which exist through individual National Member Organisations [5, 6]. This aims to set standards for education and training. A number of criteria are required for recognition of any such scheme (table 2). A total of 10 countries currently have a Registration Scheme which is recognized by EFOMP. The existence of a CPD scheme is an essential component of any such scheme for Medical Physicists.

- Statement of aims
- Properly constituted Registration Council
- Statement of required competences
- Training programme consistent with EFOMP's policy
- Mechanism for identifying specialist areas of registrants
- Regular renewal mechanism including CPD program
- Rules of Professional Conduct
- Disciplinary process

**Table 2.** Criteria which need to be in existence in order for a national registration scheme for medical physicists to be recognized by EFOMP

The CPD scheme as operated by EFOMP operates through “credits” which can be obtained through a number of ways e.g. conference and workshop attendance, paper publication etc. Guidelines for formal recognition by EFOMP of National Registration Schemes for Medical Physicists have been established since 1995 through its’ Policy Statement 6. EFOMP approval includes the requirement for “a regular renewal mechanism with a requirement for evidence of continuing activity in relevant areas”. CPD is now being recommended as the best way to meet this requirement. National Member Organisations are responsible for the administration of their National CPD schemes, in a similar manner to the EFOMP-approved National Registration Schemes. Recently EFOMP has developed a process to adjudicate on the extent of CPD credits which can be earned and in essence provide a “quality stamp of approval”. Table 3 shows an overview of such activities in so far as they relate to Radiation Protection.

## 5. European Network of Medical Physics Schools

EFOMP has recently established the European Network of Medical Physics Schools – ENMPS [7]. The aim of the Network is to make training and education available throughout Europe as well as assist in the harmonisation of such training and education. The ENMPS intends to include training initiatives that National Members organise in their Countries in a European Network. The inclusion in an annual European calendar, that EFOMP will prepare and circulate, will provide more visibility to the national initiatives and will give the opportunity to European and non-European Medical Physicists to follow training courses in other countries establishing personal and scientific relationship useful for the progress of Medical Physics in Europe. In addition, ENMPS will be a useful vehicle to coordinate exchange programs of medical physicists throughout Europe. One international activity which has been extremely successful is the European School of Medical Physics which is run on an annual basis, this year from 15<sup>th</sup> October till 24<sup>th</sup> November 2009 in Archamps (near Grenoble in France) This is an internationally supported activity organized jointly by the European Science Institute and EFOMP. A week dedicated to Radiation Protection was introduced last year and will be provided for the second time. Detailed information can be found at:

<http://lemoine.web.cern.ch/lemoine/esweb/ESMPnn12.htm> .

Year	Organizer	Name of the event	City (country)	Date
2007	National "Frederic Joliot-Curie" Research Institute	First Central & Eastern European Workshop on QC, Patient Dosimetry and RP in Diagnostic and Interventional Radiology and Nuclear Medicine	Budapest (Hungary)	25-28 April
2007	Quality Assurance Reference Centre. SENTINEL	Digital Mammography and the Breast Screening Programme Symposium	Newcastle upon Tyne, (UK)	1 <sup>st</sup> February
2007	Technical University Delft	Workshop SENTINEL	Delft (Netherlands)	18-20 April
2007	IAEA <sup>1)</sup> & Azienda Ospedaliero-Universitaria S.Maria della Misericordia	IAEA group training on Dose Assessment and Dose Management in Diagnostic and Interventional Radiology	Udine (Italy)	13-17 June
2007	AIFM <sup>2)</sup> Scuola Superiore di Fisica in Medicina "Piero Caldirola"	The Radioprotection of the Workers and Population: Important Aspects Connected to the Sanitary Activities	Villa Olmo (COMO) (Italy)	7-9 November
2007	AIFM <sup>2)</sup> Scuola Superiore di Fisica in Medicina "Piero Caldirola"	External Beam Radiotherapy: Physics and Dosimetry	Villa Olmo (COMO) (Italy)	17-21 November
2008	AIFM <sup>2)</sup> Scuola Superiore di Fisica in Medicina "Piero Caldirola"	Physics, dosimetry and optimization in nuclear medicine (diagnostic and therapy)	Gazzada (VA) (Italy)	14-16 May
2008	EFOMP, PSMP <sup>3)</sup> and AGH Univ. of Sc & Techn.	Radiation Protection of the Patient (Workshop & Tutorial)	Krakow (Poland)	16-17 September
2008	Holycross Cancer Center	Modern treatment techniques and in-vivo dosimetry	Kielce (Poland)	18-20 Nov. 2008
2009	Heidelberg University, Department of Postgrad. Studies in cooperation with German Cancer Research Center Heidelberg	9 <sup>th</sup> Teaching Course on IMRT/IGRT	Heidelberg (Germany)	2 <sup>nd</sup> – 4 <sup>th</sup> July 2009
2009	Holycross Cancer Center	Workshop "IV School of Radiotherapy"	Kielce (Poland)	22- 25 June
2009	Mater Misericordiae University Hospital	2009 Radiation Protection Autumn Workshop	Dublin (Ireland)	2 <sup>nd</sup> September

Table 3. List of events accredited by EFOMP (2007-2009) directly related to radiation protection.



## 6. Radiation Protection for other Health Professionals

Medical Physicists do not only train themselves, but also provide a considerable amount of training to other healthcare professionals such as medical doctors and radiographers as well as others [7] EFOMP is in the process of establishing a Special Interest Group under the auspices of its Scientific Subcommittee to provide a focus to develop this further. EFOMP believes that this will lead not only to better education but also will raise the profile of the profession.

## 7. Conclusion

This paper demonstrates that EFOMP has initiated and is involved in a significant number of activities regarding the Education and Training of Medical Physicists and other Health Professionals. In all of these activities, radiation protection plays a significant if not central role. It can be argued that the mechanisms established by EFOMP provide a model to coordinate specific radiation protection training, outside medicine in Europe. Examples such as the “tuning process”, validation of practical training, CPD requirements and recognition of national accreditation schemes can all be applied in the radiation protection arena.

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# ENEN'S CHALLENGES IN RESPONSE TO THE INDUSTRY AND REGULATORY NEEDS

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## ABSTRACT

The European Nuclear Education Network (ENEN) Association is a non-profit organization with objective of the preservation and further development of expertise in the nuclear fields by higher education and training. The ENEN has provided support to its Members for the organization of and participation to selected E&T courses in nuclear fields and developed the European Master of Science in Nuclear Engineering. In 2009 three European Fission Training Scheme projects started to establish a common certificate for professionals at European level. In December 2008 the European Council welcomed the existence within the EU of coordinated teaching and training leading to qualifications in the nuclear field, provided notably by the ENEN, and expressed its hope that, with the help of the EU, ENEN and its members will continue to develop the coordination of nuclear education and training in Europe. The ENEN endeavours to respond to their expectations in the years to come.

### 1. Objective and Structure

The “European Nuclear Engineering Network” project was launched under the 5<sup>th</sup> Framework EC Programme in January 2002. It established the basis for conserving nuclear knowledge and expertise, created a European Higher Education Area for nuclear disciplines, and initiated the implementation of the Bologna declaration in nuclear disciplines [1]. One of the main achievements of this project was the establishment by the partners of the “European Nuclear Education Network (ENEN) Association. The ENEN project was thus given a more permanent character and a legal status of a nonprofit international organization on the 22<sup>nd</sup> of September 2003 under the French law of 1901 [2].

The main objective of ENEN is the preservation and the further development of expertise in the nuclear fields by higher education and training in response to the concerns expressed by international organisations with respect to the availability of a sufficient number of experts in the nuclear disciplines [3][4].

The ENEN Association has two kinds of members. All members should have a legal status in an EU member state or a candidate country. The Effective Members, primarily academics, provide high-level scientific education in the nuclear field in combination with research work, and use selective admission criteria. The Associated Members, such as nuclear research centres, industries and regulatory bodies, have a long-term tradition of relations with effective members in the field of research, training or education and are committed to supporting the ENEN Association. As of March 2009, the ENEN Association has members in 17 European countries, consisting of 31 Effective Members and 20 Associated Members.

Since 2007, the ENEN Association has concluded a Memorandum of Understanding (MoU) with partners beyond Europe for further cooperation (South Africa, Russian Federation, Japan, etc.)

## **2. Main achievements since 2003**

### **2.1 European Master of Science in Nuclear Engineering**

Supported by the 5<sup>th</sup> and 6<sup>th</sup> Framework Programme of the European Community, the ENEN Association has established and continues to monitor the equivalence of nuclear engineering education curricula at the ENEN member universities through its Teaching and Academic Affairs Working Group. As a result, the ENEN developed the European Master of Science in Nuclear Engineering. A reference curriculum, consisting of a core package of courses and optional substitute courses in nuclear disciplines, has been designed and mutually recognized by the ENEN members. To advertise and promote this realization, ENEN has established the qualification of European Master of Science in Nuclear Engineering (EMSNE). For this purpose, ENEN developed by-laws and procedures for handling and selecting the candidates and for awarding the EMSNE certificate. An information leaflet to attract applications for this EMSNE certificate has been designed [5] [6].

A European Master of Science in Nuclear Disciplines will be delivered under ENEN certification in the near future extending ENEN's certification to other disciplines such as radioprotection and waste management and disposal . By-laws have to be established.

### **2.2 International Exchange Courses, Advanced Courses and Training Seminars**

The equivalence of nuclear engineering curricula relies on the mutual recognition of courses among the ENEN member universities. ENEN therefore also has the task of promoting student and faculty exchanges by encouraging and supporting the organization of international exchange courses at Master level, advanced courses at PhD level as well as training courses for young professionals.

A typical example is the Eugene Wigner course, a three-week course on nuclear reactor physics including theory lectures and practical exercises at three different reactors, which has been organized five times since 2003 by a group of universities and research centers in central Europe, addressing nuclear engineers and young professionals. Advanced courses have been organized by ENEN in the framework of the Integrated Project EUROTRANS (see paragraph 5.5 below).

### **2.3 NEPTUNO (FP6) Deliverables, Database and Communication System2**

Other ENEN products related to the implementation of the EMSNE, to exchange courses as well as to training sessions for young professionals are available on the website of the Sixth Framework Programme project – Nuclear European Platform of Training and University Organizations (NEPTUNO). Deliverables of this Coordination Action include guidelines, best practices and do-it-yourself kits for the organization of international ENEN exchange courses, with examples of flyers and application forms [7]. The NEPTUNO Communication System has been also developed at: <http://www.sckcen.be/neptuno>

### **2.4 ENEN II Project (FP6) - Extension to other nuclear disciplines**

The ENEN-II Coordination Action consolidates and expands the achievements of the ENEN and the NEPTUNO projects attained by the European Nuclear Education Network Association in respectively the 5<sup>th</sup> and 6<sup>th</sup> Framework Programme of the European Commission [8]. The objective of the ENEN-II project was to develop the ENEN Association

in a sustainable way in the areas of nuclear engineering, radioprotection and radwaste management, including underground disposal. The current developments in the 7<sup>th</sup> Framework show that this has partially been achieved. Indeed, the interaction between the different communities, engineering, radiation protection and waste management, has been considerably strengthened. The ENEN Association experience has been exploited to the benefit of the other communities in the development of their networks and the definition of their education curricula and the training programmes. Although the training projects ENEN-III, PETRUS-II and ENETRAP-II now starting under the 7<sup>th</sup> Framework Programme are distinct activities, they have been prepared in mutual consultation by the three communities and ENEN Association is a partner in the three consortia, assuming a pivotal role in the coordination and streamlining of education and training activities in the European Union. The ENEN-II project activities have been mainly structured around the five Working Areas (WA) of the ENEN Association in close collaboration with selected consortium partners.

## **2.5 Nuclear Fission Training Scheme- ENEN III, PETRUS II and ENETRAP II**

The ENEN Association is involved in three projects for European Fission Training Schemes under the 7<sup>th</sup> Framework Programme of the European Commission, i.e. ENEN III on nuclear engineering, PETRUS II on geological disposal and underground storage of radioactive waste [9], and ENETRAP II on radiation protection [10]. The introduction of the ENEN III project is as follows:

### **ENEN-III**

The ENEN Association submitted a project proposal for European Fission Training Schemes under the 7<sup>th</sup> Framework Programme of the European Commission. The proposal covers the structuring, organization, coordination and implementation of training schemes in cooperation with local, national and international training organizations, to provide training courses and sessions at the required level to professionals in nuclear organizations or their contractors and subcontractors. The training schemes provide a portfolio of courses, training sessions, seminars and workshops, offered to the professionals for continuous learning, for updating their knowledge and developing their skills to maintain their performance at the current state-of-the-practice and to anticipate the implementation of new scientific and technological developments. The training schemes allow the individual professional to acquire a profile of skills and expertise, which will be documented in his training passport. The essence of such passport is that it is recognized within the EU (and possibly abroad) by the whole nuclear sector, which provides mobility to the individual looking for employment and an EU wide recruitment field for employers in the nuclear sector. The recognition is subject to qualification and validation of the training courses according to a set of commonly agreed criteria, which can be ratified by law or established on a consensus basis within a network.

The assessment of the needs identified a list of generic types of training where specific training schemes have to be developed including training sessions, seminars, workshops, etc. to constitute the portfolio offered to postgraduates and professionals for training and further personal development. Training schemes in the following four generic types will be developed in the project:

- Type A) Basic training in selected nuclear topics for non-nuclear engineers and professionals in the nuclear industry.
- Type B) Basic training in selected nuclear topics for personnel of contractors and subcontractors of nuclear facilities
- Type C) Technical training for the design and construction challenges of Generation III

Nuclear Power Plants

- Type D) Technical training on the concepts and design of GEN IV nuclear reactors

### **3. International cooperation**

#### *European Union*

The ENEN Association is intricately involved in several activities on nuclear education and training in the European Union. In addition, the ENEN Association intends to contribute to the European Institute of Technology.

In the framework of , the Sustainable Nuclear Energy Technology Platform (SNE-TP) launched in 2007 with the aims of coordinating Research, Development, Demonstration and Deployment (RDD&D) in the field of nuclear fission energy, the ENEN co-chairs with the EDF the Working Group on Education, Training and Knowledge Management. The objective is to make proposals to the SNE-TP Governing Board on a future framework of nuclear education, training and knowledge management at European level and implement it in a sustainable manner to ensure the further development of nuclear energy technology in Europe. Major stakeholders participate to the activities of this platform with its three working groups; Strategic Research Agenda (SRA), Deployment Strategy (DS) and Education Training and Knowledge Management (ETKM). From this involvement and by its support the ENEN expects closer contacts and interactions with major industrial partners to increase its visibility and enhance their perception of the ENEN's role in professional training and mobility in addition to its reputation as a network of academia.

#### *International Atomic Energy Agency*

The ENEN Association has been involved in several technical meetings, consultants' meetings, workshops and conferences related to education, training and knowledge management organized by the International Atomic Energy Agency (IAEA).

The ENEN Association exchanges information and participates on a regular basis to meetings of the Asian Network for Education in Nuclear Technology which has been operated by the IAEA. Asian network representatives are invited to the meetings of the ENEN Association.

### **4. Further challenges**

The ENEN Association has developed a knowledge and human network of European high-level education and training in nuclear-related subjects, in particular within the nuclear disciplines of engineering, radiation protection, radioactive waste management and decommissioning, together with relevant academic and industrial entities and international organizations. In the framework of the ENEN Association major education and some training institutions in Europe are working together, and the ENEN is acting through education and training for the renewal of competencies across the nuclear energy life cycle (design and build, operate, decommission and dispose).

Through the Network, the adjustment of curricula and training packages has been enhanced and contributed to the young professionals, academic entities and the end-users needs, thereby improving employment and career opportunities, and the qualifications of the young professionals. Its further challenges are:

- o Expand into nuclear disciplines outside nuclear engineering such as radiation protection, radio chemistry, waste management;

- Expand activities from the academic and research environment into the industrial and regulatory organisations and attract their membership;
- Define, harmonise and promote international mutual recognition of professional training for key functions in nuclear industries, regulatory bodies and nuclear applications;
- Participate to EC framework projects, in particular in the European Higher Education and European Research Areas; and
- Continue to support and strengthen cooperation with other international and regional networks.

ENEN Association's members include today major universities in the EU27 involved in the education of nuclear disciplines at masters and PhD levels as well as leading research centres. Universities from worldwide, such as Russia, South Africa and Japan decided to join its activities through the establishment of a Memorandum of Understanding and new collaborations will be established in the near future with third countries such as China etc. Still the sustainability of ENEN will rely on a more significant increase of the involvement of "future employers", industry and regulatory bodies.

In several FP7 projects, ENEN III, ENETRAP II, PETRUS II, NUPLANTS, etc ENEN Association will be working with major industry and regulatory bodies. More synergy will be established through the activities of the third working group of SNE-TP, chaired by industry partner EDF and ENEN and its interaction with the two other working groups. For ENEN this will constitute a great opportunity to expand its activities from the academic and research environment to the industrial and regulatory organisations and to attract their membership.

The ENEN Association, its structural bodies and working groups and their members endeavour to implement this challenging programme, which will significantly contribute to the development of higher nuclear education and expertise within the European Union as well as on a global level.

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# ROLE OF SMALL RESEARCH REACTORS IN EDUCATION AND TRAINING IN RADIOLOGICAL PROTECTION

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## ABSTRACT

The number of research reactors has gradually decreased due to ageing, reduced utilization and uncertainties in fuel policies. However, there is an increased need of highly specialized facilities to support the training of personnel for the operation of a broad range of installations from nuclear reactors to medical facilities using radiations. Low power research reactors are versatile tools for education and training in radiological protection. While isotope production and state-of-the-art neutron research are better performed in high power research reactors, education and training can be better performed in low and medium power facilities, without affecting other activities. A review of the training activities supported by the small research reactors in Vienna, Lisbon, Budapest and Prague will be given in this paper, with emphasis on practical examples.

## 1. Introduction

Education and training of young professionals in nuclear-related science and technology is a concern in many countries, in particular since the nineties [1]. The needs in the area of radiological protection are actually broader, due to its importance for the operation of a wide range of installations, from nuclear reactors to medical installations using radiations.

Specialized experimental facilities capable of supporting a diverse curriculum, such as research reactors, hot cells, radiochemistry facilities and radiation measurement facilities are ageing and many were decommissioned. Research reactors in particular suffer from uncertainties in spent fuel policies, which have a higher impact in countries with no (or a reduced) nuclear power program.

Low power research reactors are versatile tools for education and training in radiological protection. While isotope production and state-of-the-art neutron research are better performed in high power research reactors, education and training can be better performed in low and medium power facilities, without affecting other activities.

A review of the training activities supported by the small research reactors in Vienna, Lisbon, Budapest and Prague will be done in this paper, with emphasis on practical examples.

## 2. Overview of the research reactors

The Atominstitut Vienna (ATI) is attached to the Vienna University of Technology and operates a 250 kW TRIGA Mark-II reactor since March 1962. This research reactor is the only nuclear facility in Austria and is presently the only contributor to nuclear knowledge management in the country because two other Austrian research reactors (in Seibersdorf and Graz) were decommissioned during the past decade. The fact that it is the nearest nuclear facility to the IAEA further increases its international importance. The ATI reactor uses both Low Enriched Uranium (LEU) fuel and Highly Enriched Uranium (HEU) fuel [2].

The Nuclear and Technological Institute operates the Portuguese Research Reactor (RPI) since April 1961. The RPI is a 1 MW pool-type reactor, converted from HEU to LEU fuel in 2007 [3]. As in the previous case, this reactor is the only nuclear installation in the country. Although not integrated in a university, the RPI supports education and training programs inter alia in the three main universities in Lisbon.

The Institute of Nuclear Techniques (NTI) is part of the Faculty of Natural Sciences of the Budapest University of Technology and Economics, Hungary. NTI operates a 100 kW pool-type reactor of Hungarian design since 1971. The NTI reactor uses LEU fuel since its start-up. The reactor is the focal point of exercises for undergraduate and graduate students and serves as a neutron- and gamma-radiation source [4].

The Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague operates the VR-1 "Sparrow" training reactor since December 1990. The VR-1 operates normally at 1 kW and at 5 kW for short periods. It was converted from HEU to LEU fuel in 2005 [5].

The nominal age of these facilities ranges from 19 to 48 years. One must note however that significant refurbishment and modernization of the above facilities has been undertaken, so critical components and systems are considerably more recent [6-8].

## 3. Overview of education and training activities

Table 1 presents an overview of the education courses, ordered by subject, which are supported by the four research reactors in this work. The subject classes are the ones used in the NEPTUNO [9] project funded by the European Commission under its 6<sup>th</sup> Framework Program and reflect the situation in 2006 with minor updates.

The ATI offers about 100 highly specialized theoretical lectures and more than 10 practical courses where students have to perform experiments in small groups. The program includes also several courses on radiation protection. Many of them use the research reactor as a neutron and gamma source. On an international scale the ATI co-operates closely with the nearby located IAEA and CTBTO in international research projects, coordinated research programs and as a supplier of expert services. Regular training courses are carried out for Safeguards trainees of the IAEA and fellowship places are offered for scientists from developing countries. Since 1984 more than 130 trainees spent about 4 weeks of intensive practical training at the ATI and many of them joined the IAEA as safeguards inspectors. Other fellows spent between one to twelve months at the ATI and are integrated in the work program of the institute. Experience showed that these fellowships result in a long-term professional relationship with ATI and its teams. Specialized practical courses are also carried out for foreign nuclear institutions in countries such as Germany, Czech Republic, Slovak Republic, and the United Kingdom. Although Austria has a strong anti-nuclear policy, nuclear and corresponding radiation protection knowledge in this country is preserved by the ATI's competences.



Tab 1: Overview of training and education courses supported by the research reactors in this work, following the categories used in the NEPTUNO project.

Subject	ATI	RPI	NTI	VR-1
Nuclear Energy: Introduction	X	X	X	X
Introduction to Nuclear Physics	X			
Nuclear Reactor Theory	X	X	X	X
Nuclear Thermal-Hydraulics			X	
Nuclear Materials			X	
Experimental Reactor Physics	X		X	X
Nuclear Fuel Cycle			X	X
Radiochemistry	X	X	X	
Operation and Control	X		X	X
Radiation Protection and Nuclear Measurements	X	X	X	X
Reliability and Safety				X
Waste Management and Decommissioning				
Nuclear Fusion				X
Advanced Courses	X			X

In addition a new training program started directed to nuclear emerging countries which plan their first step into the nuclear area. In May 2009 a six weeks course were carried out at the ATI to supply participants on a large spectrum of nuclear issues to help them in their decision about steps towards nuclear reactors.

The NTI and VR-1 reactors are also in a university environment, but in countries (Hungary, Czech Republic) with nuclear energy, in contrast with Austria and Portugal. They are used in the education and training of university students, in scientific research and in the training of specialists for the nuclear power industry. Both support courses in a wide range of subjects as summarized in Table 1. The ATI, NTI and VR-1 reactors share several initiatives, such as the Eugene Wigner Course (together with the Slovak Technical University, Bratislava) held yearly since 2003.

The RPI does not benefit from a central location in Europe; thus its activities are focused mostly in Portugal. Even if not integrated in a university, the RPI supports theoretical lectures and practical sessions in chemistry, physics and engineering in the three main universities in Lisbon, as well as specialized training sessions for these and other universities. In 2009 it also supported an ERASMUS Intensive Course on Accelerator and Reactor Operation organized by the Cooperation for Higher Education on Radiological and Nuclear Engineering (CHERNE) group [10], with 27 students from 9 European universities.

#### 4. Specific advantages of research reactors

Research reactors have unique characteristics that can be used as an advantage for education and training in radiological protection:

- Intensity of the radiation fields depends on the reactor's power;
- Simultaneous gamma and neutron fields;
- Production of specific isotopes;
- Pre-operational and operational surveys.

Research reactors are "programmable" radiation sources. As the power can be varied several orders of magnitude within some minutes, one can have neutron and gamma radiation with variable intensity, at request, while keeping the same geometry in a given setup. Figure 1 shows a simple example of spectra obtained with a He-3 neutron detector (proportional counter) in the thermal column of the RPI at various powers from 1 to 10 kW. These spectra show the linear behaviour of the detector, with a clear separation of events

due to neutrons from the low amplitude events due to gammas. Further spectra at higher power would show that the conditions would be above the practical operating limit of the detector, which is an important lesson for the trainees.

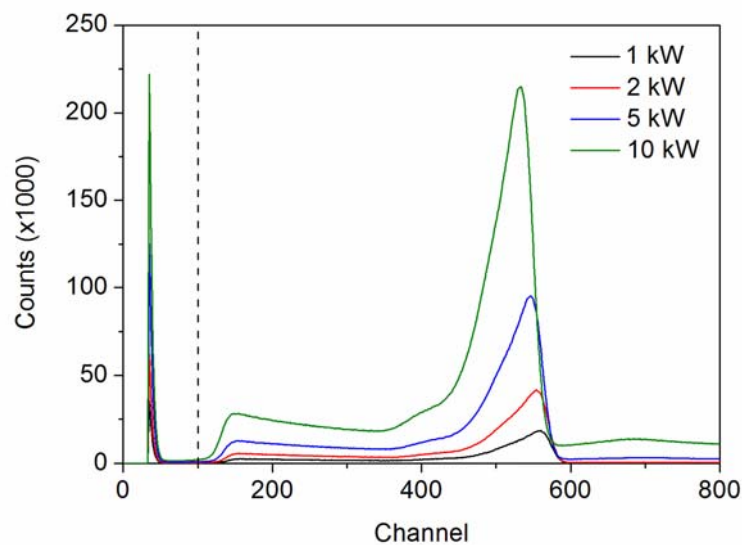


Fig 1: Spectra obtained with a He-3 neutron detector at different operating powers, from 1 to 10 kW. The spectra show the linear behaviour of the neutron detector, with a clear separation of events due to neutrons (to the right of the dashed line) from the ones due to gammas (to the left of the line). Further increasing the operating power would render the detector no longer responsive.

When using a beam port in a reactor, gamma radiation is normally present together with the neutrons, as shown in Fig. 1. This is not necessarily a nuisance, as it allows inter alia to study:

- Interference phenomena in active and passive detectors.
- Properties of different materials as shield for gammas and neutrons – e.g. students will find that the Pb they know to be a good gamma shielding material will also attenuate neutrons.
- Optimization of combined shielding, discussing the advantages and disadvantages of using first a material with higher efficiency for gammas or for neutrons.

In practical courses on radiation protection, it is important to be able to produce radioactive isotopes precisely tailored for particular experiments. Through the use of the reactor as a neutron source this is easy to realize by neutron activation. By choice of appropriate samples (chemical composition, mass) and appropriate irradiation parameters (irradiation time, neutron flux, and irradiation position in the reactor), activity and dose rate of samples can easily be adapted to different radiation protection experiments. By the use of this method specific isotopes are produced, which can be used amongst others for the following training aspects of radiation protection:

- Average activity, average half-life: Theoretical prediction and verification of dose rates at certain distances of the irradiated sample including the explanation of terms like absorbed dose, KERMA, dose equivalent and effective dose.
- Low activity, short half-life: Determination of half-lives.
- Average activity, long half-life: Handling of unsealed radioactive materials.
- High activity, long half-life: Handling of sealed radioactive materials.
- Average activity, short half-life: Contamination and decontamination.

Through the subsequent use of radiochemical procedures in the radio-chemical laboratories of the Institute, the resulting knowledge will be deepened. For example, the “Plutonium - URanium Extraction” (PUREX) separation process or the absorption of radioactive isotopes

in organic substances can be introduced experimentally in this way. Through the use of such procedures a safe handling of unsealed radioactive material can be excellently taught.

Research reactors have a wide range of monitoring systems for liquid and airborne effluents. Although many of these monitoring systems are not student-friendly, it is relatively easy to perform exercises in which the students collect air, water and swipe samples, measure the samples with appropriate detectors and correlate the results with other monitoring systems at different operating powers.

While isotope production and state-of-the-art neutron research are better performed in high power research reactors, education and training can be better performed in low and medium power facilities, without a large impact in normal operation. The activities above described are just highlights of the experimental training in the ATI, ITN, NTI and VR-1 reactors in the area of radiation protection.

## 5. Conclusions

Research reactors are versatile tools for education and training in radiological protection, presenting excellent opportunities to teach practical radiation protection. Any research reactor can in principle be used, even if education and training can be better performed in low and medium power facilities, as it will not impact significantly normal operation for other users.

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## **APPROACHES IN SECTOR SPECIFIC TRAINING**

# SECTOR-SPECIFIC IN-HOUSE EDUCATION AND TRAINING AT SIEMENS

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## ABSTRACT

As medical X-ray systems are medical devices, they are to be treated according to the **Medical Device Directive**. Accordingly, many aspects of radiation protection are dealt with by design. This fact of “built-in” radiation protection in combination with applying radiation to patients makes the radiation protection training indeed sector-specific. The field service engineer’s day to day workload involves, quite naturally, basic knowledge of radiation protection. The level of knowledge, however, is limited to the safe operation of medical X-ray equipment as well as the correct adjustment and testing procedures. It should be possible to establish a basic level of knowledge for this occupation which is agreed upon worldwide. Then the operation and service of X-ray equipment would become safer worldwide, and the local authorities could depend upon a certain safety standard

### 1. The Sector I would like to report on is **medical X-ray equipment**.

Since Konrad Wilhelm Röntgen’s discovery of the X-rays and their penetrating abilities more than one hundred years have elapsed and we still use the same old radiation today to look into the human body. As on the physics side nothing has changed since then, our way of handling radiation definitely has.

When I joined the X-ray field in 1965 there was but one rule presented to me by the big boss on my very first day: You have to satisfy our customers! If there is a conflict coming up and you call me first I’ll back you up. If however the customer calls me first I’m on his side. Now, at that time mobile phones were not available and so I learned to avoid conflicts. This little episode points out that nobody really cared what we did to the X-ray unit as long as the customer was satisfied. Today, the situation is completely different and the field of medical X-ray equipment is strictly controlled.

For defining the **specific radiation protection knowledge** required by our field service engineers it is helpful to understand the environmental situation medical X-ray equipment is subjected to.

#### 1.1 The X-ray Unit

The **Design** is ruled by the **Medical Device Directive 93/42/EEC**, which was to put into national legislation by the member states and is also basically accepted worldwide.

According to this directive, a medical device is **classified** according to its inherent potential hazards in combination with its intended use.

This “intended use” asks for **essential requirements** and performance which are defined by a series of **harmonized standards** (IEC 60601-x-x). Compliance to these standards is essential during manufacturing and guarantees built-in safety features including radiation protection measures.

In order to place a system on the EC-wide market it has to undergo a **conformity assessment procedure** which is based on its classification, and ranges from testing the individual unit to certification of manufacturing. These certifications are performed by a **notified body** and result in a conformity statement and a **CE-mark** showing the four digit identification number of the notified body.

At the end of this procedure we have an X-ray system that meets all functional and safety related demands.

## 1.2 The X-ray department

To ensure safe operation, **radiation protection areas** are established according to the level of radiation exposure.

The examination room with the X-ray unit inside becomes the **controlled area** where an effective dose of more than 6mSv per year is to be expected. Persons working in this area have to monitor their personal dose to document how well they have protected themselves against scattered radiation.

Areas outside the controlled area where persons may get more than 1mSv per year are declared **supervised areas**.

**Public areas** must be kept below 1mSv per year by structural radiation protection.

Prior to operation, the structural radiation protection is tested by a government approved physicist performing radiation measurements in the various areas while the X-ray unit is operated under standardised conditions.

That leaves us with a safe X-ray unit in radiation protected rooms.

## 1.3 Operation of X-ray systems

The very specific part of the medical X-ray business is the deliberate **application of radiation to persons** in order to get a radiograph.

While the Medical Device Directive is very specific about the essential requirements and the conformity assessment procedure, it leaves the **responsibility of operation to the member states**.

Our German authorities have used this freedom to specify essential requirements **depending on the intended use** and also set limits to the **image receiver dose** accordingly. Setting the strict demand:

**“The required image quality must be achieved with reasonably low dose”**

In the light of this, the automatic exposure control systems of our X-ray units are set to different levels of image receiver dose providing different resolution of detail. These dose settings provide a good base for a proper diagnosis with a minimum of biological hazard to the patient. The actual absorbed dose, however, depends very much on the way the examination is performed; the number of exposures and the total fluoroscopy time along with other parameters.

Recently, the focus of radiation protection turned away from pure technical parameters and concentrates more on the patient dose directly. As a result of this the patient dose is monitored by a **dose area product** measurement and reference values for the various kinds of examination are published by the EC. These reference values have become the guide line for the examination. The radiologist is now challenged to make a diagnosis within the reference dose.

## 2. Specific radiation protection knowledge

Considering the complex structure of medical X-ray systems and their operation, it seems a good thing to establish distinctive functional levels and define the radiation protection knowledge required for each.

- **Level 0, design**

The designing engineers have to adhere to the harmonized standards according to the MDD. The prototype unit has to be tested in cooperation with the physicists of the radiation protection department. Manufacturing procedures are established in cooperation with physicists and engineers of the Notified Body. Next, instructions are written for all steps of manufacturing, installation, operation and maintenance.

*At this level knowledge of radiation physics and protection are definitely required.*

- **Level 1, manufacturing**

At this stage of production, assembly and testing in the factory, extensive radiation protection knowledge is not required. *If settings have to be done using radiation, the personal are trained and supervised by the radiation protection officer.*

- **Level 2, putting into operation**

Here, the X-ray engineer does the on site adjustment and testing and presents the system to the hospital/government physicist. What he, normally, is not aware of is the fact that he complies to the request

**“The required image quality must be achieved with reasonably low dose”**

by setting the dose and testing image quality according to unit specific instructions. *At this stage he operates the unit under his responsibility which requires a minimum knowledge of radiation physics, radiation protection and biological hazards.*

- **Level 3, maintenance**

Keeping the system operational seems to be a pure technical task. However, our field service engineer has to be able to *identify the internal and external radiation protection devices and check their functional integrity.*

- **Level 4, application support**

With modern, computer controlled X-ray systems the technical side is run automatically and the radiologist can concentrate fully on the patient and the examination. According to the kind of examination performed the X-ray system controller operates on various instruction sets called organ programs. Each organ program contains parameters affecting radiation quality, image receiver dose and image processing.

While the field service engineer is not allowed to apply radiation to patients, however, with growing experience, he has to learn the sequence of actions in a radiological department and understand the various examinations. *As an application specialist he has to understand the radiologists request and fine tune the organ program parameters, knowing their influence on patient dose and image quality.*

## 3. Sector-specific in-house education and training

Since you are now familiar with the regulatory and operational environment of medical X-ray equipment I like to point out how we train our field service engineers to meet the demands put onto them.

### 3.1 The statistics

Our company employs about 5300 X-ray engineers worldwide which have to be kept up to date in regular training classes. For the technical training on diagnostic X-ray equipment alone, we conduct about 450 classes at the training facilities in Erlangen, Germany, Cary, United States of America and Shanghai, Peoples Republic of China. In addition to the product oriented classes we conduct about 12 fundamental X-ray classes with 10 participants for new employees yearly.

### 3.2 Vocational qualification

The local business units employ personnel with very good electronic and mechanical education. So, in our training program we do not offer dedicated classes in electronics or mechanics. The level of education, however, can be very different between countries. So can the English language skills. This forces us as trainers to stick to simple English and simple facts.

### 3.3 Training on knowledge in radiation protection

The **evident radiation protection training** required for level 2 (putting into operation) takes place during the **fundamental X-ray class**. It comprises X-ray physics, biological effects of radiation and radiation protection measures as straight forward lessons including practical demonstrations when possible. The more subtle training occurs during the class where the general functions of the essential components and their interrelations are explained and demonstrated.

As pointed out earlier, the training on dose adjustment and measurement, the mechanical alignment procedure of radiation field and light localizer as well as basic image quality tests can be seen in the light of radiation protection training. At the end of the class when all the interactions and various functions are known, they learn how fluoroscopy parameters can be set to reduce the patient dose without affecting the image quality too much.

During this fundamental training the X-ray engineer learns to handle X-ray equipment safely and is enabled to join advanced equipment training. Since X-ray physics and the physical radiation protection is the same all over the world, we assume that this training is recognized as sufficient worldwide. However, training on the **governmental handling** of X-ray equipment has to be provided by the local business units since we may never have uniform regulations worldwide.

