CONTENTS

WELCOME

It is my great pleasure to welcome you to Reykjavík and to the Conference of the Nordic Society for Radiation Protection. Iceland's beautiful and often rough nature is truly wonderful to visit at this time of year as is Reykjavík with its vibrant atmosphere. The conference venue, Grand Hotel, provides a very good venue for a conference like ours and we are happy to welcome about 150 participants.

The Nordic countries, Denmark, Finland, Iceland, Norway and Sweden, have a long history of co-operation in many areas of society. In the field of radiation protection, there has been an active and efficient co-operation on many levels between the Nordic authorities for over 50 years. This co-operation remains an important contribution to the high level of radiation and nuclear safety that we enjoy in all the five countries today.

The Nordic Society for Radiation Protection, being a regional society rather than a national society, is a very good example of the Nordic spirit of family and community across the five countries.

Our aim for this conference is to provide an overview of the state of the art of radiation protection. We have received many high quality papers from you, the conference participants, and the organizing committee has put together an interesting programme covering the many areas of radiation protection. The focus of the first day of the conference is on the international challenges and opportunities facing radiation protection. We are fortunate to have several outstanding speakers from various international organisations and agencies, providing us with different perspectives on these issues.

I know that you will have a great week at the conference and I hope that, in addition to all the professional activities, you will manage to find some time to explore and enjoy Reykjavík.

We hope that you will enjoy your stay in Iceland.

Sigurður M. Magnússon

President of the NSFS

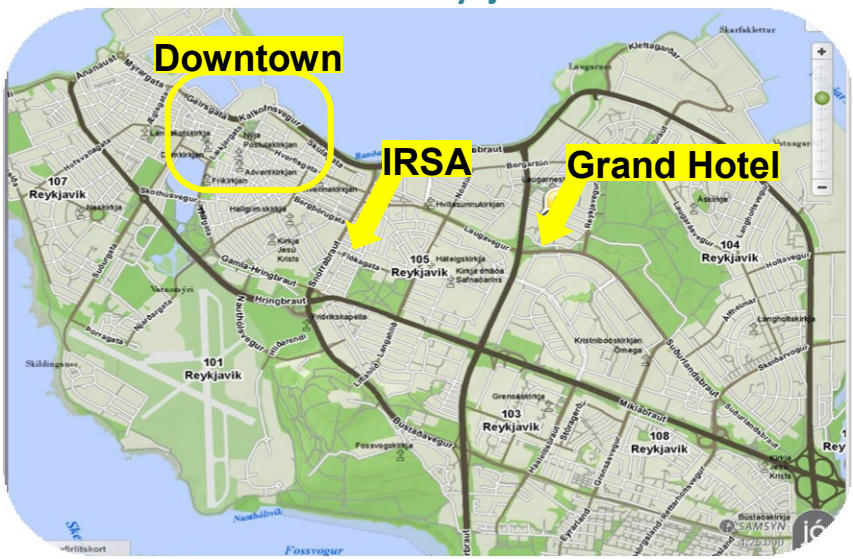
NSFS-2011 conference
Reykjavík, Iceland

Dates	**August 22nd-25th, 2011**
Theme	**Challenges and opportunities**
Venue	**Grand Hótel Reykjavík, Sigtúni 38, 105 Reykjavík**
Registration and further information	**Conference web page** **http://yourhost.is/NSFS-2011**

Social programme and other events

Saturday August 20 08:00-10:00	**Reykjavík Marathon**
Saturday August 20 (all day)	**Reykjavík Culture Festival, a smorgasbord of music, art and culture offered all over the downtown area**
Sunday August 21 16:00-18:00	**Sign-in and pick up of conference materials at Grand Hotel**
Sunday August 21 18:00-20:00	**A Get-Together at the Culture House** Hverfisgata 15, 101 Reykjavík
Monday August 22 18:30	**Conference Dinner at Kolabrautin restaurant in the just-opened Harpa Concert Hall**
Tuesday August 23 19:00	**Young members' evening out at the Sea Baron: a rustic and popular seafood restaurant** (Geirsgata 8, 101 Reykjavík)

Central Reykjavík



Reykjavík downtown area

MONDAY, August 22nd

08:15-09:15	**Session 1: Opening and Bo Lindell Lecture** **Chair: Ann-Louise Eksborg, Sweden**
	Conference opening Sigurður M. Magnússon, president, NSFS
S1-O1	**Bo Lindell Award and Lecture: Past, present, and future problems -are there any solutions?** The lecture is given by the 2011 Bo Lindell Award recipient Jack Valentin (Sweden), former scientific secretary, ICRP
09:20-10:25	**Session 2: Challenges in Radiation Protection** **Chair: Jukka Laaksonen, Finland**
S2-O1	**International Commission on Radiological Protection: Challenges and opportunities in the next 20 years** Christopher Clement, ICRP
S2-O2	**Challenges in radiation safety from an international perspective** Renate Czarwinski, IAEA
10:25-10:50	**Coffee Break**
10:50-12:30	**Session 3: Challenges, continued** **Chair: Ole Harbitz, Norway**
S3-O1	**The changing world of radiological protection: Challenges and opportunities from an NEA perspective** Ted Lazo, NEA
S3-O2	**EPA's role in U.S. radiation protection: past successes and Challenges Ahead** Mike Boyd, Environmental Protection Agency, USA
S3-O3	**Challenges and Opportunities for Radiation Protection -2011** Kenneth R. Kase, IRPA
12:30-13:45	**Lunch**

13:45-14:50	**Session 4: EU-BSS** **Chair: Mette Øhlenschlæger, Denmark**
S4-O1	**Draft Revised EU BSS: Part I, Existing and Emergency Exposure Situations** Augustin Janssens, EU
S4-O2	**Draft Revised EU BSS: Part II, Planned Exposure Situations** Kaare Ulbak, SIS, Denmark
14:50-15:20	**Coffee Break**
15:20-17:05	**Session 5: Nordic Nuclear Safety Research (NKS)** **Chair: Sigurður M. Magnússon, Iceland**
S5-O1	**Overview of the NKS-R programme and summary of ongoing activities** Karoliina Ekström, Fortum Power and Heat, Finland
S5-O2	**An overview of the NKS-B Programme 2008-2011** Justin Gwynn, NRPA, Norway
S5-O3	**International Gamma Spectrometric Assessment Exercises Using Simulated Spectra** Mark Dowdall, NRPA, Norway
S5-O4	**Evaluation of the Radiological Emergency Field Operative Exercise, RE-FOX, taking place in Sweden 2012 with Nordic countries invited -Suggestion for a NKS-project.** Robert Finck, SSM, Sweden
S5-O5	**Radioecology and Radiation Emergency Preparedness in Iceland for 25 years -A Tribute to NKS** Sigurður E. Pálsson, IRSA, Iceland
18:30	**Conference dinner** **At Kolabrautin restaurant** **in Harpa Concert Hall**

Session 6: Medical 1

08:15-10:10 **Chair: Hannu Jarvinen, Finland**

S6-O1 **European population dose from radiodiagnostic procedures -early results of Dose Datamed 2**
Ritva Bly, STUK, Finland

S6-O2 **Trends in examination frequency and population doses in Norway, 2002 - 2008.**
Hilde M. Olerud, NRPA, Norway

S6-O3 **Frequency of medical x-ray examinations and Patient and Population Doses in Iceland in 2008**
Guðlaugur Einarsson, IRSA, Iceland

S6-O4 **Optimisation in diagnostic radiology -how EMAN can contribute to improvements**
Anja Almén, SSM, Sweden

S6-O5 **Administrative Inspection of Danish X-ray Clinics**
Annika Bjerkborn, SIS, Denmark

S6-O6 **Patient organ radiation doses during treatment for aneurismal subarachnoid haemorrhage**
Michael Sandborg, Linköping University, Sweden

S6-O7 **Radiation dose in cardiac CT measured with TLDs and compared with DLP**
Heiðbjört Í. Friðriksdóttir, Akureyri Hospital, Iceland

Posters

S6-P1 **Staff Doses in Interventional Cardiology**
Hanne Waltenburg, SIS, Denmark

S6-P2 **Changes in collective dose a result of underlying variations in frequency and dose.**
Anders Frank, SSM, Sweden

S6-P3 **Thermoluminescence dosimetry used as a postal quality audit in intraoral radiology**
Anna Kelaranta, STUK, Finland

S6-P4 **What about veterinarians' use of x-ray equipment? -Results from a nation-wide survey on the use of diagnostic x-ray among veterinarians in Norway**
Marie Solberg, NRPA, Norway

S6-P5 **Creating New Guidelines for CT Reference Dosimetry**

S6-P6	**Occupational dose of technical staff at radiotherapy simulation PET/CT studies** Francisco H. Cutanda, Hospital Gregorio Marañón, Spain
S6-P7	**Advice to refrain from non-medical ultrasound examinations of the foetus** Catarina Danestig Sjögren, SSM, Sweden
S6-P8	**DAP in Panoramic and Chepalometric examinations in Iceland** Daníel Y. Shimmyo, IRSA, Iceland

10:10-10:40	**Coffee Break: Viewing of posters**

Session 7: Medical 2

10:40-12:30 **Chair: Hilde M. Olerud, Norway**

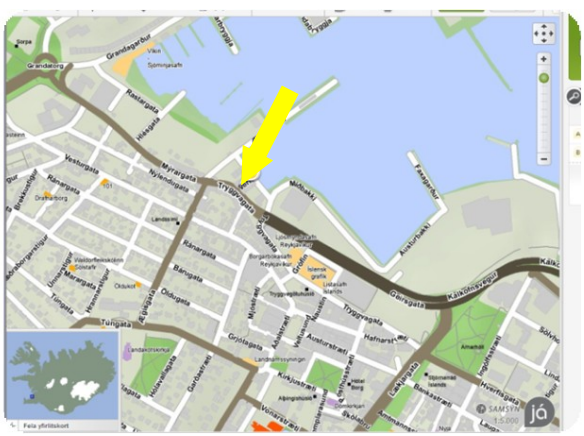
S7-O1	**Guidance on internal audits and self-assessments: support to external clinical audits.** Hannu Järvinen, STUK, Finland
S7-O2	**Dose Measurements on Dental Tomographs and CBCTs** Peter K. Frederiksen, SIS, Denmark
S7-O3	**Nordic survey on national management and requirements for use of dental Cone Beam CT** Eva G. Friberg, NRPA, Norway
S7-O4	**External effects of an out-patient PetCT facility** Francisco H. Cutanda , Hospital Gregorio Marañón, Spain
S7-O5	**Radiation doses 2001-2010 to staff working in a large PET and PET/CT department** Søren Holm, Rigshospitalet, Copenhagen, Danmark
S7-O6	**Implementation of Radiation Measurement Criteria and Limits for Guidelines for Small Radioactive Spills at Landspitali University Hospital** Valdís Guðmundsdóttir, Landspítali University Hospital, Iceland
S7-O7	**Interactive Web Services for Optimizing Nuclear Medicine** Carl Bladh-Johansson, SSM, Sweden

12:30-13:45	**Lunch**

TUESDAY, August 23rd – afternoon

13:45-15:35	**Session 8: Emergency Preparedness 1** **Chair: Sven P. Nielsen, Denmark**
S8-O1	**Action levels and guidelines for Swedish Armed Forces operations in radioactively contaminated environments** Jonas Boson, FOI, Sweden
S8-O2	**Officer on Duty at the Swedish Radiation Safety Authority** Karin Fritioff, SSM, Sweden
S8-O3	**Use of deliberative stakeholder involvement in preparation of radiological emergency operating procedures at a steel mill** Markku Koskelainen, STUK, Finland
S8-O4	**RadiaCopter -UAS Gamma Spectrometry for Detection and Identification of Radioactive Sources** Magnus Gårdestig, Linköping University, Sweden
S8-O5	**A real-time statistical alarm method for mobile gamma spectrometry: combining binomial counting with a goodness-of-fit** Peder Kock, Lund University, Sweden
S8-O6	**NKS NordRisk II: Atlas of long-range atmospheric dispersion model calculations** Jens Havskov Sørensen, DMI, Danmark
	Posters
S8-P1	**RadiaDroid -Simulated Radiation Detection in Smartphones** Magnus Gårdestig, Linköping University, Sweden
S8-P2	**Challenges in the case of an incident during transport of spent nuclear fuel along the Norwegian cost** Karl Eliassen, NRPA, Norway
S8-P3	**The European platform on preparedness for nuclear and radiological emergency response and recovery (NERIS Platform)** Raimo Mustonen, STUK, Finland
S8-P4	**Georeferenced data sharing during radiological accidents** Tuomas Peltonen, STUK, Finland
S8-P5	**Alpha- and beta contamination of surfaces. Which levels of contamination are possible to detect with manual search?** Angelica Hedman, FOI, Sweden
S8-P6	**Source preparation of Actinides and Polonium using coins** Elis Holm, NRPA, Norway
S8-P7	**Using the LaBr3:Ce scintillation detector for mobile γ-spectrometry** Jonas Nilson, Lund University, Sweden
S8-P8	**A comparison between multiple car-borne gamma-ray measurements performed during two separate missions at the same route** Kenneth Lidström, FOI, Sweden

15:35-16:15	**Coffee Break: viewing of posters**
16:15-18:05	**Session 9: Emergency Preparedness 2** **Chair: Kasper Andersson, Denmark**
S9-O1	**Outlines of a content management system for emergency preparedness and response** Michael Ammann, STUK, Finland
S9-O2	**The Danish CBRN Institute -joint civil-military terror preparedness** Carsten Israelson, CBRN, Denmark
S9-O3	**Local-national forum for emergency and recovery strategies** Inger M. Eikelmann, NRPA, Norway
S9-O4	**Swedish Armed Forces deployable R/N-laboratory** Michael Granström, Armed Forces, Sweden
S9-O5	**Dimensioning of Norwegian nuclear and radiological emergency preparedness and crisis management** Øyvind G. Selnæs, NRPA, Norway
S9-O6	**SecurEau -Security and decontamination of drinking water distribution systems following a deliberate contamination** Tuukka Turtiainen, STUK, Finland
S9-O7	**Aspects of dispersion of airborne radioactivity in a city centre** Erik Johansson, FOI, Sweden
19:00	**Young members' evening out!** Meet at Sea Baron seafood restaurant, everyone welcome. Bring your own beverage.



WEDNESDAY, August 24th – morning

08:15-10:00	**Session 10:Dosimetry and Industrial Radiation Protection** **Chair: Tor Wöhni, Norway**
S10-O1	**UV radiation induced processes in AlN and its potential application for solid state dosimetry** Laima Trinkler, University of Latvia
S10-O2	**Dose assessment after an historic intake of uranium** Ann-Helen Haugen**,** IFE, Norway
S10-O3	**OSL on tooth enamel -a Potential Emergency Radiation Dose Assessment Tool** Terese Geber, Lund University, Sweden
S10-O4	**Uranium in urine and hair of occupationally unexposed Finnish people** Maarit Muikku, STUK, Finland
S10-O5	**Licensing of complex facilities other than nuclear power plants** Carl-Göran Stålnacke, SSM, Sweden
S10-O6	**Radiation Safety Assessment of industry licensees** Camilla Bysell, SSM, Sweden
S10-O7	**Radiation accident at a Swedish mining company** Peter Frisk, SSM, Sweden
	Posters
S10-P1	**Gafchromic film as a fast visual indicator of radiation exposure of first responders at a radiological or nuclear accident** Ünal Ören, Lund University, Sweden
S10-P2	**Whole-body counters for measurement of internal contamination in Finland** Jussi Huikar, STUK, Finland
S10-P3	**Uptake and retention of per os administered cobalt in human subjects** Ylva Ranebo, Lund University, Sweden
S10-P4	**A study on PTW 10000, 1000 and 28 cc spherical ioniation chambers** Silvia Vargas Castrillón, CIEMAT, Spain
10:00-10:30	**Coffee Break: Viewing of posters**

10:30-12:15	Session 11: Concepts and Policy Chair: Wendla Paile, Finland
S11-O1	**New perspectives for radiation protection concepts in the frame of sustainability** Gilbert Eggermont, VUB University, Belgium
S11-O2	**Is guidance in ICRP publications consistent on the application of reference levels?** Per Hedeman-Jensen, Danish Decommissioning, Denmark
S11-O3	**Teaching laymen an in depth understanding of ionising radiation** Christer Samuelsson, Lund University, Sweden
S11-O4	**Current problems of quantities in radiation protection and their possible solutions** Jozef Sabol, Czech Technical University, Czech Republic
S11-O5	**How the use of the concept "Dose Constraint" may help to lower annual individual doses** Virva Nilsson, Forsmark Kraftgupp AB, Sweden
S11-O6	**Radiation Safety Assessment of licensees using with Open Sources** Helene Jönsson, SSM, Sweden
	Posters
S11-P1	**Ethical guidance, stakeholder involvement and radiation protection culture in the Belgian Society for Radiation Protection** Gilbert Eggemont, Belgian Society for Radiation Protection
S11-P2	**CEEPRA - Collaboration Network on EuroArctic Environmental Radiation Protection and Research** Maarit Risto, STUK, Finland
12:15-13:30	**Lunch: Viewing of posters**

WEDNESDAY, August 24th – afternoon

13:30-15:45	**Session 12: Natural Radioactivity and Radioecology** **Chair: Klas Rosén, Sweden**
S12-O1	**NORM and other radioactive sources found in scrap metal yards in Sweden** Ann-Louis Söderman, SSM, Sweden
S12-O2	**Developing an Survey of the impact of enhanced natural radioactivity on human and natural environment** Rajdeep Sidhu, IFE, Norway
S12-O3	**Radon in Finnish mines 1972-2010** Siiri-Maria Aallos-Ståhl, STUK, Finland
S12-O4	**Radon prevention in new construction in Finland** Hannu Arvela, STUK, Finland
S12-O5	**Effectiveness of anti-radon measures in Norwegian homes, seven years after mitigation** Ingvild E. