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APPROACHES IN SECTOR SPECIFIC TRAINING

SECTOR-SPECIFIC IN-HOUSE EDUCATION AND TRAINING AT SIEMENS

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ABSTRACT

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

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

Since Konrad Wilhelm Röntgen's discovery of the X-rays and their penetrating abilities more than one hundred years have elapsed and we still use the same old radiation today to look into the human body. As on the physics side nothing has changed since then, our way of handling radiation definitely has.
When I joined the X-ray field in 1965 there was but one rule presented to me by the big boss on my very first day: You have to satisfy our customers! If there is a conflict coming up and you call me first I'll back you up. If however the customer calls me first I'm on his side. Now, at that time mobile phones were not available and so I learned to avoid conflicts. This little episode points out that nobody really cared what we did to the X-ray unit as long as the customer was satisfied.
Today, the situation is completely different and the field of medical X-ray equipment is strictly controlled.

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

1.1 The X-ray Unit

The **Design** is ruled by the **Medical Device Directive** 93/42/EEC, which was to put into national legislation by the member states and is also basically accepted worldwide.
According to this directive, a medical device is **classified** according to its inherent potential hazards in combination with its intended use.

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

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

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

1.2 The X-ray department

To ensure safe operation, **radiation protection areas** are established according to the level of radiation exposure.
The examination room with the X-ray unit inside becomes the **controlled area** where an effective dose of more than 6mSv per year is to be expected. Persons working in this area have to monitor their personal dose to document how well they have protected themselves against scattered radiation.
Areas outside the controlled area where persons may get more than 1mSv per year are declared **supervised areas**.
Public areas must be kept below 1mSv per year by structural radiation protection.

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

1.3 Operation of X-ray systems

The very specific part of the medical X-ray business is the deliberate **application of radiation to persons** in order to get a radiograph.
While the Medical Device Directive is very specific about the essential requirements and the conformity assessment procedure, it leaves the **responsibility of operation to the member states**.
Our German authorities have used this freedom to specify essential requirements **depending on the intended use** and also set limits to the **image receiver dose** accordingly. Setting the strict demand:

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

In the light of this, the automatic exposure control systems of our X-ray units are set to different levels of image receiver dose providing different resolution of detail. These dose settings provide a good base for a proper diagnosis with a minimum of biological hazard to the patient. The actual absorbed dose, however, depends very much on the way the examination is performed; the number of exposures and the total fluoroscopy time along with other parameters.
Recently, the focus of radiation protection turned away from pure technical parameters and concentrates more on the patient dose directly. As a result of this the patient dose is monitored by a **dose area product** measurement and reference values for the various kinds of examination are published by the EC. These reference values have become the guide line for the examination. The radiologist is now challenged to make a diagnosis within the reference dose.

2. Specific radiation protection knowledge

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

- **Level 0, design**
  The designing engineers have to adhere to the harmonized standards according to the MDD. The prototype unit has to be tested in cooperation with the physicists of the radiation protection department. Manufacturing procedures are established in cooperation with physicists and engineers of the Notified Body. Next, instructions are written for all steps of manufacturing, installation, operation and maintenance.
  At this level knowledge of radiation physics and protection are definitely required.
- **Level 1, manufacturing**
  At this stage of production, assembly and testing in the factory, extensive radiation protection knowledge is not required. *If settings have to be done using radiation, the personal are trained and supervised by the radiation protection officer.*
- **Level 2, putting into operation**
  Here, the X-ray engineer does the on site adjustment and testing and presents the system to the hospital/government physicist. What he, normally, is not aware of is the fact that he complies to the request
  "The required image quality must be achieved with reasonably low dose"
  by setting the dose and testing image quality according to unit specific instructions. *At this stage he operates the unit under his responsibility which requires a minimum knowledge of radiation physics, radiation protection and biological hazards*.
- **Level 3, maintenance**
  Keeping the system operational seems to be a pure technical task. However, our field service engineer has to be able to *identify the internal and external radiation protection devices and check their functional integrity*.
- **Level 4, application support**
  With modern, computer controlled X-ray systems the technical side is run automatically and the radiologist can concentrate fully on the patient and the examination. According to the kind of examination performed the X-ray system controller operates on various instruction sets called organ programs. Each organ program contains parameters affecting radiation quality, image receiver dose and image processing.
  While the field service engineer is not allowed to apply radiation to patients, however, with growing experience, he has to learn the sequence of actions in a radiological department and understand the various examinations. *As an application specialist he has to understand the radiologists request and fine tune the organ program parameters, knowing their influence on patient dose and image quality*.

