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# Poster

# Education, training and knowledge managment

# ACADEMIC DESIGN OF CANADA'S

# ENERGY SYSTEMS AND NUCLEAR SCIENCE RESEARCH CENTRE

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## ABSTRACT

The University of Ontario Institute of Technology (UOIT) is at the forefront of alternative energy and nuclear research that focuses on the energy challenges that are faced by the province of Ontario, the industrial heartland of Canada. While the university was established as recently as 2002 and opened its doors to its first students in 2003, it has already developed a comprehensive set of undergraduate and graduate programs, and a reputation for research intensiveness. UOIT offers dedicated programs in nuclear engineering and energy systems engineering to ensure a continued supply of trained employees in these fields. The ability to provide talented and skilled personnel to the energy sector has emerged as a critical requirement of ensuring Ontario's energy future, and to meet this need UOIT requires additional teaching and research space in order to offer its energy related programs. The Governments of Canada and of the Province of Ontario recognized UOIT's achievements and contributions to post-secondary education in the field of clean energy in general and nuclear power in particular, and as part of the economic stimuli funded by both levels of government, approved $45M CAD for the construction of a 10,000 $m^2$ "Energy Systems and Nuclear Science Research Centre" at UOIT. The building is scheduled to be ready for occupancy in the summer of 2011. The paper presents the key considerations that lead to the design of the building, and gives details of the education and research programs that were the key in determining the design and layout of the research centre.

## 1. Introduction

The University of Ontario Institute of Technology was established in 2002 by the Government of Ontario, the first new university in the province in 40 years. The key reasons for the location and timing of the new university included the relatively low participation rates in university education of high-school graduates living in the region immediately to the east of Toronto, the demographics (large percentage of skilled workers reaching retirement age), and the inadequacy of the existing universities to produce the number of highly skilled personnel in certain professions. One of the common characteristics of the desired graduates was "job-readiness" for occupations that required university degree programs with high technological content – hence the designation of "Institute of Technology" in the university's name. The seven Schools, each offering one or two undergraduate degree programs starting in 2003, were in the following fields: Business and Information Technology; Education; Energy Engineering and Nuclear Science; Health Science (Nursing); Justice Studies; Manufacturing Engineering; Science. Over the last eight years each of these Schools grew into a Faculty, each of which now offers several undergraduate and graduate programs, as well as doctorate degrees in specific fields. At the time of writing, the academic staff is approaching 500, there are more than 6,500 students in undergraduate and graduate programs, and 3,000 have already graduated.

At the time UOIT was established, it was expected to be principally an undergraduate teaching university, and one of its key mandates was to provide opportunities for graduates of community college programs to gain credits for courses completed at the college level towards gaining a university degree. The typical expectation has been that three years of college education would be equivalent to one and a half year of university studies. By offering courses during a summer “bridge” program that covered subjects not taken at the college, it became possible for the college graduates to gain a university degree, typically in a field related to their college studies, in two additional years of studies. Conversely, graduates of some university degree programs desired to gain the type of practical experience offered by college programs, thereby establishing two-way “pathways” between college and university. Since UOIT was established to share a common campus with the local community college (Durham College), these two institutions have a unique opportunity to offer programs that improve the employment opportunities of graduates from both types of post-secondary institutions.

At the time UOIT was established with a mandate to be “market oriented” this goal was seen in terms of the programs the institution was to offer. However, when it came to hiring the professors and the academic leadership, it soon became apparent that the “market” also demanded that the terms of employment must reflect the conditions at the existing universities, from which most of the UOIT academics were to come. Key to university academic careers in Canada is the concept of tenure, which is achieved through demonstrated excellence in both teaching and research. The high quality professoriate that UOIT wished to hire required that the means to gain tenure had to be present, in other words a university that emphasized both teaching and research. While the initial financial and building plans were focused on creating teaching space, the necessity to conduct research raised the need for specialized laboratory space. In the early years, before undergraduate enrollment reached maturity, some of this need was met by the facilities doing double duty as both teaching and research labs. As graduate programs became established, the need for dedicated research space became essential. While some of this need can be met by moving selected undergraduate programs to leased facilities that contain mostly classrooms and offices, but for engineering areas in particular, new buildings with dedicated research laboratories had to be constructed.

As part of the economic stimulus provided by both the federal and provincial governments, UOIT received funding to build additional research space for the automotive engineering program, as well as a new building for energy systems and nuclear science. This paper presents some of the specific considerations and planned functions of the building shown below: the “Energy Systems and Nuclear Science Research Centre” or “ERC”.

Fig. 1. Artist’s impression of the Energy Systems and Nuclear Science Research Centre

## 2. Academic Programs

The programs offered in the Faculty of Energy Systems and Nuclear Science (FESNS) have been created in consultation with key industry representatives in the fields of energy and radiation, to meet the many challenges and growing employment demand in these fields. The Bachelor of Engineering in Nuclear Engineering, and the Bachelor of Engineering in Energy Systems Engineering are both programs that are not offered by any other Canadian university.

The four-year honours Bachelor of Engineering in Nuclear Engineering program was designed to meet a worldwide need for graduates in the field of nuclear engineering. Although the primary focus of the program is nuclear power plant engineering, the curriculum is sufficiently broad-based that graduates will be well qualified for careers in many applications of nuclear technology and energy related fields. The first two years of study provide students with a solid foundation in the fundamentals of mathematics and sciences, with years three and four concentrating on engineering sciences and specific nuclear engineering courses.

Complementing the nuclear engineering program is one in Radiation Science and Health Physics. This four-year honours bachelor of science degree program provides an advanced curriculum with a strong emphasis on safety aspects of radiation, as well as the application of nuclear technologies in the health care field where the expanding use of imaging technologies is creating a demand for graduates. Options for technology applications in the agriculture and industrial sectors are available in third and fourth years. The curriculum is designed to provide students with a comprehensive knowledge of advanced science and applications of radiation protection, as well as the application of radiation technologies to health care, industry and agriculture. [1]

Students in the honours bachelor of engineering in energy systems engineering learn the skills to design and develop tomorrow's energy systems. The program was developed to meet the rapidly increasing demand for graduates with the knowledge and skills required to help Canada and the rest of the world meet the terms of the Kyoto and Copenhagen agreements, while ensuring that the growing consumption of energy can be satisfied economically and with minimum impact on the environment. The curriculum was designed to provide an understanding of the principles and applications of the full range of energy systems and technologies from traditional fossil-fuelled energy sources to alternative energy technologies. This includes the production, storage, distribution and utilization of energy throughout the life-cycle of the respective systems.

In the fall of 2008, the Faculty launched the first two of of its graduate programs – a Master of Applied Science and a Master of Engineering in Nuclear Engineering. The Nuclear Engineering graduate program encompasses the nuclear power industry, from fuel manufacture to radioactive waste disposal and the many and varied applications of radiation in industrial and medical disciplines, with a strong emphasis on health physics. The master's program is comprised of two fields: Nuclear Power and Radiological and Health Physics. Typical workplace activities include fundamental and applied research, design and development of new equipment, systems and procedures, maintenance and modifications, commissioning and decommissioning of equipment and complete facilities, operation, analysis and regulatory affairs. The Faculty has launched the PhD in Nuclear Engineering program on May 1, 2010. [2]

The expanded space provided by the new ERC building for the Faculty of Energy Systems and Nuclear Science will provide opportunities for student expansion in the current roster of programs offered and allow for future growth in new energy related programs. The use of educational technology will be used to further develop part-time distance learning offerings and allow for expansion of the on-line degree completion program currently offered. The

Masters program in Nuclear Engineering is currently being offered in a hybrid format to energy industry professionals increasing opportunities for further knowledge and skill development that otherwise would be unavailable for these individuals to pursue. To that end, new media site technology has been installed in two classrooms on the UOIT campus this fall to support this initiative and it is anticipated that a new energy building would be supportive of additional distance delivery technologies for use in the teaching of traditional students and professionals in the field.

## 3. Research and Development

The faculty's research includes nuclear reactor design and safety analysis, nuclear power plant design and simulation, safety-critical digital instrumentation and control systems, reliability engineering, human machine interface and uncertainty analysis, radiation biophysics and dosimetry, environmental effects of radiation, health and medical physics, biological effects of tritium and low-energy x-rays, radioactive waste management, electrochemical and corrosion effects. Summary descriptions of the main research areas are as follows:

a) aerosol research to investigate potential hazards from terrorist use of radiological dispersal devices (RDDs). The laboratory facilities include a medium-scale aerosol test cell and portable instrumentation such as a portable particle sizer, hotwire anemometer, and thermo-hygrometer. The research is widely applicable to determination of hazard from airborne contaminants. Related research is conducted on radiation-based methods for looking through walls. The technology, called coded aperture imaging, can be used to generate high-quality images through visually opaque structures, such as walls or pipes.

b) design, construction and evaluation of innovative devices for the real-time measurement of complex radiation fields encountered in nuclear power plants and advancement of the computer simulation and modeling of the interaction of humans and non-human biota with these fields. The long-term objective of this work is the provision of an advanced operational health physics tool through the integration of the research methods and results into an online health physics and environmental protection information management system.

c) reactor physics, neutron and radiation transport and mathematical modeling and numerical methods. For the computationally inclined, work is ongoing on developing computational methods for the neutron transport problems stemming from the neutronic design of new-generation nuclear reactors; and for the experimentally inclined, another project under way is the development of a platform to allow students to perform laboratory experiments remotely by using a simple browser interface.

d) reliability and safety assessment for safety-critical systems, maintenance strategy determination, networked control systems, decentralized control sensor networks and embedded systems.

e) corrosion and corrosion-assisted failure of metals. The focus of the research has been materials related to the nuclear industry, and in particular, materials under consideration for the construction of nuclear fuel waste containers. Related research focuses on the development of new technologies for the production of nuclear fuels.

f) thermal hydraulics of nuclear reactors and Generation IV nuclear reactor concepts, thermal sciences (boiling, forced convection including supercritical pressures) and heat engineering (two-phase thermo-syphons, heat exchangers, heat-recovery systems).

## 4. Energy Efficiency and Reduction of Emissions

In keeping with UOIT's current practice of employing sustainable and eco-friendly design and construction methods, designers will incorporate a number of advanced environmental features into the design and construction of the ERC. These include the goal of exceeding minimum building envelope performance standards by 25%, the use of green roofs, geothermal heating and cooling systems, and ensuring optimal energy performance.

At UOIT, a portion of each academic building rooftop is "green". This flat-roof technology uses soil beds filled with low-maintenance plants that are native to Ontario. Green roofs are able to offset some of the negative effects caused by urban development as concrete structures prevent rainwater from being absorbed into the soil and cleaned naturally. Instead, some rainwater is captured and held before it can reach the ground, meaning this moisture is eventually returned to the atmosphere. Any surplus runs off into an underground, 250,000-litre storage area and is used for irrigation, thereby reducing municipal water use.

Canada's deepest Borehole Thermal Energy System (BTES) beneath the Polonsky Commons at UOIT has played a major role in the creation of an energy efficient campus. The BTES is made up of more than 370 thermal wells in a field that is 200-metres deep. Fluid circulates through tubes in the well, collects heat from the earth, and is carried into the buildings to provide warmth in the winter months. During the summer, the system pulls heat from the buildings and places it into the ground. The capacity of the BTES is such that the ERC will be connected to it for the purpose of building heating and cooling.

## 5. Conclusions

In recognition of UOIT's achievements and contributions to post-secondary education in the field of clean energy in general and nuclear power in particular, the Governments of Canada and of the Province of Ontario have provided $45M CAD for the construction of a 10,000 $m^2$ "Energy Systems and Nuclear Science Research Centre" in Oshawa. The building will include six classrooms, six teaching laboratories, 16 research laboratories, meeting rooms, as well as office space for faculty, staff and graduate students. The teaching labs encompass equipment for wind, solar, geothermal, nuclear energy and for measuring the environmental effects of radiation. The research laboratories are designed for maximum flexibility, so that space can be assigned dynamically in response to the varying number and scope of research projects in the various fields of specialization. Research will be conducted in the fields of nuclear power plant design, applied radiation, supercritical thermalhydraulics, nuclear instrumentation, non-destructive testing, containment systems design, aerosol dispersion, high temperature materials, pollution control, environmental technology and energy control and safety.

## 6. References


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# USING A RESEARCH REACTOR TO TEACH PRACTICAL RADIATION PROTECTION

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## ABSTRACT

To teach students about the practical handling of radioactive materials and the related radiation protection, it is advantageous to be able to produce radioactive material with specific properties.
Through the neutron activation of specific samples, radio-nuclides can be produced that are precisely tailored for particular experiments, both in type of radiation (beta, gamma) as well as in activity and half-life. At the Atominstitut in Vienna, a 250 kW TRIGA Mark II research reactor is used for the production of these nuclides.
In this paper, four practical exercises are presented, covering many questions and challenges that occur in radiation protection.
The first exercise uses neutron activation of sodium-chloride to cover theoretical aspects of the calculation of dose rates (using dose rate constants) through the activation of Na-23, Cl-35 and Cl-37 (including cross sections, half-life, inverse square law), as well as a practical examination (handling of dose rate meters).
The second exercise gives students the opportunity to decontaminate a laboratory after an incident under realistic circumstances. For this exercise, $KNO_3$ is activated in the reactor. The resulting K-nuclide produces no risk of inadequate decontamination for the laboratory, since the half-life of K-42 is only 12 h.
The third exercise is designed to teach students how to deal with unsealed radioactive material by irradiation of ammonium dihydrogenphosphate. In this case, an only-beta-active (P-32) fertilizer is produced, which is applied to plants in subsequent chemical processing. In the following step, the “quality of this fertilizer” is determined by measuring the absorbed activity of the plant leaves using a GM-counter.
The fourth exercise is another approach in working with unsealed radioactive material. It simulates the PUREX process to separate uranium from fission products using a liquid – liquid extraction.

## 1 Introduction

The Atominstitut Vienna operates a 250 kW TRIGA Mark-II reactor since March 1962 used for nuclear education and training in many fields. Students graduate with a Masters - or PhD degree from the Atominstitut attached to the Vienna University of Technology.
To perform nuclear relevant academic studies the Atominstitut offers about 100 highly specialised theoretical lectures and many practical courses where students have to perform experiments in small groups. Although the TRIGA reactor is a rather low power research reactor, it is very easy and cheap to operate and an excellent tool to transfer knowledge and experience to the younger generation.

## 2 Practical training on radiation protection

In the field of radiation protection a lot of theoretical lectures are offered to students to present basics. To deepen that knowledge it is essential to work with radioactive material. One of many experiments carried out at the institute is to hide Co-60, Cs-137, Am-241, and a Pu-Be neutron source in a laboratory. These sources, which have activities of some MBq up to GBq have to be located by the students, who are equipped with dose-rate-meters.

Subsequently the sources have to be transferred to suitable shielding containers in a proper way.
Some other experiments can be carried out using the research reactor. An excerpt of these experiments is presented in the following chapter.

# 3 Experiments using the TRIGA MARK II reactor

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 radio nuclides are produced, which can be used amongst others for the following training aspects of radiation protection:

- **Average activity, average half-live:** 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-live:** Determination of half-lives
- **Average activity, long half-live:** Handling of unsealed radioactive materials
- **High activity, long half-live:** Handling of sealed radioactive materials
- **Average activity, short half-live:** Contamination and decontamination

The following examples show how the advantage of the reactor is used at the Atominstitut.

## 3.1 Dose-rate calculations

In this exercise basic-calculations of relevant parameters in radiation protection are demonstrated. With a pneumatic transfer system a sample of 500 mg NaCl is irradiated in the reactor at a flux density of $2.10^{12}$ $cm^{-2}s^{-1}$ for 1 minute. The following exercises have to be solved by the students using a chart of nuclides:

- Natural abundance: How much Na-23, Cl-35, Cl-37 are in 500 mg NaCl?
- Cross sections for thermal neutrons?
- Half-life and activity of Na-24, Cl-36, Cl-38, S-35, P-32 after irradiation?
- Total activity after irradiation?
- Total activity after 2h decay?
- Dose rate constants: calculation using decay-schemes
- Dose rate calculations in different distances

The calculated data are finally verified by irradiating the sample in the reactor. So the handling of different measuring devices as dose rate meters and hand-held gamma-spectrometers (e.g. a NaI-Identifinder) can be demonstrated.

## 3.2 Contamination and decontamination

Another basic exercise in radiation protection is the procedure of decontamination after a contamination incident has occurred. To demonstrate this incident in a realistic way one has to contaminate (and decontaminate) a real laboratory. Of course it is a big advantage, if you do not use nuclides like Cs-137 with a half-live of 30 years. One possibility is to use nuclide generators (Cs-Ba, Mo-Tc-99m). But a better way is to apply nuclides with short half-lives produced in a reactor. For our decontamination-experiment potassium is irradiated. The resulting radionuclide is K-42 with a relatively short half-live of 12 hours.
In detail the following procedure is carried out:

- Irradiating 100 mg $KNO_3$ at a flux density of $2.10^{12}$ $cm^{-2}s^{-1}$ for 1 minute
- Dissolution in water
- Contamination of e.g. floor, worktables, chemical instruments
- Demonstration of the ALARA principle, safety precautions, working in teams
- Exclusion zones, protective clothing (gloves, masks,..)
- Handling contamination monitors
- Decontamination procedures

After the decontamination procedure is finished, it can also be assumed that the used materials (towels, gloves,..) are contaminated with a long-living radionuclide. This leads to discussions of handling long-living radioactive waste considering the relevant legal regulations.

### 3.3 Fertilizer uptake in plants

The next step in practical application of radiation protection implements the handling of unsealed radioactive material and the involved relevant preventive measures. In this experiment a fertilizer (ammonium dihydrogenphosphate, $(NH_4)H_2PO_4$) is applied to plants (e.g tomato plants). To demonstrate how the fertilizer is taken up by the plants, the ammonium dihydrogenphosphate is activated in the reactor to produce radioactive P-32. The remaining components of this chemical compound are not activated.
In detail the following procedure is carried out:

- Irradiating 100 mg $(NH_4)H_2PO_4$ at a flux density of $2.10^{12}$ $cm^{-2}s^{-1}$ for 10 hours
- Dissolving in 100 ml water (resulting in ~$6.10^4$ Bq/ml)
- Measuring 10 µl of this solution with a GM-counter
- Uptake of the solution by a plant for a few hours
- Cutting out 5 mm discs of leaves
- Measuring them with a GM-counter
- Calculation of fertilizer uptake
- Distribution of the fertilizer in the plant (autoradiography)

Finally the difference of dose-rate-meters and contamination monitors can be shown. Although the contamination monitor indicates radiation, the dose-rate-meter does not, because P-32 emits only beta-radiation.

### 3.4 Simulating the PUREX process

Another very interesting procedure for students is the simulation of the PUREX process. In this experiment, fission products (simulated by a typical fission product: La-140) are separated from uranium by a liquid - liquid extraction procedure using tributyl phosphate (TBP) in hexane.
In detail the following steps are carried out:

- Irradiation of 400 mg $La(NO_3)_3 \cdot 6\ H_2O$ at a flux density of $2.10^{12}$ $cm^{-2}s^{-1}$ for 3 minutes.
- Decay for about 15 hours (La-140: $T_{½}$ = 40h).
- The first part of the "spent fuel solution" is obtained by dissolution of the $La(NO_3)_3 \cdot 6\ H_2O$ in 30 ml of $H_2O$. It is advisable to add one drop of nitric acid to prevent hydrolysis of the lanthanum ions.
- The second part of the "spent fuel solution" consists of a mixture of 1 g uranyl nitrate ($UO_2(NO_3)_2 \cdot 6\ H_2O$) and 6 g of sodium nitrate in diluted nitric acid (10 ml of 65% $HNO_3$ + 10 ml $H_2O$).

- The lanthanum nitrate solution is added to the $UO_2(NO_3)_2$ and $NaNO_3$ containing solution to obtain the final “spent fuel solution”.
- 5 ml of this spent fuel solution are extracted in a separatory funnel with 5 ml of a 20% solution of TBP in hexane.
- While shaking, the uranium is transferred to the organic phase, whereas the “fission products” (La-140) remain in the aqueous phase.
- The organic phase is washed twice with 5 ml of 6 M $HNO_3$. The washing solution is added to the aqueous “radioactive waste” solution.
- Measuring the remaining fission products in the organic phase by gamma spectroscopy.

The efficiency of this procedure can impressively be demonstrated by comparison of the initial count rate of spent fuel solution in a fixed measurement position in a gamma detector with the remaining La-140 activity (e.g. 1596 keV) in the organic phase: The activity decrease can yield up to 5 or 6 orders of magnitude.
The uranium-rich organic solution can be washed with pure $H_2O$ to transfer the uranium back into the aqueous phase again.
The uranyl ion in the aqueous phase can be detected qualitatively by addition of potassium ferrocyanate ($K_4[Fe(CN)_6]$), which yields a characteristic brown precipitate.

# 4 Conclusions

Through the subsequent use of radio-chemical procedures in the radio-chemical laboratories of the institute, the resulting knowledge in the field of radiation protection can be deepened. For example processes such as the PUREX process, or the absorption of radio-nuclides in organic substances can be introduced experimentally. Through the use of such procedures a safe handling of unsealed radioactive material can be excellently taught. Finally, it can be concluded that the use of a research reactor provides excellent opportunities to teach practical radiation protection.

# 5 References

[1] www.ati.ac.at
[2] www.tuwien.ac.at

# RESULTS AND LESSONS LEARNED OF THE FIRST EDITION OF THE MASTER IN NUCLEAR ENGINEERING & APPLICATIONS (MINA)

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## ABSTRACT

The Master in Nuclear Engineering and Applications (MINA) was born to build up a bridge between University education and the technical skills demanded by nuclear industry and organizations, particularly in Spain. Motivated by nuclear renaissance, knowledge preservation and the bases of the European Education area, the new approach adopted to accomplish such a challenge has been heavily based on a professional profile defined by the Spanish nuclear community.

The first edition success (MINA-2008) has been assessed through a set of indicators, which encompass a broad range of aspects, from the number of registrations to the employment rate. This paper summarizes and discusses such an assessment. Additionally, a critical thorough review has allowed identifying a few aspects that could be improved. All the lessons learned have been translated into specific measures implemented in the MINA-2009 edition.

Among the indicators, participation and industrial support were considered of utmost importance. MINA-2008 had 18 students, out of which 60% were financially supported to some extent thanks to the nuclear industry and organizations (during the conduction of the master project, this support was even enhanced). Beyond the economic contribution, nuclear companies and institutions were strongly involved in all the phases of MINA-2008, from the definition of the program up to the supervision of more than 70 % of the master projects. As a result of the lessons learned, the subjects have been grouped in modules and a more practical approach has been pursued in the teaching/learning process.

## 1. Introduction

Nuclear power capacity in Spain is higher than 7800 MWe, which represents around 8% of the total installed capacity and about 16% of the power production. No matter the future [1], distribution of the energy mix, operation, maintenance and even decommissioning of the current reactor fleet, will demand highly qualified engineers and technicians with sound backgrounds to address those upcoming challenges. This need will be fostered by two additional circumstances: globalization, which is already bringing Spanish engineers anywhere in the world where this demand exists (Brazil, Argentina, South-Africa, USA and more); and knowledge preservation at this very moment at which a large number of nuclear professionals are reaching their retirement ages.

In this national and international context, CIEMAT and UAM recognized the opportunity to adopt a new ambitious and encouraging approach in the training of nuclear professionals: the Master in Nuclear Engineering and Applications (MINA). The first edition, MINA-2008, carried out from October 2008 to July 2009, was founded on three basic pillars: CIEMAT experience on educating nuclear professionals, UAM experience on providing academic skills, and, no less important, a tailored format to accommodate the Master to the current needs of the nuclear Spanish sector. In short, MINA was born with a strong professional approach.

With a duration of an academic year (approximately 1,500 h), MINA-2008 provided an exhaustive and extensive vision of the underlying disciplines of the existing and future applications of the nuclear technology. The Master programme, developed through a joint and close collaboration among industry engineers, research institutions and Universities, allowed a practical approach in which individual student projects (500 h) are mostly proposed and supervised by industry staff, so that MINA students become familiar with their environments and tools.

The MINA fundamentals have been described elsewhere ([2], [3]) and will be shortly mentioned here. In addition, a set of indicators has been set to monitor the result of the first edition of MINA in several regards. From this assessment as well as from a critical review of some logistic aspects, a set of lessons have been learned and have resulted in specific modifications in the second edition: MINA-2009.

## 2. Results of MINA 2008

The MINA first edition can be considered successful in many regards. This statement is supported through an analysis of six indicators, which nature allows a thorough review of the project.

### 2.1 Participation

MINA-2008 had 14 students registered to full time Master. In addition, 28 participants from several companies and other nuclear organizations (4 students more in terms of full time Master) attended specific subjects. This level participation shows a new trend from what had been observed in previous training initiatives in Nuclear Technology between CIEMAT and UAM in the early years of this decade.

The background of the participants was diverse: eight students had a degree in Physics, one more in Chemistry and the remaining five had studied different engineering specialities. Most of the students were Spanish, but three of them were foreigners, from Colombia, Chile and Italy.

### 2.2 Effective support of the sector

MINA was born with a broad support from nuclear industry, universities and institutions. As a matter of fact, it has been integrated in the Spanish Technological Platform on Nuclear Fission (CEIDEN), which coordinates the different plans and national programs and the participation in some international R&D programs. Several aspects allow recognizing this support in the first edition of the Master:

- 50 % of the lecturers and more than 70 % of the projects were responsibility of companies and institutions of the nuclear sector. In spite of the thematic diversity, special mention deserves the decommissioning of nuclear installations as one of the major activity areas, and the neutron transport code MCNP, as one of the most usual tools in tasks development.
- Financial contributions received from the private and public sectors by MINA have allowed granting complete registration scholarships and 50% fee off for some students. In addition, during the final project phase, some companies have extended their contributions through a sort of payment to those students who conduct their master projects under their supervision.
- MINA gives high importance to the practical aspects such as technical visits. In this sense, several national facilities covering much of the fuel cycle were visited, from the Spanish fuel fabrication plant to the centralized low and intermediate level waste disposal facility or the temporary individualized disposals in different Spanish NPP.

## 2.3 Accomplishment of the program

A theoretical estimation of duration of the subjects was made [3]. Though punctual differences existed with regard to the initial planning, in most cases the master schedule was planned in such a way that the program was driven according to those forecasts (Fig.1). An exhaustive relation of subjects and duration can be found in (www.ciemat.es/MINA).

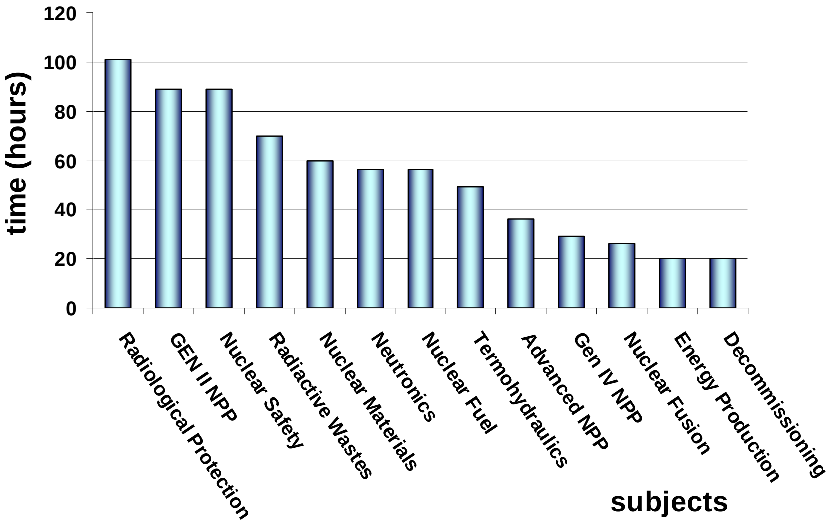


Fig 1. Subjects duration in MINA-2008

## 2.4 Documentation and access to the information

Lecturers prepared “ad-hoc” presentations for MINA under a given format and they made them them available to the students through the CIEMAT's virtual learning platform. Through this web-site based “exchange room”, students had also access to teachers for questions, inquiries and requests of further information. In addition to the specific slides, more than 50 % of the lessons given were written and distributed too (worth noting that MINA expectations was just 30%, so that all the classes will be properly documented by the $4^{th}$ MINA edition).

## 2.5 High exigency level

As stated above, MINA is committed to guarantee student’s competence. This purpose required to set high demands to be met by students. A proof of such a high standard is the student’s mark distribution in subjects like Thermo-hydraulics, Power cycles, Nuclear Safety and Security, etc. (Fig. 2).

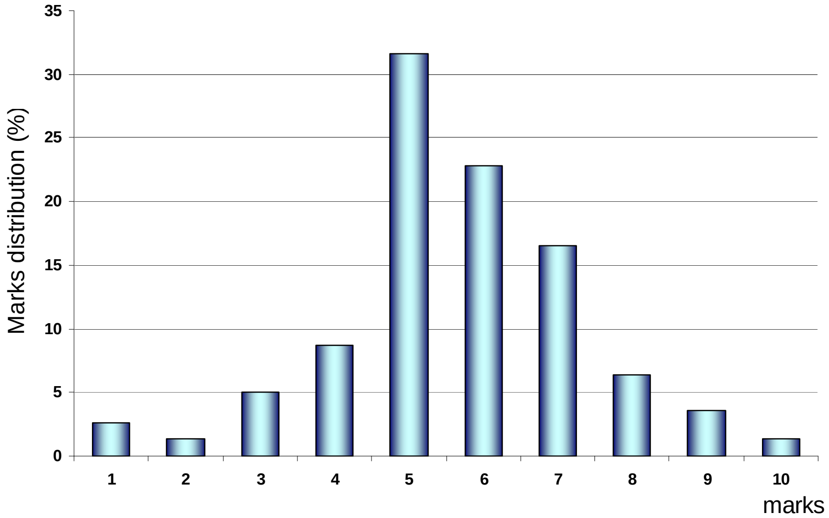


Fig 2. MINA-2008 mark distribution

A quasi-normal distribution centred around the 5-6 score band (weighted average about 6) can be observed, with more than 80 % exceeding the minimal threshold, and about a 16 % of students that had to demonstrate their skills in subsequent tests.

## 2.6 Evaluation from the students

A survey concerning MINA-2008 was made available to the students through the website. As noted in Fig. 3, questions regarding subjects and professors are asked to can get the whole picture between students and subjects. In general, students valued positively aspects such as acquired knowledge, good distribution of the information, the high level of specialization and skills of the lecturers and the perception of a current vision of the nuclear world. The Figure 3 shows the average punctuation to all the aspects considered.

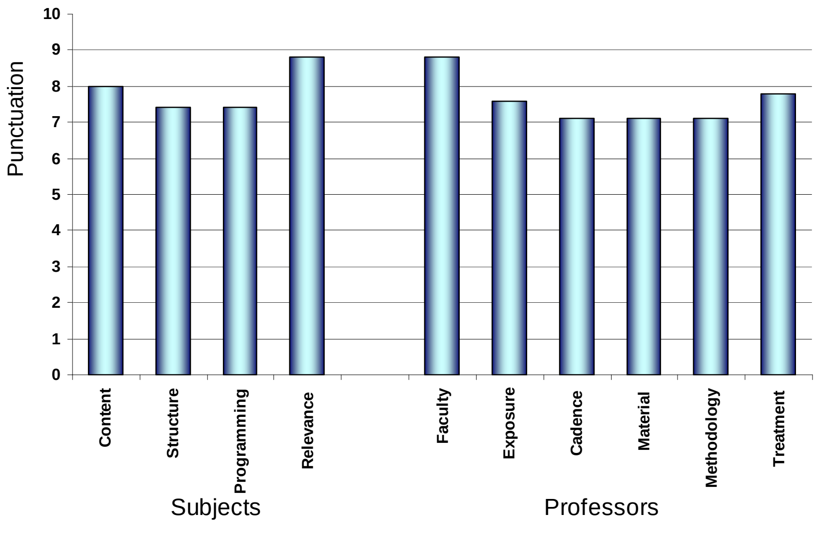


Fig 3. MINA'S evaluation by students

# 3. Global critical Analysis

A critical review was conducted to identify areas susceptible of improvement in future editions of MINA. As a result, some specifics were found not to be entirely satisfactory:

- The number of theoretical lessons in MINA-2008 was very high. This had two effects on the students: substantial reduction of time for individual work and increase of the inefficiency due to fatigue accumulation.

- The number of exams was greater than 25. This kept the students highly stressed for long periods of time, which forcefully reduced their attention to matters other than the one of the upcoming exam.

- Some examinations were held during the project phase of the master. This situation must be avoided in future editions so that students concentrate solely on their project activities, free of the above mentioned stress.

- The attitude of the students was closer to college students' than to professional's. Given the professional nature intended in MINA, this was seen as something to be prevented in future MINA editions by adopting some measures to change students's perception of MINA.

## 4. Future editions of Master MINA

The analysis of MINA-2008 has allowed noting that while the fundamentals and general coordination deserve a positive assessment, the organizational and methodological aspects could be optimized. Accordingly, the following sections describe the main developments envisaged in the next edition of the Master.

### 4.1. Organizational aspects

Following the EU trends, a new modular training scheme has been introduced. Subjects have been grouped into modules ("modularisation"). Each module has a total duration of 150 hours (of which, on average, over 50% are assigned to individual work of the students and the rest represent theoretical or practical classes) and integrates at least two subjects. A coordinator will ensure the thematic consistency and seek an appropriate interface between the subjects of each module.

Figure 4 shows a schematic of the 7 modules. This structure reflects that the Introductory Aspects flows into the three fundamental pillars: Radiological Protection, Nuclear Power Plants and Innovative Systems. From the second of them, a broad spectrum of key disciplines structured in 4 modules is covered; such disciplines are particularly related to current technology.