The radiation protection training required for **service and maintenance** (level 3) is part of the regular technical training classes without being labelled as such. Here the objectives are: system functions, adjustment, testing and trouble shooting.

For level 4 training we offer dedicated **application classes** for the very experienced field service engineers. These application classes differ in modality - that is in application range and equipment - and enable the engineers to support the radiologist in optimizing the unit's performance.

It goes without saying that in **all our training classes** we start with a reminder of the basic radiation protection rules

### 3.4 Governmental handling in Germany

In Germany the handling of X-ray equipment is governed by the **X-ray ordinance** which in turn is based on the EC regulations

As a consequence of it, all German field service engineers get a training to obtain the **Requisite Knowledge and Know-How in Radiation Protection**.

Along with this they are introduced into the German regulatory environment. Only then they are allowed to service X-ray equipment in their own responsibility.

Additional classes provide training in the required

#### **Acceptance and Constancy Tests**

which are part of the governmental approval procedure.



# Education and Training of Radiation Protection Officers in Sweden

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## Introduction

The nuclear facilities in Sweden have their own radiation protection (RP) personnel, as legislated, but according to the Swedish system, the additional personnel needed during the annual outages etc. is hired from a number of external companies.

The nuclear facilities' own RP-personnel is categorized in two different categories, RP-Technician and RP-Officer. External RP-personnel in Sweden is categorized in three different categories, where RP-Technician category C, is the lowest and RP-Technician category A, corresponding to nuclear facilities' RP-Officer, is the highest.

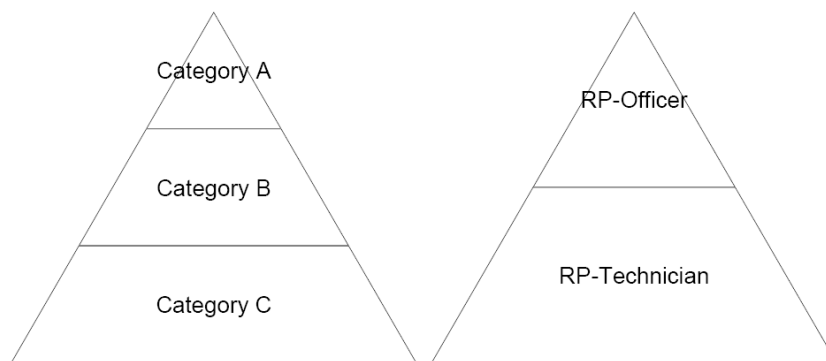


Figure 1. Three different levels of RPO's in Sweden (external versus nuclear facility)

The companies themselves have the responsibility to assure the quality of their personnel according to the rules and regulations of the authority and the nuclear facilities. Traditionally the companies have taken care of the education and training (E&T) of their own personnel themselves without any more specific co-ordination between the companies and the nuclear facilities.

In a meeting year 2002 the heads of RP-groups at Swedish nuclear facilities and the representatives from the external RP-companies discussed the E&T of external RP-personnel. This discussion resulted in an exclusive co-operation between the different nuclear facilities and external companies in educating and training radiation protection technicians (RPT) and officers (RPO).

In the beginning of the year 2003 a joint work group called "FORS" was started. The idea behind this work group is that the nuclear facilities, together with the external RP-companies, form an education design based on a task analysis done at all levels of E&T. All the members in the FORS-group have a solid background in practical RP work but some are nowadays on other positions within the nuclear industry.

## Education and Training of Radiation Protection Officers in Sweden

### Executing the Task

The first task for the FORS-group was to create a foundation for a renewed education for A-Technicians/ RP-Officers, the so-called “FS-1” –course.

This education was traditionally executed by Kärnkraftsäkerhet och Utbildning, KSU, a company owned by the nuclear facilities in Sweden. The material, the requirements and the goals for the course had not been audited in a number of years and it was necessary to do that.

The work was started with performing a detailed task analysis on all the levels of education of RP-personnel. The task analysis resulted in a number of competence areas where it is considered that all the competence areas in a lower category are included in the demands of the higher category. The different competence areas identified were

- Radiation protection
- Fire protection
- Industrial safety
- Knowledge of the main processes and systems at different type of nuclear power plants (BWR, PWR)
- Language skills
- Computer skills
- Project management (on A-level/Engineer only)
- Labour management (on A-level/Engineer only)
- Communication and presentation (on A-level/Engineer only)

Each competence area was then divided into a number of different competences and skills needed. The levels of the competences and skills were expressed as either “knowledge of” or “proficiency”.

### Education for RP-Technician Category A/RP-Officer

After completing the task analysis the foundation for the renewed education for A-Technicians/RP-Officers was created. The structure included:

- Radiation physics
- Measuring techniques, theory
- Measuring techniques, practice
- Radiochemistry
- Laboratory work
- Communication techniques
- Radiation biology
- ICRP etc.
- ALARA in practice
- SSM – the Swedish Radiation Safety Authority (legislation etc.)
- ISOE

## Education and Training of Radiation Protection Officers in Sweden

- RP-experiences from the world around

The course consists of two weeks at the university followed by self studies and examination by extensive homework instead of an exam. It was considered to be better to use homework than a written exam because this way the task is much more extensive and all-round. Also the fact that one can fail an exam because of nerves etc. speaks for this manner. The results support this method.

The pilot course was held in April 2004. The questionnaire among the first group of students pointed out a number of improvements needed in the study material. For example the lecture on communication techniques was erased from the schedule because it was considered as an area for the companies to take care of themselves.

The second course was held in April 2005 and the questionnaire showed that the improvements made were correct. A new approach was proved: before taking part in the course the students received a welcome package including the study material and a personal welcome letter with a number of arithmetical problems and a collection of formulas needed when solving the problems. This was experienced as a motivating factor and the students were considerably better prepared.

Before being qualified to take part in an A-education the student has to have practical experience at a nuclear facility for at least 32 work weeks as RP-Technician category B, including at least four of the following areas:

- Reactor hall
- Containment
- Reactor building
- Turbine building
- Waste management
- Active workshop
- CLAB (Swedish Central Interim Storage for Spent Nuclear Fuel) or
- Transport of spent nuclear fuel

Minimum two work weeks per area and documented.

The course has been run at least once a year since 2004.

The need for further education, as well, was identified while the FS-1 –course was examined and revised. It was fully possible that personnel had taken part in a FS-1 –course 15 years ago but not taken part in any higher RP-education after that. Therefore a so-called FS-2 –course was created.

The main features in a FS-2 –course are to repeat some basics and retain the existing knowledge and skills, but most of all, the course functions as a forum for discussion and exchange of experiences within the country and internationally.

### **Education for RP-Technician Category B**

Traditionally there has been a larger gap between the level of education for RP-Technician category A/RP-Officer and RP-Technician category B. According to questionnaires made among the RP-Technicians category B there is a lack of knowledge needed before taking on the A-education.

## Education and Training of Radiation Protection Officers in Sweden

The most extensive part in the work of the FORS-group was to create a new foundation for B-education as well as produce the material for the education, including student material and instructor's guide.

The task analysis executed year 2003 was used as a basis for this work as well. There was no material completely ready to be used so the members of the FORS-group divided the competence areas and were working separately, only having a number of meetings for check-up of the material.

The work resulted in two books, the first one containing:

- Radiation physics
- Radiation biology
- RP-operations at the facilities (including ICRP, ISOE, national legislation etc.)
- Classification of areas
- RP-instruments
- Transport of radioactive material
- Waste management
- Industrial safety
- Arithmetical problems to solve and
- Group work

The second book was concerning BWR and PWR extensively (the reactor types in operation in Sweden) and a short description of other, most common reactor types.

Before being qualified to take part in an B-education the student has to have practical experience at the facility for at least 16 work weeks as RP-Technician category C, including at least two of the following areas:

- Reactor hall
- Containment
- Reactor building
- Turbine building
- Waste management
- Active workshop
- CLAB (Swedish Central Interim Storage for Spent Nuclear Fuel) or
- Transport of spent nuclear fuel

Minimum two work weeks per area and documented.

The course concerns one week at some of the nuclear facilities in a class room followed by a written exam two weeks later. It can be discussed whether or not this method is preferable because of the positive results gained in connection to A-education and it's homework as a method of examination. It is quite normal that some of the students have to take a re-exam in order to pass all the parts and be qualified as RP-Technician category B.

## Education and Training of Radiation Protection Officers in Sweden

### **Education for RP-Technician Category C**

According to the task analysis executed year 2003 the category C education was the one with least problems. There is a material ready to be used.

The course contains the following areas:

- "Radiation Protection" (a two-day education administrated by KSU)
- "Hot Work" (a one-day education held by the Swedish Fire Protection Association)
- Life-saving / First Aid (a half-day education held by the Swedish Work Environment Authority)
- Safety Information (common for all the Swedish nuclear facilities)
- Reactor types in operation in Sweden (BWR, PWR)
- Personnel decontamination
- Waste management
- Radiation environment at NPP's and classification of areas and
- A one-week practice at a nuclear power plant (by schedule)

The course concerns one week at some of the nuclear facilities in a class room followed by a written exam two weeks later. It can be discussed whether or not this method is preferable because of the positive results gained in connection to A-education and it's homework as a method of examination. It is quite normal that some of the students have to take a re-exam in order to pass all the parts and be qualified as RP-Technician category C.

It is important to keep the existing material up-to-date. The revision of the student material will be done by the FORS-group as well.

### **The Results in General**

The line of education and training for RP-Technicians and –Officers in Sweden can be expressed as "stairs" where the knowledge and skills of the lower step is always included in a higher one.

## Education and Training of Radiation Protection Officers in Sweden

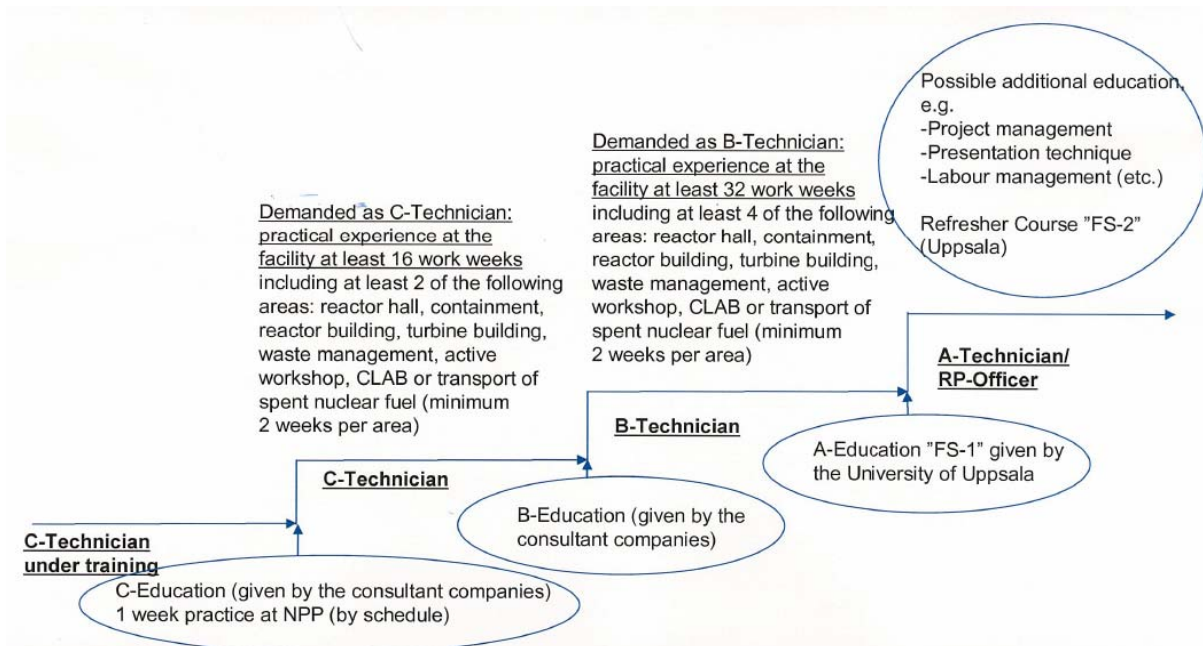


Figure 2. Education and training of the radiation protection technicians and officers in Sweden

After the FORS-group was finished with different steps in it's work, all the nuclear facilities have standardized the demands on RP-personnel on all the levels mentioned in this paper. The work of the FORS-group is considered as very valuable for the RP-professionals.

### Work still needed to be done

In the nearest future it is essential not to let the quality of the education to degrade. The education material goal analysis and contents must be revised on a regular basis and updated when needed.

There is an ongoing inquiry about possibilities to better co-ordinate the whole chain of educating RP-professionals in Sweden. It is possible, for example, to arrange the education at Barsebäck NPP (in service operation prior to decommissioning). This would give an unique opportunity to educate RP-personnel in an authentic environment. Both the nuclear facilities and external companies have to be committed for this to work.

It is quite common, nowadays, that Swedish RP-Technicians work abroad, in UK or Canada, for example. It is very important to guarantee an exchange of all the experience and knowledge they possess. There is a need to create a system for this exchange to be facilitated.

The heads of the RP-units at Swedish nuclear facilities constitute the steering group for this co-operation. They keep the RP-Managers updated and address issues if/when needed. The FORS-group will continue it's work and is responsible for the work in practice.

The goal is also to transfer the main responsibility for E&T of the consultant companies' personnel from the companies themselves to the nuclear facilities. This in order to guarantee an equal level of E&T with every separate course. There is an ongoing discussion about how this is going to be done in practice.

## Education and Training of Radiation Protection Officers in Sweden

### **Future Challenges**

It is quite common that a major part of the personnel of the consultant companies work as RP-technicians or –officers while studying, mostly at the university. It is an assured summer job because of the yearly outages in the summer time in Sweden. But it is, unfortunately, quite common that the same persons after graduating do not return to this profession. Or that people staying within the profession are satisfied with a lower level of RP-education, e.g. work as RP-technician category B the rest of their work lives.

There are possibilities to choose some of the next steps of the “career ladder”, to become a project manager or a radiation protection expert etc. In a not so far future more resources are needed, on a higher level of profession as well.

It is important to, somehow, attract the younger generation to become a lasting part of this profession and to be willing to further educate themselves within it.

# NOT ABLE TO DISTINGUISH BETWEEN X-RAY TUBE AND IMAGE INTENSIFIER: FACT OR FICTION?

## SKILLS IN RADIATION PROTECTION WITH FOCUS OUTSIDE RADIOLOGICAL DEPARTMENTS

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### ABSTRACT

The Norwegian Radiation Protection Authority has revealed inadequate skills in radiation protection in 91% of the Hospital Trusts (HT) inspected during 2008 and 2009. The lack of skills in radiation protection was mainly associated with physicians and nurses who operated C-arms outside the radiological departments. It's not a fiction that operators of mobile C-arms don't know the difference between the X-ray tube and the image intensifier. Reason: Most HT's had an insufficient system for systematic and frequent education and training in radiation protection, responsible persons were unaware their responsibilities, general lack of involvement and focus on radiation protection outside radiological departments. By focusing on radiation protection in the basic education of physicians and nurses, introducing "driving licenses" for operating C-arms and work for a change in attitudes towards radiation protection, can hopefully improve the general skills in radiation protection significantly and prevent radiation hazards caused by malpractice.

### 1. Introduction

C-arms are a common tool in many interventional and surgical procedures performed outside radiological departments. Common for these procedures is that the C-arm often is operated by physicians and nurses without any formal education and training in radiation protection. Modern C-arms have now become highly technically advanced, are used in more and more complex and time consuming procedures and have the potential to deliver high patient doses if operated by unskilled persons. To overcome this problem the Medical Exposure Directive (MED) states in article 7 that radiation protection should be implemented in the basic education for physicians [1]. Norway, as a non-member of the European Union, is not obligated to implement the requirements given in the MED. As a consequence, radiation protection is practically absent in the basic curriculum of Norwegian medical schools.

The public health care system in Norway is administrated under the Ministry of Health and Care Services. There are approximately 70 public hospitals organized in 21 Hospital Trusts (HT) located under four regional Health Authorities (HA). The HT is the legal entity. Norway got a new radiation protection regulation in 2004 [2]. According to this regulation, all HTs are obligated to ensure that all personnel involved in radiological examinations have sufficient qualifications and skills in radiation protection. Another consequence of this regulation was the need for an authorization from the Norwegian Radiation Protection Authority (NRPA) in order to use advanced X-ray equipment for medical purposes. In their application forms, 54% of the HTs reported inadequate skills in radiation protection among personnel involved in radiological examinations at their local hospitals. The lack of skills in radiation protection was mainly associated with physicians and nurses who operated mobile C-arms outside the radiological departments. The authorization to these HTs was issued under the condition that reported non-conformities regarding skills in radiation protection were fully implemented within a given time limit. After some reminders, all of the HTs confirmed compliance with the



regulation. The aim of this work was to verify through inspections whether the HTs self declared compliance regarding training in radiation protection were sufficient or not.

## 2. Material and method

The NRPA carried out inspections at 52% of all HTs during the year 2008 and 2009. To get a representative picture of the national situation, HTs were picked systematically from all four HAs, as shown in table 1. Normally two hospitals within each inspected HT were visited, covering a total of 26% of all the Norwegian public hospitals.

**Table 1:** Overview of the inspections of hospital trusts (HT) carried out in 2008 and 2009.

Inspection year	Regional Health Authority (HA)	No. of inspected HT (% of total HTs in HA)
2008	South-East	3 (33%)
	West	2 (50%)
2009	Mid	3 (75%)
	North	3 (75%)
<b>SUMMARY</b>	<b>Covering all HAs</b>	<b>Total 11 HTs (52% of all HTs)</b>

The inspections were a direct follow-up of the authorization given to the HTs, with focus to verify that all necessary requirements in the radiation protection regulation were implemented. The inspections were notified 4-6 weeks in advance, and all major focus topics were addressed in the notification letter. This paper covers only the findings related to skills and training in radiation protection with special focus on use of X-ray equipment outside radiological departments. The groups of X-ray guided procedures chosen for further investigation at the inspections were orthopaedic, ERCP<sup>1</sup> and cardiac procedures. The number of included groups of procedures varied from HT to HT depending on its availability and the inspection schedule.

The inspections were quality system audits, based on document reviews, interviews, on-site inspections and verifications. Documents to be reviewed were collected both in advance of and during the inspections. All HTs were asked to submit their procedure(s) for education and training in radiation protection, if available. Interviews covered staff having personnel management and physicians and nurses who were involved in the predefined groups of X-ray guided procedures, both experienced and new employees. The interviewed persons were mainly picked by the HT itself, but some ad-hoc interviews of C-arm users were carried out at the same time as the on-site visual inspection of the C-arms. Spot checks to verify if all involved persons had received training in radiation protection were done for the orthopaedic procedures, by asking for their documentation of training (i.e. signed lists of attending persons). All non-conformities revealed during the inspections were presented in a closing meeting at the end of the inspection. All non-conformities had to be accepted on-site by the responsible persons representing the HTs. Misunderstandings, if any, could in this way immediately be taken into account and corrected for.

## 3. Results

All HTs had in the authorization process confirmed that they had an operating system to ensure that all personnel involved in radiological examinations have sufficient qualifications and skills in radiation protection. Despite of this, procedures for education and training in radiation protection were received from only 64% of the HTs. Reviews of these procedures are summarized in table 2. All of the procedures were written by either the radiation protection officer (RPO) or a senior radiographer from the radiological department. Only those procedures with traceability to a quality assurance system (71%) hold an acceptable quality. Only two of the received procedures had ever been revised.

<sup>1</sup> Endoscopic Retrograde Cholangiopancreatography

**Table 2:** Summary of the review of the procedures in education and training in radiation protection received in advance of the inspections.

Topic of review	Included	Most common finding
Traceable to QA system	71%	Dated in 2007-2008, two had been revised
Placed responsibility	100%	Responsibility in line (director of department)
Area of application	100%	All involved with no RP <sup>2</sup> in formal education
General training in RP <sup>2</sup>	100%	Yearly courses offered by RPO <sup>1</sup>
Training in operating X-ray unit	100%	New equipment, offered by vendors, little RP <sup>2</sup>
Demand for documentation	100%	Signed list for attendance

<sup>1</sup> Radiation Protection Officer

<sup>2</sup> Radiation Protection

To verify if the HTs procedure for education and training in radiation protection were followed locally at the different hospitals and departments using X-ray, interviews of the staff were carried out. Staff involved in orthopaedic, ERCP and cardiac procedures was interviewed at respectively 100%, 64% and 27% of the HTs. According to the procedures, the responsibility for ensuring that all staff involved in X-ray guided procedures were placed on the head of the department. Despite of this, many of them were unaware of their responsibility for radiation protection and also unfamiliar with the presence of the procedure in general. A clear distinction between the levels of awareness of radiation protection was observed between nurses and physicians within all the included groups of procedures, nurses having the highest level of awareness. Only one HT had a systematic system for education and training in radiation protection. In the other HTs, courses in radiation protection were occasionally held by the RPO without any systematic approach. The level of attendance on these courses varied between the different professionals (physicians and nurses), departments and hospitals within each HT. Existing systems for documentation of performed education and training, if any, were highly insufficient at all HTs. The spot check verification of documentation for staff involved in orthopaedic procedures revealed that 45% and 91% of the HTs had some documentation of performed education and training of respectively physicians and nurses. None of the documentation presented were according to requirements in their own procedures.

Interviews also revealed serious lack of skills in radiation protection. Typical examples were: unable to identify the X-ray tube from the image intensifier of the C-arm, inadequate knowledge of the operating consol, unknown with the three cardinal principles for staff protection (time, distance and shielding), no deliberate use of collimation and/or pulsed fluoroscopy and total lack of knowledge about patient doses and risks. In many HTs nurses assisted the physicians by operating the C-arm console. For those cases it was not uncommon to just switch on the X-ray unit and start to fluoroscopy regardless of the default exposure settings on the consol.

The inspections performed by NRPA concluded that 91% of the inspected HTs had non-conformities with the requirements regarding skills and training in radiation protection. This finding makes the HTs self declared compliances with the regulation highly questionable.

#### 4. Discussion and conclusion

The lack of skills in radiation protection among personnel outside radiological departments is clearly not a fiction. How can the real world be that different from the assumed situation based on the issued authorizations? HT's had an insufficient system for systematic and frequent education and training in radiation protection, responsible persons were unaware their responsibilities, general lack of involvement and focus on radiation protection outside radiological departments are some of the answers. These findings may be a consequence of the way the Norwegian public health care system is organized. Large organizations like Norwegian HTs, which consist of many hospitals often spread over a large geographical area, make communication and the premises for establishing common procedures in radiation protection a challenge. The lack of knowledge about doses and risks among

leaders often tends to unconsciously undermine the importance of radiation protection. As a consequence, radiation protection is often ignored or not prioritized, even though the responsibility is clearly defined.

The fact that as much as 91% of the inspected HTs had non-conformities regarding skills and training in radiation protection rise other questions: Can the HTs self declared compliance with the regulation be trustworthy? Have the HTs by purpose misinformed the NRPA or is the self declaration made in the best well meaning? Lack of basic knowledge in radiation protection may itself result in different interpretations of what is sufficient enough to fulfil the requirements in the regulation.

With modern C-arms becoming more and more complex with the possibility to give high patient doses if operated by unskilled persons, the revealed conditions at Norwegian hospitals give rise to concern. There is an urgent need for increasing the knowledge of patient doses and risks among physicians and nurses. The most efficient way to overcome this situation is by introducing radiation protection in the basic education of physicians as stated in the MED. More sufficient systems for ensuring adequate skills locally at the HTs should also be of high priority. One way to improve the level of skills locally is by introducing "driving licenses" for operating X-ray units. Such a system makes it also easier for the responsible persons to keep track of each individual employees performed training courses and level of skills in radiation protection. Meanwhile, focus should be on recognizing the importance of having a well functioning system for education and training in radiation protection locally at each HT.

Finally, a big challenge is to overcome the bad attitude towards radiation protection present in some physician specialties, especially among orthopaedics. All HTs reported a low level of attendance by physicians on those courses that had been arranged in radiation protection, mainly because of the physicians lack of interest. Working for a change in attitudes can hopefully improve the general skills and awareness of radiation protection among physicians, significantly. It has been proven that just by teaching some "do's" and "don'ts" can have a tremendously impact on patient doses, especially if competence in radiation protection is totally absent [3]. To conclude, there is a common responsibility of the community to improve the operators skills in radiation protection and in this way try to prevent radiation induced hazards caused by malpractice.

## **5. References**

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# OPTIMIZING RADIATION PROTECTION IN MEDICAL PRACTICE

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## ABSTRACT

The main aim of medical practice is to deal with the health problems of patients, and quite often radiation protection issues are left aside. The development of radiation protection training in medical applications is complex due to the different backgrounds of the various occupational categories involved. ORAMED (Optimization of RAdiation Protection for MEDical Staff) is a collaborative project funded by FP7. The main objective is to enhance the safety and efficacy of the uses of radiation in diagnosis and therapy for medical staff. To fulfil this objective several training actions have been planned and are under progress.

The approach undertaken to ensure correct dissemination of the conclusions of the study and to guarantee a practical impact on medical staff is presented. The training material, especially focused on practical issues, is based on the results obtained by the different European research groups participating in the project. It can be used together with other available general radiation protection material.

## 1. Introduction

Education and training is a key factor in establishing effective radiation protection programmes. The use of ionizing radiation in medical applications constitutes the major field of non-natural exposure to the worldwide population, mainly as patients, and about 50% of radiation monitored workers belong to the medical field [1]. Thus, any training initiative in this field can result in important improvements on radiation protection practice. In addition, the new developments in medical technology and the increased complexity of medical radiation techniques require new skills and a continuous up-dated training of the personnel. However, the development of radiation protection training in medical applications is complex due to the different backgrounds of the various occupational categories involved. In addition, since the main aim of the use of radiation in medicine is to deal with the health problems of patients, quite often radiation protection issues are left aside.

There are several national and international training programmes under progress which aim at ensuring appropriate radiation protection both for patients and workers. Among others, we can outline the IAEA radiation protection programmes, which provide Member States with training material and have a very active website that is frequently up-dated with new

information on radiation protection of patients, videos and new training material [2]. The European Commission has promoted, under the topic Education and Training, several projects that deal with radiation protection in various work sectors [3,4]. Finally, it is also worth mentioning ICRP work in this field and more specifically, the available training material on radiation protection in medicine, which is freely downloadable from the website [5].

The training proposal that is presented in this work has a much more specific scope and aims at providing practical skills and knowledge in some topics where there is a need to improve standards of protection for medical staff for procedures resulting in potentially high exposures. The areas of interest were identified in the CONRAD project [6] and are being studied within the framework of the ORAMED (Optimization of Radiation Protection for Medical Staff) project, a collaborative project funded by the European Atomic Energy Community's Seventh Framework Programme [7]. The main objective of ORAMED is to enhance the safety and efficacy of the uses of radiation in diagnostics and therapy. The project was launched in February 2008 and will be finished in February 2011, thus the activities are still under progress. In this paper we describe the areas covered by the training material and the approach undertaken to ensure correct dissemination of the conclusions of the study to the medical staff and to guarantee an improvement in medical practice. Finally, as an example, we discuss the experience of a first training course given to nuclear medicine staff.

## **2. Scope**

The state-of-the-art analysis performed before starting ORAMED project showed high extremity doses and a lack of systematic data analysis on exposures to the staff in interventional radiology and nuclear medicine. Therefore, ORAMED aimed at developing methodologies for better assessing and reducing exposures to medical staff in these fields. Four main topics are addressed [7].

### **2.1 Optimization of radiation protection in interventional radiology**

An extensive campaign of measurements and Monte Carlo calculations of extremity and eye lens doses in interventional radiology is under progress to obtain a set of standardized data on doses for staff in interventional radiology and cardiology and to design recommended radiation protection measures and procedures to both guarantee and optimize staff protection.

### **2.2 Development of practical eye lens dosimetry in interventional radiology**

An increased evidence of radiation-related lens opacities in interventional radiologists has been reported in recent years [8]. However, the eye lens doses are never measured in routine applications and, at the present time, there is no available dosimeter for eye lens measurements. In addition, there is a lack of procedures to measure eye lens doses. At the moment, a formalism to calculate and reproduce the operational quantity, personal dose equivalent at a depth of 3 mm of tissue,  $H_p(3,\alpha)$ , in calibration laboratories has been developed and a set of conversion coefficients from air kerma to  $H_p(3,\alpha)$  has been proposed [9]. Some preliminary versions of the eye-lens dosimeter prototype are being tested.

### **2.3 Optimization of the use of active personal dosimeters in interventional radiology**

Active personal dosimeters (APD) have been found to be very efficient tools to reduce occupational doses in many applications of ionizing radiation. However, their use for interventional radiology cannot be generalised because, most commercial APDs do not respond satisfactorily to low-energy photons [10-100 keV] and pulsed radiation with relatively high instantaneous dose rates. The behaviour of 7 commercial APD models, deemed suitable for application in interventional radiology, has been analysed through several tests in laboratory conditions with reference continuous and pulsed X-ray beams. In addition, tests in different hospitals are under progress to evaluate the response of APDs in real conditions.

Present results have already identified some devices that cannot be used in interventional radiology, whereas others can provide some useful indications of the personal doses during interventional procedures.

#### **2.4 Improvements in extremity dosimetry in nuclear medicine, with special emphasis for PET applications and nuclear medicine therapy**

Extremity doses in nuclear medicine, especially in therapy, can be very high if adequate radiation protection measures are not followed. As in the case of interventional radiology, a European campaign of extremity measurements in nuclear medicine departments is under progress. The doses to the different parts of the hands are systematically mapped in more than 100 workers, with special attention paid to unsealed therapy sources. Monte Carlo simulations are simultaneously performed to determine the main parameters that influence the hand dose distribution and the effectiveness of different radiation protection measures. Analysis of the results should provide knowledge about the real dose load of nuclear medicine workers and help to identify the best practices in this field.

### **3. ORAMED training material**

First of all, stakeholders for the selected topics were identified. For these stakeholders the best channels and type of material to be prepared were chosen in order to achieve the expected radiation protection education objective.

The main identified stakeholders are:

- Medical staff exposed to ionizing radiation and more specifically: interventional radiologists, cardiologists, nuclear medicine technologists, nuclear medicine therapists.
- Radiation protection officers and medical physicists in hospitals and medical facilities.
- Education and training institutions in radiation protection.
- Personal dosimetry services.
- Calibration laboratories.
- Radiation protection regulators and authorities.
- Instrument manufacturers.

Different approaches have been considered for each group. Regarding medical staff, some contacts with representatives of the professional societies have been made to establish collaboration for the discussion of the training material and for using their networks to facilitate the transfer of results and the distribution of training material. The IAEA has also offered his support to participate in the dissemination of the training material to third countries.

Training material for medical staff includes:

- Reports on guidelines about radiation protection measures to reduce staff dose in interventional radiology and nuclear medicine.
- A video with “good practices” to optimize radiation protection of medical staff,
- Transparencies to be used on training courses. This material can be, if needed, included in a more general radiation protection course. It contains information on the results of the project, and stresses the importance of radiation protection measures and of the skill of the operator.

It is planned to take advantage of information and communication technology to ensure a wider diffusion of the prepared material. In particular, an e-learning package, with different modules for the different medical specialities, is being prepared. The ORAMED website [7] is already a useful tool to share the main findings of the project and to exchange experiences and understandings on the project subjects.

Training activities foreseen in the project can be classified in three categories: on-going training for participating medical staff, training for “trainers” and e-training. In January 2011, an international workshop to present the results of the ORAMED project will be organized in Barcelona. Round tables with the identified stakeholders will be programmed to promote good discussion and feedback of the results. The e-learning modules will be presented on this occasion and made available to collaborating professional organizations and interested institutions in the field.

Training for “trainers” addresses specific activities for radiation protection officers, medical physicists in hospitals, lecturers and other people in charge of radiation protection training at medical facilities. It is intended to prepare support material, guidance and other helpful resources for trainers own use of ORAMED guidelines and training material for practitioners. The information will be available on-line, with a given password, and presented in dedicated refreshment courses or scientific meetings.

The on-going training consists of informing of the results of the work to the medical staff participating in the project or to staff from similar organizations. The feedback from one of these experiences is summarized in the following paragraph. Another interesting experience is the participation of a member of ORAMED in the Training Course on "Radiation Protection in Nuclear Medicine" organized by the Lund University, Malmö University Hospital, within the framework of the MADEIRA (Minimizing Activities and Doses by Enhancing Image quality in Radiopharmaceutical Administration) project, co-funded by the European Commission through EURATOM Seventh Framework Programme [10].

#### **4. Example: Extremity dosimetry in nuclear medicine lecture**

A 45-min lecture on extremity dosimetry in nuclear medicine was presented in several nuclear medicine departments that had participated in the ORAMED project. The presentation was included in the monthly lifelong learning sessions organised by the hospital. The audience, around 30 people, belonged to the nuclear medicine department and consisted of medical doctors, medical physicists, nuclear medicine nurses and technicians and the radiation protection officer. The lecture was given in the personnel mother tongue which helped the understanding of all participants. First of all, a general overview of the ORAMED project was given, description of work packages, state of the art and participants, both a list of institutions of the ORAMED consortium in charge of the research and a list of European hospitals where measurements are being carried out.

Secondly, a revision of the radiological characteristics of radiopharmaceuticals and of the legislation and requirements for individual monitoring was reported. Strong emphasis was given to explain the influence of the type of dosimeter used and to give recommendations on how to wear the extremity dosimeter and how to reduce personal doses. This general overview provided assistants with the essential knowledge and understanding to correctly interpret the project results.

Thirdly, the main results from the measurements in three nuclear medicine departments were presented. Hand dose distribution during preparation and administration of  $^{99m}\text{Tc}$ ,  $^{18}\text{F}$  and  $^{90}\text{Y}$  (Zevalin) and  $^{90}\text{Y}$  (SIRS sphere) were separately evaluated and compared between medical services and individuals. Photographs of the different installations, radiation protection measures and work procedures were supplied to illustrate the particularities of each situation. An open discussion was then started to emphasise the effectiveness of the radiation protection measures and of the individual skills. Functional difficulties were also debated and practical solutions were proposed.

The feedback of the participants was very positive and, in general the lecture was very much appreciated. Some of the main lessons learned by the technicians were related to the

importance and differences between protection measures, such as syringe shielding, lead apron, ring dosimeter. They also mentioned they were interested to confirm, the importance of individual skill and of time to reduce personal doses. Finally, the comparison between technologists performing the same type of work gave confidence to those that obtained lower doses and pushed those with worst performances to improve their working procedure. It was shown that the different ways that the people use to perform the same type of work has direct consequence in their doses. These considerations were useful both for those doing the actual work and for those responsible of the service and its radiation protection.

## 5. Conclusions

The training material which is being prepared within the framework of ORAMED will aim at giving a practical understanding on how to improve radiation protection practice in some medical applications where, at present, doses are potentially high. The problems which are analyzed are, in general, not included in most available training courses for medical staff. The training material based on them will improve actual education information. The contacts and collaboration with professional societies and international organizations should enable widespread dissemination of the material.

The pilot training sessions given during the project, such as the one described in this paper, should contribute to improving the final training material. A comprehensive evaluation programme to receive feedback from all interested parties is also foreseen and contributions will be considered by the authors to a regular up-date of the training material.

### Agreements

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# EDUCATION OF HEALTH PHYSICISTS AND HEALTH PHYSICS TECHNICIANS AT DANISH DECOMMISSIONING

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## ABSTRACT

Basic training programmes on radiation protection for Health Physics Technicians and Health Physicists at Danish Decommissioning have been developed. The programmes cover a wide range of topics in theoretical and applied health physics. Lectures, laboratory exercises, written exercises and on-the-job training are used as educational tools. The training of a Health Physicist (radiation protection expert, RPE) having a background education from a technical university or similar takes approximately one year of which about a month is spent at a university course on radiological protection. The basic training of a Health Physics Technician having a background education as laboratory technician or an equivalent education takes about six months. A text book on health physics (in Danish) containing 16 chapters covering more than 700 pages has been prepared as basis for the training programmes. The paper presents the content of the two training programmes and the experience gained during their execution.

## 1. Introduction

In the nuclear field it is very important for the safety of the employees that the radiation protection personnel are educated to a degree so that they can appear competent, calm, and trustworthy. Therefore the training of these people is very important. In Denmark, there is no formal education for health physicists and health physics technicians, and the only workplace is Danish Decommissioning, so the institution has to plan and carry out the education locally. The health physics technicians at Danish decommissioning are very well educated, because they must be able to work very independent, take decisions and be able to use both simple instruments and more advanced gamma-spectrometry, and to interpret and evaluate the results of the measurements.

## 2. Health Physics Technicians

The Health Physics Technicians are recruited mainly amongst laboratory technicians as they have an education where accuracy and meticulous behaviour is important. Earlier dairymen were used, as they - during their work with foodstuffs - could be expected to have a high sense of workplace hygiene and keep the equipment conventionally clean, and thereby free of contamination. Trainees at the age of 35 to 45 are preferred, as they are more experienced, have had a working life for several years, and therefore are more experienced in associating with and getting on with the rest of the workforce.

### 2.1 Syllabus

The basic training of a health physics technician takes about six months, depending of the basic education, especially the mathematical knowledge differs from person to person. As Danish Decommissioning is the only place in Denmark, where Health Physics Technicians are used, and the education only takes place in case of a vacancy, only one or two trainees are educated at the same time. It is preferable to teach at least two persons at the same time, as there is a better interaction and more discussion with several trainees in the classroom.

Each week there are three to four teaching lessons of three hours duration, a large laboratory exercise and smaller written exercises connected to the subjects of the week. The education is completed with a written examination and an oral examination.

In Tab 1 the topics and the approximate number of lessons for each topic is listed.

<b>Subject</b>	<b>Number of lessons</b>
Basic mathematics	7
Atoms and molecules	2
Nuclear decay processes	5
Radiation interactions with matter	5
Radiation fields and radiation doses	6
Radiation instruments	4
Dose meters	1
Measurement techniques	5
External radiation doses	2
Internal radiation doses	3
Devices producing radiation	3
Radiation biology	4
Radiation protection norms	3
Radiation shielding	3
Naturally occurring and man made radiation	2
Radiation doses from accidents	2
Radiation hygiene	3
Radiological emergency response	1
Doses from environmental releases	1
Nuclear facilities at the DD Site	4
Clearance measurements and accreditation of the clearance laboratory	3
Organisation and documentation	1
Waste and waste treatment documentation system	1

Tab 1: Topics and number of lessons for each topic for the education of a Health Physics Technician at Danish Decommissioning.

The teaching is given as lectures of about three hours duration with a rather intense interaction between the trainees and the lecturer. During the lecture small problems are solved by the trainees. The use of a blackboard makes the teaching process a bit slower but giving more time for the trainee to understand the problems; therefore this way of teaching is used for most of the lectures. Videos found on the internet can be quite instructive and are used to illustrate for instance radioactive decay, the fission process, interaction of radiation with matter, and how a cyclotron works.

To facilitate the learning process, and as a support later on, a text book of 700 pages covering all the radiation protection topics listed above has been prepared by the Health Physicists at Danish Decommissioning.

## 2.2 Exercises

There are about 20 laboratory exercises, covering especially the use of all the instruments in use at the health physics laboratories. Emphasis is made on gamma-spectrometry, as the results from the measurements can be difficult to assess and evaluate. Five of the exercises

deal with energy-calibration and efficiency calibration of the gamma-spectrometer, evaluation of the results, and general use of the equipment. Also measurements with gas-detectors are important in the daily work, so four of the exercises deal with the use and efficiency calibration of gas-detectors. The remaining exercises are exercises on contamination monitors, radiation monitors, the effects of different types of shielding for electrons and photons, mapping of radiation fields, different kind of dose meters used at the site, instruments for measuring radioactive discharges from the nuclear plants, calculation of internal doses from tritium on the basis of urine samples, counting statistics, etc.

The trainees must prepare a written report for each of the exercises, and the report will be evaluated by a Health Physicist.

### 2.3 Co-worker training

A very important part of the education is to participate in the daily work at the health physics laboratories. Here the trainee learns how the daily routine works are performed. These include smear sampling, analyses of smear and air samples, operating the radioactive discharge systems, routine radiation field measurements at work places, etc. The Health Physics Technicians are on 24 hour shift and participate in the emergency operations; therefore, they are also trained to react in the case of a radiological accident at the nuclear facilities.

### 2.4 Examinations

Following the six months course, there is a written examination lasting four hours. In Tab 2, two examples of the problems to be solved are given. The actual written examination included nine problems, of which some are more complicated and comprehensive than the two examples given here.

#### Problem no. 1

An employee has been working in the reactor hall for 5 hours in a constant concentration of tritium (tritiated water). A urine sample given ten days after the intake shows a tritium concentration of 10 kBq/l

1. Determine the intake of tritium,  $q_0$ , assuming that the fraction of the total excretion from the body via urine,  $F_u$ , is 60%. Daily urine excretion can be set to 1.4 l/day.
2. Determine the committed effective dose,  $E(50)$ , from the intake.

#### Problem no. 2

A sample contains a short lived radionuclide with a half-life of 10 minutes. The sample is counted for 30 minutes. The number of counts is 10000. The absolute efficiency,  $\epsilon_{abs}$ , for that specific radionuclide is 0.20 cps/Bq (0.2 counts/decay).

1. What was the activity of the sample at the beginning of the counting?
2. Determine the number of counts, if the counting time is so long, that all of the activity in the sample has decayed.

Tab 2: Two out of nine examination problems given in the written examination in December 2008.

The day after the written examination, there is an oral examination focusing on the subjects in the written examination. If there are two trainees, both will participate in the oral examination at the same time, but are given individual questions. The oral examination takes about one and a half hour.

### 3. Health Physicists

The Health Physicists are recruited among persons having a university degree in science, physics or related topics. In radiation protection it is rather important to have a basic knowledge in biology, but that has to be learned at a university course, or done as self-tuition.

#### 3.1 Syllabus

The basic training takes about one year, again depending on the basic education. Most of the subjects are dealt with and discussed in a study group consisting of the trainee and the Health Physicists in the department. Each person in the study group has in turn to make an introductory presentation of the subject for the session. The subjects and the number of sessions for each subject are listed in Tab 3. Each session last about 3 hours.

Subject	Number of sessions
Radioactivity and ionising radiation	1
Radiation interactions with matter	3
Radiation fields and radiation doses	4
Detection of radiation	4
Sampling measurements and analyses	3
External radiation doses	3
Internal radiation doses	3
Radiation shielding	4
Radiation biology and radiation risks	4
Planning of radioisotope experiments	1
Biological tracer techniques	1
Radiation protection norms	6
Naturally occurring and man-made radiation	2
Devices producing radiation	2
Doses from environmental releases	3
Physical tracer techniques	2
Radiation doses from accidents	3
Nuclear and radiation safety organisation	2
Radiological emergency response	2
Nuclear facilities at the DD-site	5
Software (radiation transport, radiation risk, dose calculations etc.)	4

Tab 3: Topics and number of sessions for each topic for the education of a Health Physicist at Danish Decommissioning.

There will be about 26 written exercises covering the different topics. These will be presented by the trainee for the study group. In addition, there are eight laboratory exercises covering the use of the radiation protection instruments at the laboratory. The trainee must prepare a written report for each of the exercises.

The trainee also participates in the projects at Danish Decommissioning. This would be the decommissioning projects, in the beginning as a trainee assistant, but as a full member of a project group, even before the education is formally finalized. The trainee could also participate in projects like in-service training for the employees at the institution, or short courses in radiation protection for external workers, doing for instance demolition work.

### 3.2 External courses

The trainee shall participate in an external course in radiation protection. Earlier, a post graduate course and an advanced course in radiation protection offered by the former National Radiological Protection Board (NRPB) were used. Unfortunately, these excellent courses were closed some years ago. Therefore, the course *Radioactive isotopes and ionizing radiation* as offered by the Department of Biology, University of Copenhagen has been used as a substitute.

The duration of the course is eight weeks (two days a week). The aim of the course is to give the participants:

- a basic understanding of the phenomena *radioactivity* and *ionising radiation*, including the effect and significance of ionizing radiation on biological systems
- a practice-oriented knowledge of radiation physics, radiation detection, aspects of health physics, and practical work with radioactively labelled compounds in biological and medical applications (principally non-clinical).

The content of the course includes:

- radioactive and stable isotopes
- radioactive decay
- types of ionizing radiation
- natural and induced radioactivity
- absorption and scattering of radiation
- energy deposition in biological tissues
- external and internal dosimetry
- radiation protection
- fundamentals of radiobiology
- detector systems for ionizing radiation
- design of biological radiotracer experiments
- legislation about radioactivity
- responsibility for laboratory work with radioactive materials.

The methods of instruction and the duration covers around 24 lectures, 23 hours of experimental laboratory classes, and six hours of seminars/discussion sessions. Elements of e-learning is used to supplement the face-to-instruction.

The course is authorized by the Danish health authorities (National Institute of Radiation Protection) as fulfilling the education requirements for persons in charge of work with open radioactive sources.

The assessment includes three hours written examination (books allowed) and immediately after the course an external censorship. Assessment is given as pass/fail.

# EDUCATION IN RADIATION PROTECTION FOR PHYSICIANS IN TRAINING. A THREE YEAR EXPERIENCE

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## ABSTRACT

During the last three years, basic education in Radiation Protection has been provided to physicians in training who each year join our hospital and other medical facilities attached to it to begin their residency period. This education is intended to complete their previous knowledge in Radiation Protection acquired during preclinical period of training in medical schools. The organization and management of the training has been assigned to Radiation Protection Departments of public teaching hospitals in Madrid. It has been developed in a one-day theoretical course, followed by an educational evaluation and a satisfaction questionnaire. Comparative analysis has been carried out between the three editions, regarding the teaching skills of the trainees and their fulfilment with the course. As a consequence, the curriculum of the programme has been updated, in order to adapt it to physicians' real knowledge and future needs, achieving a more effective programme for the trainees each year.

### 1. Introduction

The Council Directive 97/43/EURATOM of 30 June 1997 (1), on health protection of individuals against the dangers of ionizing radiation in relation to medical exposures establishes, on the 7<sup>th</sup> article, that all European member States shall ensure that practitioners and other collectives involved in radiological practices have adequate theoretical and practical training for the purpose of those practices, as well as relevant competence in Radiation Protection. Furthermore, all European Members shall encourage the introduction of a course on Radiation Protection in the basic curriculum of medical and dental schools (1,2).

The contents of this Directive have been incorporated into the Spanish legislation (3,4), establishing basic Radiation Protection education as part of both the programmes of medical schools and the training programmes of medical specialties.

According to European Commission Guidelines (2), this training should include basic Radiation Protection tuition, needed both by the prescribers and the practitioners themselves. It should be independent of the complementary training received where some of the doctors become practitioners (2,5).

Subsequently, some basic training in Radiation Protection is already being provided to medical students during the preclinical training period in Medical University Schools. They receive, through the first academic year, basic knowledge in General Physics, Radiation Physics and Radiation Protection.

Since 2007, additional Radiation Protection education has been established during the clinical period of the education, as part of the medical specialist training programme (4).

The objective of this study is to analyze and evaluate our three years of experience in basic Radiation Protection education aimed at every physician in training joining our hospital.

### 2. Material and methodology

The basic Radiation Protection education has been managed together by the regional Council and the Radiation Protection departments of the teaching hospitals in the area.

This training is organized in two different levels, one basic and one advanced, according to the different level of complexity of the radiological procedures that physicians might further

on accomplish or prescribe (4). Basic level of education includes also two different sublevels, the first one implies future physicians who will become mainly prescribers, while the second one is just intended for physicians belonging to specialties which may involve interventional procedures (urologists, orthopaedic surgeons, vascular surgeons, cardiac surgeons, digestive surgeons and cardiologists) (2). Additionally, the advanced level applies to physicians in training from radiology, nuclear medicine and radiotherapy specialties (5). The complexity and duration of the programme is rather different between the levels mentioned.

In a first approach, a basic course has been imparted to all the trainees within the first year of their residency programme at a time. The management of this basic training has been assigned to Radiation Protection Departments of teaching hospitals in Madrid.

The aim of the course is to provide basic knowledge about radiological protection in Medicine, regarding both medical and occupational exposures and also a broad perspective of the procedures involving radiations available at the hospital.

It has been developed in a one day course with a length of six hours in just one session. After the lessons, the participants have to accomplish an evaluation test and to fill in a satisfaction questionnaire.

The number of participants during the first edition of the course was 98. They were divided into two groups of 45 and 53 trainees each, celebrating the course in two following days. Both courses were held in a hospital's classroom. Although the number of students has increased up to 105 and 107 respectively in the following editions, the courses have been imparted in just one session, and they have taken place in the hospital's auditorium.

In the first edition, not only had the organization and syllabus of the course been assigned to the medical physicists of our department but also its didactic instruction. Trying to grow interest in the students, Nuclear Medicine, Radiotherapy and Radiology specialists have participated as teachers in the following editions, in order to explain their responsibility in the radiological protection aspects of the procedures, especially the justification principle of medical exposures.

The course enclosed, in the first edition, two hours of theoretical Radiation Physics, Structure of matter, X-ray generation, Radiation Detection, the x-ray tube, x-ray equipment and image formation. Those were followed by one hour of biological effects of ionizing radiation and two hours of Radiation Protection principles, legislation and Quality control in diagnostic radiology. Further editions have meant changes in some of the contents and their complexity to adequate them to the student's previous knowledge and interests.

Prior to the first teaching hour, a brief and general evaluation test was provided to the trainees, in order to assess their previous knowledge in Radiation Protection. The test consisted of 20 short questions with two possible answers: Yes or No. The same test was provided to the participants at the end the course, in order to assess which subjects had got straight after the course and which ones hadn't even then.

In the second edition, the final evaluation test was modified, consisting then of 20 questions with 4 different options which dealt not only with basic principles of Radiation Physics and Radiation Protection but also with some specific concepts discussed during the lessons. The final evaluation has remained almost the same during the last edition.

A satisfaction questionnaire, developed by the regional Council, was provided to the trainees following the final evaluation, so as to evaluate their level of fulfilment regarding teacher's explanations, contents and applications, documentation supplied and organization of the course. Besides, a section of suggestions and observations was included where any improvement or modification could be remarked. Each item of the satisfaction questionnaire was marked between 0 and 10. Special interest had items such as "Utility for their job", "Degree of knowledge acquired", or "Global assessment of the course".

### **3. Results and Discussion**

The satisfaction questionnaires of 2007 and 2008 showed that the trainees were much more interested in medical aspects, of direct application to their immediate jobs, than in basic Radiation Physics. Thus, in 2008, 60 minutes were assigned to medical specialists instead of the 30 minutes of 2007: 20 minutes each to a radiologist, a radiotherapist and a specialist in

nuclear medicine. Finally, during the third edition 30 minutes have been assigned to each specialist, 90 minutes altogether.

The complexity of the syllabus was strongly diminished in 2008, since the trainees found it extremely difficult and partially useless for their future jobs, as was revealed by the questionnaires.

Other subjects were not just lightened but suppressed; instead of them, it was decided to emphasize in the principles of Radiation Protection and the single aspects of radiological protection in Medicine (6). For this purpose, some clinical cases were included in 2009 to complete the theoretical concepts, as demanded repeatedly by the trainees. These clinical cases were focused mostly on those collectives that show higher sensitivity for radiation harm, pregnant women and children, where special care must be taken with the justification of medical exposures. Actually, the inclusion of practical cases regarding those specific collectives had already been suggested by the trainees in the questionnaires. This year, clinical cases have also involved screening programmes, which are performed over asymptomatic patients.

“Quality control in diagnostic radiology” was suppressed during 2008, for it is not actually related to physicians’ daily tasks, so it happens to be difficult to catch their attention. A few other subjects were also suppressed in the last edition, specifically Radiation Detection, operation of the x-ray tube, image formation and legislation in Radiation Protection, bearing in mind the results of the evaluation tests and also the observations made by the participants through the questionnaires.

The course has started, in its last edition, with a general overview of the equipment and procedures involving ionizing radiations present at the hospital, emphasizing in the different kinds of radiation and its harmfulness, instead of including mainly physics concepts. Also non-ionizing radiations have been incorporated to the discussion, in order to help the students discern properly between ionizing and non-ionizing radiations.

“Radiobiological effects” has appeared to be one of the subjects that hold more interest of the students, so it has remained in the contents since the beginning, though it has also got lighter.

These gradual updates carried out over the contents of the course have turned out to be quite successful, since the trainees have reached in average better qualifications year after year, although they had almost the same previous knowledge (Table 1):

**Table 1. Average qualifications out of 10 in knowledge tests**

Average qualification	2007	2008	2009
Previous Test	7.7	7.4	7.6
Final Test	9.0	8.3	9.2

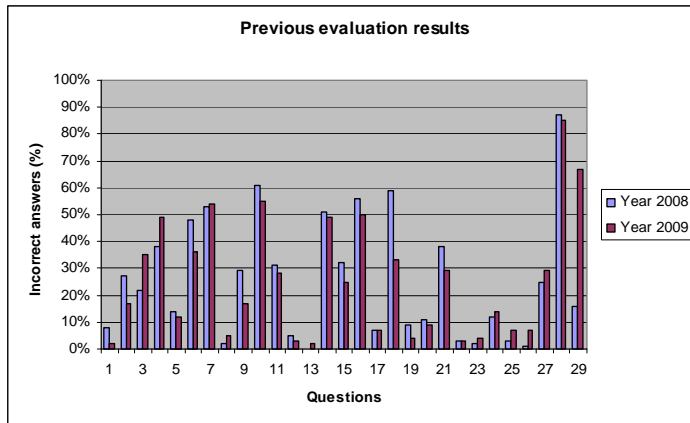
The question most frequently incorrectly answered in the previous evaluations dealt with the fact that medical exposures of patients are not subject to dose constraints. Approximately 85-90% of the trainees through the three editions got it wrong. The same question was set out in the final tests as well, when it was correctly answered by 82% of them in 2007, 86% in 2008 and 91% in 2009.

Other frequently missed questions through both previous and final tests involved, during all editions, physics subjects such as the X-ray beam, with approximately 40% wrong answers in both 2008 and 2009 final evaluations. Therefore, it has finally been decided to remove almost every physics subject from the programme, because physicians lack the theoretical basis required. Considering that just six hours were available, it was decided to focus on Radiation Protection main topics.

Graphic 1 shows that, through both 2008 and 2009 previous tests, the trainees got wrong almost the same questions (this information of the first edition is not available) and in the same proportions.

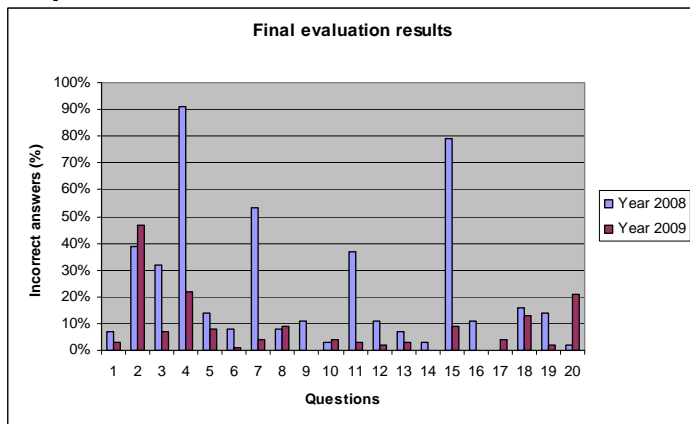


### Graphic 1. Previous evaluation results



On the other hand, graphic 2 illustrates the differences between editions during the final evaluation; first thing to come out is that 6 out of 20 questions in 2008 were incorrectly answered by over 30% of the trainees, opposite to just one question in 2009 with over 30% failed answers. Furthermore, through last edition, 12 questions out of 20 were correctly answered by at least 95% of the trainees, whereas in 2008 this success had just been achieved in 4 out of 20 questions. Question no. 4, regarding the basic principle of dose limits, represents the most obvious example of the progresses reached year after year, with 91% of incorrect answers in 2008 opposite to 22% in 2009.

### Graphic 2. Final evaluation results



This improvement in the physicians' knowledge acquired is probably due to the successive modifications that have been carried out, not just regarding the contents but the methods as well, including some practical examples in this last edition.

From the satisfaction questionnaires filled, the regional Council prepares a report, during the first semester of the following year, including the average marks obtained by the hospital in the different items included in that questionnaire. These results are shown in Table 2, regarding just years 2007 and 2008 because, as described earlier, this year's report has not been yet arranged.

Although the trainees seem to have been more fulfilled during 2007 in almost every aspect, an exception has to be remarked: they appear to be slightly more pleased with the course contents during 2008. The modification in the course location and management (shifting from two groups to just one in the auditorium) might have got a lot to do with the fact that participants were less satisfied in 2008 than 2007.

**Table 2. Average marks out of 10 in the satisfaction's survey**

	<b>2007</b>	<b>2008</b>
<b>Global assessment of the course</b>	6.70	6.20
<b>Course contents</b>	6.25	6.40
<b>Documentation provided</b>	7.25	7.25
<b>Organization</b>	6.70	6.25
<b>Utility for their job</b>	6.50	6.10
<b>Degree of knowledge acquired</b>	6.50	5.90

The Regional Council has also assembled, in the report mentioned, all the suggestions, observations and complaints made by the physicians in training. The most suggested issue through all editions has been the introduction of more practical cases. They have also pointed out to get deeper into some subjects as biological effects in pregnant women and children, and to diminish physics' contents in favour of medical ones. All this information has been deeply taken into account in order to improve the course year after year.

#### **4. Conclusions**

The physicians reveal that the course really works as a reminder of the previous knowledge in Radiation Protection acquired during the preclinical period.

The programme provides the trainees with at least a broad perspective of the procedures involving ionizing and non-ionizing radiations in the hospital. They also become aware of the importance of the basic principles of Radiation Protection, principally of the justification of every procedure they might further on prescribe in their future jobs.

Efforts have been made to improve, each year, the quality of those courses and to grow interest on the trainees. Nevertheless, the results demonstrate that a continuous evaluation of the course is essential to achieve a more successful and effective programme for the physicians. This evaluation method has allowed the optimization of both the teaching objectives and the methodology used in Radiation Protection training of this collective.

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**INTEGRATED MANAGEMENT SYSTEM  
LAYING A FOUNDATION FOR RP EXCELLENCE**

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**Abstract**

"Making the simple complicated is commonplace; making the complicated simple . . . that's creativity" [1].

Integration and simplification have become the mantra of Bruce Power's management model. Radiation Protection (RP) process enhancements demonstrate the practical initiatives we are pursuing to become Canada's world class nuclear operator.

A review of RP processes and procedures identified that they were overly complex, were focused on the subject rather than the user and lacked robust oversight. In addition, an overly complex system of zoning was leading to difficulty in compliance due to the necessary complexity in procedures to use the system. Bruce Power is reducing from four zones into two and significantly simplifying processes and procedures as a result. Together with a restructuring of our qualification requirements to better fit the work that is actually conducted, we are enhancing safety and performance by ensuring that only individuals ready to use their qualifications when called upon are qualified, rather than our previous practice of offering a high level of radiological qualification to individuals who may not use this in their day to day work.

Bruce Power is driving programmatic excellence to yield enhanced safety, operational performance and business results through the application of the Governance, Oversight, Support and Perform (GOSP) Model of accountability. The use of effective change leadership techniques such as employee engagement, training and communication has been instrumental in managing the complex change in RP strategy and methodology. This paper will outline the approach to implementing changes to the RP organization, process and document structures in the context of Bruce Power's pursuit of excellence within its integrated management system. Topics covered will include the communication and learning awareness strategies utilized to build commitment for the change, integration with other key process areas such as operations, training, and safety, as well as a review of key challenges and lessons learned about the implementation.

**1. Introduction**

The managed system concept is both simple in its totality and complex in being readily grasped. A standard definition of "integration" in the context of managed systems is the "*Process of attaining close and seamless coordination between several departments, groups, organizations, systems, etc.*" [1]

The term "management arrangements" approximates the concept and is used to capture the idea

that the management system comprises of physical/tangible elements and intangible elements, plus the necessary documentation for the functions of the management system. In addition, the design of an organization is an essential element of the overall managed system and forms the foundation which enables the business to act with agility and provides adaptive support for ensuring robust and informed risk-based decision making across the organization for the whole enterprise and its strategic business direction. The better an organization's diverse elements are consciously integrated within its managed system model, the more effective it can be in adapting to changes in environment, business need or regulation.

This paper discusses the concept of integration in regards to managed systems. It will examine the practical issues of developing a robust yet flexible management system with particular focus on the requirements, regulation, and business framework of Canada's nuclear industry and the specific experience of Bruce Power in implementing an enhanced Radiation Protection Program as part of its Integrated Management System.

## **2. Value of Integration**

According to the Chartered Quality Institute, “*An integrated management system (IMS) is a management system which integrates all components of a business into one coherent system so as to enable the achievement of its purpose and mission*”. [2]

The above definitions of what constitutes an Integrated Management System (IMS) or simply “management system” (MS) began to be discussed and described in the Nuclear Industry with the introduction of ISO 9000 that was developed for the manufacturing sector. Current views on management systems integration emerged from the ongoing considerations in the period 1970-1980 as quality control and quality assurance document-driven approaches evolved into Total Quality Management (TQM). Today these are referred to as integrated management systems, management systems or integrated safety management systems.

A common understanding of what is truly implied by an “integrated approach” amongst regulators and licensees alike has been slow to evolve, partly due to the requirement to change the paradigm of quality control essentially being a compliance-based activity towards a more strategic business focused approach. This change in scope, prescriptiveness, and opportunity for divergence amongst industry participants may be viewed with suspicion by nuclear operators and regulators.

The drive towards integration of managed systems in the nuclear industry brings the potential for competitive advantage and is one of the enablers of operational excellence, ultimately contributing to a better positioned industry able to consistently deliver high standards of excellence within a healthy safety culture environment – a benefit to industry as a whole.

According to the Chartered Quality Institute, there are several good reasons for integration, including:

- reducing duplication and its associated costs – financial, resource, time to market, etc.
- reducing risks with its associated impact on increased profitability

- balancing the sometimes conflicting priorities and objectives of the organization by clarifying relationships between the parts and the whole and eliminating conflicting responsibilities and relationships
- emphasizing achievement of desired outcomes by focusing on business goals
- formalising informal systems
- harmonising and optimising practices to gain the scale benefits of standardization
- improving communication
- facilitating training and development

Elements that demonstrate integration reveal themselves in the form, content and structure of the management system for the organization that it is describing. Integration is demonstrated through the scope of the management system if that scope addresses the totality of the organization's processes and systems and embraces elements such as health, safety, environment, security, human resources, finance, reputation, corporate culture, etc. and these are described as relevant to the organization's values, operations and objectives. The management controls (standing committees, meetings, oversight of processes, etc.) used by leadership to oversee the business should also be defined and consistent within an integrated management system

Integration is not just the adoption of a particular standard; it is combining and aligning others standards demonstrating how they align in mutual support of the business.

Additional elements or characteristics demonstrating integration would show up in a minimalist approach towards documentation and process structure – many of the concepts used in the automotive sector and developed in Japan around “lean” processes apply. In practice this means understanding and applying the principles of process mapping strategically, cross-functionally and for the key sub- processes.

Because of the complexity of most organizations, particularly the nuclear industry with its highly regulated environment, any move towards simplification through integration will enable better understanding of requirements, better adaptability to a changing environment and will ultimately contribute to better safety and cost performance.

### **3. Managing change in an integrated environment**

Change management is essential when transforming performance within an organization. Effective change management has the ability to help an organization view change as an opportunity to strengthen performance, while providing guidance in creating and maintaining the desirable cultural and operational adaptability and agility.

Traditional perspectives of quality assurance within our industry are based on relatively static requirements and documented structures; there is an implicit expectation that the documents establish the standards and the organization adapts within the constraints of the documented requirements.

The more forward-thinking approach to integrated management systems is that the organization is a living organism which continuously evolves as it pursues operational excellence or associated business goals. The quality requirements should not constrain an organization from being flexible, adaptable and innovative, rather in an integrated management system approach, the imperative to evolve places a significant challenge on effective change management. Configuration management aspects of maintaining a living integrated management system must be not only established but embraced.

Change management is essential when transforming performance within an organization. An integrated management system which includes effective change management processes supports organizational agility and enables effective implementation of continuous business improvement or more accelerated business transformation.

Change management principles typically cover sponsorship, planning, measurement, engagement and the support structure. Each of these is addressed below:

Sponsorship means that the change program has the visible support of key decision makers throughout the organization and resources are committed to the program.

Planning implies that preparation for change is conducted methodically before program implementation and committed to writing. Plans are agreed with major stakeholders and objectives, resources, roles and risks are clarified.

Measurement requires that program objectives be stated in measurable terms and program progress is monitored and communicated to major stakeholders.

Engagement implies that stakeholders are engaged in genuine two-way dialogue in an atmosphere of openness, mutual respect and trust.

Support structures ensure that program implementation and change recipients are given the resources and supporting systems they require during and after change implementation.

The change management process plays a crucial role in the integration of the management system. The principles above are challenging to consistently put into practice but are an essential prerequisite to maintain configuration control of the integrated management system. Overall, understanding change management, its principles and the approach to accomplish changes and maintain the management system as a living system is crucial for successful integration.

#### **4. Bruce Power's journey towards an integrated management system**

Bruce Power's Management System (BPMS) has undergone significant enhancement and evolution since late 2006 when the Bruce Power Executive Team commissioned a high level external assessment of our management system approach. The independent review had the objective of assessing the company's management system manual and evaluating how well it would support a "Governance Oversight Support and Perform" (GOSP) model of accountability, and advising on recommended changes.

To support operational excellence, Bruce Power chose to adopt an accountability model which provided clear roles and responsibilities. The GOSP Model ensures each member of the organization clearly understand their role with Bruce Power and are accountable for their role. The GOSP principles ensure consistency through the implementation of the standardized policies, programs, processes, and industry best practices. All major program responsibilities are distinguished between ownership of programmatic standards (governance and oversight) and execution (support and perform).

## **6.1 Governance**

The Governance function relates to the accountability to establish the programmatic guidelines and performance expectations for a given function. Governance accountabilities include the ongoing assurance that the programs and processes are “leading practices” and that they are implemented consistently throughout Bruce Power by all performing organizations.

## **6.2 Oversight**

The Oversight function relates to the accountability to critically monitor, assess and evaluate the conduct of nuclear stations to ensure that programmatic standards and expectations are met. This includes the independent (of perform organization) analysis of trends, data or performance information that provides assurance that functional outcomes are achieved and policy boundaries are being respected.

## **6.3 Support**

The Support function relates to the accountability to provide supplemental resources to organizations doing the execution of an agreed upon basis. The specifications for timing, content, and location, etc., are established by the Perform organization accountable for ultimately delivering the functional product.

## **6.4 Perform**

The Perform function relates to the single point accountability to execute and achieve outcomes for a given function/process in accordance with the defined methods and goals. This includes the accountability to develop plans, schedules, scope and detailed implementing procedures and to implement those plans to deliver the work products of the function. When other organizations perform support, the Perform organization remains accountable for ensuring overall results.

The independent assessment of Bruce Power’s managed system arrangements focused not on a document or system that enables the company to satisfy regulatory requirements but rather addressed issues such as whether our management system:

- Reflects management’s decisions about how to run the business
- Communicates clearly to the organization and is ingrained in the culture
- Is based on accountability for results bolstered by sound processes/programs



- Ensures single owner for governance and oversight of each function and clear alignment of perform accountabilities
- If performance is centralized, ensures a clear accountability to the line organization
- Creates sustainability of results
- Is embraced by the organization
- Is sufficiently flexible to allow changes made by line management
- Is viewed as a tool that enables change, not an impediment to change
- Recognizes there is no single “ideal” model; the value is in the development and use of the model

The findings from the independent review confirmed that the Management System met the base regulatory requirements of meeting the standard for management systems at nuclear power facilities in Canada, a condition of our licence. However, it also identified several areas where enhancements should be made to provide a foundation for managing our business in the future, including:

- Executive Team ownership and consistent application
- Clarity of accountability within the organization
- Usability
- Flexibility to evolve as Bruce Power evolves

Whilst radical change to the BPMS structure could undermine the organization’s credibility, it was decided that some aspects of the BPMS should be revisited to improve value to the organization. As a result a more streamlined, user-friendly and integrated management system was designed to enable operational excellence through reinforcement of the GOSP model of accountability, significantly enhanced integration and a more robust change management process to ensure configuration control of the managed system overall.

Some of the activities completed since that time have included:

- The development of a new integrated pictorial view of the elements of our managed system; significant in that, previously, our manual contained dozens of separate figures describing various aspects of our managed system. The single integrated view was a first step in setting integration as a key design principle. This continues to evolve and Bruce Power is exploring the next evolution of this representation to encompass balanced scorecard or strategy map approaches.
- The creation of a set of “Nuclear Worker Fundamentals” setting out standards and expectations for workers in areas such as Radiation Protection, Maintenance, Operations, Chemistry, etc. and providing a means to link coaching and performance feedback across our entire organization.
- A significant reframing of our Management System Manual, together with more

streamlined and comprehensive processes to maintain the integrity of the BPMS overall, including oversight and change management.

- The acceleration of a project to enhance the quality of our documentation
- Organizational restructuring to align with GOSP principles including the creation new accountabilities and better defined roles for those providing programmatic governance and oversight of all of our major processes.
- The development of Program Excellence training across each of our functional areas.
- The investment in new systems and technology to benefit from enhanced integration and streamlining of processes including our work management and document management systems.
- The systematic review of critical processes and program areas such as Radiation Protection to better reflect the overall direction and requirements of an integrated and performance based approach with a strong governance model.

The BPMS is allowed to evolve with time so competitive advantages are maintained. Our policies, programs, and procedures are continuously assessed to ensure corrective actions, benchmarked best practices, and all process innovations are captured. No single element of the BPMS operates independently. All parts of the management system are interconnected and interdependent and rest on a series of leadership principles. By design, the BPMS significantly contributes to the establishment of a culture that assures nuclear safety. It also provides the necessary guidance for making risk-based decisions that satisfy safety, commercial and corporate reputation performance. [3]

## **5. Developing a Leadership Position to Drive Improvements in RP**

The changes to the Bruce Power Management System described above created the infrastructure within which the Radiation Protection (RP) Functional Area could be enhanced. Without the implementation of a GOSP model of accountability, strong leadership vision, better defined organizational, process and documentation hierarchies, a focus on operational excellence and a commitment to the importance of change management, these improvements could not have been realized.

A crucial first step included the realignment of organizational responsibilities for RP around the GOSP model, with a Corporate Functional Area Manager (CFAM) for RP accountable for Governance and Oversight of the RP Program reporting through a different organizational line than the Site Functional Area Managers (SFAMs), responsible for the Perform aspects of the GOSP model in regards to execution against the RP standards and programmatic requirements.

The CFAM and peer SFAMs meet regularly through a formal RP Peer Group, sponsored by a senior executive, to address all changes to RP programs, processes, organization structure and initiatives. The CFAM chairs the Peer Group and ensures that decisions are made in the interest of the fleet, balancing the needs of individual nuclear power plant SFAM representatives.

At Bruce Power, a CFAM is the owner of one or more Bruce Power Programs associated with a

Functional Area such as RP, Maintenance, Chemistry, Business Planning, Training, etc.  
The CFAM:

- Is the Programmatic authority and leader of their Functional Area
- Owns the suite of all documentation associated with the identified processes and has accountability for implementation of program improvements
- Ensures world class operations for their function is rigorously defined, consistently executed, actively managed, and continuously improved
- Is the standard bearer and owner of performance in their Functional Area
- Leads their function, guides the organization and creates passion for achieving world class operations for their area

The performance of a given program must be considered in the context of the overall system of programs that support the company's vision for safe, reliable, and cost-effective operation. CFAMs work together to optimize the overall system of processes, avoiding an isolated focus on only their own programs. CFAMs are responsible for improvement planning to ensure processes are aligned to support business goals. CFAMs coordinate the various functions and work activities at all levels of a process, regardless of the organizations involved. They have the resource control and job skills to evaluate overall process operation and to evaluate potential process or Program improvements. They design and manage the Program end-to-end so as to ensure optimal overall performance.

Each CFAM is responsible for planning, implementing and controlling their core business process to ensure effectiveness, efficiency and compliance. This includes:

- Verifying that their process is mapped, measured, defined and documented in consideration of quality, quantity, timeliness, cost, safety, stakeholder, methodology and resource requirements, including relevant licensing and/or adopted industry requirements.
- Establishing, implementing and maintaining their process, including delegating to others any or all aspects thereof, while retaining overall programmatic Governance and Oversight accountability.
- Ensuring that the process/organizational interfaces and elements required to support their Program are established, in consultation with the Support and/or Perform organization(s).
- Ensuring that the resources (trained/qualified staff, information, facilities, material, tools, test equipment, special controls) required to support their Program are provided.
- Ensuring that the performance of their Program is adequately monitored, assessed (at least annually), reported and overseen, and that required corrective actions or desired enhancement opportunities are initiated and completed in a timely manner.

Under the GOSP Model, various aspects of "Support" function are executed by either the CFAM

or the SFAM.

## **6. Implementing Excellence in Radiation Protection at Bruce Power**

With the appropriate structure, accountability model and leadership defined, the challenge became developing a vision for excellence in Radiation Protection at Bruce Power.

Bruce Power is Canada's first and only private nuclear generator. We are a partnership among publicly traded companies, a pension fund and our unions. Our 2,300-acre site houses the Bruce A and B generating stations, which each hold four CANDU reactors. Six of those units are currently operational and combine to produce more than 4,700 megawatts and we are in the process of restarting the remaining two units at Bruce A, which will provide another 1,500 megawatts of emission-free electricity. Bruce Power has more than 56 kilometres of roads and many of the amenities of a small city including its own fire department, radioactive laundry facility, learning centre, medical staff, security and works department. We operate in a heavily regulated, unionized environment.

Until recently, our RP program was characterized by poor performance relative to industry leading practice, although we were compliant with regulatory requirements. Within the RP function, we suffered from significant staff turnover and less than optimal staff relations. Radiological zones for radioactive contamination control across the site were based on a 4 zoned system which had been in place since the plant had been built leading to inefficiencies and a dilution of RP standards. Additionally, equipment being used for RP monitoring was diverse and ageing. To enhance radiation safety and improve efficiency across the production cycle, we couldn't afford not to invest in significant improvements to our RP program and practices. However, the way we worked and the deep-rooted cultural impacts of making a change of the magnitude required to deliver transformational results would be significant.

A strategy/vision document was created for radiation protection identifying the required organisational changes, staffing changes, standards changes, process changes, plant and equipment changes needed to reach a higher standard of radiation protection in the company. The strategy/vision was presented to senior management and accepted. A short, mid and long term plan was created to implement that strategy/vision. The short term plan was converted into actions for the first year of the vision/strategy implementation. For the first year the changes included the following, each of which is described in detail below:

- Organisation structure
- Hiring, retention, development, and training of staff
- Union relationships
- Plant layout and equipment
- Licensing and regulatory relationship
- Processes
- Documentation

## **6.1 Organisation Structure**

Historically, the RP organisation structure has been challenged as a result of a lack of identified resources to fulfill responsibilities of program, an empowerment system for staff in radiation protection that has led to a reduction in performance quality and a lack of radiation protection expertise within the organisation or properly identified RP roles to provide quality performance.

Actions to address this have included:

- Re-writing job documents and defining roles for senior health physicists more clearly
- Defining license “critical” positions for radiation protection in the organisational structure. This required detailed succession planning and enhanced human resources support
- Incorporating new roles, authorities and responsibilities (CFAM, SFAM, health physicists) into new governance documentation
- Identifying new oversight functions for supervisors and expert RP staff
- Re-defining an organisation structure, roles and responsibilities for RP technicians to allow for the development and use of expertise to ensure quality performance

Development of a business case is in progress for the new RP organisational structure and discussions have begun with our unions to collaborate on ensuring any proposed changes are successful.

## **6.2 Hiring, Retention, Development and Training of Staff**

Historically, the RP organisation suffered from rapid staff turnover and had difficulty finding and retaining resources. This resulted in an RP team with mostly junior staff with limited experience.

Actions to address have focused on engaging experienced senior health physicists from outside the Company to directly mentor Bruce Power health physicists and develop:

- Better systems and processes for incumbent health physicists to operate
- Training for health physicists which includes the identification of required experience, self study, formal training and provides a field check out for work in each duty area within the program
- Expert training for RP technicians to benchmark standards
- Reduced and more fit for purpose “user” training for all other staff
- Procedures documenting the roles and responsibilities of health physicists to assist in their development

The use of experienced staff has resulted in better relationships with incumbent staff who feel

they are better supported and equipped to perform their job functions. Additionally, the new HP training now secures a long term development plan for these staff and for the Company.

### **6.3 Union Relationships**

Historically, relationships with union workers, health physicists and technicians have been poor. This has resulted in many grievances, loss of key staff and a lack of progress being able to be made on RP program improvements due to lack of union co-operation with proposed changes.

Actions to address this have included:

- Re-establishment of good working relationships with the union at all interface meetings through resurrection and resolution of outstanding issues
- Resolution of outstanding grievance with health physicists over job documents
- Early discussions with union on proposed RP program changes, union participation in design teams and ongoing negotiations before, throughout and after changes

An example of success in this area was the lack of shop floor response when clothing requirements were changed overnight from a uniform that had been used for over thirty years to a new protective clothing standard.

### **6.4 Plant Layout and Equipment**

Historically, radiological zones for radioactive contamination control across the site were based on a 4 zoned system which had been in place since the plant had been built and was based on a design that operated in the original prototype design of the reactor. The system led to inefficiencies in workers getting to work, diluted radiation protection standards and duplicated efforts as a result of subsequent inter-zonal transfers. Additionally, the equipment being used for monitoring was diverse, ageing and providing low standards. Protective clothing for RP work had also been in use for the same time period, despite advances in clothing, monitoring standards and concepts.

Actions to address this have included:

- Development of new re-zoning concept with two zones instead of four
- Development of a business case for the re-zoning plan, including the identification of non-radiation protection benefits from plan such as improved productivity
- Staged introduction of re-zoning to allow for worker acceptance and practice changes prior to full re-zoning
- Replacement of a large number of diverse types of basic, ageing monitoring equipment with a smaller amount of new monitoring equipment of a higher standard
- Installation of physical, rather than administrative controls to enhance compliance with radiation protection requirements
- Collaborating with our union on the development of a new protective clothing standard

- Collaborating with staff and leadership supporting our radioactive laundry facility to identify new requirements and processes to complement the change in protective clothing standards
- Identification of alternative commercial suppliers for products and services to enhance and augment our standards and expectations
- Significant and early interaction with our regulator to gain early acceptance of the proposed re-zoning plan
- Use of contract resources to bring external HP expertise and dedication to the project
- Introduction of new protective equipment for highly radioactive environments

The re-zoning project, which is one of the largest projects that Bruce Power has undertaken has now reached the end of its first stage and, despite the magnitude and significance of the changes involved, has been generally well received and accepted.

## **6.5 Licensing and Regulatory Relationship**

Historically, there was confusion between the requirements and standards of the dozen different nuclear licenses with which the Company was required to comply. These distinct requirements had not previously been clearly delineated in the RP Program. The regulatory interface had been maintained by one individual in the company. Our key licensing document had not been changed for many years as it was considered too difficult to re-write a document that was linked to the license (as it would require regulator approval). This was to the point where significant document errors on important matters remained uncorrected for an unacceptable length of time. The document describing the RP program and Policy was also out of alignment with the Bruce Power Management System; it was a detailed list of requirements (80 pages long) and also forced the company to continue practices that were outdated and to report frequently to the regulator on non-compliances with the document. This led to confusion for staff but also to a poor reputation with our regulator in regards to regulatory compliance.

Actions to address this have included:

- Working with our Licensing team on separating the licensing requirements for different licenses and creating new governance for the licenses that were not properly addressed previously
- Defining to the regulator why documentation needed to change and how it would so that they would clearly understand the rationale for the change. This included providing a detailed disposition of the old program document.
- Providing early and ongoing communication with the regulator on proposed plant, equipment, clothing and process changes
- Creating an RP Program document that met company documentation standards and allowed the company more flexibility to make plant, equipment, clothing and process changes without prior regulatory approval
- Working with our Licensing team to identify new training in legal responsibilities

## **6.6 Processes**

Historically, there were many poorly defined processes or a lack of process for various activities under the RP Program. Processes had been linked to RP personnel experience, rather than governance and when experienced personnel left the company, there was no record of the processes followed.

Typical problems included a lack of expertise in investigating radiological events and conducting ALARA reviews of work. These activities were conducted by experienced staff to non documented processes. New inexperienced staff were unable to conduct these activities to the required standard.

Actions to address this have included:

- Defining new processes for dose planning, dose tracking and dose control in line with industry standards
- Developing performance metrics at a precursor level to identify poor performance prior to it affecting a high level metric
- Defining processes undertaken by experienced HP personnel, but not usually recorded in governance to assist with role and staff development
- Developing continued use of a new web-site to improve communication on key issues
- Developing new monitoring standards for previously un-monitored hazards
- Developing a new inter-disciplinary source term monitoring program to tie in radiation protection with operations, maintenance, fuel handling and chemistry activities

## **6.7 Documentation**

As previously described, the previous version of Bruce Power's RP Program document was a long list of requirements with multiple overlaps and standards difficult to find by topic. There was no process flow or logic to the suite of documentation and understanding how to use it required significant training which was typically not repeated after initial roll out. As a result, documentation had become un-used; non-compliance and deviation from set standards was common.

The governing RP Program document was written as a licensing document as opposed to a true process or program document and had not been changed for many years. Since the document contained errors and was outdated, it had lost its credibility and use, yet remained as our licensing basis preventing the Company from making changes and improvements to processes that were contained in the document. Additionally, the documentation was all based on the self protection model of radiation protection – individuals are trained to perform radiation tasks associated with their job and all program documents and procedures are written to this effect. There was a lack of management oversight built into this model and therefore suite of documents. This was not a managed system and simply relied on worker compliance.



Actions to address this have included:

- Re-writing of the program document from an 80 page document to a 20 page document, allowing greater flexibility for licensing basis and a more logical sequencing of programmatic requirements to allow easier use
- Creation of hierarchy of documentation with lower tier documents on the various topics covered by the program. This allowed the inclusion of programs that were previously not a part of the program, yet were industry standard topics. The hierarchy also allowed for easier reference on topics since the documents on given topics are now all found in specific areas of the program. Topics were chosen also to be related to roles and responsibilities, such that workers using the program only have to refer to one specific program area. Documents only for use by RP/HP staff are contained in a separate section of the program. This is intended to result in greater worker compliance with the program. Additionally, management oversight was built into the new suite of documentation
- Re-alignment of all documentation in accordance with the new hierarchy. This involved splitting documents, referencing documents, etc, in line with the new structure
- Separation of documentation with different licensing basis within the hierarchy so that the differences in regulatory standards could be clearly identified
- Informal regulatory approval and comments obtained prior to formal regulatory submission
- Extensive roll out of documentation is being conducted prior to implementation
- Training should be able to be simplified as a result of the new structure
- Future changes to the program content will now be able to be made without re-writing the entire suite of documentation and without reference to the regulator for approval

## **7. Management of Change in Implementing Improvements to RP Program**

Development and implementation of an extensive communications campaign to reinforce the physical and cultural changes required to ensure effective management of change has been instrumental in our successes to date. Throughout all of the above initiatives and actions, a solid management of change plan was critical in our success. We have seen evidence of more successful implementation in those areas where more significant communication and change management efforts were undertaken. Early efforts to engage staff, unions and the regulator, coupled with strong leadership support and sponsorship for these transformational changes has paid dividends in terms of implementation timeline and ease.

Some of the tactics adopted included the use of a newly developed radiation protection web-site, the use of site wide telephone conferences, the development of a substantial roll out package for supervisors, the use of multi-media (TV, videos, power point presentations in multiple formats, screen savers), the use of mock ups, pamphlets, company newsletters, customer response to questions, etc.

A wide variety of modes of communication were used to 'get the message out' regarding the changeover of our Personal Protective Equipment (PPE):

- RP website updates
- Features in our monthly Safety videos over several consecutive months
- Corporate Intranet home page updates
- Bruce Power TV features
- Bruce Power computer screen savers
- Articles in “The Point”, our weekly staff magazine
- Site Wide Leadership Call for all managers
- Manager's Messages (sent by e-mail) for all managers
- Posters in Guardhouses
- Electronic Communications at our stations
- Workshops for our first line supervisors
- Special updates to staff from our Chief Nuclear Officer
- Global emails to all staff
- Mock up of new PPE in high traffic areas
- Discussion at our Management Leadership Meetings and station shift turnover meetings
- Roll-out day communications (live)
- Handouts

Overall feedback was very positive and the rezoning team received many comments back that the communications used were the 'plan for the future'. One of the largest benefit of such an open forum was the opportunity to not only talk about rezoning/PPE changeover but also about the need for RP procedural compliance, the conceptual plan for future rezoning activities, the need for people to be thinking about how that would change their work so they can plan ahead, other planned RP projects and address any specific questions about RP in general.

## **8. Conclusion**

The development of standards around integrated management systems is one aspect of the broader opportunity to effectively implement integrated and standardized practices across an organization. Pursuing integration requires new thinking about the relationship of quality to the functioning of the entire organization.

Practitioners or organizational champions of integration must understand that an organization is a living organism which is more than the sum of its parts. Senior leadership require vision and commitment towards standardization, elimination of wasteful processes, practices and interfaces

and a thorough understanding of the role of configuration control in supporting the maintenance of an integrated management system throughout its evolution in order to reap the benefits of integration.

The journey towards integration and excellence need not be an all or nothing approach – as demonstrated in the Bruce Power example, identifying key success factors towards integration and standardization such as the adoption of the Governance, Oversight, Support and Perform (GOSP) model of accountability, together with the enhanced role of Program Owners and the senior leadership commitment to simplifying and standardizing processes and aligning organizational accountabilities has resulted in measurable improvements justifying the investment in the changes.

The significant improvements in the approach towards RP at Bruce Power encompasses all elements of the managed system – vision, process controls, process and programmatic improvements and organizational arrangements to deliver enhanced results. The role of change management and communication in the adoption of the change must not be underestimated. The real value derived from the significant investment Bruce Power has made in enhancements to the RP Program including physical structures, processes, training, roles and responsibilities will emerge over the coming years but early indications are already demonstrating positive and measurable results. With similar transformational improvements across other business critical functional areas, Bruce Power is well positioned to continue to be a leader in the nuclear industry in Canada develop its reputation as a respected and emulated player on the world nuclear stage.

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## **BROADENING THE PERSPECTIVE**

# IDAHO STATE UNIVERSITY RADIOLOGICAL PROTECTION EDUCATION AND TRAINING FOR THE NUCLEAR RENAISSANCE

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## ABSTRACT

The need to strengthen the nuclear science and technology infrastructure in Idaho and the U.S. was recognized recently by the Idaho State Board of Education. This resulted in an assigned mission that guided Idaho State University (ISU) to expand its programming and continue leadership in the area of nuclear science. Specifically, the health physics and nuclear engineering programs have embarked on a collaboration program for strengthening its educational, research, and outreach programs through:

- Nuclear science, physics and health physics research collaborations
- New joint faculty positions
- Joint graduate fellowships
- Integration of curricula and courses, including new courses required by students of both programs
- Increased use of distance learning
- Joint outreach efforts for student recruitment

In the short time that the ISU nuclear engineering and health physics programs have established a formal collaborative effort, funding has been secured for joint faculty positions, undergraduate scholarships, graduate fellowships and research projects.

## 1. Introduction

Recently, there has been great emphasis on the impending human capital crisis in radiological science, nuclear science and engineering. Several professional organizations and governmental agencies have stressed the need for maintaining highly educated and skilled personnel to ensure the long-term viability of nuclear technology [1-5]. The development and maintenance of this specialized work force is needed due to the impending loss of many experienced personnel who are nearing retirement. With the loss of these employees also comes the loss of historical and collective knowledge and lessons learned. The work force dilemma will exacerbate as the “nuclear renaissance” becomes a reality in the U.S. A specialized workforce will be needed for both present and future nuclear science and technology initiatives. In addition, recruiting and training talented and motivated faculty is crucial to combat this imminent workforce calamity. In health physics, the retiring nuclear workforce (coupled with the potential nuclear renaissance and license extensions of current commercial nuclear power reactors) creates a need for trained reactor and environmental health physicists which has never been greater.

## 2. Background

### 2.1 Idaho State University (ISU)

Idaho State University (ISU) is a state-funded doctoral university, consisting of six colleges and a Graduate School. ISU is situated in southeastern Idaho in close proximity to the Idaho National Laboratory (INL). INL, administered by the U.S. Department of Energy (DOE) and headquartered in Idaho Falls, has been designated as the principal nuclear energy research laboratory for the nation. ISU has its main campus in Pocatello, 50 miles south of Idaho Falls, with a large branch campus in Idaho Falls. Total enrolment at the university is approximately

15,000 with nearly 18% of these students taking classes at the Idaho Falls University Place campus. The two campuses are connected via compressed and IP audio/video video technology to administer approximately eight interactive classes simultaneously to students located at both campuses. Instructors who teach these distance classes are expected to divide their lecture time between sites, so that both populations have routine face-to-face classroom contact.

The need to strengthen the nuclear science and technology infrastructure in Idaho and the entire nation was recognized recently by the Idaho State Board of Education. This resulted in an assigned mission that guided Idaho State University (ISU) to include in its Strategic Plan a commitment to expand its programming and continue leadership in the area of nuclear science. In keeping with the objectives of the Strategic Plan, ISU has made exemplary progress in building strong nuclear engineering and health physics programs. Specifically, the health physics and nuclear engineering programs have embarked on a rigorous collaboration for strengthening its educational, research, and outreach programs. The administration of Idaho State University recognizes the importance of its nuclear programs to both the Idaho National Laboratory (INL) and to the business community of southeastern Idaho, which is strongly tied to the mission of the INL. Consequently, success of the nuclear energy mission ISU is of considerable significance to the nuclear energy developments throughout the nation and the world. This importance is also recognized by the INL management, which has partnered with ISU, along with the other two Idaho research universities (neither of which has a B.S. health physics or nuclear engineering program).

Many of the nuclear science and engineering interactions between INL and the Idaho universities come through the new Center for Advanced Energy Studies (CAES), a public-private partnership of the INL with the three Idaho research universities (Boise State University, Idaho State University and University of Idaho). A new CAES research centre building (5,200 m<sup>2</sup>, of which approximately one half are devoted to laboratories) has recently been erected on the Idaho Falls University Place campus within walking distance to the INL Engineering and Research Office Building. This new research centre brings INL engineers and scientists together with ISU faculty and students in conducting joint R&D programs over a wide range of disciplines involved with nuclear energy.

## **2.2 Health Physics and Nuclear Engineering**

ISU is the only university in Idaho to provide baccalaureate and graduate degrees in health physics (in the Department of Physics) as well as the only university in the country to offer all four degrees of the Associate of Science (A.S.), B.S., M.S., and Ph.D. in health physics [6]. In addition ISU is the only higher education institution in the U.S. to have both its B.S. and M.S. degree programs recognized by the Accreditation Board for Engineering and Technology (ABET) in health physics under ABET's Applied Science Accreditation Commission (ASAC). Currently, the program has 5 A.S. students, 20 B.S. students, 20 M.S. students, and 15 Ph.D. students enrolled. The department has a faculty complement of four full-time members in the health physics program and several part-time or adjunct members that contribute to teaching. Several health physics faculty participate in research at the Idaho Accelerator Center (IAC), which is one of the largest accelerator facilities in the world.

Similarly, ISU offers B.S., M.S. and Ph.D. degrees in nuclear engineering and is the only institution in Idaho to provide both Baccalaureate and graduate degrees in nuclear engineering. Currently the department has a student population of around 95 undergraduates and 35 graduate students (25 M.S. candidates, 10 Ph.D.). Students have the opportunity to utilize the educational and research opportunities of the AGN-201 reactor at the ISU Nuclear Reactor Laboratory. The nuclear engineering faculty today numbers eight: five tenured or tenure-track, three research/affiliate faculty, and one lecturer. Nationally ISU is just one of about twenty higher education institutions with a viable nuclear engineering department.

### 3. Collaboration Plan

Although the nuclear engineering and health physics programs are in separate departments, the two have developed strong working relationships together over the years with the understanding that each discipline utilizes the knowledge, professional contacts, and facilities of the other. Additionally, the two departments have constructed a formal plan for collaboration. The intent of the plan is to increase student numbers at all degree levels and boost research funding. The collaboration effort includes the following key points:

- Nuclear energy research collaborations through CAES
- Nuclear science, physics and health physics research collaborations through the Idaho Accelerator Center (IAC)
- New joint faculty positions with expertise in reactor design and/or health physics
- Joint graduate fellowships
- Integration of curricula and courses, including new courses required by students of both programs
- Increased use of distance learning for recruiting of A.S.(radiological technicians), B.S., and M.S. degree seeking students
- Joint outreach efforts for student recruitment

### 4. Results

In just over one year since this program was initiated, several successes have already been realized. In the short time that the ISU nuclear engineering and health physics programs have established a formal collaborative effort, substantial progress has been made. First, funding (~\$1,000,000) has been secured through competitive grants from the U.S. Nuclear Regulatory Commission (NRC) for joint faculty positions, undergraduate scholarships and graduate fellowships. Specifically, the scholarships and fellowships will fully fund approximately 12 students per year. Two new faculty members are currently being hired from the U.S. NRC and ISU strategic funds. In addition, substantial funding has been acquired from the U.S. DOE for research and infrastructure projects. New radioanalytical and health physics instrumentation will be purchased for the CAES centre to be used for research and educational purposes. This equipment was secured through joint grant proposals between ISU and the University of Idaho. Funding has also been secured through the IAC for research projects related to radioisotope production, nuclear forensics, and homeland security. These projects will employ faculty and students in health physics and nuclear engineering.

The collaboration efforts have also led to increased educational programs and opportunities for students. In addition to the U.S. NRC grants mentioned previously, fellowships and scholarships were also awarded by the U.S. DOE. The scholarships and fellowships will fully fund an additional 5 students per year. The compressed and IP audio/video video technology of ISU has also been improved. This improvement includes real-time video encoding and recording which allows students to view class lectures even if they are not at either the Pocatello or Idaho Falls campus. This has allowed students from all over the U.S. to enroll in the degree programs and take classes, particularly in health physics. Efforts are still being made in recruitment of students (through advertisement of research and funding opportunities) and integration of ISU health physics and nuclear engineering classes and programs. Finally, ISU and the University of Idaho are combining or jointly offering several classes so that students from both universities have a larger selection of classes to take and more exposure to diverse faculty. In particular, University of Idaho students can take health physics classes, which aren't offered at their university.

It is the hope that continued success through funding and additional research collaborations will result. ISU believes this unique partnership will be successful in all aspects and will help in supplying a much needed nuclear science and technology workforce.

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# EDUCATIONAL PROGRAMME IN NUCLEAR SECURITY

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## ABSTRACT

Higher education plays a central role in the development of both individuals and societies as it enhances sustainable social, economic, technical and cultural development. Education in general and higher education in particular are not subjects of a common global policy; the competence for the content and the organization of studies remains at national level. This applies to nuclear security education as well.

The International Atomic Energy Agency (IAEA) has taken the lead and has developed together with academics and nuclear security experts from Member States a guideline for a *Master of Science and a Certificate Programme in Nuclear Security*. This guideline should assist States in adapting such academic programmes in the future and will be published in 2009.

This paper discusses the development, content and structure of the guideline entitled *Educational Programme in Nuclear Security* that aims at supporting States to establish sustainable nuclear security knowledge, skills and the related culture in a State and outlines practice in this area in States.

## 1. Introduction

The need for human resource development programmes in nuclear security was emphasized at a number of IAEA General Conferences and the Board of Governors Meetings. In September 2005, the Board of Governors considered and approved a new *Nuclear Security Plan* covering the period 2006–2009<sup>1</sup>, which emphasized the importance of human resource development. This plan forecasts the development of guidance for an educational programme in nuclear security that could be used by all States. This goal is continued in the Nuclear Security Plan 2010 – 2013<sup>2</sup>.

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<sup>1</sup> GOV/2005/50 [1]

<sup>2</sup> GOV/2009/54-GC(53)/18

In spite of the recognized need for a well defined human resource development programme in nuclear security, only a few universities<sup>3</sup> in the world have developed technically oriented educational programmes related to this area. Therefore, the IAEA has taken the lead, and has developed — together with academics and experts from Member States — an *Educational Programme in Nuclear Security*, providing guidance for a Master of Science (M.Sc.) programme and a certificate programme to assist States in adapting such programmes in the future.

## **2. The IAEA Educational Programme in Nuclear Security – A Guideline for a Master of Science and a Certificate Programme in Nuclear Security**

The IAEA recognizes the need for different levels of nuclear security expertise in a State. Depending on the national nuclear infrastructure, well trained people in certain areas of nuclear security are needed, as well as specialists with a nuclear security specialization, and/or well educated experts with in-depth knowledge in all areas of nuclear security. A certain specialization and in-depth expertise can only be provided through higher education, while specific knowledge and skills in some areas of nuclear security can be provided during selected training activities offered by comprehensive nuclear security training programmes. Due to the fact that no comprehensive educational programme in nuclear security so far exists, the IAEA has decided to develop – together with academics and experts from its Member States – an educational programme covering all aspects of nuclear security.

### **2.1. Programme development**

In the past, the IAEA has assisted in the development of an academic programme in physical protection of nuclear material and associated facilities. This programme, among others, and the comprehensive nuclear security training programme, which was developed during the recent years by the IAEA, has been used as the starting point for the curriculum development.

From August to October 2007, the IAEA Office of Nuclear Security developed a first draft of the *IAEA Educational Programme* that was reviewed in a consultants meeting in October 2007 by several scholars from universities teaching nuclear engineering and law enforcement and nuclear security experts. The revised document was reviewed during a second consultants meeting in January 2008 and a workshop in March 2008. Finally, this reviewed version of the IAEA Educational Programme was presented to the IAEA Member States at the open-ended technical meeting which took place in August 2008. The document is in final draft and will be published in 2009.

### **2.2. Objective and content**

The *Educational Programme* should be considered as guideline to facilitate the development of a comprehensive national human resource development programme in nuclear security with the purpose of building and maintaining knowledge and sustaining qualified individuals dealing with the challenges that the future will bring in this area. The programme is designed to provide both the theoretical knowledge and practical skills necessary to meet the nuclear security requirements outlined in the international framework and in the *Nuclear Security Series* of publications. Emphasis is placed on the implementation of these requirements and recommendations in States with different systems in place. On the basis of this guide, each university should be able to develop its own unique programme tailored to suit the State's educational needs in this area and to meet the national requirements.

The scope of the recommended *Educational Programme* is broad and will cover education in all areas of nuclear security, ranging from an M.Sc. programme for development of highly educated staff with in-depth knowledge in this area to a certificate programme for

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<sup>3</sup> In the guideline, the term 'university' is taken to mean all higher education establishments, including colleges, polytechnics and the 'Grandes Ecoles'.

development of certified nuclear security specialists. Although the *Educational Programme* does not outline explicitly an undergraduate programme or a diploma programme, the recommended *Master of Science Programme* could be used as the basis for the development of such kind of programmes.

Educational programmes in nuclear security should be addressed to people interested in careers in all aspects of nuclear security working at different entities, such as e.g. regulatory authorities, nuclear industry, Ministry of Justice, Finance, Health/Environment/Science, and Transport, Customs, Police, or Intelligence Services. *Nuclear Security* is multidisciplinary and can therefore offer job opportunities at a wide range of entities.

### 2.3. Structure

The *Educational Programme* is divided into four main chapters and two appendices.

Chapter 1 provides an overview of the background, objectives, scope and structure of this publication and points out the relationship to existing educational programmes including nuclear security components, and training programmes in this area.

Chapter 2 focuses on the human resource development aspect of capacity building in nuclear security in general and discusses different options to establish nuclear security education at universities as well as issues to be taken into consideration.

Chapter 3 provides an overview of the recommended M.Sc. programme, including recommended prerequisite courses, and a list of required and elective courses. It proposes a pre-thesis practice and touches on the M.Sc. thesis itself. Further, this chapter indicates a possible schedule for the implementation of the M.Sc. programme, including suggested duration for each course in hours, and illustrates the interrelation between the different M.Sc. courses.

Chapter 4 gives an introduction to the certificate programme, including a list of core courses, and additional courses.

Appendices I and II provide a brief description of each course and the respective learning objectives, as well as detailed information on the different topics to be studied in the individual courses. Where appropriate, practical/laboratory exercises are listed and reference publications are recommended. The references are not exhaustive as they are limited to relevant IAEA conventions<sup>4</sup> and publications<sup>5</sup>, related IAEA training material, United Nations' (UN) Security Council resolutions<sup>6</sup> and topic related UN conventions<sup>7</sup>. This allows university curriculum developers from different countries to recommend any other national or international publication considered as relevant for the individual course topic.

### 2.4. The Master of Science programme (M.Sc. programme)

The structure of the recommended M.Sc. programme consists of 12 required courses and 11 elective courses. The design of each course is characterized by a combination of theoretical and practical sessions, such as demonstrations, laboratory exercises or case studies which should be in line with the teaching policy of the implementing university and defined by the individual faculty.

The 12 required courses are covering the main nuclear security areas 'prevention, detection, and response' and other fundamental areas, such as nuclear security culture, legal framework, nuclear technologies and applications, and radiation protection. By selecting some of the elective courses providing comprehensive knowledge in selected topics, students can obtain a specialization in certain areas of nuclear security along with more

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<sup>4</sup> Such as the Convention on the Physical Protection of Nuclear Material [2]

<sup>5</sup> Such as Nuclear Security Series No. 1 [3]

<sup>6</sup> Such as UNSCR 1540 [4]

<sup>7</sup> Such as the International Convention for the Suppression of Acts of Nuclear Terrorism [5]

advanced knowledge, such as nuclear material accountancy and control, nuclear forensics and attributions or IT/cyber security.

The successful completion of the programme includes a pre-thesis practice that should be performed in a security office of a nuclear facility, at an emergency response organization, with law enforcement agencies, such as customs authorities or at the university under the supervision of a university professor or an experienced nuclear security officer approved by the university, and the preparation and defence of an M.Sc. thesis in the area of prevention, detection or response, according to the selection of the majority of elective courses.

## **2.5. The Certificate Programme**

The availability of qualified specialists in all areas of nuclear security is essential for the establishment of a nuclear security regime in a State. As experienced in other technical areas, the graduate certificate programme in nuclear security could be developed by various institutions, such as universities under their continuing educational programmes, professional societies or governmental organizations.

The determination of the required prerequisites for participating in a certificate programme in nuclear security should be made by the respective university or academic institution. However, applicants aiming to undertake the certificate programme should have sufficient background knowledge or relevant working experience to be able to follow the course material, as per requirement of the university or academic institution. The recommended prerequisite courses for the participation in the certificate programme are the same as for the M.Sc. programme. The recommended duration of the certificate programme is 16 weeks, which corresponds to a typical university semester. The proposed certificate programme is flexible enough to tailor duration and course contents to the specific nuclear security training needs of individual States.

## **3. Practice in States**

### **3.1. Europe**

In Europe, on the basis of the Bologna declaration and the European Credit Transfer System (ECTS), the European Nuclear Education Network (ENEN) Association has established, under the European Commission-EURATOM Framework Programme projects, the ENEN Certificate “European Master of Science in Nuclear Engineering (EMSNE)”[6] for the classic nuclear engineering courses covering well reactor operation and nuclear safety aspects. The main requirements of EMSNE is to complete a full two years program (120 ECTS), including at least 60 ECTS taken at purely nuclear subjects, at least 20 ECTS taken from a foreign institution, and a Master thesis. The EMSNE is implemented since 2005 based on a common reference curriculum, mutual recognition among the ENEN Members and promotion of the mobility of students throughout Europe.

The EMSNE does not include courses on nuclear security. According to the needs, however, further development of the EMSNE into other nuclear disciplines, such as a European Master in Nuclear Security is being considered based on the IAEA Guideline Educational Programme in Nuclear Security.

### **3.2. Russian Federation**

In the Russian Federation, the Moscow Engineering Physics Institute (MEPhI) and the Tomsk Polytechnic University (TPU) offer educational programmes in *Material Protection, Control and Accounting* (MPC&A) that provide excellent background for the development of a comprehensive nuclear security educational programme.

In 2008, the Master Programme in *Nuclear Control and Regulation* was established at the Applied Physics and Engineering Department of TPU. This Programme will be based on the

*IAEA Educational Programme in Nuclear Security* and will use resources from the MPC&A programme.

Both academic programmes will be addressed to students and specialists working within the competent authorities for nuclear security and other institutions or organizations responsible for nuclear security in a country. The different programmes will be open to students from the Russian Federation as well as international students. Due to the geographical position of Tomsk, it is expected that in the first instance Russian students and students from Asian countries might be interested in enrolling in the academic programmes.

The TPU plans to launch the national Master Development Programme in autumn 2009 by providing courses taught by TPU experts. In parallel, the following steps will be initiated:

- The current national academic curriculum has to be modified and expanded in order to align it with the *IAEA Educational Programme*.
- The provision of international experts for pilot courses should be assured and at the same time the development of qualified nuclear security instructors needs to be organized.
- The development and expansion of existing training laboratories needs to be planned.

All works will be undertaken by the TPU in cooperation with the IAEA involving also other countries and organizations.

#### **4. Conclusion**

The *Educational Programme in Nuclear Security* is intended to be a 'tool box' that provides a comprehensive and current overview of nuclear security. It is designed to assist States to develop their own nuclear security educational programmes, based on their individual educational needs. Moreover, this guidance document, which will be published in 2009, should be useful in the development of a comprehensive national human resource development programme in nuclear security with the purpose of building and maintaining knowledge and sustaining qualified individuals dealing with the challenges that the future will bring in this area.

States from different regions in the world have already expressed their interest in developing a nuclear security educational programme in line with the *Educational Programme in Nuclear Security*. And the IAEA has received several requests for assistance in this process. The Agency stands ready to help States in their efforts to bring sustainable nuclear security knowledge to their countries and to improve the performance in preventing, detecting and responding to malicious acts involving nuclear and other radioactive material.

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# INTEGRATION OF RADIATION PROTECTION INTO GENERAL HEALTH AND SAFETY TRAINING?

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## ABSTRACT

Responsibility for health, safety and environment (HSE) issues at the workplace lies with the employer. The employer is advised and supported by safety experts from the various areas of HSE. German law calls for all persons involved in these activities to work together closely. This pragmatic approach enables synergies to be better harnessed and increases efficiency.

However, experience, both in Germany and elsewhere, shows that the safety experts from the different disciplines do not always “speak the same language”, which causes their collaboration, effectiveness and efficiency to suffer.

By comparing general occupational safety and health (OSH) and the specialist field of radiation protection, this paper will provide an example to highlight the important role played by the general risk evaluation, principles for action and the specific protection objectives in creating an efficient OSH management system. The need for these topics to be integrated into the training of the various safety experts will be illustrated.

## 1. Introduction

In 1996, Council Framework Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (1) (the “Health and Safety Directive”) was transposed into German law, along with other European health and safety directives, in the *Arbeitsschutzgesetz* (Act on Occupational Safety and Health) (2). The Act, abbreviated to “ArbSchG” in German, applies to all fields of work. This is a pragmatic approach since workplace evaluations (e.g. in a radionuclide laboratory) encompass not only radiation protection but also areas such as fire protection, hazardous substances, workplace ergonomics, genetic engineering and explosion protection. Environmental aspects also have to be considered.

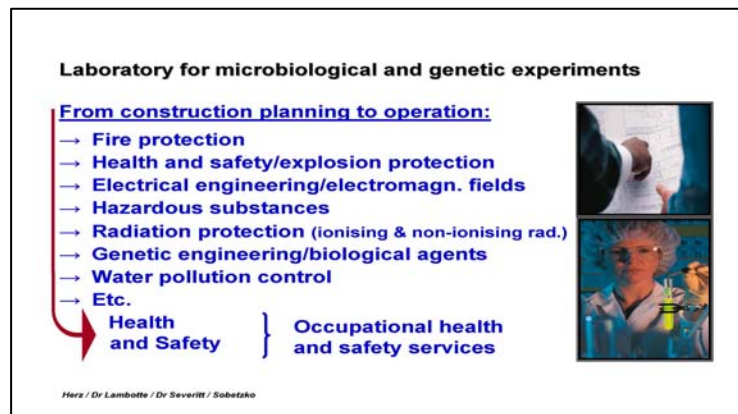


Fig 1: Example of an interdisciplinary HSE scenario (radionuclide laboratory)

Each of these areas is subject to special legislation. In the area of radiation protection, the legislation is based on the EURATOM directives.

Responsibility for ensuring health and safety at work and environmental protection lies with the employer. The employer is advised and supported by safety experts from the various areas of HSE. However, employers and employees only react positively to these safety experts if they collaborate in a constructive manner, propose joint strategies with which to solve complex problems and support both the employer and the employees in their efforts to implement those strategies. The overall evaluation should therefore also include radiation protection aspects.

German law calls for all persons involved in HSE to work together closely. This approach is pragmatic too since it makes it easier to harness synergies and increase efficiency. The elements required for a continuous improvement process in prevention can also be derived from the legislation, providing a further aid to ensure proper, consistent implementation of measures.

However, experience shows that the safety experts from the different disciplines do not always “speak the same language”, which causes their collaboration, effectiveness and efficiency to suffer. This is far from being an exclusively German problem. What causes it?

This is one of the questions with which the *Kooperationskreis „Synergien in der betrieblichen Sicherheit“* (KKSyS – “Synergies in Health and Safety” Cooperation Group) (3) is concerned. KKSyS is a joint working group of the *Deutsch-Schweizerische Fachverband für Strahlenschutz* (German-Swiss Radiation Protection Association, FS) and the *Verband Deutscher Sicherheitsingenieure* (Association of German Safety Engineers, VDSI). It is composed of safety experts from various disciplines. The group’s very first meeting in October 2003 showed how different the safety experts’ “languages” were. To stop ourselves constantly talking at cross purposes, we decided our first task should be to analyse where our communication difficulties lay. The first disciplines we looked at were general OSH as compared to the specialist area of radiation protection (ionising radiation) since communication between these two areas had proved most difficult. The results and conclusions are presented in the following sections.

## **2. From analysis of the problem to the continuous improvement process in prevention**

### **2.1 Protection objectives**

A simple real-life example can help illustrate the difficulty – the “hammer and window problem” in a radionuclide laboratory.

The laboratory is located on the ground floor. As there is no second escape route to the corridor, a window has been defined as an escape route.

In Germany, the evaluation of this scenario would involve the following areas (persons):

- radiation protection (radiation protection officer),
- fire prevention (fire protection officer) and
- general occupational safety (safety specialist).

If the work of these three persons is uncoordinated, i.e. if they do **not** work in collaboration, the solution often takes the form shown in Fig 2.

Numerous pictograms and tools that would confuse those trying to escape in an emergency, a fire for instance.

Why does this situation occur?

During their training, the safety experts will have been taught all about the typical protection objectives in their specific fields. In the case described here, these objectives would be as follows:

- For the radiation protection officer:  
No radioactive substances should be released into the environment. To this end, the low pressure in the laboratory must be permanently maintained. The solution typically used to meet this protection objective is to prevent windows from being opened.
- For the fire protection officer:

In the event of a fire, it must be possible (without any aids) to leave the laboratory via a second escape route, in the case described here at least via one window.

The solution typically used to meet this protection objective when there is no window handle is to provide a hammer and brief instructions on how to use the hammer in order to make the escape route usable.

- For the safety specialist:

The second escape route must be usable without any further risks.

The solution typically used to meet this protection objective is to provide face protection and gloves to prevent cuts when breaking the glass.

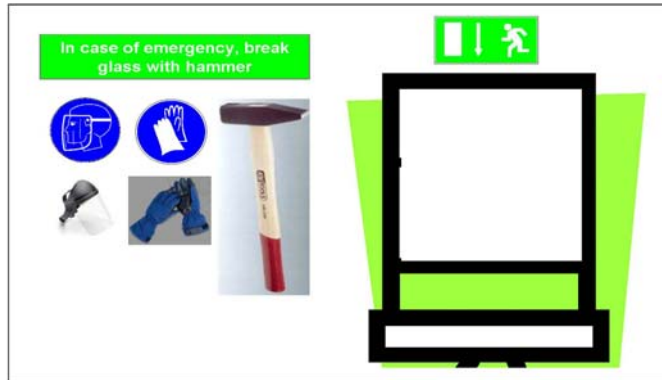


Fig 2: Poor solution of the hammer and window problem in a radionuclide laboratory

If the three experts consult with one another from the outset, the three different protection objectives will also be taken into account from the outset. The solution could then take the form shown in Fig 3.

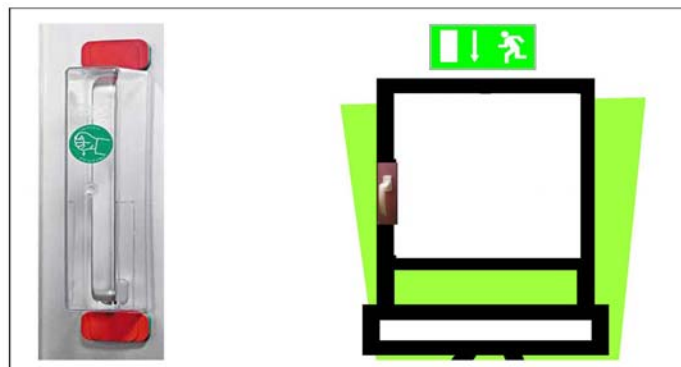


Fig. 3: Optimum solution for the named problem – installation of a cover over the window handle to be removed in an emergency.

But how do these three experts know that the scenario described here involves them?

## 2.2 Risk evaluation and principles to be applied when specifying the necessary measures

That question is easy to answer. The “Health and Safety” Framework Directive (1) and thus the German ArbSchG (2) stipulate that the employer must conduct a risk evaluation. The risks associated with the employees’ work have to be identified and OSH measures specified in order to minimise those risks. The principles to be adhered to when specifying said measures are shown in Tab 1. Interestingly, these principles can also be found in the area of radiation protection (Tab 1) although the national legislation is based on EURATOM directives, not EU directives.

The workflow described below has proved successful for general risk evaluations in practice:

1. Specification of the area to be evaluated
2. Identification of the risks



3. Specification of the protection objectives
4. Specification of the technical, organisational and personal protective measures
5. Implementation of the measures
6. Monitoring of initial implementation, effect and continued implementation
7. Documentation

<b>General OSH Principle</b>	<b>Radiation protection (ionising radiation) Principle</b>
Required action: Prevention of causes and minimisation of remaining risks	Required action: Prevention of unnecessary (contamination and) radiation exposure and minimisation even below the exposure limits
Sequence of protective measures: Technical protective measures before organisational ones and both before personal protective measures ("TOP model")	Sequence of protective measures: "Protection for persons exposed to radiation at work should primarily be provided by means of structural and technical devices or suitable work methods"
Consideration of the state of the art and other substantiated findings from the field of human factors engineering	Consideration of the state of the art

Tab 1: Principles to be applied when specifying the necessary measures

A detailed examination of items 1 and 2 reveals which safety experts should be integrated in the process. Items 3 to 5 are dealt with by those safety experts in concert. Items 6 and 7 require the specialist knowledge of the various safety experts again.

Irrespective of the general risk evaluation, the same points have to be considered for radiation protection even though the legislation is based on the EURATOM directive. Items 1 to 4 are performed during the permit application phase. Items 5 to 7 are carried out when the permit is granted and during subsequent operation. Thus, the workflow for a risk evaluation is generally familiar in the field of radiation protection – it merely goes by another name.

KKSyS also compared other aspects relating to experts from general OSH and radiation protection, e.g. specific tasks. Here too, there were a surprising number of parallels and common features.

This section can thus be summed up by saying that the communication difficulties between the various safety experts are mainly due to their different protection objectives.

### **2.3 The continuous improvement process in prevention**

By grouping and arranging all of the aspects compared, one can create the elements of a management instrument, the continuous improvement process in prevention (Fig 4).

All of the safety experts can be integrated into this model. Its elements are stipulated by law.

### **3. Integration of radiation protection into general health and safety training?**

There should always be safety experts for specialist areas, e.g. radiation protection (ionising radiation), genetic engineering and hazardous substances. Their training should continue to focus on the protection objectives currently identified since they are closely linked to the characteristics of the sources of risk in their fields. In radiation protection, all of the protection objectives are based on the fact that radiation is ionising. The objectives aim to minimise the

dose. This requires specialist knowledge, beyond general OSH. The high standard achieved so far should not be abandoned.

What needs to be cultivated is the way in which the safety experts collaborate. They need to be made aware of the issues whilst still in training. Units should be integrated into the training to make them aware of the interfaces between and common features of their roles. Even though the objection is often raised that “These areas are already grouped together in one department in our company’s structure”, such a set-up by no means guarantees that the safety experts in the company actually talk to one another – as experience shows.

Over the past few years, KKSyS has mainly worked on raising awareness of this issue in the German-speaking world. For instance, it developed and ran a one-day seminar with practical exercises, covering all of the topics discussed in this article. This was followed by papers at internal seminars held by research institutions and enterprises, at public events, such as conferences on radiation protection and OSH and special events staged by ministries. The topic has now been permanently adopted by some providers of state-recognised continuing training for radiation protection officers. The interest in the topic shows how much there is still to be done.

An international recommendation on the integration of the topic of “Synergies in Health and Safety”, with at least “general risk evaluation”, “other safety experts and their protection objectives” and “the continuous improvement process in prevention” as sub-topics and an explanation of the links between them, into the initial and continuing training of the different safety experts would be advisable. Practical exercises, e.g. on the risk evaluation, would complete the package.

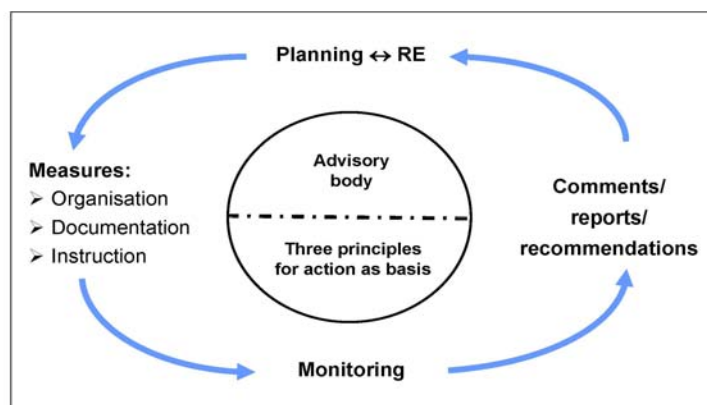


Fig 4: The continuous improvement process in prevention. RE = Risk evaluation

#### 4. References

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# **RECENT DEVELOPMENTS IN RECOGNITION AND HARMONIZATION OF REQUIREMENTS**

# United States Nuclear Regulatory Commission Training Program

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## ABSTRACT

The Mission of the United States Nuclear Regulatory Commission (NRC) is to ensure adequate protection of public health and safety, to promote common defense and security, and to protect the environment in the use of nuclear materials in the United States. The ability of the NRC to accomplish its mission is, in part, dependent on the qualifications of its personnel. One aspect of the qualification process involves formal training which is managed by NRC Human Resources Training and Development (HRTD). In this paper we will provide an overview of the training program managed by HRTD for the NRC, including the organizational structure, the subject areas covered, the documents which specify training requirements, how training is provided, the methods used for evaluating effectiveness and a discussion of some of the challenges currently being addressed

## 1. Introduction

The Nuclear Regulatory Commission (NRC) is an agency of the United States Government with the responsibility to regulate the nation's civilian use of nuclear materials for the protection of public health and safety and the environment. The NRC's regulatory mission covers three main arenas: a) nuclear reactors, b) materials (such as industrial and medical applications) and c) waste (the nuclear fuel cycle, low and high level radioactive waste). The goals of the NRC are Safety and Security as noted in its Strategic Plan which is available along with additional information regarding the NRC at [www.nrc.gov](http://www.nrc.gov)

The NRC is divided into several technical offices each of which has responsibility for specific aspects of its mission. The following is a list of some of these offices:

- Office of Nuclear Reactor Regulation (NRR) - responsible for overseeing existing nuclear reactors
- Office of New Reactors (NRO) - responsible for overseeing construction and licensing of the new generation of reactors
- Office of Nuclear Material Safety and Safeguards (NMSS) - responsible for regulation of the nuclear fuel cycle including uranium milling, conversion, enrichment and fuel fabrication. It is also responsible for the safe storage, transportation and disposal of high-level radioactive waste and spent nuclear fuel; and the transportation of radioactive materials.
- Office of Federal and State Materials and Environmental Management Programs (FSME) - responsible for overseeing both the Federal and State regulation of radioactive material. States which have entered into an agreement with the NRC assume regulatory responsibility within their borders for all nuclear materials except for reactors and federal installations. Currently, of the 50 States, 37 are Agreement States. More information about the Agreement State Program including training issues may be found at: <http://nrc-stp.ornl.gov/> .

The NRC Headquarters (HQ) building is located in Rockville, Maryland; however, there are also four Regional Offices:

Region I - King of Prussia, Pennsylvania (near Philadelphia)  
Region II - Atlanta, Georgia  
Region III - Lisle, Illinois (near Chicago)  
Region IV - Arlington, Texas (near Dallas)

While the headquarters offices are responsible for establishing regulatory policy, the regional offices implement the NRC's regulations by conducting inspections. In the case of medical and industrial applications, the Regions issue licenses for the possession and use of radioactive material and then inspect those licensees to ensure that they are in compliance with their license commitments and the regulations, and, that they are protecting the public, radiation workers and the environment

## **2. Training**

To accomplish its mission, the NRC requires a highly competent technical workforce possessing the knowledge and skills to implement the regulations and protect public health and safety.

The responsibility for insuring the qualification of the staff to perform their duties rests with the Human Resources Training and Development (HRTD) which is a division within the Office of Human Resources (HR).

### **2.1 HRTD**

The director of HRTD is the Chief Learning Officer (CLO) who has responsibility for all NRC training activities.

HRTD is divided into five training branches:

- Professional Development and Policy Branch (PDPB) - responsible for training in areas such as familiarity with computer software, leadership and management and other similar non-technical skills training.
- Regulatory Fundamentals Training Branch (RFTB) - responsible for generic reactor technology training, Site Access Training (also known as General Employee Training) and other reactor support training primarily for HQ personnel.
- Reactor Technology Training Branch (RTTB(B)) - responsible for advanced technical training in boiling water reactor (BWR) technology.
- Reactor Technology Training Branch (RTTB(P)) - responsible for advanced technical training in pressurized water reactor (PWR) technology.
- Specialized Technical Training Branch (STTB) - responsible for a wide variety of technical training including radiological safety of medical and industrial applications, risk assessment, security, licensing and inspection, root cause analysis, codes and standards, engineering support and essentially any other subject not directly related to reactor technology.

## 2.2 Training Facilities

The first two branches listed above are located in the Professional Development Center (PDC) in Bethesda, Maryland near the NRC HQ facility. The remaining three are located at the Technical Training Center (TTC) in Chattanooga, Tennessee (Figure 1) which is a remote facility not adjacent to any NRC Office or Region. This permits students to concentrate on their training activities with minimal distractions.



**Figure 1 - Technical Training Center, Chattanooga, Tennessee**



**Figure 2 - Nuclear Reactor Control Room Simulator**

The TTC facility includes six classrooms with a capacity of 18 to 44 students and four full scope control room simulators representing the four vendors of nuclear plants in the United States (Figure 2).

Also available are classroom training aids including reactor components, medical and industrial devices, radiation detection instruments and similar items for hands-on activities (Figure 3).



**Figure 3 - Materials Training Aids**

## 2.3 Training Courses

The technical training courses are given a 3 digit numerical designation preceded by a letter which represents the subject area (e.g., F-XXX). The letters are explained in Table 1. The numbers in parentheses indicate the total number of course offered in that subject area:

E - engineering support (13)	P - probabilistic risk assessment (22)
F - fuel cycle (8)	R - reactor technology (45)
G - regulatory skills (19)	S - safeguards and security (13)
H - health physics/radiation safety (26)	

**Table 1 - Training Course Subject Areas**

## 2.4 Course Catalogue

Unfortunately, the entire NRC training catalogue is currently available only on the NRC internal website. However, a subset of the catalogue focussing on the areas of responsibility of the Agreement States (medical and industrial applications and regulatory skills) may be viewed at: <https://ilearnnrc.plateau.com/plateau/user/portal.do?siteID=ExternalCatalog> . Additional information regarding NRC training courses may be obtained by contacting the Office of International Programs (OIP) at <http://www.nrc.gov/about-nrc/ip/contact-ip.html> .

Anyone interested in attending NRC sponsored training courses should contact OIP. Seats in our courses are available at no cost on a “space available” basis.

A few examples of the training courses provided by STTB are listed in Table 2. Unless otherwise specified, all courses are five days or less in duration.

NOTE: Courses with an “S” following the course number (e.g., F-102S) indicates a self study course.

<b>E Courses</b>	
E-115 - Medium Voltage Circuit Breakers	E-117 - Concrete Technology & Codes
<b>F Courses</b>	
F-102S - General Health Physics Practices for Fuel Cycle Facilities	F-206S - Fire Protection for Fuel Cycle Facilities
<b>G Courses</b>	
G-108 - Inspection Procedures	G-205 - Root Cause/Incident Investigation
<b>H Courses</b>	
H-122 - Basic Health Physics (2 weeks)	H-314 - Safety Aspects of Well Logging
H-305 - Safety Aspects of Industrial Radiography	H-313 - Brachytherapy, Gamma Knife and Emerging Technologies
<b>P Courses</b>	
P-200 - System Modelling Techniques	P-203 Human Reliability Assessment
<b>R Courses</b>	
R-105 - Nuclear Technology for Security	
<b>S Courses</b>	
S-201 - NRC Materials Control & Security Systems & Principles	S-503 - Advanced Intrusion Detection Systems

**Table 2 - Sample Courses**

## 2.5 Location

All reactor technology courses are taught by NRC staff at the TTC or PDC. However, the training courses offered by STTB are presented by various groups in various locations. Many of the courses such as medical, radiography and irradiator courses are presented by contractors who possess the expertise, equipment and facilities to provide hands-on activities as well as classroom lectures. For example, MDS Nordion Inc in Laval, Quebec, Canada has been the source for Irradiator Technology training.

Some health physics and regulatory skills courses are presented by STTB staff while others, like the Licensing and Inspection courses, are presented by experienced license reviewers and inspectors from the NRC Regions.

## 2.6 Qualification Programs

The NRC has established Qualification Programs for most of its technical staff. These programs provide detailed, step-by step processes to insure that individuals are qualified prior to being permitted to perform inspections or other significant activities unsupervised. These qualification programs are contained in Inspection Manual Chapters (IMC) which may be viewed at <http://www.nrc.gov/reading-rm/doc-collections/insp-manual/> . The following are the primary technical qualification programs:

- IMC 1245 - Qualification Program for Operating Reactor Programs
- IMC 1246 - Formal Qualification Programs in the Nuclear Material Safety and Safeguards Program Area
- IMC1247 - Qualification Program for Fuel Facility Inspectors in the Nuclear Material Safety and Safeguards Program Area
- IMC1252 - Construction Inspector Training and Qualification Program

## 3. Current Issues

### 3.1 Course Evaluations

Evaluating the effectiveness of training is an important consideration. In general the goal is to determine: the reaction to the training (student post-course evaluations), the learning

achieved (exam results), the impact on behaviour (application of the learning during work assignments) and the results (such as a measured increase in productivity or efficiency).

The NRC currently uses the overall assessment of the course as a metric to determine success. There are five possible outcomes: Unsatisfactory, Marginal, Satisfactory, Good or Excellent. Success is achieved if 95% of the composite ratings for the year are satisfactory or better. In 2008, of 2,394 evaluations, 98.6% were satisfactory or better.

The questions on the evaluation forms have traditionally concentrated on the course content. Space is also provided for any additional comments. However, recently, there has been a directive to include specific questions relating to the performance of the instructors. Assessment of an instructor's knowledge and performance has traditionally been the responsibility of the individual's supervisor. It remains to be seen whether these additional questions will provide added value to the evaluation process.

### **3.2 Student Behaviour**

A Working Group has been formed to establish a set of "Rules of Behaviour" for students. This resulted from instances where students attended training with inappropriate attire, used cell phones and PDAs during class and in recognition that electronic devices may be used to store reference material which could be used during examinations. Students must be made aware of any rules and those rules must be clearly defined.

Recognizing the difficulty in recruiting experienced professionals, the NRC is actively recruiting new university graduates in science and engineering disciplines to develop qualified staff in-house. Some of these "behaviour" issues may simply be a manifestation of cross-generational influences since many of these new hires are young, technologically advanced and come directly from university with no industry work experience.

## **4. Conclusion**

The Nuclear Regulatory Commission's training program is a good one but it is not perfect. The newly appointed Chief Learning Officer has established a vision for the organization that will assist in our goal of continuous improvement. To achieve this vision it is important that:

- We know what knowledge and skills (competencies) the NRC workforce needs in order to effectively execute its mission and strategic goals.
- We know what the gap is between the level of knowledge and competencies our workforce currently possesses and what it needs.
- Our courses and other learning interventions are directly aligned to the needed knowledge and competencies.
- We are using the right (efficient and effective) modes of learning intervention delivery and capitalizing on the potential that technology offers.
- Our learning interventions are of known effectiveness in closing competency gaps and in improving accomplishment of mission and strategic goals.
- We are identifying, capturing, and making accessible the high-value and high-risk knowledge that already exists within our workforce.

We have much to learn from others who may have already addressed these issues and we are willing to share with others whatever information we can for our mutual benefit.



**ENETRAPII: WP5**  
**DEVELOP AND APPLY MECHANISMS FOR THE EVALUATION OF**  
**TRAINING MATERIAL, EVENTS AND PROVIDERS**

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**ABSTRACT**

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

## 1. Introduction

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

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

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

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

and the Radiation Protection Officer as:

*“An individual technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of the requirement of the Standards and whose capacity to act is recognized by the competent authorities”.*

These are the definitions as proposed in Item 4.5 Draft European Basic Safety Standards Directive - version 8 May 2009.

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

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

## 2. WP5 Objective, description of work and deliverables

The main objective of WP5 is:

*To develop a mechanism for the comparison, through a transparent and objective methodology, of training materials, courses and training providers, which can be used by regulatory authorities to evaluate their national radiation protection training programme for compliance with the European Radiation Protection Training Scheme (ERPTS).*

To reach this objective of WP5, the next items will be addressed:

1. Organisation of a kick-off meeting and subsequent WP5 meetings
2. Defining a detailed work programme for WP5 and subsequent division of tasks.
3. Identification of the elements that are essential for the comparison of training materials.

4. Identification of the elements that are essential for the comparison of training courses, including exercises, On-the-Job-Training, Work Experience, examinations, etc.
5. Defining the range of detail for course elements that is sufficient for compliance with the ERPTS.
6. Identification of the criteria and indicators that are essential for the comparison and evaluation of training providers.
7. Setting up and apply a quality assurance protocol for the comparison of training materials, courses and providers on the basis of the above-mentioned elements.
8. Reporting to the Steering Committee.

All items are drawn up in more detail in the next chapter.

The next deliverables will be produced. The items mentioned above will be input for the deliverables.

- WD5.1 Methodology and quality assurance protocol for comparison and evaluation of training material
- WD5.2 Methodology and quality assurance protocol for comparison and of training events
- WD5.3 Methodology and quality assurance protocol for comparison and evaluation of training providers
- WD5.4 Application of the defined mechanisms to some examples of training material, providers and events

The WP5 leader is NRG (The Netherlands). The work package partners are CEA/INSTN (France), FZK-FTU (Germany), ENEA (Italy), HPA-CRCE (United Kingdom), ENEN (European), ITN (Portugal) and UPB (Romania).

### **3. Detailed work programme**

The work package will be split up in four parts, related to the four deliverables. The research for the first three items (WD5.1 to WD5.3) will be carried out parallel. When all methodologies and protocols are finished, they can be applied to some examples of training materials, training events and training providers.

The first two years are going to be used for a survey to existing and new comparison methods and protocols (WP5) and a definition of the European standards (WP3 and WP4). In the first year an inventory takes place towards of the comparison methods currently applied in the WP5-partners countries. The preferred comparison methods will be worked out in more detail during the following year, after which it can be used for the comparison with the new European standard (WP3 and WP4) during the last year.

#### **3.1 Organisation of a kick-off meeting and subsequent WP5 meetings**

The kick-off meeting of WP5 is scheduled for November 2009. Preferably the kick-off meetings of the different work packages in the ENETRAPII project will be combined.

Two subsequent meetings of the WP5 participants are foreseen. It is tried for financial reasons to couple the WP5 meetings to other ENETRAPII events.

The first one will take place when the inventory to existing comparison methodologies is finished (12 months after the kick-off meeting of WP5). Its goal is to decide on a comparison method or methods that is (are) going to be used in WP5 for the training material, training providers and training events.

The second meeting is foreseen when the comparison method(s) is (are) worked out in detail at the end of the second year (24 months after the kick-off meeting of WP5).

#### **3.2 Defining a detailed work programme for WP5 and subsequent division of tasks**

The work programme for WP5 will be an adapted version of this paper. The tasks will be divided amongst the partners at the kick-off meeting.

### **3.3 Identification of the elements that are essential for the comparison of training materials**

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

The inventory starts with the subjects addressed in the syllabus EG133 (EG Basic Syllabus 98/C133/03), the IAEA syllabus (IAEA Basic Syllabus PGEC), the European Master's degree in Radiation Protection syllabus – EMRP - (result of WP8 ENETRAP), the existing tables of subjects for education and training in radiation protection and similar tables used in different countries.

### **3.4 Identification of the elements that are essential for the comparison of training courses, including exercises, practical works, On-the-Job-Training, Work Experience, examinations, etc.**

For comparison of the training courses an inventory will be carried out amongst WP5 partners about the number of hours spent on the identified elements. These hours have to be classified as class hours (theoretical, problem solving, examination), practical hours, on the job training and work experience, etc. The results of this inventory will be used to determine a reference standard.

### **3.5 Defining the range of detail for course elements that is sufficient for compliance with the ERPTS**

The range of detail will be based on the European standards, determined by ENETRAPII WP3 and WP4. The subdivision, mentioned earlier and the range of detail of the European standards will result in a reference table, which indicates the detail of the subjects that need to be addressed in education and training for RPEs and RPOs. This also holds for the elements needed for course comparison and for event comparison.

### **3.6 Identification of the elements that are essential for the comparison of training providers**

For the comparison of training providers an inventory will be carried out about the elements of quality assurance. This inventory will take into account requirements by regulations and international standards, e.g. ISO 17024 and topics addressed by stakeholders. The WP5 partners will be asked to collect the topics of the stakeholders as input to obtain a list of demands for training providers

### **3.7 Setting up and apply a quality assurance protocol for the comparison of training materials, courses and providers on the basis of the above-mentioned elements**

Discussed and selected comparison methods will be joined to create in a protocol. The usefulness of this protocol will be verified by applying it to some training materials, courses and providers.

### **3.8 Reporting to the Steering Committee**

The WP5 leader (NRG) will report to the steering committee about the progress at each SC meeting. The progress reports will be based in the input of the WP5 leader and the WP5 partners. A progress reports will be sent to the SC after 12 months, 24 months and 36 months.

# HARMONIZATION OF NATIONAL AND REGIONAL EDUCATION AND TRAINING IN RADIATION PROTECTION IN CASE OF BELARUS

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## ABSTRACT

The approaches to train specialists in radiation protection in the region of Former soviet Union countries and possible pathways to harmonise nuclear and non-nuclear education and training in radiation safety, justification of needs, appropriate education and training curricula, optimization of list and curricula of post-graduate and re-training courses within the framework of international co-operation between European Union and Former Soviet Union countries are considered. The main goal of this report is to draw attention of the European Union countries on new possibilities for co-operation and to develop proposals for getting started in this way.

### 1. Historical background

Training in radiation protection In Former Soviet Union (FSU) was concentrated in several huge Russian centres like Moscow, Leningrad (Saint Petersburg now) and their affiliations mostly situated in some settlements secret at that time like Obninsk, Sarov, Krasnoyarsk-16 etc. The radiation protection was “parked” in 3 main brunches: nuclear technologies, medicine and military applications. Environmental issues of radiation protection where not separate from nuclear technologies and their military applications and, as the result, were outcasts of political decisions.

Relating to Belarus at times of the FSU one can mention some experience in training on nuclear physics, radiochemistry and radiation chemistry (Belarus State University) for nuclear research institute of the National Academy of Sciences and the Research Institute of Nuclear Problems of Belarus State University with minor distribution to institutions and enterprises using ionising radiation sources. Small amount of medical doctors involved in use of medical applications of ionizing radiation was being trained in Minsk medical institute in that time. No engineers for medical applications were trained at all. All of them had come into the brunch from nuclear physics and general engineering. Re-training in the field was almost absent but some professional updating and refreshing was carried out within the ministries that were responsible for use of radiation sources. There were separate regulatory bodies for industrial and medical applications that attracted specialists from the practices with refreshing and enhancing their knowledge in central training institutions of FSU in Moscow, Leningrad, Obninsk, etc. That is why there was the lack of local specialists in radiation protection at the moment of Chernobyl accident in Belarus. The same situation, may be, a little bit better was at that time in Ukraine and the west districts of Russia affected by Chernobyl releases.

The situation was worse in other FSU republic: Armenia, Azerbaijan, Baltic countries, Georgia, Moldova, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan. The training was almost absent at all levels except, may be, small amount of people in several local universities like in Armenia having nuclear power plant (NPP) at that moment. It was habitual, like training specialists for Ignalina NPP in Lithuania, to give basic general training at the first 2-3 years in national universities and to deliver than for completing education in Moscow and Obninsk.

As result, after the disintegration of the Soviet Union there were no sustainable education and training in radiation protection in all FSU countries except Russia, and, may be, only

Ukraine was close to the sustainability in the field but political processes and lack of national funds prevented at that time to form the system quickly. Because of mostly political reasons the possibility to continue education and training specialists in radiation protection for national needs of FSU countries in Russia has been lost in the beginning of 1990<sup>th</sup>.

## **2. Why Belarus, why ISEU?**

Belarus has become as the centre of counteraction to these centrifugal effects in FSU mostly suddenly (figuratively saying, like a 'strange attractor') but there were several strong reasons to that.

After 6 years spent from Chernobyl, in 1992 the International Sakharov College on Radioecology was created. The project was launched due to proposal of the 1<sup>st</sup> memorial Andrey Sakharov Congress held in Moscow in 1991 that had advised to create such kinds of higher institutions as internationally co-operating bodies to assist to alleviating the environmental and medical consequences of Chernobyl in 3 countries: Belarus, Russia and Ukraine. To facilitate the international co-operation and to promote to the dissemination of international experience and approaches the congress had proposed to establish an International Advisory Committee in each institution. It was the only Government of Belarus that has created the institution of such kind with the International Advisory Committee (the first head, Prof. Richard Wilson, Harvard University, USA) after huge organizational work done by Alexander Lutsko, the first rector of the College that soon, in 1995, had become the International Radioecology Institute and than the International Sakharov Environmental University (ISEU) in 1998. Being focused at the first time on only radiological consequences of Chernobyl accident the institution has steadily expanded its efforts to education and training for all fields embracing by radiation protection.

Still Prof. Alexander Lutsko (he suddenly died in 1997) had drawn attention of the ISEU staff onto efforts of the International Atomic Energy Agency (IAEA) to promote education and training in radiation protection. The 1<sup>st</sup> for ISEU national technical co-operation project with IAEA was implemented in 1999-2000. At the same time the Educational committee of the Community of Independent States (CIS) created after disintegration of the Soviet Union had taken the decision to establish the Standing commission on training in radioecology, radiobiology and radiation safety of several CIS countries (firstly, Belarus Kazakhstan, Moldova, Russia and Ukraine). This outcome had happened also due to the initiative of Alexander Lutsko, continued by the second ISEU rector, Prof. Alexander Milyutin and current rector Prof. Semyon Kundas. The work of the commission goes slowly because of lack of funds issuing by CIS for that but it has established officially the co-operation in training in radiation protection among CIS countries at the regional level.

The co-operation with IAEA has resulted in establishing the regional Post-Graduate Course (PGEC) on radiation protection and safety of radiation sources on the base of ISEU in Russian language for FSU and mostly Eastern-European countries which specialists use Russian in their professional work. There were 116 specialists trained at PGEC in ISEU, Minsk, since 2001. Graduates are awarded by Belarus national diploma on re-training within the speciality "Radiation protection and safety of radiation sources" established since 2006 in full accordance with the IAEA PGEC Syllabus. ISEU has got the licence from the Ministry of Education of Belarus to award participants by such diploma.

The strong technical support of IAEA brought the international content and approach to education and training in radiation protection in Belarus and operation of the CIS Standing commission had provided the basis for the ISEU to pretend to be a regional training centre in radiation protection. At the same time Belarus Parliament Standing commission on alleviation of Chernobyl consequences had advised in 2005 to direct ISEU efforts in training not only onto Chernobyl problems but also to all radiation protection issues for Belarus and to convert the speciality "Radioecology" from pure environmental to more engineering mode. It was partially realizing within the specialization "Radiology" introduced into the speciality "Radioecology" in 2001 but real sufficient changes in the national education and training has started in Belarus only in last 2 years.

In September 2008 training specialists on new for Belarus speciality “Nuclear and Radiation Safety” had started in ISEU. There was some preliminarily work done in 2 years before to create the education and training in the field including radiation safety in non-nuclear sector. The experience of Russia, Ukraine and also France, Great Britain and, to some extent, United States were also taken into account. It would be impossible without the ‘Nuclear Renaissance’ being come to Belarus just after the end in 2008 of moratorium on to build NPP taken by Belarus Parliament many years ago. The decision of Belarus leadership to install NPP in Belarus, sufficient organising efforts and financial contribution from the Government of Belarus has opened the new era in ISEU activities in radiation protection.

As it was in the Soviet Union and is continuing in CIS now the nuclear brunch is the locomotive of education and training in radiation protection at all. Training specialists on safe use of different radiation sources is the specialization now in the speciality “Nuclear and radiation safety”. It is essential to emphasize, that education and training in non-nuclear radiation protection has the opportunity to obey solid material resources in this case. At the same time, permanent growth of uses of radiation sources in medicine and industry, rapid aging the staff turn the attention of profile Ministries of Belarus (the Ministry of Health, first of all) to the capabilities of ISEU developing in the last years due to contribution of the IAEA and national nuclear programme.

### **3. New opportunities**

Recent progress in co-operation between CIS countries and especially in rather new European-Asian Economical Society (EAES), comprised Belarus, Kazakhstan, Kyrgyzstan, Russia and Uzbekistan, established the Council for co-operation in the peaceful use of atomic energy, provides new possibilities in the European and the World co-operation. Thus, The Council has launched the International Nuclear Innovation Consortium (INIC) united higher educational institutions involved in the nuclear field in EAES countries. The 1<sup>st</sup> meeting was held in the Moscow Engineering Physical Institute (MEPhI) as the head of INIC in May, 2008. In May, 2009 Russian President, Dmitri Medvedev has signed the bill to establish the Federal Nuclear University uniting all the former MEPhI affiliations like the Obninsk Institute of Atomic Energy and also some faculties and parts of other institutions, including Ural Polytechnic University, Tomsk Technical University and other institutions strong in nuclear field under the MEPhI umbrella. In combination with activities at the regional level it opens new opportunities in the international co-operation in education and training in radiation protection at all. And the role of ISEU in this case can be to focus efforts of the regional community to harmonize their approaches in education and training in the field between each other and with the European Union to have the firm basis for the sustainability and equality of approaches to radiation protection.