3. Sector-specific in-house education and training

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

3.1 The statistics

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

3.2 Vocational qualification

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

3.3 Training on knowledge in radiation protection

The **evident radiation protection training** required for level 2 (putting into operation) takes place during the **fundamental X-ray class**. It comprises X-ray physics, biological effects of radiation and radiation protection measures as straight forward lessons including practical demonstrations when possible. The more subtle training occurs during the class where the general functions of the essential components and their interrelations are explained and demonstrated.
As pointed out earlier, the training on dose adjustment and measurement, the mechanical alignment procedure of radiation field and light localizer as well as basic image quality tests can be seen in the light of radiation protection training. At the end of the class when all the interactions and various functions are known, they learn how fluoroscopy parameters can be set to reduce the patient dose without affecting the image quality too much.
During this fundamental training the X-ray engineer learns to handle X-ray equipment safely and is enabled to join advanced equipment training. Since X-ray physics and the physical radiation protection is the same all over the world, we assume that this training is recognized as sufficient worldwide. However, training on the **governmental handling** of X-ray equipment has to be provided by the local business units since we may never have uniform regulations worldwide.

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

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

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

3.4 Governmental handling in Germany

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

As a consequence of it, all German field service engineers get a training to obtain the
Requisite Knowledge and Know-How in Radiation Protection.
Along with this they are introduced into the German regulatory environment. Only then they are allowed to service X-ray equipment in their own responsibility.

Additional classes provide training in the required
Acceptance and Constancy Tests
which are part of the governmental approval procedure.

Education and Training of Radiation Protection Officers in Sweden

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Introduction

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

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

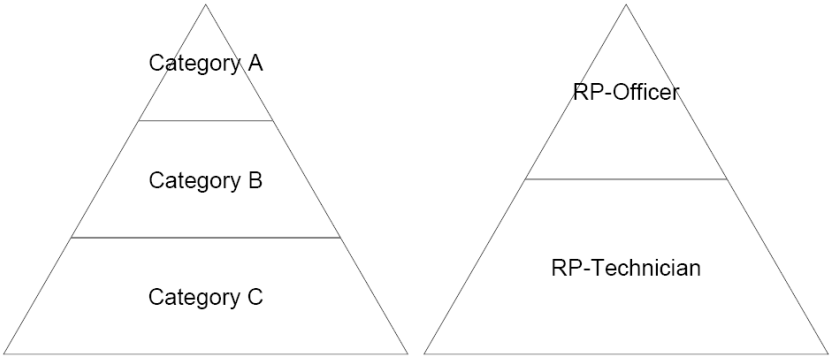

Figure 1. Three different levels of RPO´s in Sweden (external versus nuclear facility)

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

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

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

Executing the Task

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

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

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

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

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

Education for RP-Technician Category A/RP-Officer

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

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

- RP-experiences from the world around

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

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

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

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

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

Minimum two work weeks per area and documented.

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

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

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

Education for RP-Technician Category B

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

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

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

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

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

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

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

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

Minimum two work weeks per area and documented.

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

Education for RP-Technician Category C

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

The course contains the following areas:

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

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

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

The Results in General

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

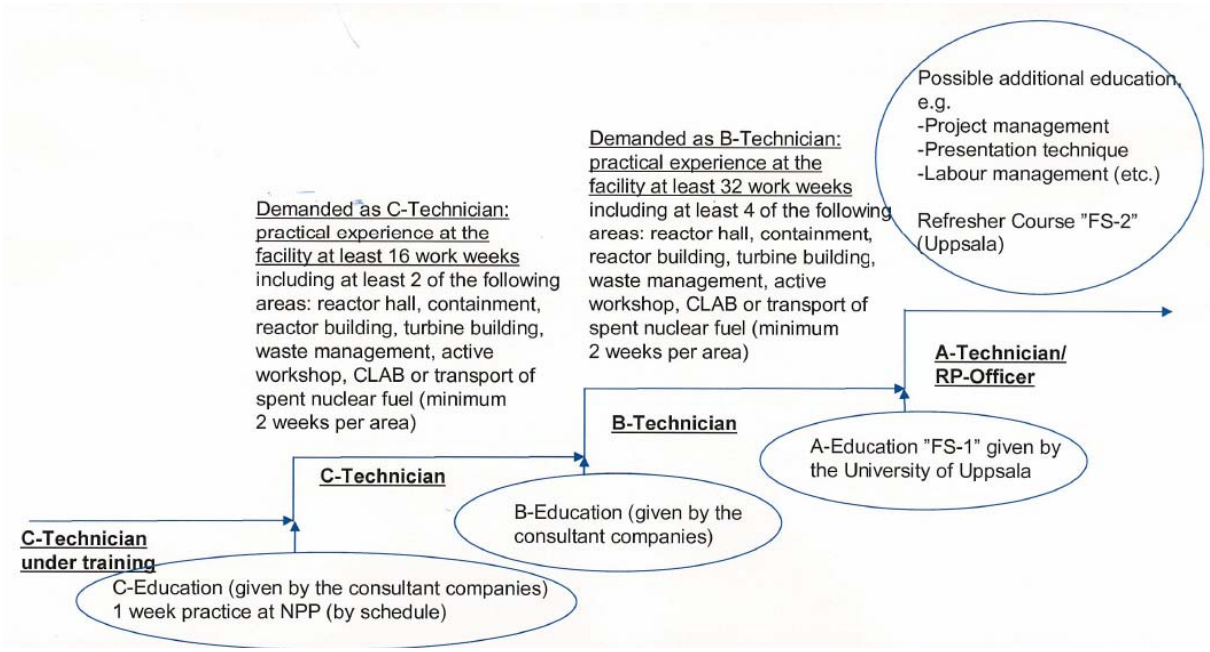

Figure 2. Education and training of the radiation protection technicians and officers in Sweden

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

Work still needed to be done

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

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

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

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

The goal is also to transfer the main responsibility for E&T of the consultant companies´ personnel from the companies themselves to the nuclear facilities. This in order to guarantee an equal level of E&T with every separate course. There is an ongoing discussion about how this is going to be done in practice.

Future Challenges

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

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

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

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

SKILLS IN RADIATION PROTECTION WITH FOCUS OUTSIDE RADIOLOGICAL DEPARTMENTS

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ABSTRACT

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

1. Introduction

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

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

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

2. Material and method

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

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

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

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

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

3. Results

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

[1] Endoscopic Retrograde Cholangiopancreatography

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

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

[1] Radiation Protection Officer
[2] Radiation Protection

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

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

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

4. Discussion and conclusion

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

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

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

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

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

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OPTIMIZING RADIATION PROTECTION IN MEDICAL PRACTICE

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ABSTRACT

The main aim of medical practice is to deal with the health problems of patients, and quite often radiation protection issues are left aside. The development of radiation protection training in medical applications is complex due to the different backgrounds of the various occupational categories involved. ORAMED (Optimization of RAdiation Protection for MEDical Staff) is a collaborative project funded by FP7. The main objective is to enhance the safety and efficacy of the uses of radiation in diagnosis and therapy for medical staff. To fulfil this objective several training actions have been planned and are under progress.
The approach undertaken to ensure correct dissemination of the conclusions of the study and to guarantee a practical impact on medical staff is presented. The training material, especially focused on practical issues, is based on the results obtained by the different European research groups participating in the project. It can be used together with other available general radiation protection material.

1. Introduction

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

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

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

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

2. Scope

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

2.1 Optimization of radiation protection in interventional radiology

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

2.2 Development of practical eye lens dosimetry in interventional radiology

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

2.3 Optimization of the use of active personal dosemeters in interventional radiology

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

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

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

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

3. ORAMED training material

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

The main identified stakeholders are:

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

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

Training material for medical staff includes:

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

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

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

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

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

4. Example: Extremity dosimetry in nuclear medicine lecture

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

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

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

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

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

5. Conclusions

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

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

Agreements

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EDUCATION OF HEALTH PHYSICISTS AND HEALTH PHYSICS TECHNICIANS AT DANISH DECOMMISSIONING

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ABSTRACT

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

1. Introduction

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

2. Health Physics Technicians

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

2.1 Syllabus

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

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

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

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

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

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

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

2.2 Exercises

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

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

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

2.3 Co-worker training

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

2.4 Examinations

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

Problem no. 1 An employee has been working in the reactor hall for 5 hours in a constant concentration of tritium (tritiated water). A urine sample given ten days after the intake shows a tritium concentration of 10 kBq/l 1. Determine the intake of tritium, q_0, assuming that the fraction of the total excretion from the body via urine, F_u, is 60%. Daily urine excretion can be set to 1.4 l/day. 2. Determine the committed effective dose, $E(50)$, from the intake.
Problem no. 2 A sample contains a short lived radionuclide with a half-life of 10 minutes. The sample is counted for 30 minutes. The number of counts is 10000. The absolute efficiency, ε_{abs}, for that specific radionuclide is 0.20 cps/Bq (0.2 counts/decay). 1. What was the activity of the sample at the beginning of the counting? 2. Determine the number of counts, if the counting time is so long, that all of the activity in the sample has decayed.

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

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

3. Health Physicists

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

3.1 Syllabus

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

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

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

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

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

3.2 External courses

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

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

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

The content of the course includes:

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

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

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

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

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

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ABSTRACT

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

1. Introduction

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

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

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

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

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

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

2. Material and methodology

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

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

on accomplish or prescribe (4). Basic level of education includes also two different sublevels, the first one implies future physicians who will become mainly prescribers, while the second one is just intended for physicians belonging to specialties which may involve interventional procedures (urologists, orthopaedic surgeons, vascular surgeons, cardiac surgeons, digestive surgeons and cardiologists) (2). Additionally, the advanced level applies to physicians in training from radiology, nuclear medicine and radiotherapy specialties (5). The complexity and duration of the programme is rather different between the levels mentioned.
In a first approach, a basic course has been imparted to all the trainees within the first year of their residency programme at a time. The management of this basic training has been assigned to Radiation Protection Departments of teaching hospitals in Madrid.
The aim of the course is to provide basic knowledge about radiological protection in Medicine, regarding both medical and occupational exposures and also a broad perspective of the procedures involving radiations available at the hospital.
It has been developed in a one day course with a length of six hours in just one session. After the lessons, the participants have to accomplish an evaluation test and to fill in a satisfaction questionnaire.
The number of participants during the first edition of the course was 98. They were divided into two groups of 45 and 53 trainees each, celebrating the course in two following days. Both courses were held in a hospital's classroom. Although the number of students has increased up to 105 and 107 respectively in the following editions, the courses have been imparted in just one session, and they have taken place in the hospital's auditorium.
In the first edition, not only had the organization and syllabus of the course been assigned to the medical physicists of our department but also its didactic instruction. Trying to grow interest in the students, Nuclear Medicine, Radiotherapy and Radiology specialists have participated as teachers in the following editions, in order to explain their responsibility in the radiological protection aspects of the procedures, especially the justification principle of medical exposures.
The course enclosed, in the first edition, two hours of theoretical Radiation Physics, Structure of matter, X-ray generation, Radiation Detection, the x-ray tube, x-ray equipment and image formation. Those were followed by one hour of biological effects of ionizing radiation and two hours of Radiation Protection principles, legislation and Quality control in diagnostic radiology. Further editions have meant changes in some of the contents and their complexity to adequate them to the student's previous knowledge and interests.
Prior to the first teaching hour, a brief and general evaluation test was provided to the trainees, in order to assess their previous knowledge in Radiation Protection. The test consisted of 20 short questions with two possible answers: Yes or No. The same test was provided to the participants at the end the course, in order to assess which subjects had got straight after the course and which ones hadn't even then.
In the second edition, the final evaluation test was modified, consisting then of 20 questions with 4 different options which dealt not only with basic principles of Radiation Physics and Radiation Protection but also with some specific concepts discussed during the lessons. The final evaluation has remained almost the same during the last edition.
A satisfaction questionnaire, developed by the regional Council, was provided to the trainees following the final evaluation, so as to evaluate their level of fulfilment regarding teacher's explanations, contents and applications, documentation supplied and organization of the course. Besides, a section of suggestions and observations was included where any improvement or modification could be remarked. Each item of the satisfaction questionnaire was marked between 0 and 10. Special interest had items such us "Utility for their job", "Degree of knowledge acquired", or "Global assessment of the course".