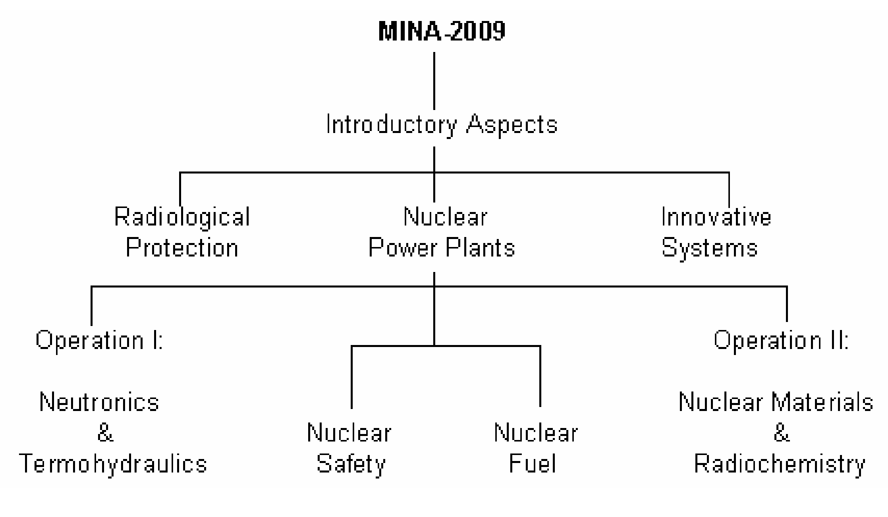


Fig. 4 Modular Structure in MINA

Furthermore, the modular structure is a step towards adapting MINA-2009 to the guidelines of the official degrees, according to the process of convergence with the European Higher Education Area.

## 4.2 Methodological aspects

Among the diverse instruments through which the activities of MINA are conducted, two of them will undergo a substantial change with respect to MINA-2008: teaching and evaluation.

### 4.2.1 Pedagogical methodology

With regard to the teaching methodology, two aspects have deserved reconsideration: the conception of the subjects and the emphasis on the practical tasks.

- Striving for the maximum consistency between subjects and students performance. Even though the didactic of all the subjects will be kept as a main goal, a more balanced assessment of student skills is pursued. Examinations will be a main tool (not the only one) is those subjects lasting more than 10 h, but alternatives methods of skill assessment will be proposed for those with a kind of seminar structure (less than 10 h).

- Fostering working skills. The future editions of MINA will maximize the know-how weight with respect to mere theoretical study. That is, practical aspects will gain further relevance and more time will be given to realization of laboratory and computing practices, the resolution of practical cases and/or problems or the use of calculation codes. This shift in the teaching means that individual work will be favoured and then turned into a key element in the assessment process and, at the same time, subject programmes will be adapted. This scheme will make students have the same lecturing time and individual work time during MINA-2009.

### 4.2.2 Methodology of evaluation.

The changes that are proposed in the methodology of evaluation have two fundamental targets: to achieve a balanced weighing of the aptitudes of the student and avoid the unnecessary polarization of his attention towards the examinations. To achieve it, the following measurements have been articulated:

- High weighing of the practical aspects in MINA (50 %). Problems, practices, practical cases, etc., will be no less than 50 % of the qualification of every subject. Nevertheless, a minimal of 3.5 in the examination will be demanded to be able to do the weighed average. In case that this condition is not fulfilled, the qualification will be the minor of the obtained ones.

- Reduction of the number of examinations. Related subjects will be evaluated with a single examination grouping all of them. In addition, those subjects with a marked descriptive character will be evaluated through alternative ways (any sort of practical evaluation will be supported from MINA management).

- Final examination. Those students who pass less than 75 % of the examinations, will have to pass a final examination focused on those fundamental subjects (with specific weight in those who they failed).

## 4.3 Specific aspects

Apart from the general modifications described in the previous subsections, actions of a more limited scope have been started, affecting to individual subjects. They are based, principally, on the opinions shown by the pupils of MINA-2008 by means of the polls that were put at their disposal. Such actions cover from minor initiatives, as the update of the used material or the synchronization of theory and practices of a subject, up to others of clear importance, as the combination of certain subjects, among which it is possible to quote, Neutronics, Reactor Control and Shielding.

# 5. Final remarks

The Master in Nuclear Engineering and Applications, is a CIEMAT-UAM joint venture to achieve a renewed approach for the education and training on nuclear technology. Its robust and sound foundations were set by striving for a high competence which was eventually defined by the national nuclear industry.

Nevertheless, the MINA management team has given utmost importance to keep an eye on those aspects where further improvements could be implemented without quitting the basics of the Master. In order to do so, several regards of the first MINA edition has been assessed, both qualitatively and quantitatively, as shown in previous sections. Some of the indicators used (i.e., number of students, industry participation, conduction of the program, etc.) have been discussed and such analysis led to a conclusion:

The first edition of the Master, MINA-2008 involved deeply both industry and students. Despite the demanding nature of the project, the “new professionals” ranked high the master as a whole in its very many aspects (i.e., teachers, professors, logistics, etc.).

The experience gained through MINA-2008 allowed noting specific areas, both organizational and methodological, which optimization in future editions of the Master will help to guarantee meeting the objectives set at the beginning. Some of the most significant are: the modular structure, the reinforcement of practice vs. theory and/or the definition of alternate examination procedures.

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# REACTOR DOSIMETRY KNOWLEDGE PRESERVATION AND DEVELOPMENT

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## ABSTRACT

The nuclear safety requirements and philosophy have changed by the development of new nuclear systems and this imposes special research and development activity. Reactor dosimetry which is applied for determination of neutron field parameters and neutron flux responses in different regions of the reactor system plays an important role in determining of radiation exposure on reactor system elements as reactor vessel, internals, shielding; dose determination for material damage study; in dose determination and conditioning of irradiation for medicine and industry application as well as in induced activity determination for decommissioning purposes. The management of nuclear knowledge has emerged as a growing challenge in recent years. The need to preserve and transfer nuclear knowledge is compounded by recent trends such as ageing of the nuclear workforce, declining student numbers in nuclear related fields, and the threat of losing accumulated nuclear knowledge.

## 1. Challenges of the nuclear energy renaissance

Today's nuclear renaissance in national and European aspect, expressed in building of new NPPs, as well as the development of Gen. IV nuclear reactors, meets new challenges of accuracy of the reactor analysis methods used for reliable operation and nuclear safety assessment. The nuclear safety requirements and philosophy have changed by the development of new nuclear systems and this imposes special research and development activity. The EC documents as the SET-PLAN and SNE-TP derived from "Energy Policy for Europe" [1] trace the strategic directions in nuclear knowledge management.

The growing lack of experienced employees in the nuclear field is recognised everywhere as a problem affecting the ability of the industry to retain the current high levels of expertise necessary to maintain nuclear safety. This contrasts with the Nuclear Energy renaissance. The concept could be adapted to many types of activities, but addresses the scope of the first Chapter of the Strategic Research Agenda developed within SNE-TP: Current and Future Light Water Reactors, representing Generation II and Generation III. The concept is the creation of training and professional development at a higher level, tailored for professionals with years of experience. In order to face the new challenges in nuclear safety such as reactor ageing, new fuel management, facility dismantling, waste disposal as well as the development of new generation reactors, across the world, thousands and thousands of nuclear scientists and technicians must be educated, recruited and trained without delay to quench this thirst of competence.

Nuclear Safety Culture is a topic of paramount importance for all nuclear operators as well as for all operators of installations dedicated to radiology and radiotherapy. It concerns also the regulators and related support organisations. Its efficient practice is an absolute must for nuclear power plants, for production and transport of fissile materials and radioisotopes, and for related research activities.

## 2. What is Reactor Dosimetry

Reactor Dosimetry (RD) is an element of Nuclear Safety Culture. It is applied for determination of radiation exposure on reactor system elements as reactor vessel, internals, shielding in determining of consecutive effects from the irradiation; for dose determination and conditioning of irradiation for medicine and industry application; for induced activity determination for decommissioning purposes.

RD is a field that embraces measurements, calculations and assessments of the exposure of radiation exposure in different locations of irradiation system. Areas typically covered by RD are: neutron and gamma-ray transport calculations and associated uncertainty analysis; dosimetry and retrospective dosimetry for radiation damage assessment of reactor structural materials; dosimetry for core characterization and reactor physics; characterisation of neutron and gamma-ray environments; damage correlation and exposure parameters; monitoring of irradiation experiments; benchmarking, calibrations and standards; advanced reactors and neutron sources.

The reactor dosimetry, through calculations and measurements, provides a good enough description of the neutron field parameters of the RPV environment [2].

The irradiation conditions (neutron flux, fluence and spectrum) appear as factors [3, 4] determining the radiation embrittlement of the vessel materials, and consequently limiting the Reactor Pressure Vesel (RPV) life time of light water reactors PWR and WWER. RD is an important component of the full system of methods, tools and knowledge, needed for non-destructive determination of the neutron exposure and prediction of radiation damage of the materials of reactor system, and in this way to plan ways for improving NPP lifetime extension.

### 3. Insufficiencies of RD

The main insufficiencies of RD address to two very different problems: need of some methodology improvements together their verification, and growing lack of human resources. Regarding the RD which application is the WWERs RPV metal damage assessment for life time prediction insufficiencies of RD addressing the neutron fluence determination are related with: no direct measurements on RPV and internals; shortcomings of surveillance assemblies' design and location; relatively short half life (312 days) of the radio-nuclide $^{54}$Mn available in the metal; very complex construction of the RPV and surveillances with very different material properties and associated design uncertainties.

More complicate is the problem with human resources. Some negative processes from the near past as the world tendency of receding of the nuclear as well as financial non-attractiveness of nuclear profession have lead to specialists' number decreasing. It has been observed a decrease of knowledge and expertise in RD during the last decade. Senior engineers and scientifics retired and no proper human resources, means and tools have been set up to remedy the situation. It is obvious that one generation is missing between the well experienced and the new researchers, who have to continue the works needed for maintaining and development of the nuclear field, in particular of RD. The management of nuclear knowledge has emerged as a growing challenge in recent years. The need to preserve and transfer nuclear knowledge is compounded by recent trends such as ageing of the nuclear workforce, declining student numbers in nuclear related fields, and the threat of losing accumulated nuclear knowledge.

## 4. Good practice and lessons learned

The neutron fluence evaluation methodology has been developed in close collaboration of working teams from Russia, Czech Republic, Germany, Spain, Belgium, Bulgaria, Hungary, Netherlands and Ukraine under various research projects as AMES, MADAM, RETROSPEC, REDOS, COBRA, TACIS, COVERS, RADE of EC Euratom, RER/4/017 of IAEA and national funds. The common works were a good base for verification of the methods and development of common methodology. WWERs RPV benchmarks [5, 6] were created for validation and improvement of the methodology for RPV neutron fluence evaluation. They were developed at the critical assembly LR0, INR (Rez, Czech Republic)on the base of Mock-ups which simulate the irradiation conditions of VVER-440 and VVER-1000 vessels.

In particular, the verified RD methodology has been being applied for Kozloduy NPP for evaluation of the RPV neutron fluence and justification of the safe lifetime of Units 1 to 4 with WWER-440 and Units 5 and 6 with WWER-1000.