The experience gained since 1991 in FSU countries shows that it would be wasting time and efforts if the harmonization would be started from the equalization of organization of academic life like involving into Bologna Process. Despite of the evident progress in that (for instance, Russia and Kazakhstan had strongly joined to the process) it takes some time to concord all points of view at national levels. For instance, Bologna process has not been started in Belarus yet. But there are specific features of our internal regulations established by the Ministry of education that can be considered very close to European two level higher education. It seems that harmonization can be carried out now within the following directions not strongly connected to the Bologna policy:

- harmonization of professional requirements to graduates;
- creating comparison table of equal qualifications and positions in radiation protection in different countries;
- enforcing exchange between counterparts by information on education and training in radiation protection;
- establishing the permanent exchange by training methodologies including distance learning and e-learning;
- promotion to fellowships and scientific visits of the staff of different universities to exchange the findings and to learn at the place;



- accumulation of the database of the best practices in education and training in radiation protection.

The final aim is to reach the mutual recognition of professional qualifications in different states. This work is doing within the European Union. There is the good moment to join the harmonization process going now in the Eastern part of the Europe and the Middle Asia to the European Union approach.

#### **4. Towards organizing the process**

The big renovation of professional requirements to the specialists in radiation protection is started in the Russian Federation within the more wide process of establishing up-to-date requirements collected in so called 'professiongrams'. Introducing into some of them one may reveal the good comprehension to that is proposed by IAEA and is being processed within the European Union (EU). There is only a need to adjust the requirements and to create the comparison table of equal professions.

Then, there will be an opportunity to derive the appropriate content of education and training from the professiongrams harmonized and developed and to standardize it. The content must be fitted to be provided by different ways of the organization of training habitual to different countries. The main goal in this part is to reach the same message to be conveyed.

To assure that the process is going on concordance with appropriate international approach the quality assurance programme is to be established in each country being a counterpart in this co-operation. Standards of ISO-9000 series provide the firm basis for that. It should be mentioned that almost all Kazakh universities are passed through this processes of validation. Approximately the 3rd part of Russian universities are also accredited in the way if ISO 9000. This is the turn for Belarus. Recently, Belarus Rector Council and the Ministry of Education have taken the decision to bring national quality assurance programme of education and training in compliance with ISO-9000 series. Special working plan to implement this decision is adopted. It seems that despite of sometimes critical differences between national approaches to organization of education and training the internationally assumed procedure of quality assurance can be the key to open the doors.

It should be added that the Ministry of Education of the Republic of Belarus has ordered to Belarus universities to develop new syllabi for 2 year Master Courses versus existing 1 year ones. At the same time the Minister of Education urge universities to develop the Master courses curricula to be able to provide training in English. It means, that these curricula must be in total accordance with similar curricula providing by European universities.

To reach these goals establishing of close co-operation of EU and CIS universities providing education and training in radiation protection is desirable. It can be done within several international programmes like a regional project for IAEA and/or a TEMPUS project. There can be not one to cover particular topics in radiation protection of mutual interests of counterparts.

#### **5. Main RP education and training stream in ISEU**

Harmonization has to be start from the comparison of approach in the education and training content at the same levels of education. In this way one should taken into account details of existing curriculum in nuclear and radiation safety in ISEU.

The first level curriculum for training of specialists in nuclear and radiation safety being implemented now in ISEU is based mainly on the combination of MEdPhD's academic plans for correspondent specialities and the ISEU experience on training in radioecology. The major ruling idea was to provide to students a sound basic knowledge in:

- higher mathematics with probability theory and statistics (2 years, 32 credits);
- general physics (2,5 years, 31.5 credits);
- chemistry (2 years, 16.5 credits);
- basic life and environmental science (2 years, 13.5 credits) with basic environmental practice (2 weeks);
- basic computer science (1.5 years, 9 credits).

It is supposed to provide a firm platform for professional and special subjects that occupy the 47% of the curriculum. They can be split into the following groups:

- *special phys-math* subjects including physics of a nucleus and ionizing radiation, radiation detection and measurement, etc.(21,6%);
- *special phys-chem* subjects as radiochemistry, radiation chemistry, radioactive waste management (5,1%);
- *special biomedical* subjects as biological effects of ionizing radiation and basic radioecology (3,2%);
- *general engineering* subjects including theoretical mechanics, basic radioelectronics, basic design, material science etc. (22,7%);
- *special engineering* subjects including radiation shielding, nuclear reactors, reliability and risk management, metrology, etc. (12,5%)
- *specific economics and law* issues (8%)
- *special interdisciplinary subjects* including dosimetry, general and radiation safety, basics of radiation monitoring, safety for cases of planned and existing exposure, emergency response, etc (15,9%).

There is the specific point of ISEU curricula that all students are trained deeply in foreign languages (English is mandatory – 688 hours, second foreign language – 456 hours with options for French, German. Spanish). It should assist to a future specialist not only to read and write but to communicate in the field of his/her professional interests and also be able to take a part in international co-operation.

The duration of training at the 1<sup>st</sup> level is 5.5 years now. It includes 17 weeks of practice at radiation objects and defending the diploma project or work.

Training at the Master course in nuclear and radiation safety (2<sup>nd</sup> level of higher education) is 1 year now. We consider the possibility to expand it to 2 years with specific training in radiation protection issues related to uses of ionizing radiation.

Re-training and professional updating is going in ISEU now within the line established by IAEA. But there is big need for the country to join all the activities in the field under this umbrella.

We also keep in mind the growing demand of medical physicists. Their education and training does not exist in Belarus now. We need substantial assistance from well experienced EU bodies in establishing that.

## **6. What can be of interest for EU from this co-operation**

There can be many of contributions to be in benefit to European universities from possible co-operation programme. It would be desirable if the project would comprise not only well experienced universities especially from new EU countries but new ones that are aimed to develop some particular radiation protection profile, for instance, in medical physics or industrial applications. It would involve them in the main flow and will provide an opportunity to get additional assistance from EU and other international bodies in the benefit to harmonization of training approach and capabilities

CIS universities can share with their EU counterparts by their findings in training materials, organization and technical support of knowledge evaluation including distance methods and some webwise tools, etc. Sound experience of MEFPI and other institutions in Russia uniting into Federal Nuclear University can be of special interest for many of EU universities.

It seems that implementing the projects the counterparts might find many peculiarities that would be fruitful for their development. ISEU, particularly is looking for co-operation in education and training for medical applications of ionizing radiation.

## Professional Qualification in Radiological Protection: Update on the Portuguese Needs

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### Abstract

A recently published decree-law (*Dec.-Lei nº 227/2008 de 25 Novembro*) introduces three levels of professional qualification in radiological protection: the Qualified Expert (QE) equivalent to the RPE, the Qualified Technician (QT) equivalent to the RPO and the Operator Technician (OT) equivalent to the RW. The law enumerates roles and duties for each of them, outlines specific training programmes and addresses pre-requisites to be fulfilled by candidates applying for the professional qualification.

Information on the contents of the decree-law will be given, and a detailed assessment of the training effort required in Portugal will be made taking into account the number and geographical distribution of equipment using ionizing radiation sources.

### 1. Introduction

Central aspects of Radiological Protection (RP), namely, RP of professionals exposed to ionizing radiations and that of patients submitted to radiological diagnostic and also to therapeutic involving ionizing radiations have been given particular attention at European level. The EU Directives 96/29 and 97/43 of Euratom that specifically address these matters had been partially transposed to the legal Portuguese framework for some time now, but only recently a long waited for law on qualifications and training of professionals was finally published

The decree-law (*Dec.-Lei nº 227/2008 de 25 Novembro*) introduces different levels of professional qualification in radiological protection, enumerating the roles and duties for each of them, outlines specific training programmes and addresses pre-requisites to be fulfilled by candidates applying for the professional qualification. In addition it addresses requirements to be fulfilled by training entities, and designates a supervising body. In spite of this, the present situation in what RP is concerned is still negatively conditioned by the fact that is not yet mandatory for an industrial installation using radiation based equipment to incorporate in its staff a Qualified Expert in radiation protection.

This may explain why the Portuguese medium and higher education institutions have paid little attention to the field of RP. However, there is an increasing awareness of the need to correct the situation. Reflecting this concern, the Instituto Superior Técnico (IST) of the Technical University of Lisbon offered a master course in Radiation Protection that were lectured, in collaboration with the Instituto Tecnológico e Nuclear (ITN), and offers presently the second edition of a professional specialization course in RP, again lectured in collaboration with ITN. Other initiatives along this line are under way, involving other institutions of the Portuguese higher education tree.

At a different level, training courses for professionals dealing with ionizing radiations (industrial equipment operators, radiologists and other health professionals), Civil Protection officials, army personnel and firemen, have been organized and lectured mainly by ITN, most of them under request. These are typically one week or less courses, for which no specific academic preparation of the trainees is required. As for the use of ionizing radiation in medical practices, current legislation imposes that all practices must be performed under the responsibility of a physician with specific knowledge of RP. Furthermore the teams that operate the equipments must include a specialist in medical physics. It is, however, to be noted that the specialized training programme of the physicians is not clearly defined, and the same somewhat applies to the training programmes of the specialists in medical physics.

The recently published legislation gives important guidelines and opens the opportunity for an effective intervention aiming at the improvement of the overall situation of RP in the country. This paper addresses briefly essential aspects of the legislation and estimates the training effort required in the coming years.

### 2. The new legislative package

The recent legislation defines the following three levels of qualification of professionals of radiation protection: Qualified Expert (QE), Qualified Technician (QT), Operator Technician (OT). For each of them it defines the

duties/functions, the specific training (duration, basic syllabus), the pre-qualification required to access training, and the conditions for the renewal of certificates.

In what concerns duties, the QE has the role to provide comprehensive, professional advice to the employer on a wide range of radiation protection matters. The QE will establish the radiation protection and safety programme in accordance with the relevant national requirements. He/her is expected to supervise radiation protection and safety within a facility, and where appropriate, coordinate the activities of the QTs working at the same facility (institution), within the framework of RP. We note that once qualified as an expert, the professional can work both in the health sector and the industry sector, irrespective of the on-the-job component of the training which is carried out in a specific field.

The activity of the QT is practice oriented, his (hers) primary function being to guarantee the application of the relevant legislative requirements and ensure that the work is carried out safely in compliance with the established RP programme. The specific duties of the QT will somehow depend on the nature of the practice.

The OT operates equipment under supervision.

Table 1 presents for the different qualification levels, background required for candidates to access ET programmes, the duration of the ET programme and the kind of evaluation of the candidates.

	QE	QT	OT
Background required to access the ET level	<p><b>University degree</b> in Physics; Technological Physics; Physical Engineering or Biomedical Engineering</p> <p>University degree in other areas through CV analysis</p>	Those mentioned for LEVEL 1 plus: Chemistry; Engineering; Medicine; Dental Medicine or Veterinarian Medicine	High school:
Duration	<b>300 h</b> in class (50% practical) + (on-the-job training – 6 months)	<b>100 h</b> in class (50% practical)	<b>12 hours</b>
Programme	IAEA and EU syllabus (apart from the training, there is no distinction between the ET programme of a health or a industry QE or QT)		Fitting the working environment
Evaluation	<b>Final exam + analysis of a detailed report</b> produced during the 6 months on-the-job training	Final exam	

**Table 1.** ET training for the different qualifications in RP.

The law states that the General Directorate of Health (DGS), which acts under the Health Ministry, is the competent body to recognize the scientific and technical competence of ET entities, to approve specific training programmes and to certify the professional qualification of professionals. The higher education institutions and ITN are recognized as competent entities in this field. All remaining entities need to seek approval from the DGS to become RP training providers enabling applicants to become qualified. Furthermore, all ET programmes will have to be approved by the DGS.

Once approved in the ET course, the candidate gets a certificate of professional qualification that has to be renewed every three years. Renewal depends on a favourable assessment of a detailed report of the three year activity, and the candidate should include proof of the attendance of refreshment courses, although they are more mandatory to achieve renewal.

For those professionals that are already in the field, the legal diploma considers equivalence schemes for them to be considered as qualified experts or technicians. In these cases the qualification certificate is issued following a positive evaluation of the curriculum of the candidate, provided the following pre-requisites are met:

	QE Level	QT Level
Education	University Degree in Physics; Physical Engineering, Technological Physics; Technological Chemistry or Biomedical Engineering	University Degree in Physics; Chemistry; Engineering; Medicine or other Health Sciences Degree Or Bach in the same subjects
Experience performing technical duties in the area	5 years	3 years

**Table 2.** Pre-requisites for professionals in the field to apply for the two top level qualifications in RP.

In this respect it is to be stressed that the choice of the legislator was to attribute automatically the qualification of QE to all medical physicists in activity.

All together, full implementation of this diploma requires an important training effort, particularly in the industry sector, especially if and when complementary legislation is issued imposing that all operation of equipment that uses ionizing radiation sources must have the supervision of certified qualified professionals.

### 3. Estimated personnel needs

The number of qualified experts in RP depends on the number and complexity of the equipments being operated. Table 3 presents the most recent data concerning all licensed equipment in Portugal, gathered by the General-Directorate of Health. Data is given for five administrative regions of continental Portugal: Alentejo, Algarve, Lisboa e Vale do Tejo, Centro, Norte and the autonomous regions of Madeira and Açores. The data is grouped into 12 categories for the sake of comparison with data from 2005. The categories are: CT scanner, Veterinary x-ray units, Dental x-ray units, Conventional x-ray units, Orthopantomograph units, Nuclear Medicine (gamma cameras), Mammography, Radioisotope laboratory, Bone densitometry, Brachytherapy, External radiotherapy (linear accelerators and cobalt units) and radiological industrial applications (gammagraphy and radiography units, density meters, level meters, thickness meters,).

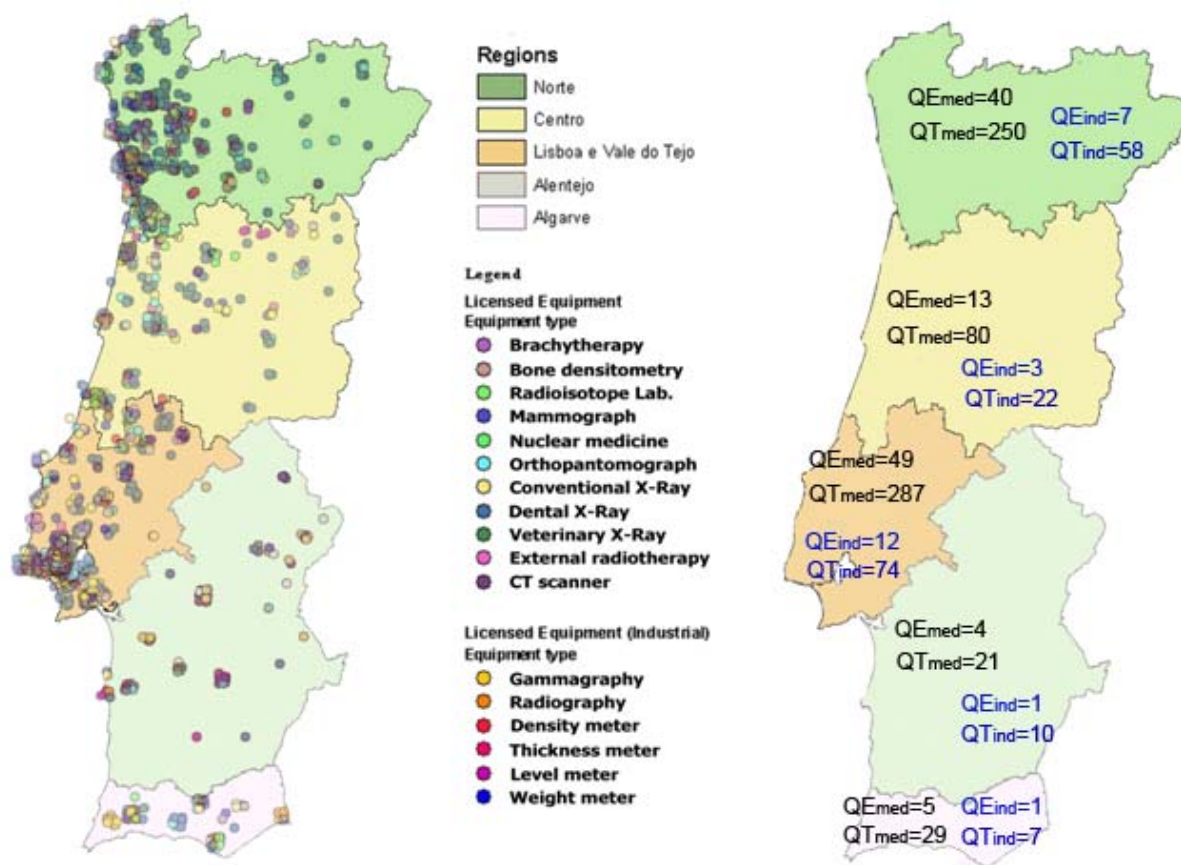
Equipment	Alentejo		Algarve		Lisboa e vale do Tejo		Centro		Norte		Madeira e Açores		Total
	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	
CT scanner	10	10	9	12	51	83	15	28	55	111	NA	5	249
Veterinarian X-ray	6	10	0	15	24	64	6	21	45	91	NA	1	202
Dental X-ray	30	30	37	42	419	490	91	93	317	377	NA	105	1137
Conventional X-ray	19	4	26	47	189	126	58	47	140	168	NA	18	383
Orthopantomography	6	9	6	21	87	148	30	48	79	146	NA	22	394
Nuclear Medicine	0	0	1	1	9	13	7	6	14	11	NA	1	32
Mammography	14	11	11	14	84	107	23	39	92	140	NA	7	318
Bone densitometry	10	11	6	13	76	106	25	41	68	116	NA	3	290
Brachytherapy	0	2	0	1	14	24	4	4	8	7	NA	3	41
Ext. radiotherapy	0	2	1	1	11	20	3	3	3	9	NA	3	38
Industry	6	48	9	47	181	346	66	94	103	256	NA	38	829
Radioisotope lab.	2	2	2	3	22	48	9	7	8	25	NA	3	88
Heavy ions cyclotron								1		1			2

**Table 3.** Licensed equipment in Portugal. (Source: Directorate-General of Health)

It is noticeable the increase in the number of licensed equipment particularly in the industry sector, reflecting both and increase in use of equipment making use of ionizing radiation, and the effectiveness of the action of the DGS.

Fig 1 presents graphically the data from 2009. It is noticeable that the equipment density is higher closer to the coast and in particular near to Lisbon and Oporto. This distribution, that is very similar to that of 2005, can be easily

correlated with the population density map of the country. The southern and in-land regions have a much lower equipment (and population) density.



**Fig 1.** Equipment distribution and corresponding estimated personnel needs.  
(Source: Directorate-General of Health, 2009)

In order to make an estimate of the personnel needs in the country we multiplied the data included in table 1 by a factor of 1.2, on the basis that: (i) facilities are still undergoing licensing; (ii) new facilities are scheduled to be installed; (iii) some licenses have expired and are seeking renewal. Using this data and assuming that the reference personnel/equipment ratios presented in table 4 are applicable, it is possible to make a rough estimate of the personnel needs for each type of equipment.

Equipment	QE	QT
Linear accelerator	0.37	2
Conventional x-ray	0.03	0,2
Brachytherapy	0.18	1
Gamma camera	0.2	2

**Table 4.** Personnel needs for each type of equipment on a radiotherapy service  
(adapted from tables I and II from Annex II of Decree-Law n<sup>o</sup> 180/2002 of August 8<sup>th</sup>)

Some assumptions were made for the remaining equipment, namely, that CT scanners, bone densitometers and veterinary x-ray units have the same personnel needs as conventional x-ray units. For dental x-ray and orthopantomograph units, it was assumed that 1 QE/QT would be able to monitor 40 facilities. For radioisotope laboratories, it was assumed that they have the same personnel needs as those of nuclear medicine units. For industrial applications it was assumed that 1 QE could handle 20 facilities of high radiological risk, and 1 QE could supervise 40 facilities of low radiological risk. Numbers of QT were adjusted taking into consideration the distribution of the number of equipment per installation.

Results from these estimates for continental Portugal are presented in table 5 and graphically in Fig 1.

Region	QE (Medical)	QT (Medical)	QE (Industry)	QT (Industry)
Alentejo	4	21	1	10
Algarve	5	29	1	7
LVT	49	287	12	74
Centro	13	80	3	22
Norte	40	250	7	58
Total	111	667	24	178

**Table 5.** *Estimated personnel needs for each administrative region*

Under the assumptions made, the numbers presented in table 5 provide an estimate on the number of qualified experts and technicians required in the country. The numbers should be considered round numbers since, on one hand, we are in presence of a dynamic situation, and on the other, there are already in the market many very qualified professionals whose qualification can be recognized through the equivalence scheme mentioned in the recently published legislation. This is particularly so for professionals working in the medical field. However, the training effort required to upgrade the present situation to an adequate level is still considerable, especially for industry applications of ionizing radiation.

#### **4. Conclusions**

We have outlined essential aspects of recently published legislation addressing ET in radiation protection, and made an estimate of the number of higher qualification professionals required in the country. Although the real numbers and the true impact of the present legislation can only be known and felt upon publication of complementary legislation defining the number of professionals per installation/equipment, and making mandatory that all installation should hire those professionals, a rough estimate of the training effort was made. Training providers should take good notice of what was published and launch training programmes in compliance with what is required for qualification. One final note to state that something that clearly is required is to strengthen the DGS team that is in charge of dealing with these matters.



# **BUILDING THE FUTURE - ATTRACTING A NEW GENERATION**



# MAINTAINING COMPETENCE IN RADIATION PROTECTION IN GERMANY

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## ABSTRACT

During the 1990s it became clear that the number of independent German university institutes conducting radiation research was declining. This development is still ongoing. Today there are only 3 chairs for radiation research in Germany.

In 2007 the German Commission on Radiological Protection called for a project to ensure the future of radiation research in Germany. The project was intended to maintain and rebuild competence, knowledge and expertise in research institutes, universities, postgraduate education and training.

A national programme based on cooperation between the Federal Ministry of Education and Research and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety was implemented in 2007.

In 2007 8 integrated projects were started, involving at least 40 partners. These projects were supported with 5 million euros per year. A second call for tender was published in 2008. 12 out of the 21 proposals submitted will be supported.

## 1 Introduction

In recent years the skills base in the field of radiation protection in German research institutes, universities and supervisory authorities has been lost to a large extent. This paper will describe ways and measures taken by the Federal Government to halt this process and build new capacities.

## 2 Need for competence assurance

In the 1950s and 60s the expansion of nuclear energy led to the creation of capacities in radiation protection and other areas, for example at large research institutes and universities.

### 2.1 Loss of competence in education and research

With the debate on the benefits and risks of ionising radiation the level of acceptance for its use became lower and radiation research was cut back. This development went along with a continuous decrease in the number of students in physics, chemistry, biology etc. It became even more pronounced when the decision was taken to phase out nuclear energy, as career opportunities in the fields of radiation biology, radiation protection technology and radioecology were considered to be very limited.

### 2.2 Loss of competence in administrations

Parallel to the reduction of capacities in research and training, jobs were cut in the Länder administrations responsible for radiation protection, reducing supervision by the state.

### 2.3 Position papers by the Commission on Radiological Protection

The German Commission on Radiological Protection (SSK) clearly highlighted this trend in a number of position papers and warned against a loss of expertise and the concomitant lack of integration into international research activities. In 2006, the SSK stated that "... there are only few institutions left in Germany that conduct radiation research on a large scale. The SSK holds the view that it would make sense to establish two or three centres of excellence as a basis for networks of which smaller units could join." [Recommendation of the SSK 01.03.2006, [www.ssk.de](http://www.ssk.de) ]

This does not refer to the safe operation of nuclear installations, but to other areas of application of ionising radiation.

One example is the field of medical applications of ionising radiation, where diagnostic examinations have increased in recent years and qualified staff is thus urgently needed.

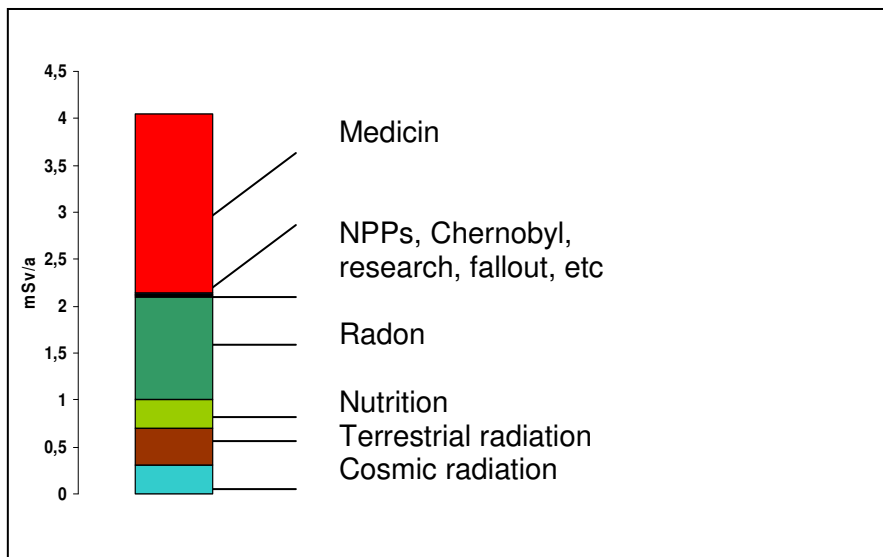


Figure 1: Share of medical radiation exposure in total radiation exposure of the general public [Data from the Federal Office for Radiation Protection]

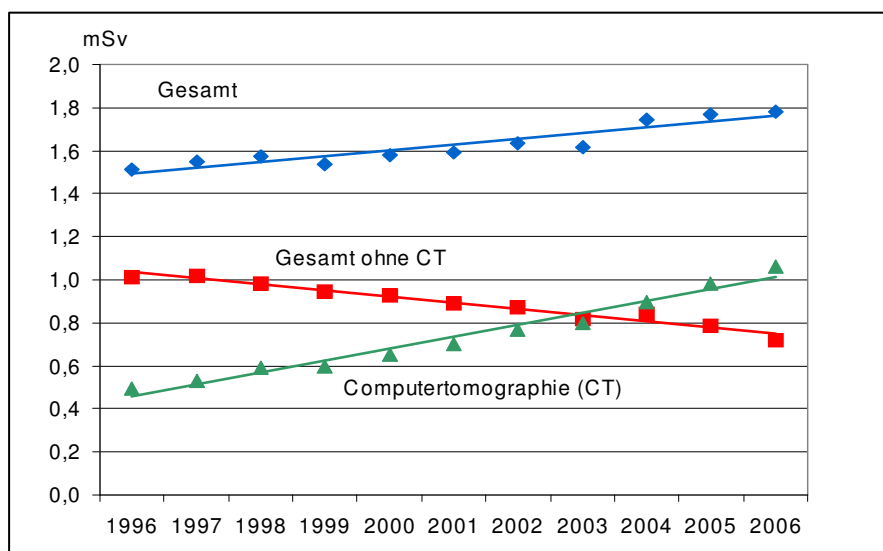


Figure 2: Development of the average effective dose in X-ray and CT examinations [Data from the Federal Office for Radiation Protection]

## 2.4 Latest scientific findings

In the past years international expert organisations have raised a range of questions in various recommendations and position papers, including on

- specific radiosensitivity of the eye lens
- dosimetry of the eye lens
- gender-specific radiosensitivity
- validity of the basic assumption that the relative radiation effect of small doses and dose rates is only half as big as for high dose ranges (cancer formation and genetic damage should be considered as well as radiation-induced cardiovascular diseases)
- specific radiosensitivity of the skin.

Further research efforts are required in these areas in particular, and findings should be incorporated in amendments to radiation protection legislation. An analysis of the situation revealed that this goal can only be reached through interdisciplinary research and cooperation between scientists, and by increasing the attractiveness of these subject areas for young scientists.

Only if the latest scientific findings are implemented can a high level of radiation protection be ensured in a qualified and effective way.

## 3 Competence assurance measures

The development described clearly shows that radiation research will remain necessary for Germany. The threat posed by the loss of competence has been recognised by the Federal Government and a national need for action has been defined. The necessity of promoting radiation research is undisputed. At the same time, capacities of the Länder authorities must be expanded.

### 3.1 Competence of the Federal Länder

It must be taken into account that in Germany, education falls within the sphere of competence of the Federal Länder. The Federal Government has only limited scope for intervention, for example by establishing university institutes and chairs. This is why the Federal Government has chosen to focus on strengthening state-owned large research institutes. For example, support will be provided for radiation research at the Helmholtz Zentrum (*German Research Center for Environmental Health*) in Munich.

At the same time, a research programme has been initiated that will be described in the following section.

### 3.2 National programme

As an important instrument for maintaining competence in radiation research, the Competence Alliance of Radiation Research was founded in 2007. On the basis of an initiative by the Federal Environment and Research Ministries (BMU and BMBF) a network was launched which unites researchers from institutes, universities (and sometimes industry) and facilitates the involvement of young scientists. The research programme covers biological, medical, epidemiological and ecological issues. Important topics are:

- radiation protection medicine
  - early diagnosis of radiation impacts, biological indicators
  - retrospective and prospective assessments of radiation exposure
  - optimisation of therapies for radiation damage
  - reduction of diagnostic uses of radiation in medicine
- medical radiation biology

- forecast methods for radiation-related diseases
- sensitivity of tumour and normal tissue
- gender-related and age-related radiosensitivity
- repair processes for radiation-induced cell damage
- effects of incorporated radionuclides
- radioecology, radiation and environment
  - transport of radionuclides in the environment
  - transport of radionuclides in food chains and biokinetic behaviour in humans

The Ministries support these research activities with approximately 5 million euros annually.

### **3.3 First results of the national programme**

The initiative has produced its first results. Eight integrated projects with a total of 40 partners were launched in 2007. The budget amounts to about 15 million Euros.

In 2008/2009, in the framework of a new funding period, a call for tender was published. The 21 project sketches submitted were evaluated and 12 projects were selected, which will start in the years to come.

The research results obtained so far by the eight integrated projects mentioned were presented in September in conjunction with the annual meeting of the Association for Biological Radiation Research. The focus was on the presentation of the results of the projects on individual radiosensitivity, research on tumour risks, further research on effect mechanisms in case of radiation exposure and on repair mechanisms in cells.

In this context support for international cooperation is indispensable. It is therefore important to strengthen and promote international cooperation in the respective research projects.

## **4 Lessons to share**

The results achieved in the integrated projects reflect a vivid interest in engaging in radiation research projects. The projects facilitated cooperation between strong and weaker partners and the increased integration of young scientists into research activities. This enthusiasm must be supported and strengthened further to make the results of the national programme accessible for the whole community.

# EUROPEAN MASTER PROGRAMMES IN RADIOECOLOGY, RADIATION PROTECTION AND ADVANCED RADIOCHEMISTRY TO MEET THE STAKEHOLDERS NEEDS FOR RECRUITMENT

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## ABSTRACT

A stakeholder needs assessment, carried out under the EU-EURAC and EU-ENEN II projects, clearly showed that, at the European level, there are a significant and constant need for post-graduates with skills in radiochemistry, radioecology, radiation dosimetry and environmental modelling and a smaller, but still important, demand for radiobiologists and bio-modellers. Most of these needs are from government organizations. If only the nuclear industry is considered, then the largest demand is for radiochemists and radiation protection dosimetrists. Given this spectrum of need and existing capacity in the areas of radiobiology it was concluded that the needs identified would be most efficiently met by three new degree programs:

- European MSc Radiation Protection
- European MSc Analytical Radiochemistry
- European MSc Radioecology

All three master programs would be developed using the framework provided by the Bologna Convention and the lecturing could be shared among specialist Scientists within a network of collaborating universities. Therefore, educational plans have been developed for the above MSc degrees. These plans envisage each degree comprising three modules that are common to all the degrees (3 x 10 ECTS credits), three specialist modules (3 x 10 ECTS credits) and a research project (1 x 60 ECTS credits). The courses should be aimed, not only to fill the identified European postgraduate education gap in radiological sciences, but also to provide a modular structure that is easily accessed by stakeholders for CPD training. It is anticipated that the European Masters will meet the academic training requirements of qualified experts", as defined by the European Commission and the IAEA. At the Norwegian University of Life Sciences (UMB) a pilot MSc in Radioecology has successfully been initiated in collaboration with UK and France.

## 1. Introduction

Postgraduate education is a matter of social concern in general, and within the nuclear field in particular. Thus, strengthening the competence within the nuclear field is consistent with the EU aim to produce an educated workforce that is able to meet the future economic and social needs of the developing EU. Radiological protection of man and environment has also become a matter of significant public concern. It follows that the establishment of public confidence in nuclear technologies will depend upon the availability of well-educated personnel and independent experts/ advisors within the fields of radiochemistry, radioecology and radiation protection. It is intended that the courses proposed in this paper will provide

appropriately educated professionals that meet the needs of European stakeholders within these fields.

In 2000 the OECD Nuclear Energy Agency produced a report: Nuclear Education and Training: Cause for Concern? This document was compiled using information supplied by 200 organizations in 16 member countries. The agency demonstrated that it was possible that many nations were training too few scientists to meet the needs of their current and future nuclear industries. In addition, a number of studies over the past five years, by different European governments, have also identified that too few scientists were being trained to meet the needs of their current and future nuclear industries. This has been attributed to decreased student interest, decreased course numbers, aging faculty members and aging facilities. Consequently, the European education skill base has become fragmented to a point where universities in most countries lack sufficient staff and equipment to provide education in all, but a few, nuclear areas. Of particular concern appeared to be special skill-base deficits within nuclear radiological protection, radioecology and radiochemistry at master and doctorate levels. Skills in these areas are required not only to deal with currently installed nuclear capacity and decommissioned facilities, but also to meet the needs presented by likely new-build nuclear capacity. As recently stated by several EU politicians and experts, there are increasing pressures to build new nuclear power stations in many EU member nations. This pressure comes from the need to meet Kyoto greenhouse gas emission targets at a time when many currently installed, CO<sub>2</sub>-clean, nuclear power stations are coming to the end of their useful lives. They also come from the decreasing stocks of domestic fossil fuels, with an increasing reliance upon politically unstable nations for the provision of oil and gas and from the increasing prices of domestic and imported fuels. Finally, the pressures are facilitated by new improved reactor systems that are being developed in Europe and USA. Therefore, the need for nuclear competence is greater now than earlier anticipated.

The EU 6<sup>th</sup> FP funded EURAC [1, 2] and the ENEN-II [3, 4] projects have aimed to assess the current and potential levels of postgraduate provision in selected linked disciplines associated with radiological protection and radioecological competence within universities and other higher education institutes within the EU and new entrant nations in the context of demand. Based on consultations with European stakeholders, EURAC recommended actions that could be taken by European Institutions and relevant organizations in Member States to secure the future of nuclear radiological protection, radiochemistry and radioecology postgraduate education in an expanded EU.

## **2. Results of surveys**

### **2.1 Existing Competence**

Studies of the status of relevant competence within Europe [5] and the future education needs within radiological protection, radioecology and radiochemistry – as identified by key stakeholders – were performed [6]. The results were collated in a database for identifying key institutions that possess the necessary competence, facilities and/or infrastructures to participate in coordinated, post-graduate, education systems, and were applied to set the standard for the scientific competence needed in future university-trained, post-graduate education at Master and PhD levels.

The survey findings indicated that the provision of postgraduate training at Master's level, specifically designed to meet the requirements of each of the above-mentioned fields was, with some important exceptions, diffuse and insufficient in most of the Member States of the EU. Nevertheless, it was evident that competence in these fields at training level is being eroded through natural wastage and is not being replaced at a rate adequate to satisfy expected future demand for these specialized skills. Finally, the survey evidences strong support for EU-wide Master's training programs in radiation protection and allied fields, as well as considerable willingness to participate in and/or host such a program/s.

It was, however, essential that diplomas obtained should be validated by higher education institutions and there was little support within the higher education sector for the excessive involvement of industry and government in the provision and designation of degree structures. Thus, a joint degree system should be developed between collaborating

academic institutions (universities) across Europe, rather than by a consortium of industry, government and private providers. However, these agencies can play an important role in the execution of post-graduate degrees by the provision of facilities for research projects. They must also play a key role in the specification of needs.

## 2.2 Future Needs

The survey of European Stakeholders [6] confirms that there is a significant current and future need for personnel trained to masters-level and beyond in the broad area of radiological protection. The questionnaire data suggested a need for some 30 technical advisors and 67 professional experts - qualified to at least masters-level - per annum. Given, that the survey did not reach / received no response from many potential employers it is reasonable to conclude that the need for appropriately qualified post-graduates per year probably exceeds 100. Moreover, it is likely that the responses given were based on the needs of the current industry and regulators etc. and take no account for possible growth in the nuclear power industry in the future.