3. Results and Discussion

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

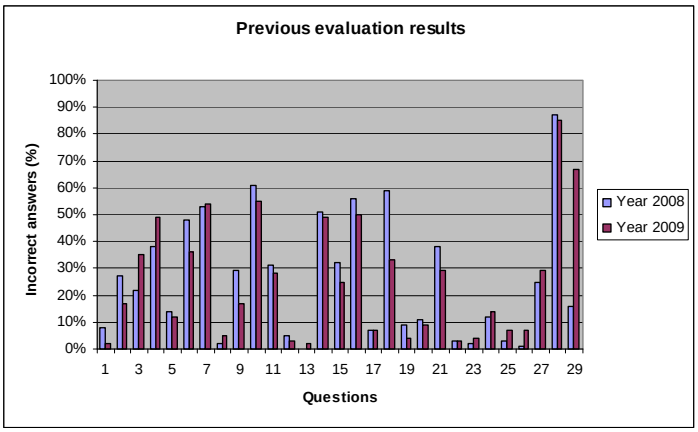
nuclear medicine. Finally, during the third edition 30 minutes have been assigned to each specialist, 90 minutes altogether.
The complexity of the syllabus was strongly diminished in 2008, since the trainees found it extremely difficult and partially useless for their future jobs, as was revealed by the questionnaires.
Other subjects were not just lightened but suppressed; instead of them, it was decided to emphasize in the principles of Radiation Protection and the single aspects of radiological protection in Medicine (6). For this purpose, some clinical cases were included in 2009 to complete the theoretical concepts, as demanded repeatedly by the trainees. These clinical cases were focused mostly on those collectives that show higher sensitivity for radiation harm, pregnant women and children, where special care must be taken with the justification of medical exposures. Actually, the inclusion of practical cases regarding those specific collectives had already been suggested by the trainees in the questionnaires. This year, clinical cases have also involved screening programmes, which are performed over asymptomatic patients.
"Quality control in diagnostic radiology" was suppressed during 2008, for it is not actually related to physicians' daily tasks, so it happens to be difficult to catch their attention. A few other subjects were also suppressed in the last edition, specifically Radiation Detection, operation of the x-ray tube, image formation and legislation in Radiation Protection, bearing in mind the results of the evaluation tests and also the observations made by the participants through the questionnaires.
The course has started, in its last edition, with a general overview of the equipment and procedures involving ionizing radiations present at the hospital, emphasizing in the different kinds of radiation and its harmfulness, instead of including mainly physics concepts. Also non-ionizing radiations have been incorporated to the discussion, in order to help the students discern properly between ionizing and non-ionizing radiations.
"Radiobiological effects" has appeared to be one of the subjects that hold more interest of the students, so it has remained in the contents since the beginning, though it has also got lighter.
These gradual updates carried out over the contents of the course have turned out to be quite successful, since the trainees have reached in average better qualifications year after year, although they had almost the same previous knowledge (Table 1):

Table 1. Average qualifications out of 10 in knowledge tests

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

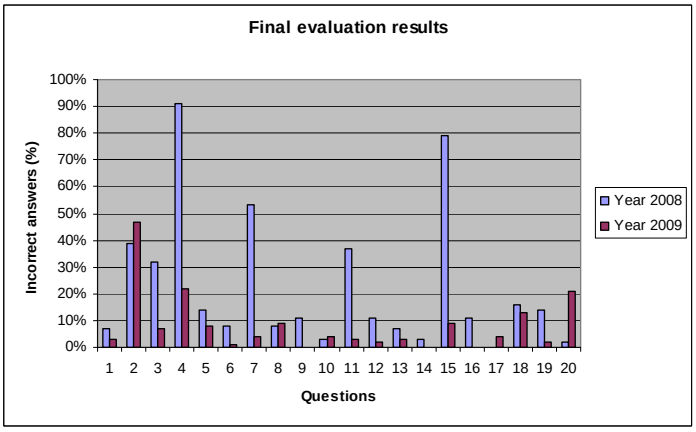
The question most frequently incorrectly answered in the previous evaluations dealt with the fact that medical exposures of patients are not subject to dose constraints. Approximately 85-90% of the trainees through the three editions got it wrong. The same question was set out in the final tests as well, when it was correctly answered by 82% of them in 2007, 86% in 2008 and 91% in 2009.
Other frequently missed questions through both previous and final tests involved, during all editions, physics subjects such as the X-ray beam, with approximately 40% wrong answers in both 2008 and 2009 final evaluations. Therefore, it has finally been decided to remove almost every physics subject from the programme, because physicians lack the theoretical basis required. Considering that just six hours were available, it was decided to focus on Radiation Protection main topics.
Graphic 1 shows that, through both 2008 and 2009 previous tests, the trainees got wrong almost the same questions (this information of the first edition is not available) and in the same proportions.

Graphic 1. Previous evaluation results



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

Graphic 2. Final evaluation results



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

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

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

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

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

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

4. Conclusions

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

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

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

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INTEGRATED MANAGEMENT SYSTEM
LAYING A FOUNDATION FOR RP EXCELLENCE

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Abstract

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

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

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

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

1. Introduction

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

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

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

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

2. Value of Integration

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

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

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

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

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

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

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

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

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

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

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

3. Managing change in an integrated environment

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

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

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

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

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

Sponsorship means that the change program has the visible support of key decision makers throughout the organization and resources are committed to the program.
Planning implies that preparation for change is conducted methodically before program implementation and committed to writing. Plans are agreed with major stakeholders and objectives, resources, roles and risks are clarified.

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

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

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

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

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

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

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

6.1 Governance

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

6.2 Oversight

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

6.3 Support

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

6.4 Perform

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

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

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

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

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

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

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

Some of the activities completed since that time have included:

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

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

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

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

5. Developing a Leadership Position to Drive Improvements in RP

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

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

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

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

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

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

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

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

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

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

or the SFAM.

6. Implementing Excellence in Radiation Protection at Bruce Power

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

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

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

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

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

6.1 Organisation Structure

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

Actions to address this have included:

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

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

6.2 Hiring, Retention, Development and Training of Staff

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

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

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

The use of experienced staff has resulted in better relationships with incumbent staff who feel

they are better supported and equipped to perform their job functions. Additionally, the new HP training now secures a long term development plan for these staff and for the Company.

6.3 Union Relationships

Historically, relationships with union workers, health physicists and technicians have been poor. This has resulted in many grievances, loss of key staff and a lack of progress being able to be made on RP program improvements due to lack of union co-operation with proposed changes.

Actions to address this have included:

- Re-establishment of good working relationships with the union at all interface meetings through resurrection and resolution of outstanding issues
- Resolution of outstanding grievance with health physicists over job documents
- Early discussions with union on proposed RP program changes, union participation in design teams and ongoing negotiations before, throughout and after changes

An example of success in this area was the lack of shop floor response when clothing requirements where changed overnight from a uniform that had been used for over thirty years to a new protective clothing standard.

6.4 Plant Layout and Equipment

Historically, radiological zones for radioactive contamination control across the site were based on a 4 zoned system which had been in place since the plant had been built and was based on a design that operated in the original prototype design of the reactor. The system led to inefficiencies in workers getting to work, diluted radiation protection standards and duplicated efforts as a result of subsequent inter-zonal transfers. Additionally, the equipment being used for monitoring was diverse, ageing and providing low standards. Protective clothing for RP work had also been in use for the same time period, despite advances in clothing, monitoring standards and concepts.

Actions to address this have included:

- Development of new re-zoning concept with two zones instead of four
- Development of a business case for the re-zoning plan, including the identification of non-radiation protection benefits from plan such as improved productivity
- Staged introduction of re-zoning to allow for worker acceptance and practice changes prior to full re-zoning
- Replacement of a large number of diverse types of basic, ageing monitoring equipment with a smaller amount of new monitoring equipment of a higher standard
- Installation of physical, rather than administrative controls to enhance compliance with radiation protection requirements
- Collaborating with our union on the development of a new protective clothing standard

- Collaborating with staff and leadership supporting our radioactive laundry facility to identify new requirements and processes to complement the change in protective clothing standards
- Identification of alternative commercial suppliers for products and services to enhance and augment our standards and expectations
- Significant and early interaction with our regulator to gain early acceptance of the proposed re-zoning plan
- Use of contract resources to bring external HP expertise and dedication to the project
- Introduction of new protective equipment for highly radioactive environments

The re-zoning project, which is one of the largest projects that Bruce Power has undertaken has now reached the end of its first stage and, despite the magnitude and significance of the changes involved, has been generally well received and accepted.