The European Working Group on Reactor Dosimetry (EWGRD) has played an important role giving a forum for exchanging ideas and discussing current results. EWGRD is being leaded by SCK-CEN, Mol, Belgium. The west EWGRD was enlarged since 1994 by the Working Group on Reactor Dosimetry for WWER (WGRD-WWER) of the countries operating WWERs. In the frames of groups' activities during the past period more than twelve workshops and meetings have been held where new results, tasks and features were presented, discussed, and planed for further study. These common activities sharply were reduced if not disappeared the last five years except the International Symposium on Reactor Dosimetry (ISRD) organized every three years by EWGRD and ASTM, USA.

## 5. Overcome insufficiencies

More active creation and development of human resources in nuclear are needed nowadays in order to be able to meet the demands of the nuclear energy renaissance and modern applications in medicine and industry. The management of nuclear knowledge has emerged as a growing challenge in recent years.

The ways to preserve and develop the RD knowledge meet the necessity of governmental understanding as well as finance supporting so to be able to: maintain RD community by joint workshops and training, involving the major in experience and age researchers in lecture preparation and the young in training. The workshops and conferences are needed to facilitate knowledge sharing and network building; maintain RD experience by commom intercomparisons; develop RD competency by works on improvements based on common research projects; involve more young researchers. The ways to preserve and develop the RD knowledge could be asked in the good practice of the near past within the European EWGRD, members of which are research organizations of the countries in Europe operating WWER, PWR and BWR type reactors.

Young scientists and engineers urgently has to be attracted to the field of reactor dosimetry in order to transfer and further develop the available know-how. The interest of young researchers could be find between: receiving additional financial support, doing new professional contacts, involving in team work, involving in research/work community, creating feeling for usefulness and necessity, create feeling for proper pride.

To overcome the insufficiencies of the reactor dosimetry methodologies, improvements based on enhanced calculational dosimetry tools, innovation of experimental methods and approaches as well as creation of new benchmarks are needed. Creation of a concrete shielding benchmark is a necessary task for thermal neutron dosimetry in NPP concrete biological shielding for solving decommissioning problems as well as for optimization of locations and design of control system detection devices used in reactor start up.

The reactor dosimetry improvements could reduce the neutron fluence uncertainty and thus substantiate the extension of NPP lifetime.

Harmonization of calculation methods used in WWER, PWR and BWR design will give more confidence in the results and better conditions for decision making. Creation conditions for participation in joint projects under EC on comparative tasks and measurements should permit to establish common criteria on the reliability of the results and the uncertainty of the evaluations. Establishing sustainable forum for developing harmonized technical procedures is one of main task of EC FP6 NULIFE project.

## 6. Impact

Reinforcement of science and technology potential of many EU institutes will give a base for supporting the nuclear operators and nuclear regulator in safety assessment as well as to strengthen the utilization of the research reactor for medicine and industry purposes. The efforts for knowledge preservation will allow the RD to meet the demand of Gen IV reactors that is the RD to be used for determination of fast and epithermal neutron spectra, which will challenge materials performance with increased radiation damage. It will be applied as an important tool for growing number of reactors that will be decommissioned.

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# MAINTENING COMPETENCE IN RADIATION PROTECTION IN FRANCE WITH THE INSTN EXPERTISE

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## ABSTRACT

One of the most important challenges in the industrial uses of ionising radiation is the implementation of efficient Radiation Protection (RP) in the occupational, public and environmental fields. 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 for, and decreasing number of, radiation protection experts available in Europe, E&T is an essential aspect to reinforce the RP expertise and to enhance a radiation protection culture. Education & Training can help local skills shortages by facilitating the mobility of graduates through European recognition of their qualifications.

This background taking into account, the National Institute for Nuclear Science and Technology (INSTN) within the french alternative energies and atomic energy commission (CEA) has been proposing 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 calls upon approximately 1,200 researchers and experts as French and foreign University Professors, engineers and experts from the industry, medical domain and regulatory agencies.

At the national level, INSTN plays a pivotal role in every 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.

Moreover, the INSTN gives answer to satisfy needs in RP training both in the requirements from professionals and operators (workers in nuclear industry, RP inspectors, Competent Person in Radiation Protection, Radioactive material drivers..;). The institute is in charge of organising short trainings for professionals (Continuous Professional Development CPD) and it brings training solutions to special needs for national and/or international trainings.

## 1. A few facts about the INSTN

As a part of the CEA (French Alternative energies and atomic energy Commission), the National Institute for Nuclear Science and Technology (INSTN) is a higher educational 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 advanced 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 adaptation of scientific and technological development.

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, 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 at INSTN

The variety and the economic importance of applications of radioactivity induces potentially increasing exposure to ionizing radiation for workers. It obviously concerns the domain for the electrical nuclear power plants with about 65,000 workers exercising their professional activity. But ionizing radiation is also increasingly used in the medical sector, exposing almost 150,000 workers (physicians, radiologists, nurses, veterinarians, dentists, medical physicists ...). Beyond these two broad areas, there are more diffuse areas of activity involving about 45,000 daily workers (research activities, the sector of transport of radioactive materials, earth and environmental sciences, the food industry ...).
The use of ionizing radiation in many business areas and the need to ensure security and protect workers' health calls for a wide range of radiation protection training. It should cover diverse educational backgrounds from simple casual user of radioactivity to the most seasoned professionals.
Since its inception, the INSTN has been involved in the field of education and training in radiation protection. Its approach in this sector is based on specific training and fully dedicated to radiation protection. Thus the INSTN disseminates a culture in radiation protection as well as substantial education and training.
With four qualifying and graduate degrees and over 35 different courses in the catalog for the users of radiation sources or personnel who are exposed; radiation protection is a major INSTN thematic (318 training courses conducted in 2009). In 2009, 3526 persons were trained at the INSTN within CPD framework across all sites. INSTN's radiation protection training is divided into 7 sectors contributing to the effective implementation of public policy for the prevention of occupational risks borne by the Ministry of Labour and the Ministry of Health.

## 3. Education in Radiation Protection

The qualitative and quantitative needs expressed by professionals and operators always show the necessity for four types of personnel trained in radiation protection. These are radiation protection workers capable of conducting radiological field surveys; technicians to implement routine radiation protection measures and monitor their effectiveness; senior technicians involved in developing radiation measures and capable of managing teams and engineers involved in design, risk prevention, control facilities and the monitoring of personnel exposed to normal or accidental situations. To meet these demands, the INSTN participates in the organization of four training qualification or degree programs in radiation protection (Figure 1).

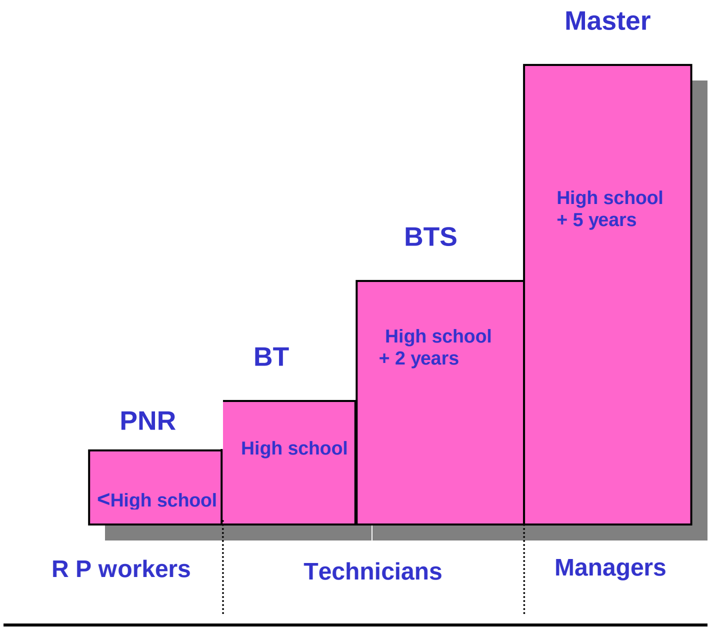


Figure 1: Education in Radiation Protection

These courses are open to students seeking access to careers in radiation protection, and to employees to enable them to improve their professional skills through professional training. Combining theoretical knowledge and operational expertise, they are recognized by professionals and operators, BTS and Masters Degree are recognized by the Ministry of Higher Education.

### 3.1 First Level in Radiation Protection (PNR)

This eight week training program meets the needs expressed by the profession, both within and outside the CEA (AREVA NC, companies providing radiation safety ...). It corresponds to a first level of general education that enables trainees to acquire knowledge and skills necessary for a technical radiation protection job. The growing need for people trained in radiation protection continues to bring more requests for PNR training.

Key figures:

- 3 trainings per year (2 at Marcoule and 1 at Cherbourg), approximately 15 participants per training.
- Number of participants since 1993: 283 (Cherbourg) and 441 (Marcoule).
- Number of people trained per year (table1)

| Year | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Number of people trained | 48 | 57 | 66 | 69 |

Table 1: Number of people trained with First Level in Radiation Protection (PNR)

### 3.2 The Technician Diploma in Radiation Protection (BT)

The course aims to teach technicians to make simple preventive radiological and conduct calculations, in interpreting them correctly and routine measurements of radioactivity control.

The trained technicians have employment opportunities in research and nuclear industry (CEA, AREVA ...), but most are already engaged in the work and undergo training at the request of their employer to acquire a specialization in radiation protection.

Since February 2002, courses have been reorganized to provide a dual education at Cadarache with periods at INSTN and periods of company practices (one month at INSTN, one month in a company). Training is still offered full time in vocational school at Cherbourg.

The goal was to reach a wider audience and offer the opportunity to acquire a solid combination of a corporate learning and theoretical studies at the INSTN. The device can accommodate students, employees in training and people seeking employment qualification contracts. The apprenticeship contract employees have also had access to training since september2003.
Key figures: Number of graduate students per year (table 2)

| Year | | 2005-2006 | 2006-2007 | 2007-2008 | 2008-2009 |
|---|---|---|---|---|---|
| Number of graduate students | Cadarache | 15 | 19 | 17 | 21 |
| | Cherbourg | 8 | 9 | 7 | 6 |

Table 2: Number of graduate students with Technician Diploma in Radiation Protection

### 3.3 The Advanced Technician Diploma in Radiation Protection (BTS)

The BTS "Control of radiation and application of technological protection" enables students to understand the problems of radiation protection and to participate in the development of appropriate measures in different situations they face. They are prepared to implement all the techniques of radiological monitoring and enforce rules to protect against radiations and contamination in accordance with the law. As for the BT, the BTS is practiced with a dual education system. It combines apprenticeships in a company and in a vocational school at INSTN in one course.
The trained specialists are particularly popular in nuclear electrical production industry, as well as in research laboratories using radioisotopes (CEA, AREVA, DCNS, EDF, research laboratories, hospitals….)
Key figures: Number of graduate students per year (table 3)

| Year | 2005-2006 | 2006-2007 | 2007-2008 | 2008-2009 |
|---|---|---|---|---|
| Number of graduate students | 21 | 18 | 16 | 24 |

Table 3: Number of graduate students with the Advanced Technician Diploma in Radiation Protection
The number of participants since 1991: 509

### 3.4 The Masters degree in Radiation Protection

This professional Master is aimed at students as part of education (M1 in basic or applied physics or equivalent degree), as well as professional trainees. These students can attend all or part of the master program and thus capitalize ECTS (European Credit Transfer System).
This education is jointly organized by the University Joseph Fourier of Grenoble (UJF) and the INSTN. This second year Master degree is an option of the UJF “Master ISM”.
A vast change occurred with the addition of two more universities in order to create the European Masters degree in Radiation Protection (EMRP), in 2006. This was one of the ENETRAP's (European Network on Education and Training in Radiological Protection) 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 Prague and the UK with the UHI North Highland College in Thurso, Scotland. The objectives of EMRP are firstly to build an integrated second year Masters 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); and secondly, to propose within this Academic course, a harmonized curriculum for Radiation Protection Expert to fulfil the requirements of the EURATOM Directive 96/29 thus favouring the mobility of experts across Europe.
With this Master unique in France, 213 students have been trained since 1995.
Key figures:
Number of graduate students per year (table 4)

| Year | 2005-2006 | 2006-2007 | 2007-2008 | 2008-2009 |
|---|---|---|---|---|
| Number of graduate students | 19 | 13 | 15 | 15 |

Table 4: Number of graduate students with the Masters degree in Radiation Protection

The modular approach allows professional to attend all or some modules of the course.
For the five past years, 8 EDF staff registered for some specific modules. The Navy routinely sends officers and medical doctors to be trained in this Master.