With regard to curriculum content for postgraduate qualifications, radiochemistry including analytical techniques, radiation protection and dosimetry, and radioecology were most commonly identified as needs. However, modelling the environmental pathways, and radiobiology/modelling biokinetics, were also strongly indicated, particularly from the 'government' and 'research' stakeholders (Fig 1). In summary, the general outcome from the survey is that there is a significant latent and future need for personnel trained to masters-level and beyond within these fields of nuclear sciences. The questionnaire data implied that some 30 Technical Advisors and 67 Professional Experts qualified to at least masters-level

will be recruited per annum. Reports from the literature project indicate that even higher numbers will potentially be recruited. Moreover, to fill the caps of higher educated personnel, it appears that recruits will have to be obtained from universities and other higher education institutions and not only traditional engineering route.

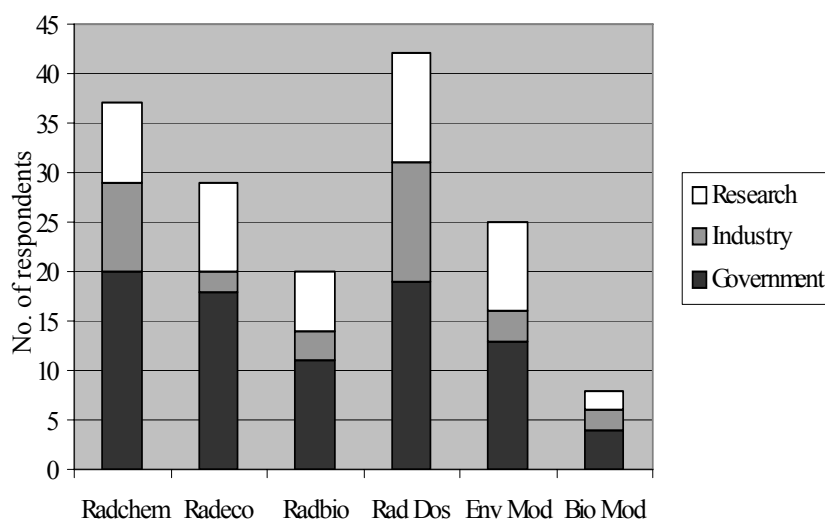


FIGURE 1 Stakeholder requirements.

## 3. Potential solutions

The outputs from "Existing competence and infrastructure" and "Future needs" surveys were used to guide the development of a European educational solution to meet the stakeholder needs. For example, only a few key institutions possess the necessary competence, facilities and/or infrastructures to participate in a coordinated post-graduate education system. It follows that it is not possible to recommend education solutions based on national post-graduate education systems/programs. Although such programs would be possible in some countries most do not have the capabilities and competence to provide post-graduate courses in the target specialist areas. Consequently, in order to meet the needs of EU members in relevant disciplines it will be necessary to specify either regional or pan-European solutions utilizing the identified academic competences.

The stakeholder needs assessment clearly showed that, at the European level, there is a significant and constant demand for post-graduates with skills in radiochemistry, radioecology, radiation dosimetry and environmental modelling and a smaller, but still

important, demand for radiobiologists and bio-modellers. Most of this demand is from government organizations. If only the nuclear industry is considered, then the largest demand is for radiochemists and radiation protection dosimetrists. Given this spectrum of need and existing capacity in the areas of radiobiology it was concluded that the needs identified would be most efficiently met by the development of three MSc degrees:

- European MSc Radiation Protection
- European MSc Analytical Radiochemistry
- European MSc Radioecology

All three masters programs will be developed according to the Bologna Convention (joint declaration of the European Ministers of Education, convened in Bologna on the 19th of June 1999[7], and then taught by specialist scientists from the network of collaborating universities. Plans have, therefore, been developed for the above degrees. These plans envisage each degree (Fig 2) comprising three modules that are common to all the degrees (3 x 10 ECTS credits), three specialist modules (3 x 10 ECTS credits) and a research project (1 x 60 ECTS credits).

Bologna agreement compliant course structures in advanced radiochemistry, radioecology and radiological protection have been developed for each degree.

### 3.1 European Masters, Common and Specialist Modules

The courses should be aimed, not only to fill the identified European postgraduate education gap in radiological sciences, but also to provide a modular structure that is easily accessed by stakeholders for CPD training. It is anticipated that the European Masters will meet the academic training requirements of “qualified experts”, as defined by the European Commission and the IAEA. Implementation of MSc Programs

At the Norwegian University of Life Sciences (UMB) a pilot MSc in Radioecology has successfully been initiated in collaboration with UK and France. An application to the Erasmus Mundus has been submitted to secure the future running of this master program, and to initiate the Msc in radiochemistry and the MSc in radiation protection. There is a need to finalize arrangements for the common modules, advertise for and recruit students for the entire degree program, and to coordinate the delivery of the common taught modules with the students and participating host higher education institutions. Feedback after the first run of the common modules will be utilized to adjust the modules utilized in their second run.

### 3.2 EU Master in Radioecology at Norwegian University of Life Sciences

The MSc in radioecology is built according to the suggestions of the EURAC project[8], with 3 common modules and 3 specialist modules (Fig 3) giving 10 ECTS credits each and a research project giving 60 ECTS credits plus a minimum 5 ECTS special syllabus (according to Bologna), giving the total of 125 ECTS. Four of the courses are held in Norway in collaboration with UK, Ireland, Spain etc., while two courses are held in France. The learning goals for the program are as follows:

- The students will be trained in radioecology and be able to conduct experimental radioecological studies. The students will have knowledge on

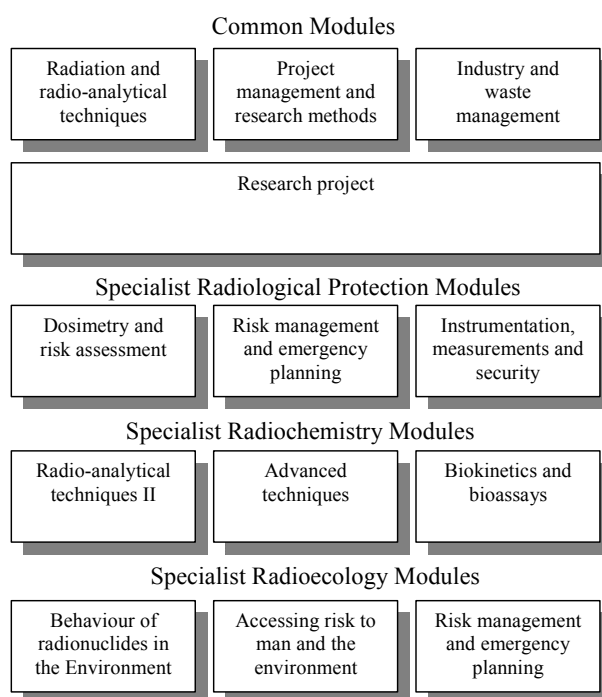


FIGURE 2. Outline of proposed module structure for European Masters degrees.



radioactive sources and understand the transport and spreading of radioactive substances in various ecosystems.

- They will understand the basis for assessing environmental impact and risks, and will be able to conduct radioecological studies using tracer techniques, radiochemical separation techniques and advanced measurement methods.
- The students will after the courses be able to assess environmental impact and risks from radioactive contamination and be able to evaluate alternative countermeasures and clean-up strategies, and thereby contribute to national preparedness associated with nuclear accidents and contamination of different ecosystems
- The courses will provide the students with working permission related to the use of open, ionizing radiation sources in their future work.

In a diverse learning process, the students will gain knowledge about radioecology; behavior of radionuclides in the environment, as well as impact and risk assessment based on radiochemistry and radiation protection, the nuclear industry and waste management, project management and research methods. The learning is based on intensive courses, laboratory work, group work, real-life case studies and thematic thesis with interdisciplinary approach, and through reflection on links between real-life situations and theory. To secure that the education is scientifically based, course modules will be presented by highly competent Norwegian and European teachers contributing with their special competence.

Evaluation of students will be based on a final exam (written) together with continuous evaluation in courses with practical field work and laboratory exercises (field reports, laboratory journals, etc.) or semester assignments. Grading will be given, including exam, semester thesis and laboratory journals etc. The special syllabus and the written Master's thesis will be evaluated, and a final grade will be given after an oral discussion.

Norwegian University of Life Sciences and collaborators have years of experience within radioecology, including fieldwork associated with national, bilateral and international projects. This gives the students opportunity to do research projects all over Europe with co-supervision from universities and stakeholders such as University College Dublin (Ireland), IRSN (France), Middlesex University (UK), University of Seville (Spain) etc.

#### 4. Conclusions

Previous EU funded project has clearly identified a significant need of future nuclear competence in Europe. The need of MSc in Radiochemistry, Radioecology and Radiation Protection has been well documented. For now, a pilot MSc course program in Radioecology has been funded by the EC commission, and is running at the Norwegian University of Life Science in collaboration with other European universities and research institutes. The course modules are held in Norway and in France, and students have the opportunities to do their research projects in collaboration with other partners with supervision from the best teachers in Europe.

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# ENETRAP II - WP10: ENTHUSING AND ATTRACTING YOUNG GENERATION WITH RADIATION PROTECTION

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## ABSTRACT

The paper aims at presenting an overview of the work in progress within ENETRAP II - WP10, regarding the best means of attracting young people to the field of radiation protection (RP).

The ENETRAP II - WP10 develops a coordinated approach on overcoming the shortage of RPE and RPO by attracting of young people to RP. WP10 deals, as well, with the development of mechanisms for The RP Action Plan implementation. The ENETRAP II approach is a stepwise process: surveying national initiatives for attracting young people in RP; analysing human resources shortage in RP; designing The RP Action Plan.

The results can be used by national regulatory authorities and education and training providers to improve their national RP training programme, in order to reverse the trend of young people turning away from science and RP. On the other hand, the results will be communicated to other networks: EUTERP, ENS, ENS-YG.

## 1. Introduction

### 1.1 The ENETRAP II project

The overall objective of ENETRAP II project is to develop European high-quality "reference standards" and good practices for education and training (E&T) in radiation protection (RP), specifically with respect to the RPE and the RPO [1]. In addition to these primary activities, consideration will be given to the best means of attracting young people to the field of radiation protection.

All the activities regarding the attracting young people to the field of radiation protection are carried out in the WP 10, named: Collaboration for building new innovative generations of specialists in radiation protection.

### 1.2 European approach on nuclear education & training and mutual recognition of professional qualifications

The conclusions of EU Council on the «need for skills in the nuclear field» (5 December 2008) emphasized two aspects [2]:

- it is essential to maintain a high level of training in the nuclear field in the European Union;
- training availability and teaching skills based on dynamic R&D are necessary in all subject areas: the design and building of installations, radiation protection, radioactive waste and materials management, operation of installations and decommissioning.

Within EURATOM Framework Programmes a EURATOM policy for Education and Training (E&T) was developed.

### **1.3 ENETRAP II-WP 10: approach in the attracting of young people to RP**

The «need for skills in the nuclear field» is a knowledge management problem. The general objective of nuclear, and in particular RP, knowledge management is twofold: attract and train a new generation of nuclear experts and maintain an adequate skills base keeping the nuclear option open.

Today's challenge in the field of RP involves measures to make the work in radiation protection more attractive for young people and to provide attractive career opportunities, and to support the young students and professionals in their need to gain and maintain high level radiation protection knowledge.

The ENETRAP II strategy in the attracting of young people to the application fields of ionising radiation and radiation protection, based on EURATOM policy for E&T, and is a stepwise process:

- surveying national and international initiatives for attracting young people to develop an interest in radiation protection;
- analysing human resources (HR) shortage in RP and defining suitable measures for addressing the HR shortage in RP;
- designing The Radiation Protection Action Plan for providing continuous professional development for science teachers;
- defining mechanisms for The RP Action Plan implementation in EU.

This paper is focused on first two steps of the ENETRAP II-WP 10 strategy.

## **2. ENETRAP II-WP 10: Results and discussions**

### **2.1 Surveying national initiatives for attracting young people in RP**

ENETRAP II aims at attracting young people to the application fields of ionising radiation and radiation protection.

In this respect the first step would be to bring together national and international initiatives on attracting young people to develop an interest in radiation protection. In the first year an inventory takes place towards existing initiatives on attracting young people in the countries of the WP 10 partners. The more successful initiatives are worked out in the second year in more detail, in order to find a suitable practice that can be used all over EU.

In the Table 1 is synthesized the experience of several ENETRAP II partners on attracting, recruiting and educating young people as experts, technicians and skilled staff in the radiation protection field: from school to university in different sectors (industry, medicine and research).

### **2.2 Analysing human resources shortage in RP**

#### **2.2.1 Shortage in RP**

The RP sector faces an acute shortage of RPE and RPO who devoted their knowledge and experience to build up a high level of radiation safety and security in all radiation applications in industry, medicine, and research in Europe. In order to maintain this high level and to further develop a European safety culture, it is necessary to attract more young people by awaking their interest in radiation applications and radiation protection already during their schooldays and later on during their out-of-school education (university or vocational education and training) [3].

Country	Initiative's name	Targeted groups	Result indices
<b>Germany-FZK</b>	Girls Day	girls in the age of 9 to 14	-
	Kinder Universität	children of the age 10 to 14 years	-
	Seminare für Schüler und Lehrer	pupils of grammar-schools	-
	Jugend forscht	pupils college (16 to 18 years)	-
	Forschungsschiff		
<b>The Netherlands - NRG</b>	Dutch Young Generation/DYG	Young people working in the nuclear industry	Developing a network of people working in RP
	NRG education in high school	High Schools students	More knowledge about ionizing radiation
	ISP Universiteit Utrecht	Secondary Schools students	More knowledge about ionizing radiation
<b>Romania-SNN</b>	"What does Nuclear energy mean?" -"Gh. Ene" painting contest	Primary Schools students	Attracting Primary Schools students to nuclear sciences and RP
	Supporting high school students to choose STEM/ RP career	High Schools students	Helping High Schools students to choose STEM/ RP career

**Tab 1: Several national initiatives on attracting young people in RP**

#### **a) Where will the future RPE & RPO come from?**

The human resources (HR) reservoir of RP sector encompasses graduates from high schools and universities with Science-Technology-Engineering and Mathematics [STEM] profile. According to different national legislation, they follow different ways towards RPE and RPO.

Surveys on the HR reservoir of RP sector emphasize some specific trends [4]:

- drop in Science Technology Engineering and Mathematics [STEM] students, as well in high school & university graduates;
- number of Science Technology Engineering and Mathematics [STEM] graduates remaining static;
- fewer than half of STEM graduates take up jobs as scientists & engineers;
- concerns identified over the long-term pipeline of young talent going from schools onto university STEM courses and subsequently into RP field.

Before defining some measures to address the problem, we need to understand how STEM students and graduates are choosing to study Science-Technology-Engineering and Mathematics [STEM].

#### **b) Choosing to study STEM**

In the Table 2 is illustrated the result of a survey [5], among 55.500 students studying Physics, and 49.000 students studying Chemistry, that emphasize how the students think on choosing to study STEM.

The figures from the Table 2 allow us to draw the following conclusions:

- science less likely than Maths and English to be seen as necessary for a good job;
- students lack understanding about STEM careers. Large majority see science & engineering in terms of working with machinery;
- 80% of students at ages 13 - 14 already have an interest in working in a specific area and consider option choices appropriate for that area.

Question	Answer [%]	
	Y	N
Are STEM necessary for a good job?	40	60
STEM encompass mainly fundamental or practical knowledge	35/ fundamental	65/ practical
At the ages 13 – 14 did you choose the high school profile?	82	18

**Tab 2: How the students think on choosing to study STEM**

### 2.2.2 Addressing the issue and defining suitable measures

Capitalizing the surveys' conclusions from above, in order to reverse the trend of young people turning away from science, ENETRAP II-WP10 could define several directions of action:

- it is necessary to act at the ages 13 - 14 students level/secondary school;
- in order to influence the age 13 - 14 students, we have to **influence the influencers**, first. That means we need more specialist STEM teachers by providing them continuous professional development for science teachers [6].

Addressing the shortage in RP is a long term process and implies two types of measures: medium and long term.

#### a) WP 10 to address shortage –medium term?

More young people would be inspired to take an interest in radiation research and prepared to take leadership positions at universities and radiation applications in industry, medicine and research in Europe.

The measures that should be taken for medium term regards communication improvement. The science, engineering, technology, and RP sectors face a huge challenge to communicate to young people the excitement and opportunities it can offer them.

ENETRAP II-WP10 specific actions for communication improvement are:

- bringing together national initiatives on attracting young people to develop an interest in radiation protection;
- using nonformal education for attracting young people to RP career; nonformal education could be delivered by providing more information on RP through the INTERNET(virtual space)/ENETRAP II web site;
- developing RP Window section within ENETRAP II project website;
- closer collaboration between employers (non-nuclear industry, medicine, research and nuclear power generation) and E&T organizations (including universities) to build and enthuse innovative STEM/RP generations;
- Increase STEM graduate intake in nuclear and RP fields;

#### b) WP 10 to address shortage-long term?

Addressing the HR shortage-long term in RP means the upgrading of the content of science/STEM teaching in EU secondary and high schools. It would be achieved by influencing the influencers, and providing continuous professional development for science/STEM teachers. Building and enthusing innovative STEM/RP generations are processes that occur at different two levels:

- **secondary school** - inspiring young people to become the scientist, engineers, and RP workers of the future; Science/STEM is endlessly fascinating and opens new windows on the world. Science lessons should be full of amazing experiences and intriguing ideas to inspire a new generation of young scientists;
- **high schools** - bringing practical science, technology and RP into the classroom; have a key role to play in encouraging young people to consider a career in the STEM/RP sector.

The specific tool for providing continuous professional development for science/STEM teachers would be the new RP professional development programme (RP-PDP). Through the RP-PDP scheme, science/STEM teachers across the EU will have access to state-of-the-art

training facilities at the National and EU level. This RP-PDP scheme will help keep teachers up to date with the latest technological innovations and give access to ideas for encouraging children to engage with science, and pursue careers in science and technology.

It is taking a proactive approach to inspiring budding scientists, and is engaged with teachers and pupils to provide first-hand experience of the vital role that science plays in the real life.

### 3. CONCLUSIONS

ENETRAP II is concerned about attracting young people to the field of radiation protection, and WP10 of the project is dedicated to build new innovative generations of specialists in radiation protection.

In order to reverse the trend of young people turning away from science, ENETRAP II suggests the following measures:

- it is necessary to act at the ages 13 - 14 students of secondary school;
- in order to influence the age 13 - 14 students, we have to influence the influencers, first. That means EU needs more specialist STEM teachers by providing them continuous professional development for science teachers.

Addressing the shortage –medium term, the ENETRAP II specific actions for communication improvement are:

- bringing together national and international initiatives on attracting young people to develop an interest in radiation protection;
- using nonformal education for attracting young people to RP career; nonformal education could be delivered by providing more information on RP through the INTERNET(virtual space);

WP 10 further developments regard the addressing the shortage–long term. It implies to influence the influencers, and providing continuous professional development for science/STEM teachers. In meeting the stated need to keep the high level skills in STEM/RP, the professional development of European lecturers in secondary and high schools must be given a high level of priority and importance.

The proposal RP-PDP shows that if we are to meet the standard and quality that is required in STEM/RP E&T, the lecturers from secondary and high schools must engage in a structured programme of professional development.

The proposed RP-PDP scheme implementation will need some legislation modification at EU and national level.

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# THE EUROPEAN MASTER'S DEGREE IN RADIATION PROTECTION "EMRP": AN ENETRAP RESULT

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## ABSTRACT

In the framework of ENETRAP project, a consortium of four universities has been established in order to set up the European Master's degree in Radiation Protection (EMRP). These four partner institutions are cooperating on developing a European Master's programme in RP based on the ENETRAP syllabus recommendations for the Radiation Protection Expert.

The EMRP is being developed in response to the increasing demand for and the decreasing supply of RPE in Europe. It will help to overcome skills shortages by facilitating the mobility of graduates.

EMRP defines the 2nd year of a Master's programme and will address the needs of all types of actors.

One year after the implementation of the EMRP pilot session, the relevant findings are: success of the European week; establishment of an approved syllabus; necessity to enlarge consortium; need to improve EMRP attractiveness and students' participation; requirements of financial resources.

### 1. Introduction

In this current context of nuclear renaissance, it has been observed in one hand the increasing demand of radiation protection specialists and in another hand the decreasing number of these RP specialist available in Europe. E&T is an essential aspect to reinforce the RP expertise and to enhance a radiation protection culture in Members States. Education & Training can help local skill shortages by facilitating the mobility of graduates through mutual recognition of their qualifications.

This paper describes a European academic strategy in RP achieved by a consortium of four universities and called European Master's degree in Radiation Protection "EMRP" established in the framework of SOCRATES/ERASMUS Programme<sup>1</sup> and following the WP8 ENETRAP outcomes.

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In September 2008, the EMRP, for the French part, started following the former French Master's degree running since 14 years. More than 210 students and Life-Long Learners have been trained through this curriculum.

This MSc level in RP of the four collaborating institutions, (the Joseph Fourier University in Grenoble (UJF), the North Highland College (UHI) in Thurso, the Czech Technical University in Prague (CTU) and the CEA National Institute for Nuclear Sciences and Technology in Grenoble (INSTN)), is intended to harness and coordinate European expertise in the field of radiation protection, in order to develop a high level Master's education programme, as called for in the Bologna declaration.

This Master's level in RP will ensure the future supply of appropriately educated and skilled personnel for institutions employing ionizing radiations across Europe.

Finally, this new Master's programme will enable graduates to achieve the status of Qualified Expert (QE) - Radiation Protection Expert (RPE) as defined initially in 1959 Directive [1] and lately in the 96/29 European directive [2, 3].

## 2. Consortium of universities

The project is being carried out by four initial partners. However, when the whole programme has been prepared and tested, it will be opened up for all higher educational institutions that accept the EMRP educational system and fulfil the necessary quality conditions. The programme will also need to pass through the national assessment or accreditation procedures valid in the countries of the initial partners and in the country of any institution that joins later. The initial partners are:

- **Joseph Fourier University (UJF)** is a rather large scientific university hosting over 17,000 students. It is established in Grenoble in the Rhône-Alpes Region of France. It has a long tradition of student mobility through various international programmes, including SOCRATES/ERASMUS. UJF is also associated with some of the most important research centres in physical sciences in Europe (ESRF, CEA/Minatoc, LPSC, ILL, and others).
- **Institut National des Sciences et Technique Nucléaires (INSTN)**, (approximately 700 students and 7,000 professionals trained) is a higher education institution located within CEA, the French nuclear research organization. It provides education and training in radiation protection at all levels to French and foreign students and professionals: for example, it is involved in the education and training of nuclear physicists and medical physicists. It collaborated with the UJF in the former Master's degree programme in Radiation Protection for more than 10 years. Its teachers are experts, coming from the CEA, from the universities, from companies involved in the relevant sectors, and from public authorities.
- **The Czech Technical University in Prague (CTU)** (approx. 24,000 students, 1,500 academic staff) is the oldest (established 1707) and largest technical university in the country. It has very extensive international contacts, including SOCRATES exchanges. The Faculty of Nuclear Sciences and Physical Engineering, which will carry out the work on the project, was founded in 1955, at the beginning of the Czechoslovak nuclear programme. During its history, the Faculty has extended its programmes to some non-nuclear branches of the exact sciences. Nowadays, about one third of its work is oriented to nuclear branches, one third to other branches of physics and applied physics, and one third to applied mathematics.  
The nuclear studies are divided into five basic specialisations amongst which the programmes in dosimetry and application of ionizing radiation, and to some extent the programmes in radiological physics, are especially very closely related to radiation protection and to the EMRP project.
- **The North Highland College UHI (NHC)**, (approx. 8,000 students), is a partner college within the University of the Highlands and Islands (UHI). The College is made up of 4 main centres, the largest of which is situated near by Dounreay Site Restoration Ltd. It was established to deliver science, engineering and management training and education for the nuclear site in 1956, and in recent years this has included both first degree and postgraduate courses and research in science and engineering. An Environmental Research Institute was established in 1999, which hosts both Master's and doctoral



students. The College has been involved with European projects, Socrates, Leonardo, ESF, ERDF, etc. In particular, NHC has been developing a European Master's in Nuclear Technology, Decommissioning, Waste Management and Non Power Applications with other partners, including UJF and INSTN.

### **3. Tasks and realisations**

Works done since the starting of the project have succeeded to:

- Establish course structure (core curriculum / specific modules), taking into account areas of excellence and the wishes of each partner, elaboration of the course programme and a detailed definition of the course units (type of course, level, ECTS considerations, lecturers, objectives, prerequisites, content, teaching methods, assessment, language).
- Implement the first session, evaluate it, publish and disseminate the EMRP project.
- Organization of the European week in Praha (January 2009).

The main steps remaining to achieve the development of the EMRP are as follows:

- Resolving administrative constraints and studying possibilities concerning the qualification awarded, and the different regulations in the participating countries relative to admission, examination, tuition fees etc.
- Refine definition of EMRP general regulation (admission requirements, educational/professional goals, final test, examinations and assessment, ECTS distribution), administrative cooperation between partners.
- Discussion about possibilities concerning the training period country, definition of training regulation, mobility, and preparation of e-learning materials.

### **4. A harmonised programme**

Students applied for the EMRP already have acquired a total of 240 ECTS from the 3-year bachelor and the first year of master programme (or a 4-year bachelor programme), majoring in a scientific or engineering discipline.

The first semester of the EMRP programme, for a total of 30 ECTS and corresponding to approx. 550 teaching hours, consists in an intensive course of theoretical lectures, practical works and technical visits to relevant sites performed by 75 professors and lecturers (in France).

This first part of the academic year covers both the core curriculum and specific modules.

This core curriculum is taught with similar content by all partners, and is prepared both in national languages (French, Czech) and in English.

Specific modules adopted by each partner are prepared and delivered locally or during the programme of students stays exchange; therefore all lectures in these specific modules should be taught in English.

The second semester is a full-time training period within an external institution or industry, which internship's proposition has been evaluated by the Steering Committee. This On the Job Training period is regarded as crucial, as it focus the student's experience on a specific professional activity and corresponds to 30 ECTS.

This modular approach allows Life-Long Learners to be taught on entire or part of this syllabus. 45 LLLs have participated since 1995 in the former French Master's degree.

The European Master's degree in Radiation Protection (EMRP) only corresponds to the 2<sup>nd</sup> year of a Master's degree specifically to address the needs for radiation protection specialists in order to protect workers and population in several various domains as:

- industrial applications of ionizing radiations (energy and non-energy sectors),
- public and environmental radiation protection,
- nuclear power plant operation, dismantling and decommissioning,
- management of nuclear waste,
- research in laboratories and universities,
- medical applications (both diagnosis and therapy) where ionizing radiations and radioactive isotopes are used.

This one year Academic programme could be sum up as follow:

SEMESTER 1						
CORE CURRICULUM			ECTS		ECTS	
CORE CURRICULUM	1	Principles of nuclear and radiation Physics	3	7	Nuclear installation	3
	2	Detection and measurement methods and dosimetry	4	8	General Industry	2
	3	Biological effect of radiation and Epidemiology	2	9	Medical applications	3
	4	Legal and regulatory basis	2	10	Decommissioning and waste management	3
	5	Occupational radiation protection	3	11	Non Ionising Radiation	1
	6	Public and environment Radiation Protection	2	12	NORM	1
				13	European Week	1
				14	technical Visits (included)	
				-	Internal Exposure: ENETRAP- EURADOS Module (elective supplementary module)	
SEMESTER 2						
Internship period (~6 monts, 30 ECTS)						

Figure 1: EMRP syllabus

Graduates have a thorough theoretical knowledge of nuclear and radiation physics and its applications in radiation protection. They also know the legal and regulatory basis at national and European level and have a practical training period of 6 months.

## 5. Mobility and the European week

Student mobility programmes will be organized taking into account the personal project preferences of each student. Emphasis will be placed on personal professional development, and on ensuring that the objectives of the European dimension are achieved. The hosting institution will be responsible for student assessment during an exchange period. The partners have defined both the minimum time period to be spent and the number of ECTS credits to be earned at a foreign partner institution in order to achieve the Joint Diploma.

To promote exchanges between the different countries, an introductory seminar, the European week, is organized in a different location each year. In the European week, all EMRP students from the different partner institutions are registered together, have introductory lectures taught partially by external specialists, and participate in field trips to nuclear institutions in the country where the week is carried out. The first "trial week" was carried out in January 2009 in Praha, with the participation of French and Czech students and with lecturers from all four institutions and European Commission lecturer. A case-study has been elaborated and proposed for all students who worked on it in mixed groups sharing their knowledge. It showed that such collaboration is well-received by all participants and that the level of the students entering collaborative project is compatible. For students and for teachers, the EMRP organizes mobilities so that the convergence of content and practice can be adequately assessed, and the European dimension can be consolidated.

## 6. EMRP organization

Since the EMRP has to cope with the challenge of distance, multiple languages, multiple local regulations, vocational training and high level initial training, innovative teaching and learning approaches have been established, taking into account the following aspects:

- EMRP languages: local languages for each partner institution are used in addition to English, *i.e.* the core curriculum is taught mostly in the national languages, while the specific modules are taught in English,
- face-to-face lectures and seminars,

- online course materials with shared discussion boards for student-student and student-tutor interaction hosted by the EMRP web site (www.emrp.info restricted access),
- webcasting and video web conferences, lectures and seminars,
- field trips, e.g., to NPPs, nuclear industries and laboratories, control institutions, nuclear waste, recycling plants and repositories, radiology, radiotherapy and nuclear medicine departments,
- conferences, which will ensure mobility of both staff and students,
- case studies presented face-to-face, by video-conferencing and online,
- practical workshops, where appropriate, delivered in a workplace setting to ensure realism,
- practical training in working situations, taking into account mobility,
- a personal path for vocational training, including a mobility project,
- European week joint seminar, an opportunity for mobility and exchange between students,
- a personal report provided at the end of the training period by each student for expert assessment, and a public presentation and defence in the final examination before the award of the degree.

The above examples illustrate that whilst a common structure has been developed for the Master's programme, the delivery mode is adjusted to suit both full time new entrants and those already working in this professional field as Life-Long Learner.

Each partner institution uses its own assessment procedure, which is based on the national legislation, university rules and traditions, and is recognized by the other partners. For the assessment of the training period in each participating institution, a panel of university staff, industry managers along with officers from radiation protection institutions and control agencies, evaluate the work done by the student and verify that he/she has acquired the competences and skills required. This panel is composed of 17 members (in France).

## 7. Conclusion

Important steps of the EMRP project have been accomplished; the common programme framework has been established and is now approved by the four partners. Some issues are still in discussion such as modalities of delivering the joint diploma and structuring students and lecturers exchange for respectively, internship period and delivering courses.

Otherwise, more training materials overcome to enhance the proposed programme.

These relevant needs require further financial means to respond to the high level of education ensured by the consortium and fulfilling the objective to provide experts with recognized skills in all radiation protection fields. Nevertheless, it is necessary to reinforce the attractiveness of the radiation protection field for young generation of students because the creation of new "nuclear related master's degree" is increasing.

As the collaboration was a successful project and while the demand of radiation protection specialist is increasing, the consortium will pursue proposing this master's degree and will enlarge the partnership through integration of other European institutions, universities and networks (ENEN, EAN...) which want to participate to the EMRP.

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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 surveillance of the activity concentration of the Rn-222- and Rn-220 daughter 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](http://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 on 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 supplementary 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 ISO 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**

<b>Standard Training Programmes</b>	<b>Schedule (No. of hours)</b>
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 Bologna'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<sup>2</sup>, (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)

1 <sup>st</sup> 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

2 <sup>nd</sup> 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

<sup>2</sup> 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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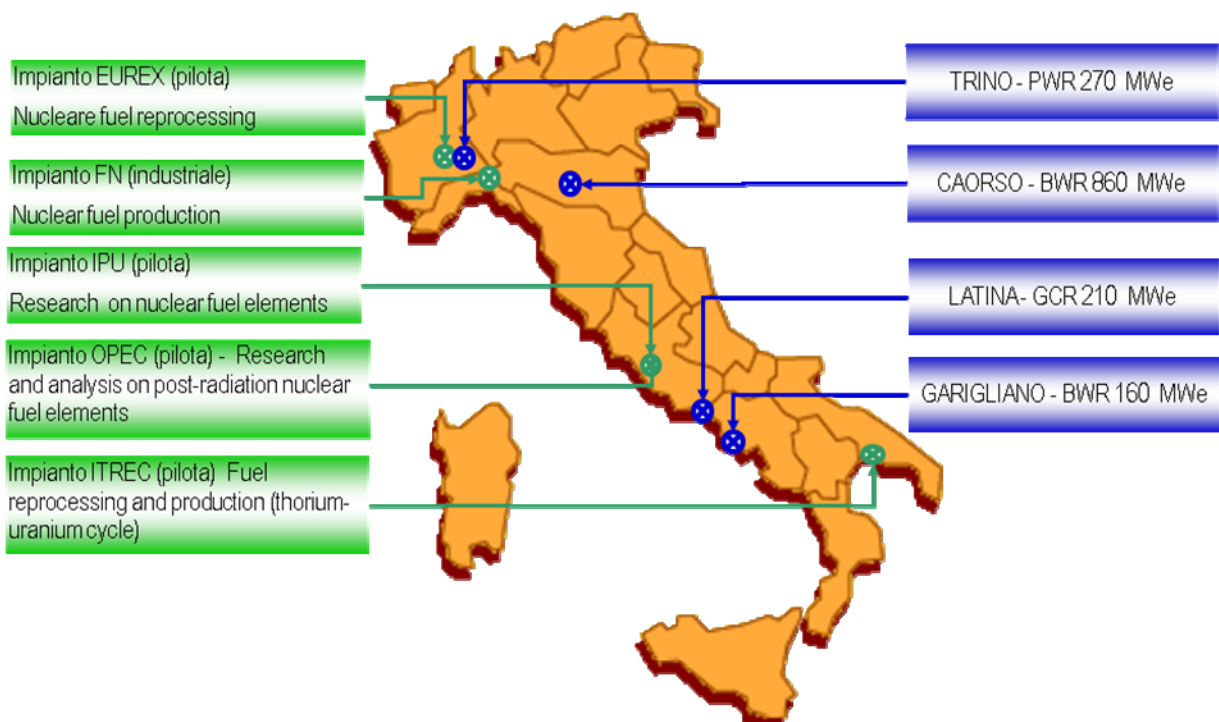
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### ABSTRACT

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 – 1<sup>st</sup> half of 2009, forecast 2009

		Activities balance 2008	Activities balance 1 <sup>st</sup> 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.

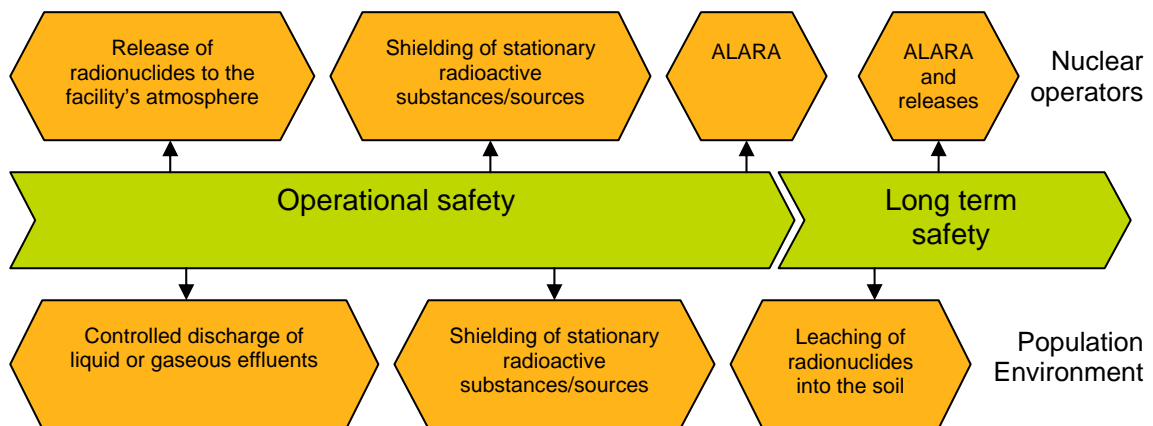


Figure 1 – Processes that occur due to nuclear activities



## 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 UO<sub>2</sub>. 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 use 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 differ 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.