6.5 Licensing and Regulatory Relationship

Historically, there was confusion between the requirements and standards of the dozen different nuclear licenses with which the Company was required to comply. These distinct requirements had not previously been clearly delineated in the RP Program. The regulatory interface had been maintained by one individual in the company. Our key licensing document had not been changed for many years as it was considered too difficult to re-write a document that was linked to the license (as it would require regulator approval). This was to the point where significant document errors on important matters remained uncorrected for an unacceptable length of time. The document describing the RP program and Policy was also out of alignment with the Bruce Power Management System; it was a detailed list of requirements (80 pages long) and also forced the company to continue practices that were outdated and to report frequently to the regulator on non-compliances with the document. This led to confusion for staff but also to a poor reputation with our regulator in regards to regulatory compliance.

Actions to address this have included:

- Working with our Licensing team on separating the licensing requirements for different licenses and creating new governance for the licenses that were not properly addressed previously
- Defining to the regulator why documentation needed to change and how it would so that they would clearly understand the rationale for the change. This included providing a detailed disposition of the old program document.
- Providing early and ongoing communication with the regulator on proposed plant, equipment, clothing and process changes
- Creating an RP Program document that met company documentation standards and allowed the company more flexibility to make plant, equipment, clothing and process changes without prior regulatory approval
- Working with our Licensing team to identify new training in legal responsibilities

6.6 Processes

Historically, there were many poorly defined processes or a lack of process for various activities under the RP Program. Processes had been linked to RP personnel experience, rather than governance and when experienced personnel left the company, there was no record of the processes followed.

Typical problems included a lack of expertise in investigating radiological events and conducting ALARA reviews of work. These activities were conducted by experienced staff to non documented processes. New inexperienced staff were unable to conduct these activities to the required standard.

Actions to address this have included:

- Defining new processes for dose planning, dose tracking and dose control in line with industry standards
- Developing performance metrics at a precursor level to identify poor performance prior to it affecting a high level metric
- Defining processes undertaken by experienced HP personnel, but not usually recorded in governance to assist with role and staff development
- Developing continued use of a new web-site to improve communication on key issues
- Developing new monitoring standards for previously un-monitored hazards
- Developing a new inter-disciplinary source term monitoring program to tie in radiation protection with operations, maintenance, fuel handling and chemistry activities

6.7 Documentation

As previously described, the previous version of Bruce Power's RP Program document was a long list of requirements with multiple overlaps and standards difficult to find by topic. There was no process flow or logic to the suite of documentation and understanding how to use it required significant training which was typically not repeated after initial roll out. As a result, documentation had become un-used; non-compliance and deviation from set standards was common.

The governing RP Program document was written as a licensing document as opposed to a true process or program document and had not been changed for many years. Since the document contained errors and was outdated, it had lost its credibility and use, yet remained as our licensing basis preventing the Company from making changes and improvements to processes that were contained in the document. Additionally, the documentation was all based on the self protection model of radiation protection – individuals are trained to perform radiation tasks associated with their job and all program documents and procedures are written to this effect. There was a lack of management oversight built into this model and therefore suite of documents. This was not a managed system and simply relied on worker compliance.