## 4. Training Courses 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 only describe in this paper the 2 most important training programs: Competent Person in Radiation Protection (PCR) and Radiation Protection Inspectors. The other training is described on the INSTN website: www-instn.cea.fr

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### 4.1 Competent Person in Radiation Protection (PCR)

When an institution is within the scope of the regulatory mechanism in radiation protection, the employer must fulfil certain administrative responsibilities including the appointment of a person competent in radiation protection (PCR). This requirement affects all professional sectors: medical, industry, research and nuclear industry. One of the PCR's tasks is to train within its company, all employees facing radiological risks. The PCR is therefore a key negotiator to implement the functional organization of radiation protection in the enterprise.
To become a PCR, the employee designated by the employer should be trained in accordance with the provisions of the order of October 26th, 2005. This regulation provides the advantage of imposing, wherever there is a risk of radiation exposure to workers, the presence of a person trained in radiation protection. This same regulation also requires the training of PCR (initial + renewal training every 5 years) taught by certified trainers and defines the procedures for certification. In fact, since September 2006, INSTN can rely on the skills of five certified trainers located on its sites in Saclay, Cherbourg and Marcoule.
The INSTN has been providing training for the PCR since 1987: more than 2,500 trainees have been trained to date. The Institute has extended its offer of a comprehensive training to all sectors involving PCRs: nuclear industry, research and medicine, and has also trained the bulk of the management or radiation protection centers CEA, AREVA and ANDRA through the training renewal PCR.

### 4.2 Radiation Protection Inspectors

Since 2004, INSTN has been providing training specific to radiation protection for staff inspection of the Nuclear Safety Authority (ASN). Participants in this session are the future agents of ASN and have to inspect the facilities industry, research and hospital sector in which workers are subjected to a risk of exposure to ionizing radiation. Endowed with high levels of education, these participants (mining engineers, pharmacists, doctors ...) acquire strong theoretical knowledge and operational radiation safety and regulation at the end of this course and benefit from the expertise of CEA trainers.
Key figures:
Since 2003, INSTN Saclay has taught 10 sessions of 15 days each for the inspection staff of the ASN after which 139 inspectors were trained in radiation protection.

## 5. Conclusion

The INSTN is one of the major players in France in education and training in 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.

# DEVELOPMENT OF A RADIATION PROTECTION TRAINING SYSTEM AND PROFESSIONAL SKILLS MODEL IN A MULTINATIONAL OIL AND GAS INDUSTRY

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## ABSTRACT

The oil and gas industry makes extensive use of radioactive sources potentially dangerous to human health and to the environment if not properly controlled, including: industrial radiography, radioactive gauges, well logging activities, use of radiotracers. In addition, the accumulation of natural radionuclides (T.E.N.O.R.M.) may occur in the Oil&Gas extraction and treatment plants.
*eni S.p.A.* operates in more than 70 countries, with a staff of 79000 employees, in all climates and environments, including the most arduous conditions, and is continuously challenged to achieve high efficiency of operation while maintaining a high standard of safety, including the radiation protection aspects. Thus, in order to maintain the control over occupational exposures to radiation, to protect the public and the environment, and in order to deal with local rules and authorities, it has been developed a Radiation Protection Professional Model including three different roles (Radiation Protection Management, Radiation Protection Coordination and Operational Radiation Protection) that could be associated with the corresponding functions: Radiation Protection Expert, Radiation Protection Advisor, Radiation Protection Specialist.
The Professional Model is a global *eni* tool devoted to the know-how and the development of the human resources, including health, safety and environmental aspects, through the identification of detailed skills and knowledge.
In order to provide the required knowledge to *eni* workers all over the world, it has been developed a programme for education and training in radiation safety in collaboration with *eni Corporate University*, the *eni* company that manages orientation, recruitment, selection, training and Knowledge Management.
Different training courses are organized to provide the training both for the Radiation Protection Coordination role (Radiation Protection Advisor course) and for the Operational Radiation Protection role (Radiation Protection Specialist course). Moreover, extensive awareness courses are organized, at the headquarter or directly on site, in order to improve the knowledge of *eni* workers regarding basic concept of radiation protection.

## 1. Introduction

### 1.1 Radiation protection in Oil&Gas industry

The oil and gas industry makes extensive use of radioactive sources potentially dangerous to human health and to the environment if not properly controlled. In addition, significant quantities of naturally occurring radioactive material (N.O.R.M.) originating from the reservoir rock are altered and concentrated during production, maintenance and decommissioning (T.E.N.O.R.M.).
*eni* operates in more than 70 countries, in all climates and environments, including the most arduous conditions, and is continuously challenged to achieve high efficiency of operation

while maintaining a high standard of safety, including the radiation protection aspects. Thus, is needed a control over occupational exposures to radiation, as well as to protect the public and the environment.

*RADI Unit* deals with all these aspects from the headquarter based in Italy, but, due to the complexity of the subject and the number of countries in which *eni* operates, it has been shown the necessity to train some experts in each subsidiary in order to deal with local rules and authorities and to have a better management of the site radiological situation. [1]

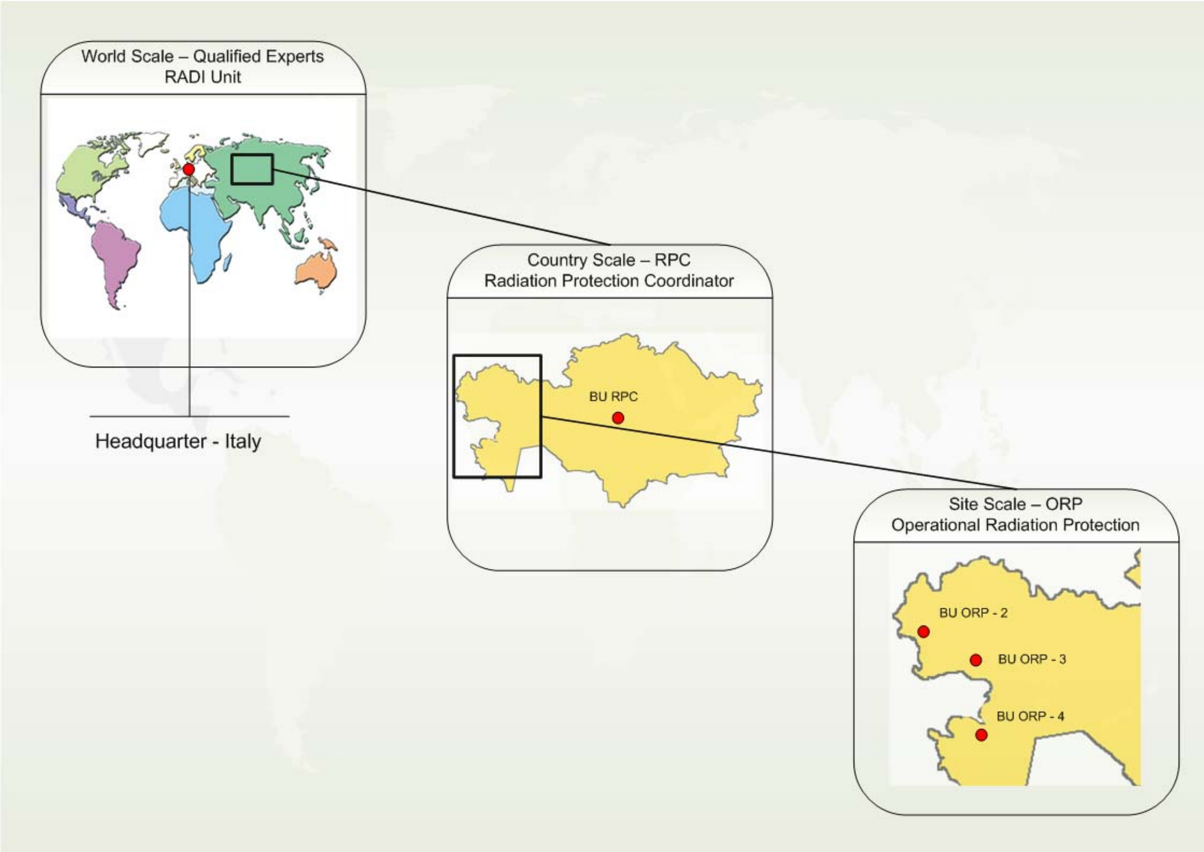


Fig 1. Radiation protection roles in *eni*

## 1.2 Radiation protection impacts of the Oil&Gas industry

There are several working activities and situations which involve potential exposure to ionizing radiation and radioactive materials in the Oil&Gas industry that need to be well managed, including [1]:

- Industrial radiography (NDT-R);
- Nuclear gauges, including those used to make level and density measurements;
- Well logging;
- Radiotracers;
- Radioactive smoke detectors;
- T.E.N.O.R.M.;

Based on our experience, the NDT-R (for the management of the external irradiation) and the T.E.N.O.R.M. (for the management of the internal contamination) reflect the most critical problems.

Both these aspects are present in nearly every country in which *eni* operates, thus, in collaboration with the *Organization Unit* that ensures the development, planning, definition and updating of the *eni* organizational structures, a professional model has been developed including three different roles that can help to manage the radiation protection all over the world: the Radiation Protection Management, the Radiation Protection Coordination and the Operational Radiation Protection.

# 2. Professional Model

## 2.1 Introduction to the Professional Model

The Professional Model is a tool devoted to the development and management of the know-how of resources, in this specific case related to radiation protection, through the identification of detailed skills and knowledge, as well as the best directions to value and disclose them.

## 2.2 Radiation Protection Roles

By the Professional Model we have introduced the following professional roles:

- Radiation Protection Management (RPM)
- Radiation Protection Coordination (RPC)
- Operational Radiation Protection (ORP)

These roles deal with the following main aspects:

- RPM:
  - Managing activities relating to radiation protection ensuring the improvement of quality and technological innovation and methodology.
  - Ensuring dissemination of knowledge regarding radiation protection.
  - Managing the compliance and verification of compliance with regard to radiation protection for activities relevant to the organization.
  - Coordinate or conduct radiation protection audits relevant to the organization or parts of it.

- RPC:
  - Coordinate the ORP and to liaise with RPM.
  - Advise the line Management in radiation protection matters and to ensure that activities are compliant with the local legislation and Company policies and procedures.
  - Ensuring dissemination of knowledge regarding radiation protection in the Business Unit (BU).
  - Managing the compliance and verification of compliance with regard to radiation protection for activities relevant to the BU.
  - Coordinate or conduct radiation protection audits relevant to the BU.
  - Contribute to the training, development and competence assessment of the Operational Radiation Protection professional role.
  - Planning, monitoring and recording aspects of radiation protection in operations at the level of BU.