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- 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 implantation. In fact, the answers given to the acceptance 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 13<sup>th</sup> 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 seminars 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 acceptance survey were very good too 87,5%.

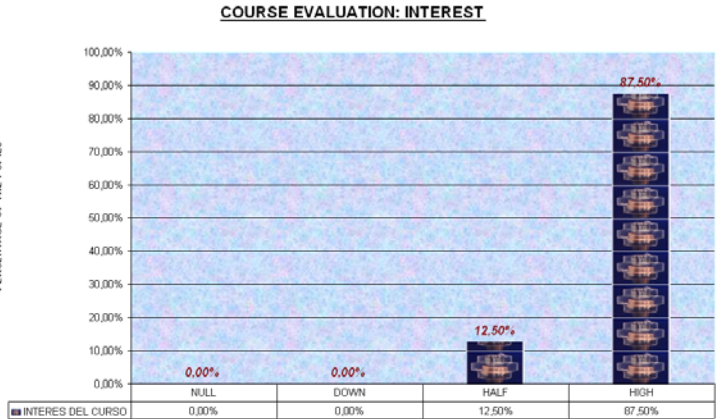


Fig. 3 Results of the course evaluation

**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.

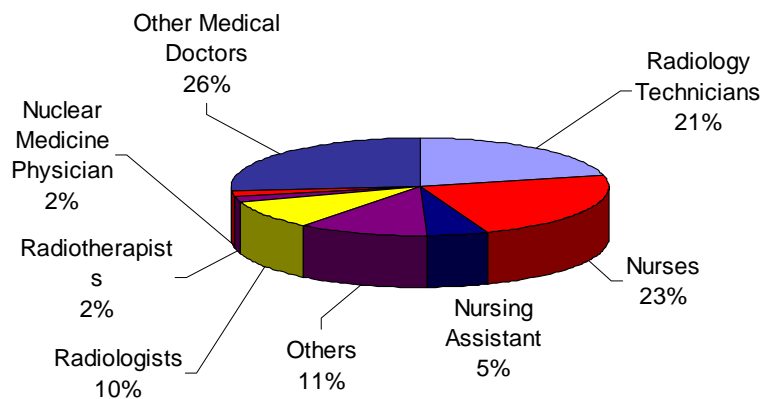


Fig 1. Professional distribution of ionising radiation exposed workers in health care sectors in the Tuscany region, Italy.

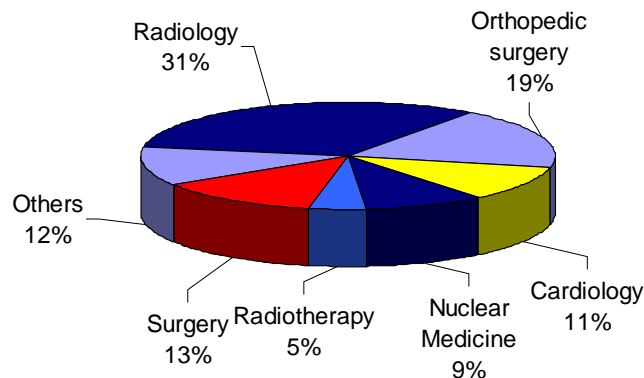


Fig 2. Exposed workers distribution between health care activities in the Tuscany region.

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, Brachithrapy) 8.2. Hazard Assessment (External Beam Radiotherapy, Brachithrapy) 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.





**Dosimetri personali**

L'estensione della problematica della sorveglianza dosimetrica a tutti i lavoratori esposti ha reso necessario lo sviluppo di strumenti per la misura della dose che siano semplici, di ridotte dimensioni e affidabili: i dosimetri personali (1, 2).

Il dosimetro personale, che viene indossato dal lavoratore per un determinato periodo di tempo, è in grado di fornire un valore ("lettura") del livello di irraggiamento del dosimetro stesso che, a seguito di opportune tarature e ottimizzazione dell'esposizione stessa, il dato dosimetrico ottenuto è direttamente correlato a quello che il lavoratore indossa più di un dosimetro (3).

**Dose efficace**

Il dosimetro rientra nella categoria dei DPI ma non è una grandezza radioprotezionistica, definita dalla ICRP (4) quanto detto essa quantifica l'esposizione per un determinato periodo di tempo, in grado di fornire un valore ("lettura") del livello di irraggiamento del dosimetro stesso che, a seguito di opportune tarature e ottimizzazione dell'esposizione stessa, il dato dosimetrico ottenuto è direttamente correlato a quello che il lavoratore indossa più di un dosimetro (3).

**Dose efficace**

La dose efficace è una grandezza radioprotezionistica, definita dalla ICRP (4) e rappresenta la dose equivalente ai diversi organi e tessuti dell'organismo secondo fattori di ponderazione che tengono conto della diversa radiosensibilità degli organi. L'unità di misura della dose efficace è il Sievert (Sv).

**Test di autovalutazione**

**1. La dose assorbita D:**

- Misura la quantità di energia nell'unità di massa rilasciata dalla radiazione
- Quantifica il danno che una radiazione produce in un tessuto
- E' sinonimo di "intensità di campo radiante"

**2. Valori tipici di dosi efficaci medie assorbita da un individuo dovuti alle fonti di irradiazioni naturali sono (ordine di grandezza):**

- Qualche Sv/anno
- Qualche mSv/anno
- Qualche mSv/giorno

**3. A parità di dose assorbita:**

- Tutte le radiazioni producono lo stesso effetto biologico
- Alcune radiazioni producono un danno maggiore di altre
- Nessuna delle precedenti affermazioni è vera

**4. A parità di dose equivalente in un determinato tessuto:**

- Tutte le radiazioni producono lo stesso effetto biologico
- Alcune radiazioni producono un danno maggiore di altre
- Tutti i tessuti subiscono lo stesso danno.

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<sup>1</sup>. These equipment could be grouped, from the point of view of radiological safety, in 3 items: (i) the

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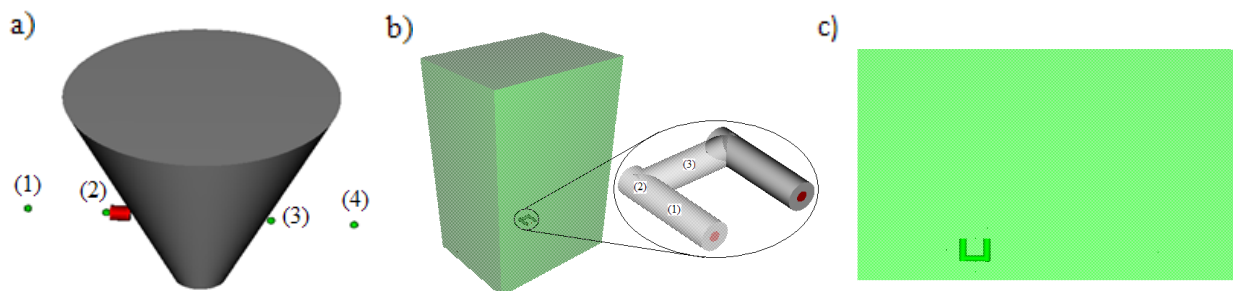
<sup>1</sup> Data provided by the Directorate General of Health (DGS).

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  $^{60}\text{Co}$  source ( $2.05 \times 10^9$  Bq), and one irradiation device used in gammagraphy, with a  $^{192}\text{Ir}$  source ( $1.51 \times 10^{12}$  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 been 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 ( $\Phi/K$ ) was used. For the gammagraphy analysis coefficients flux to  $H^*(10)$  were used ( $\Phi/H^*(10)$ ). 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).

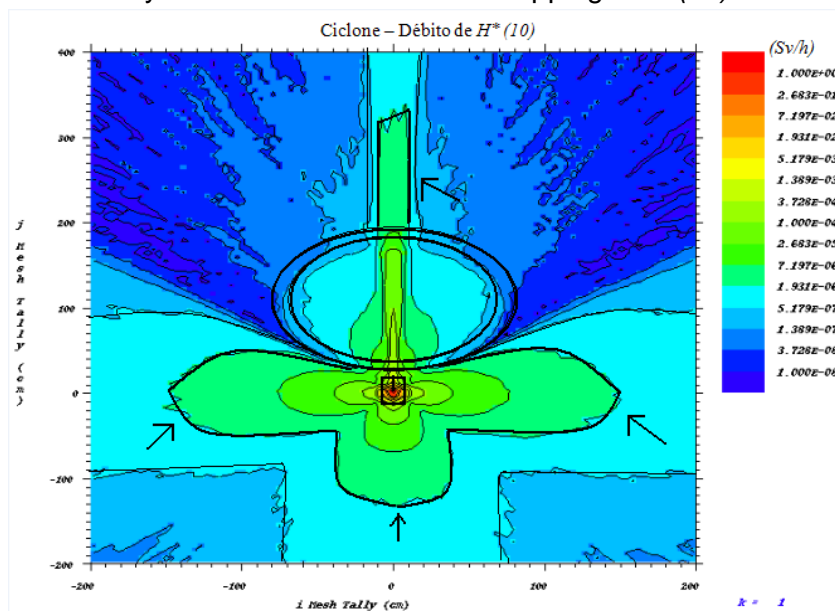
## Results and discussion

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 ( $\mu\text{Gy/h}$ )	MCNP ( $\mu\text{Gy/h}$ )
1	$3.0 \pm 0,2$	3
2	$125.0 \pm 8,8$	129
3	$3.0 \pm 0,2$	3
4	$1.0 \pm 0,1$	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.

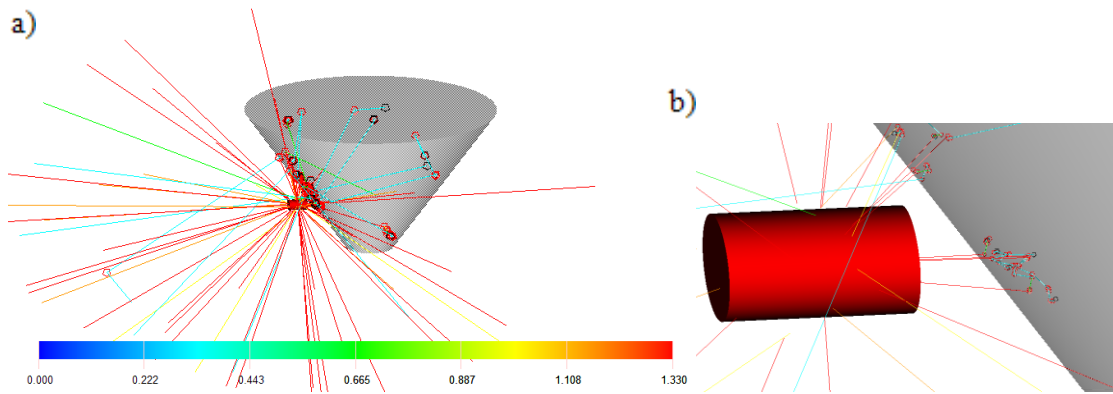


**Fig 2** – Dose mapping around the level gauge

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  $\mu\text{Sv/h}$  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.

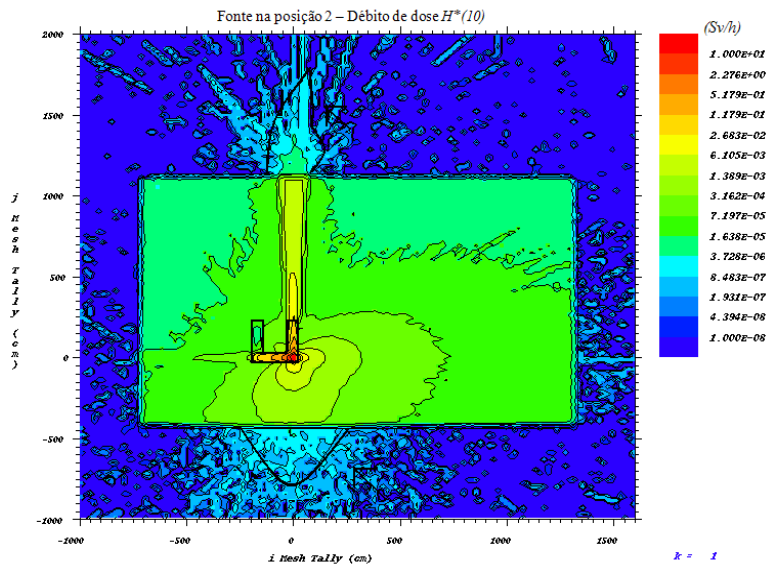
Thanks to Sabrina it is possible to obtain images where the particles tracks are actually visible, as well as their energies and different interactions with matter [2]. An image of the particles tracks for the level gauge mentioned so far is illustrated in Figure 3. The energies mentioned are in MeV.



**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  $^{60}\text{Co}$  [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.

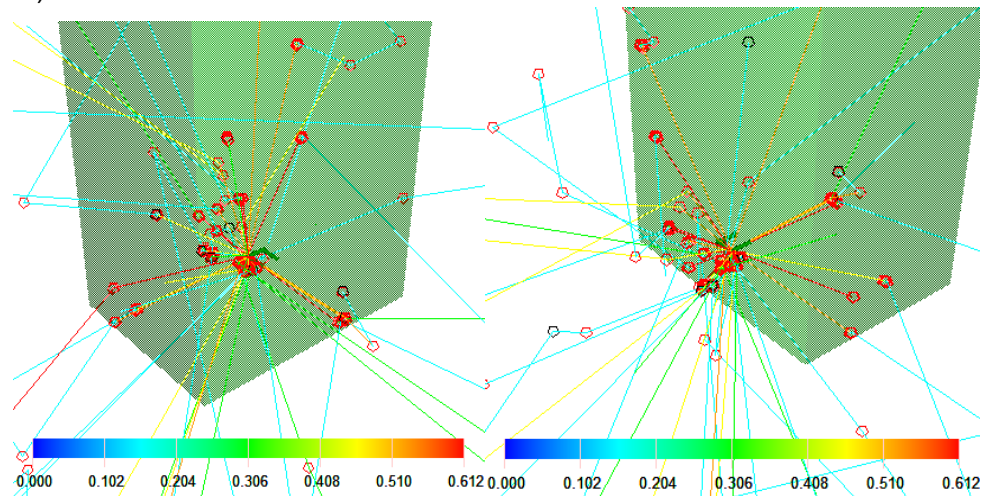
The second studied case is one application of the gammagraphy technique. The  $^{192}\text{Ir}$  source was considered in three different positions. In this contribution results corresponding position 2 (see Fig. 1b) is shown. The corresponding dose mapping is shown in Figure 4.



**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  $\mu\text{Sv/h}$ ). 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.

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# 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.

<b>Name</b>	<b>Description</b>
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)

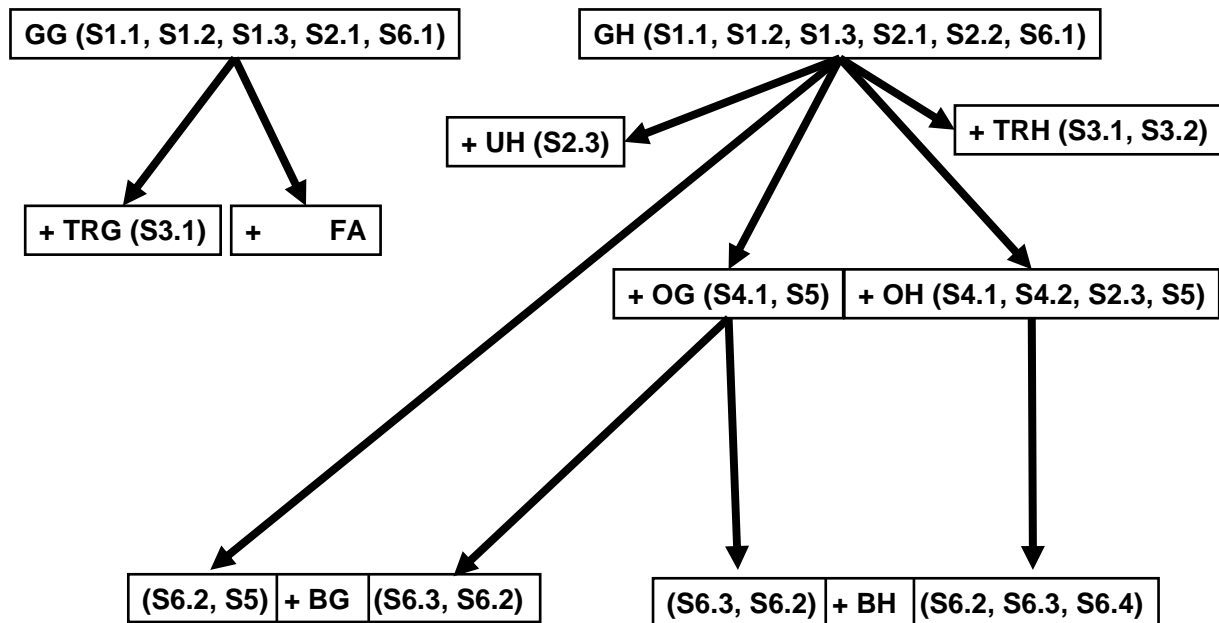


Figure 1: Modular structure of radiation protection courses. This structure allows combining different modules to obtain a required qualification.

#### 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 where 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 where 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 their 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 or 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 than 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 termoluminiscens 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.

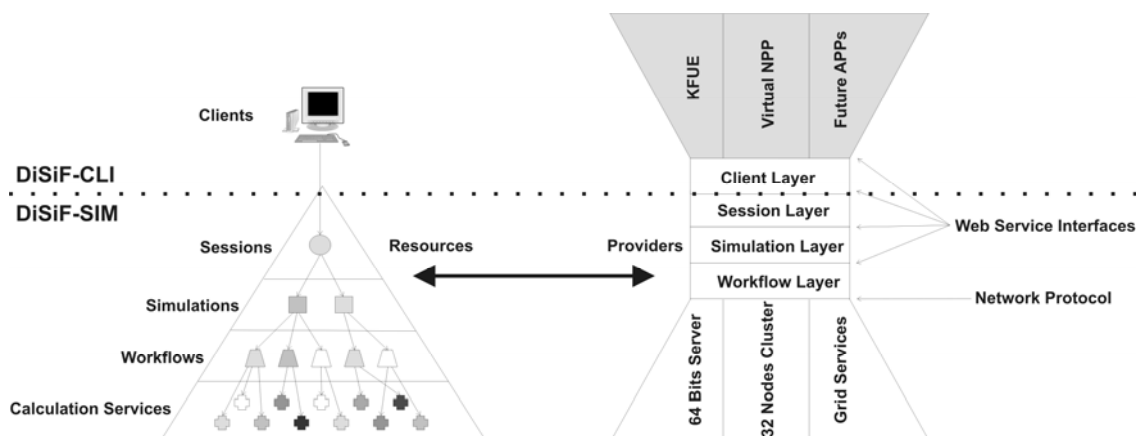


Fig. 1: Next generation ABR-KFUE system architecture [3]

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.

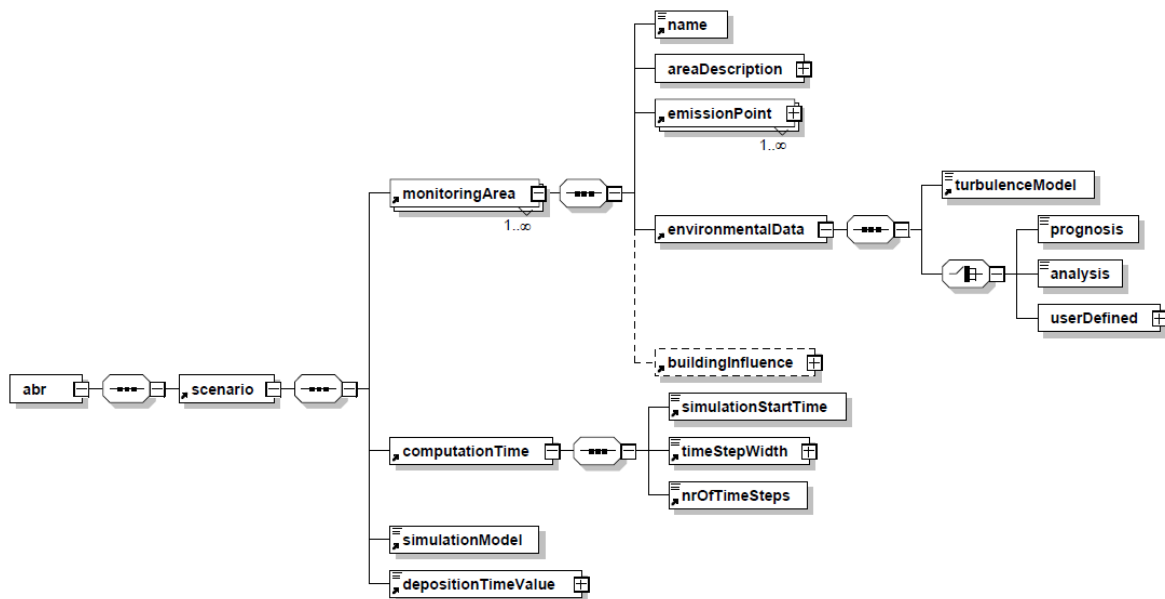


Fig. 2: Unified XML client interface

### 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.

Surface wind speed (ms <sup>-1</sup> )	Day with insolation			Night	
	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.

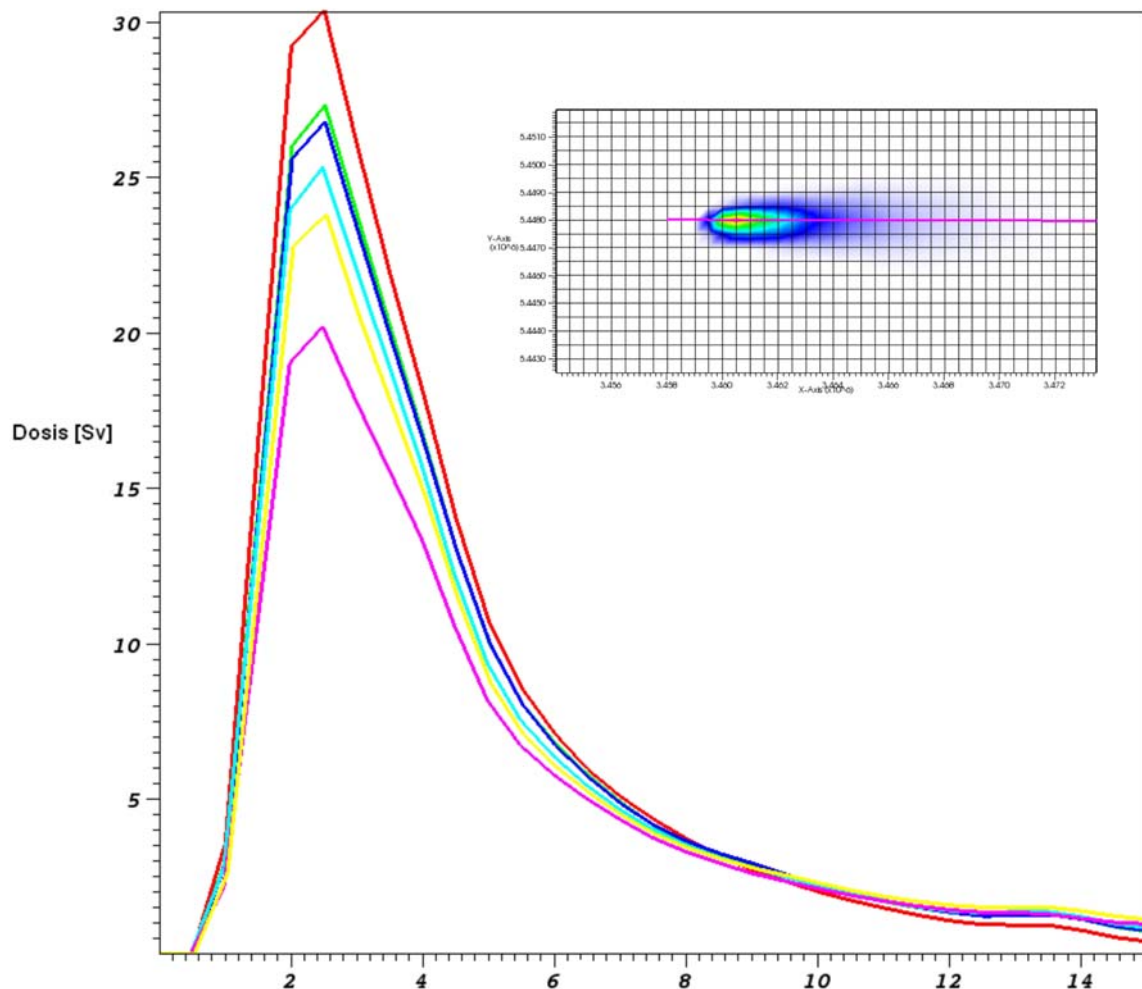


Fig. 3: Effect of diffusion categories A through F on the ground-level radiation exposure

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.

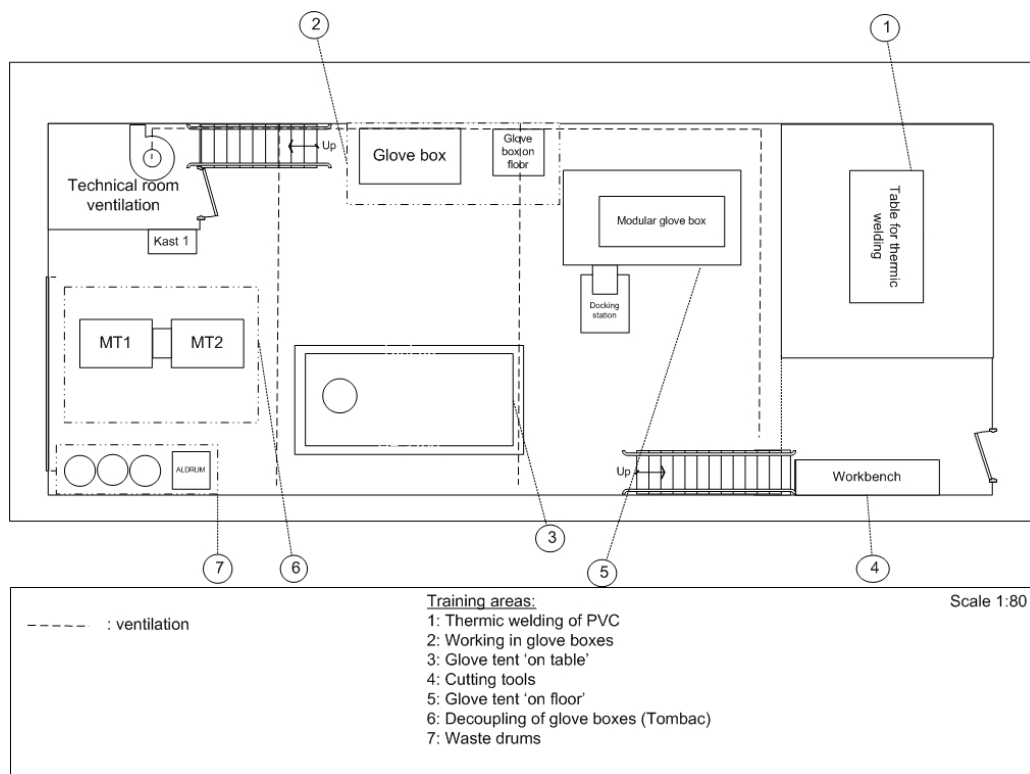


Fig 1. Organisation and implanting of the boxschool

## 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.

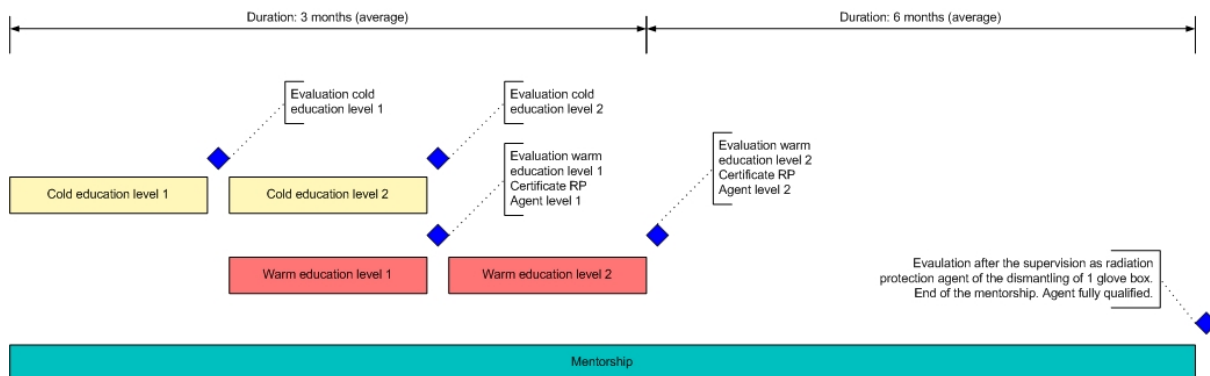


Fig 2. Different stages in the training programme

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.

<b>LEVEL 1</b>	<b>GENERAL</b>
	Presentation of the training programme
	LTC ( <i>"List of Tasks and Checks"</i> )
	DASAO
	<b>SAFETY TRAININGS</b>
	Access to the facility
	Access to the controlled area
	Fire prevention and fighting (in glove boxes)
	Criticality
	<b>WORKING IN GLOVE BOXES</b>
	Working in glove boxes
	Use of a full face mask
	Glove controls
	Thermic welding
	Glove replacement
	Bag-in & Bag-out technology
	Decontamination
	<b>DISASSEMBLING TECHNIQUES</b>
	Use of tools for disassembling
	<b>CUTTING TOOLS</b>
	Use of cutting tools
	<b>WASTE TREATMENT</b>
	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	
<b>TRANSPORT/TRANSFERT</b>	
Transport of waste packages	
Transport of a glove box	
<b>SPECIFIC RADIATION PROTECTION 1</b>	
Interventions on primary confinement	
Control of surface and air contamination	
Control and maintenance of measuring equipment	
Shielding	
Principles of people decontamination	
<b>LEVEL 2</b>	<b>GLOVE TENT</b>
	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
	<b>DISCOUPLING OF GLOVE BOXES</b>
	Decontamination
	Knowledge of different types of coupling
	Confinement's keeping
	Discoupling
	<b>SPECIFIC RADIATION PROTECTION 2</b>
	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, advice and skills of different people in order to improve the quality of the training programme.

### **3.4 Result analysis**

Due to the fact that none 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 its 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, his 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 its efficiency until so far. It concerned 9 radiation protection agents and 65 nuclear 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.

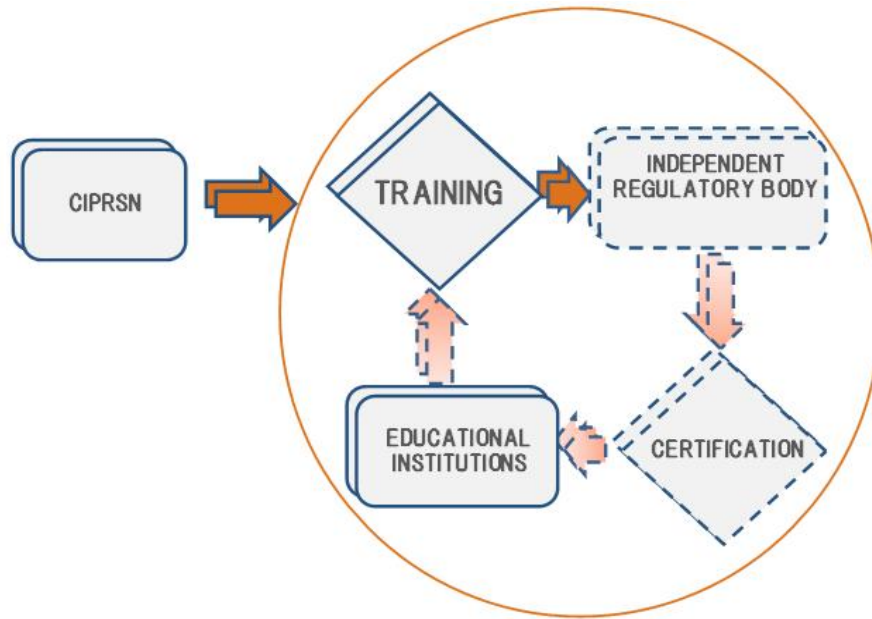
### **3. How to move forward?**

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.

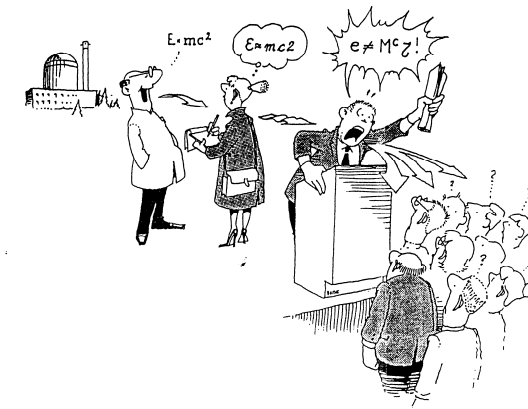


Fig 1. Same information, different message

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.



## How is harm measured?

### Equivalent dose (Sv)

**Quantifies the potential biological effect in humans due to the radiation received**



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 session 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-II 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 7<sup>th</sup> 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 12<sup>th</sup> 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.

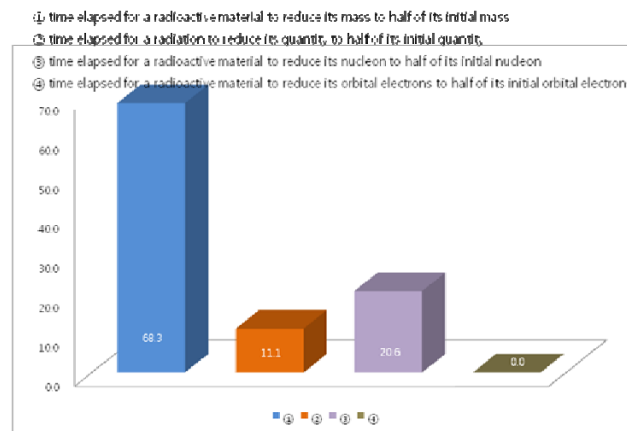


Fig. 1. Response result for understanding of terms 'half-life'

## (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.

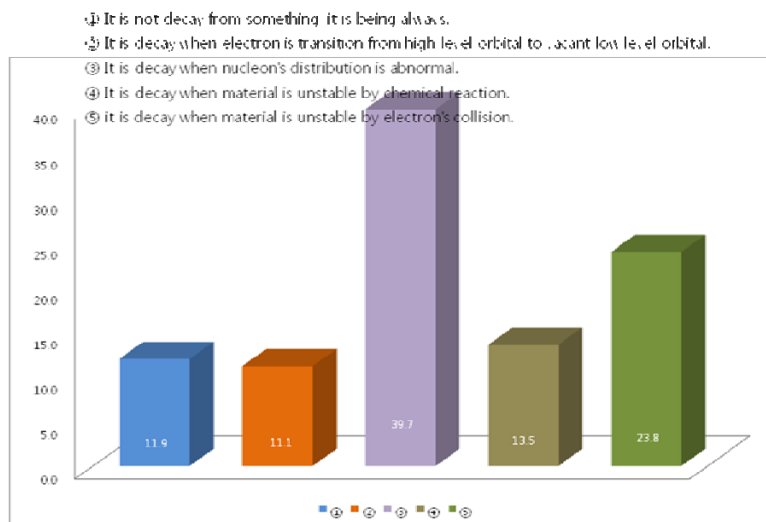


Fig. 2. Response result for 'decay of radiation'

## 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 medical, 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
High concept	Generation of radiation	insufficiency
	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<sup>th</sup> 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<sup>th</sup> 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<sup>th</sup> grade but also the 'Environment' chapter in Common Science in the 10<sup>th</sup> 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 Immunohemotherapy 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 now, 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.).

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