Actions to address this have included:

- Re-writing of the program document from an 80 page document to a 20 page document, allowing greater flexibility for licensing basis and a more logical sequencing of programmatic requirements to allow easier use
- Creation of hierarchy of documentation with lower tier documents on the various topics covered by the program. This allowed the inclusion of programs that were previously not a part of the program, yet were industry standard topics. The hierarchy also allowed for easier reference on topics since the documents on given topics are now all found in specific areas of the program. Topics were chosen also to be related to roles and responsibilities, such that workers using the program only have to refer to one specific program area. Documents only for use by RP/HP staff are contained in a separate section of the program. This is intended to result in greater worker compliance with the program. Additionally, management oversight was built into the new suite of documentation
- Re-alignment of all documentation in accordance with the new hierarchy. This involved splitting documents, referencing documents, etc, in line with the new structure
- Separation of documentation with different licensing basis within the hierarchy so that the differences in regulatory standards could be clearly identified
- Informal regulatory approval and comments obtained prior to formal regulatory submission
- Extensive roll out of documentation is being conducted prior to implementation
- Training should be able to be simplified as a result of the new structure
- Future changes to the program content will now be able to be made without re-writing the entire suite of documentation and without reference to the regulator for approval

7. Management of Change in Implementing Improvements to RP Program

Development and implementation of an extensive communications campaign to reinforce the physical and cultural changes required to ensure effective management of change has been instrumental in our successes to date. Throughout all of the above initiatives and actions, a solid management of change plan was critical in our success. We have seen evidence of more successful implementation in those areas where more significant communication and change management efforts were undertaken. Early efforts to engage staff, unions and the regulator, coupled with strong leadership support and sponsorship for these transformational changes has paid dividends in terms of implementation timeline and ease.

Some of the tactics adopted included the use of a newly developed radiation protection web-site, the use of site wide telephone conferences, the development of a substantial roll out package for supervisors, the use of multi-media (TV, videos, power point presentations in multiple formats, screen savers), the use of mock ups, pamphlets, company newsletters, customer response to questions, etc.

A wide variety of modes of communication were used to 'get the message out' regarding the changeover of our Personal Protective Equipment (PPE):

- RP website updates
- Features in our monthly Safety videos over several consecutive months
- Corporate Intranet home page updates
- Bruce Power TV features
- Bruce Power computer screen savers
- Articles in “The Point”, our weekly staff magazine
- Site Wide Leadership Call for all managers
- Manager's Messages (sent by e-mail) for all managers
- Posters in Guardhouses
- Electronic Communications at our stations
- Workshops for our first line supervisors
- Special updates to staff from our Chief Nuclear Officer
- Global emails to all staff
- Mock up of new PPE in high traffic areas
- Discussion at our Management Leadership Meetings and station shift turnover meetings
- Roll-out day communications (live)
- Handouts

Overall feedback was very positive and the rezoning team received many comments back that the communications used were the 'plan for the future'. One of the largest benefit of such an open forum was the opportunity to not only talk about rezoning/PPE changeover but also about the need for RP procedural compliance, the conceptual plan for future rezoning activities, the need for people to being thinking about how that would change their work so they can plan ahead, other planed RP projects and address any specific questions about RP in general.

8. Conclusion

The development of standards around integrated management systems is one aspect of the broader opportunity to effectively implement integrated and standardized practices across an organization. Pursuing integration requires new thinking about the relationship of quality to the functioning of the entire organization.

Practitioners or organizational champions of integration must understand that an organization is a living organism which is more than the sum of its parts. Senior leadership require vision and commitment towards standardization, elimination of wasteful processes, practices and interfaces

and a thorough understanding of the role of configuration control in supporting the maintenance of an integrated management system throughout its evolution in order to reap the benefits of integration.

The journey towards integration and excellence need not be an all or nothing approach – as demonstrated in the Bruce Power example, identifying key success factors towards integration and standardization such as the adoption of the Governance, Oversight, Support and Perform (GOSP) model of accountability, together with the enhanced role of Program Owners and the senior leadership commitment to simplifying and standardizing processes and aligning organizational accountabilities has resulted in measurable improvements justifying the investment in the changes.

The significant improvements in the approach towards RP at Bruce Power encompasses all elements of the managed system – vision, process controls, process and programmatic improvements and organizational arrangements to deliver enhanced results. The role of change management and communication in the adoption of the change must not be underestimated. The real value derived from the significant investment Bruce Power has made in enhancements to the RP Program including physical structures, processes, training, roles and responsibilities will emerge over the coming years but early indications are already demonstrating positive and measurable results. With similar transformational improvements across other business critical functional areas, Bruce Power is well positioned to continue to be a leader in the nuclear industry in Canada develop its reputation as a respected and emulated player on the world nuclear stage.

9. References

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