- ORP:
  - Liaise with RPC.
  - Planning, monitoring and recording aspects of radiation protection in operations at the level of plant/site.
  - Conduct radiation protection inspection relevant at the level of plant/site.

# 3. Training

## 3.1 Introduction of the Training Programme

In order to provide the required knowledge to our workers, in collaboration with *eni Corporate University*, the *eni* company that manages orientation, recruitment, selection, training and Knowledge Management, a programme for education and training in radiation safety has been developed.

The development of the training courses has been based on the international best practices [2] involving the preparation of a training schedule, lesson plans, training materials, practical training sessions and assessment procedures.

## 3.2 Design of the Training

By considering the needs of all interested parties, the main aims of the training courses have been determined:

- **Radiation Awareness Course**: provide to workers that could be involved with ionizing and non ionizing radiation awareness regarding Radiation Protection aspects;

- **Radiation Protection Specialist Course**: provide to workers involved in the management of radiation protection in the BU sites an operative knowledge of Radiation Protection;

- **Radiation Protection Advisor Course**: provide to workers involved in the management of radiation protection in the BU headquarter an operative and management knowledge of Radiation Protection.

Every year the training courses are organized for the BUs, not only in order to train the future Radiation Protection Advisors or the Radiation Protection Specialists, but also with the Radiation Awareness Course in order to share information with every worker that could be involved with ionizing and non ionizing radiation.

Regarding the training schedule, practical exercises, video presentations and interactive group sessions have been introduced at regular intervals throughout the courses in order to break the lecture blocks into manageable units and to reinforce the subject matter.

During the training and at the end of each course assessments of the competence are taken to determine whether the learning objectives have been met and the necessary level of competence has been achieved. [2]

In order to give the course participants a valuable opportunity to observe the practical application of requirements and procedures for radiation protection, technical visits to facilities where ionizing radiation is used have been often included in the course schedule (e.g. Industrial Radiography in refineries and TENORM survey in oil plants).

As it is important that all workers refresh and update their knowledge and skills, a programme of refresher training has been planned every three years.

Following, in Tab.1, the contents of the courses that are provided and the level of knowledge required for the single module (L=LOW, M=MEDIUM, H=HIGH) are shown.

| | **RA Course** | **RPS Course** | **RPA Course** |
|---|---|---|---|
| **Contents** | **4 hours** | **3 days** | **4 weeks** |

| | Level of knowledge | | |
|---|---|---|---|
| **Basics of Radiation Protection** | | | |
| History of radioactivity. | - | L | M |
| Basics of atomic and nuclear physics. | L | M | M |
| Natural sources. | L | M | H |
| Artificial sources. | L | M | H |
| Interaction of radiation with matter. | - | L | M |
| External irradiation. | M | M | H |
| Internal contamination. | M | M | H |
| Biological effects of radiation. | L | M | M |
| Exposure to non ionising radiation - theory and direct measurement in situ. | L | M | H |
| **Radiation Measurement** | | | |
| Quantities and units. | - | L | M |
| Dosimetric services - theory and practical in laboratory. | - | L | M |
| Radiometric analysis - theory and practical in laboratory. | - | L | M |
| Detection and measurement methods - theory and direct measurement in situ. | - | M | H |
| **Radiation Protection Management System** | | | |
| International radiation protection organizations. | - | - | L |
| ICRP principles. | L | M | H |
| International legal and regulatory basis. | - | L | M |
| National legal and regulatory basis. | L | H | H |
| **Operations in presence of radioactivity** | | | |
| Industrial radiography (activities, handling & storage, emergency management, accident case history) - theory and visit to a NDT-R company. | L | H | H |
| Logging activities (activities, handling & storage, emergency management) - theory and visit to a logging activities company | L | H | H |
| Nuclear gauges (flowmeter, density meter, radioactive smoke detectors) - theory and visit to a refinery | L | H | H |
| Transport radioactive source. | L | H | H |
| Technologically Enhanced Naturally Occurring Radioactive Material - theory and visit to facilities. | L | H | H |

Tab 1: Contents of the courses and level of knowledge required

## 4. References


[1]. SAFETY REPORTS SERIES No. 34, Radiation protection and the management of radioactive waste in the oil and gas industry. IAEA 2003.

[2]. SAFETY REPORTS SERIES No. 20, Training in radiation protection and the safe use of radiation sources. IAEA 2001.

# USING A WHOLE BODY COUNTER TO ATTRACT A YOUNGER GENERATION TO RADIATION AND RADIATION PROTECTION TOPICS

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## ABSTRACT

Currently there is a lack of young academics in the nuclear field especially in the field of radiation protection RP. One of the reasons is the very small number of students in the so called STEM subjects (science, technology, engineering and mathematics) which distribute among the different topics in these fields. One important task to overcome the foreseeable shortage of RP professionals is to attract pupils to this field.
In routine monitoring the whole body counter of the Institute of Radiation Research (ISF) is used to identify and quantify radioactive materials that are incorporated in the human body using the technique of gamma spectroscopy. The in-vivo monitoring lab participates in activities for pupils at school level, e.g. Kinderuniversität, practical studies of secondary level pupils and “Girls day”. Pupils that come to the lab are ages 14 to 18. The whole body counter is an optimal tool for these children to experience (natural) radioactivity and radiation protection issues. First pupils get a short introduction on radioactivity and gamma spectroscopy at a level adjusted to their current knowledge. After this they are measuring themselves in the whole body counter. A routine measurement of 300s is able to show the natural occurring K-40 in their bodies. After their own measurements they do calibration measurements using a bottle phantom with a set up adjusted to their own body weights. The bottle phantom is filled with a potassium chloride (KCl) solution and contains no other radioactivity than the natural K-40 content of the KCl. Thus no further radiation protection measures need to be taken for using this phantom. A simple Excel-Sheet is then used to estimate their own K-40 activity by comparing the spectra of their measurement to the ones of the calibration measurements.
This “hands on” experience and the connection of radiation and their own bodies often is a “eureka” effect and opens discussion on preconceptions of radiation and the need of RP. The “course” as presented here can easily be adjusted to the different ages and levels of knowledge of the pupils. Our experience with these events shows a large interest and an active participation of the pupils especially in the discussions at the end of the day. Feedback of the participants is predominantly positive and shows the inherent interest in STEM which can be awakened or kept awake by such events.

## Introduction

Currently there is a lack of young academics in the nuclear field especially in the field of radiation protection. One of the reasons is the very small number of students in the so called STEM subjects (science, technology, engineering and mathematics) which distribute among the different topics in these fields. One important task to overcome the foreseeable shortage is to attract pupils to this field. This issue has been identified by many organisations and some projects have been initiated. For example one workpackage of the ENETRAP2 (Education and Training in RAdiological Protection) project has been dedicated to “Enthusing and attracting young generation with radiation protection” [1].
The Institute for Radiation Research (ISF) at the Karlsruhe Institute of Technology (KIT) participates in academic education in the nuclear field. Lectures on Radiation Protection topics are held by scientists of the ISF, who also supervise practical studies and theses (bachelor, master and PhD) performed in the institute. ISF is linked to the KIT Department of Safety Management which runs several physical and chemistry laboratories, including

radioanalytical and dosimetric services for the KIT site and for external customers. One of the laboratories is the in-vivo monitoring lab (IVM), which operates one whole body counter and three partial body counting systems. The lab is used for incorporation monitoring of employees working with radioactive material, by direct measurement of gamma radiation emitted from ingested and/or inhaled radionuclides. Approximately 2000 measurements are done per year for KIT and external customers. Besides the routine work of IVM the counters are also used for scientific experiments and educational purposes such as demonstrations in radiation protection courses or the education of pupils which will be described in this paper.

## Material and Methods

### 2.1 The whole body counter

The whole body counter at IVM is a stretcher surrounded by four NaI(Tl) detectors (diameter 8inch) which is placed in a low level shielding chamber. The minimum detectable activities for the routine measurements of 300s are low enough to identify and quantify the natural occurring nuclide K-40 inside a human body. Details about the lab and the whole body counter can be found in [2].

### 2.2 The K-40 Bottle Phantom

Calibration of in-vivo Measurements are usually done by measurements of known activities distributed in anthropomorphic phantoms [3]. At IVM a so called brick phantom is used for the routine calibration measurements. Additionally a bottle phantom is used for quality assurance (QA)-measurements, e.g. checking of efficiency factors after a modification of the counter. This bottle phantom is made up of a set of Kautex [4] bottles (2 litre and 1 litre) which are filled with a solution of potassium chloride. The bottle phantom contains no other radioactivity than the natural K-40 content of the KCl-solution. The concentration has been chosen to be 2g Potassium per kg (i.e. 64Bq K-40 per kg), which corresponds to the average concentration of Potassium in man [5]. Thus measurements of this phantom can also be used to determine minimum detectable activities.

Phantoms of different body weights can be constructed by placing the according number of bottles on the stretcher. The positions are chosen to (more or less) depict the shape of a lying human. Reference positions are defined for 10 to 100kg in steps of 10kg. A set up of the 70kg Bottle Phantom is shown in figure 1. The phantom is easy to handle and set up in the whole body counter. One only has to take care that the bottles are properly closed in order not to spill water. Due to the low activities and the natural occurring material no further precautions need to be taken while handling the phantom. This makes the bottle phantom an ideal tool for education of pupils, because no formal radiation protection issues need to be fulfilled for this training lesson.

Fig 1.  The 70kg Bottle Phantom in the KIT whole body counter

## Design of a typical "training event" for pupils

In-vivo Lab at KIT offers training events for pupils in secondary schools. Most of these events are half or one day visits, but the structure as presented below can be extended up to one week of practical studies. Groups shall be kept small (up to 5 or 6 pupils) to have optimal mentoring conditions. The programme we designed aims to give a "hands on" experience of radioactivity in man. Pupils shall get an idea of radioactivity (inside the human body), its consequences and how to measure the content of radionuclides in a body.

Groups that visit the lab get a short introduction to radioactivity and gamma spectroscopy adjusted to their level of knowledge. Most of the pupils are aged 14 to 18 and have none or only little knowledge of the basics. Thus first some questions on their knowledge about and experiences with radiation are asked. The introduction is primarily done by a small presentation with few slides for illustration, but we try to have an open informal discussion with the pupils during this demonstration. During the whole day the group is encouraged to ask their questions. The introduction itself is kept short in order not to overexert the audience. After the lesson the pupils get a guided tour of the laboratory. Here the duties and responsibilities of the lab are presented. Some posters describing the lab are displayed in the waiting area of the whole body counter and are used for illustration. After this short tour the pupils start to measure each other. A routine measurement of 300s is done for every pupil. The spectrum itself and its evaluation are explained to the pupils using the first spectrum measured. The level of detail in the explanations is adjusted to their level of knowledge.

In IVM-routine the measured spectra are evaluated by fitting a weighted sum of reference spectra (taken from measurements of phantoms) to the actual measurements. The scaling factors then give the activities. For the pupil's spectra K-40 is the only nuclide present, thus only a K-40 reference spectrum is needed. After measuring themselves the pupils measure bottle phantoms according to their weight (which is usually 50-70kg). They get the plans with the reference positions of the bottles and start setting up the according phantoms. Each phantom is measured for 1800s. The statistical errors of these measurements are rather high, but still acceptable for the educational purpose. The time during these measurements is used to discuss about the consequences of the activity inside humans. Here issues like dose and risk are explained, again at a level adjusted to their knowledge.

All of the measured spectra are then exported to Excel files where they can be evaluated "by hand". An Excel spreadsheet (figure 2) has been prepared for this purpose. The spectra are copied to this file and the further information (measurement time, activity inside the phantom, …) are entered. The two spectra (pupil's measurement and calibration phantom) are corrected for chamber background and displayed. The counts inside a defined region of interest (centred around the K-40 peak at 1460keV) are calculated and displayed. The calibration spectrum can be scaled by changing the value of defined cell of the Spreadsheet (the cell with green background in figure 2). Pupils can then adjust this value until the ratio of the integrated counts in measurement and calibration are 1.0. Here they experience the process of fitting two spectra, depending on their knowledge the mathematical background is explained to them in more detail. Finally they can enter their names and print out their own assessment of activity. For more experienced pupils an advanced Excel-Sheet has been prepared. With this Excel Sheet a mass-dependent calibration curve can be constructed from a series of measurement of different phantoms. The curve is then used to evaluate the measurement. This sheet requires a more sound knowledge of mathematics and more explanations, thus it is only used for workshops which last more than one day. Then also more detailed work on set up of the measurement electronics is explained to and performed by the pupils. Optionally the workshops are extended to include work on partial body measurements.

At the end of the visit all pupils get a folder with information material (e.g. the slides presented or hand outs of the posters displayed in the lab) and print outs of the pictures taken during the day.

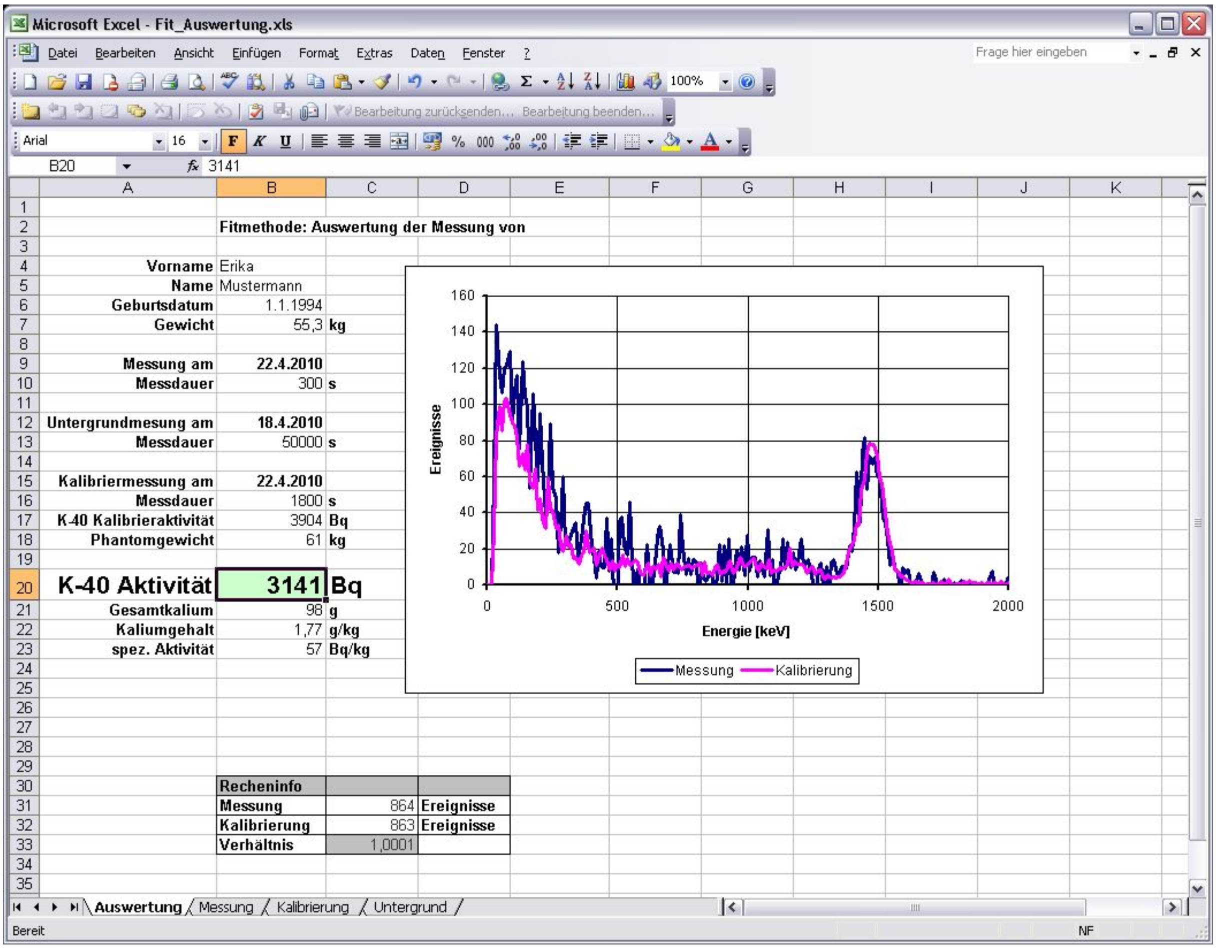


Fig 2. Screenshot of the Excel sheet used to evaluate the measured spectra. A fitting of the calibration spectrum to the measured spectrum is performed by altering the activity values in the cell highlighted in green.

In these visits to IVM the pupils do the essential steps of in-vivo measurements by themselves. They calibrate the counter by measurements of phantoms, they measure a subject (themselves) and they calculate the activity from these measurements.

## Experiences and Discussion

Since 2007 several groups of pupils have visited the In-vivo monitoring lab at KIT and participated in these “training events”. Most of the events were part of larger actions e.g. “Kinderuniversität” or “Girls day”, but also groups did their practical studies of secondary level pupils (BOGy) at the lab. One of the events that takes place on a yearly base is “Girls’Day – ‘Future Prospects for Girls’” which is supported by German Federal Ministry of Education and Research (BMBF) and Ministry of Family, Senior Citizens, Women and Youth (BMFSFJ) and European Social Fund. Girls day is intended to provide information about a wide range of jobs that require training as well as courses of studies in the areas of technology, natural sciences, IT and craft. Girls can try out their skills in a practical way, make important contacts and get to know women in management positions and those who are entrepreneurs” [6]. Karlsruhe Institute of Technology participates in this event and offers several actions on different topics. One of these actions is “Radioactivity in humans” at in-vivo monitoring laboratory which is fully booked every year since 2007. The girls (aged 15 to 17) do the half-day “course” as described above and get an impression of the work at our lab.

Pupils that come to the lab for other courses are ages 14 to 18. Younger pupils may not be able to follow the whole day(s) because they often miss some prerequisites (e.g. concept of atoms) which then need to be explained during the course. This will drown the pupils with information and should be avoided. We tried to keep the “new” contents of the course as low as possible, thus some basic elements of STEM education are required. For a deeper understanding and treatment of this topic the “course” can be embedded in regular classes (e.g. physics) or as project work in schools. Here IVM offers support to interested teachers.

Overall reactions on our training events are positive. The “hands on” experience and the connection of natural radiation and their own bodies often is a “eureka” effect and opens discussions on preconceptions of radiation and the need of radiation protection. During these discussions further information (depending on the knowledge, interests and capacity of the pupils) is presented. Here e.g. Cs-137 in mushrooms or medical application of radioisotopes is discussed. The “course” as presented here can easily be adjusted to the different ages and levels of knowledge of the pupils. Our experience with these events shows a large interest and an active participation of the pupils especially in the discussions at the end of the day. Feedback of the participants is predominantly positive and shows the inherent interest in STEM which can be awakened or kept awake by such events.


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# WESTINGHOUSE EUROPEAN TRAINEE PROGRAM

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## 1. Introduction

Westinghouse Electric Company is proud of giving its employees the possibility to work and act globally. The company's *European Trainee Program* provides an opportunity to work within different fields of business within Westinghouse, participating in a wide range of projects and experiencing and learning from the different cultures of the company.

## 2. First experience

In 2006 the first Trainee Program, Fig. 1, started with seven Swedish Trainees. During these eighteen months they worked 12 months in Sweden and then went off to six-month-assignments in France and in the US.

Fig 1. Trainee Group No. 1 at Westinghouse Sweden

## 3. European Trainee Program 2008/09

In April 2008, the first European Trainee Program, Fig. 2, was launched with ten Trainees from four different countries: five from Sweden, two from Germany, two from Spain and one from Belgium. As with the previous program, its length was eighteen months.

During the first year, the European Trainees had the opportunity to work in various areas within their country of hire, as well as to visit different Westinghouse headquarters in Europe and the US to learn more about the global business.

Their kick-off session took place in ***Västerås***, Sweden in April 2008. During four days, the Trainees participated in group dynamic exercises as well as presentations of the business of

Westinghouse abroad and in Sweden. Two of the most interesting parts of this session were the visits to the Fuel Factory and to the Field Services mock-ups.

Fig 2. The European Trainee Group at kick-off in Västerås, Sweden on April 1, 2008

The second session took place in June 2008 in **Monroeville**, Pennsylvania (USA), where Westinghouse had its main headquarters, nowadays located in Cranberry, PA. During two weeks, the trainees got to know even more about Westinghouse through visits, lectures and forums for open discussions. The visits comprised for example the tubing factory at Blairsville, the Field Services main headquarters in Madison and the George Westinghouse Research and Technology Park near Pittsburgh. The meetings included presentations of each Westinghouse business unit, detailed information about future projects and round table discussions with managers.

The third session occurred in September 2008 in **Madrid**, Spain. During four days, the Trainees attended presentations about the business of Westinghouse in Spain, as well as various technical and management courses. Highlights of the week included the visit of “El Cabril”, the Spanish low-level waste disposal and Córdoba, one of Spain’s most beautiful cities.

The next session took place in **Nivelles**, Belgium, in December 2008. During five days the Trainees took some useful management courses and got a good overview of the activities of Westinghouse Belgium. The Trainees also visited one of the most important research centers in Europe: the SKC-CEN as well as the controlled area of Field Services.

The last session took place in **Mannheim**, Germany, in February 2009. During four days the Trainees took some further management-related courses and got to know Westinghouse Germany a little more. They also had the opportunity to visit a nuclear power plant in operation, which was both really interesting and very useful.

For the last six months of the program, the Trainees were able to choose a location for their international assignment: two Trainees went to the US, two went to Belgium, two went to Spain and one each went to Sweden, Germany, UK and France.

## 4. Second European Trainee Program

In October 2009 a new wave of the European Trainee Program started, with trainees from Sweden, Spain, Germany, Belgium and France as well. The program has the same basic outline as before. The Trainees have the opportunity to become acquainted with Westinghouse during 18 months with the most part of the program spent in the country of hire, and the last six months on abroad assignment.

Fig 3. The European Trainee Group at kick-off in Västerås, Sweden on October, 2009

## 5. Conclusions

The European Trainee Program gave the trainees the chance to work in an international environment for one year and a half. During the time based in their country of hire, they all tried different departments and projects to get to know more about the work being performed. It gave them also the chance to work with different managers and colleagues.

During the visits to the different headquarters the trainees got a very good overview of Westinghouse’s activities around the world and got familiar with the company’s philosophy and way of work. It was also a fantastic opportunity to meet high level managers and visit interesting places related to Westinghouse business and the nuclear industry.

One of the most valuable parts of the program was the experience of being part of a group with people of different cultures. It was a useful insight to see how different even European cultures can be in the way of doing business.

The international assignment was of course also a good way of broadening the mind to different ways of working. It was also a great opportunity of networking for the future. This will definitely be useful in sharing opportunities and knowledge across different countries.

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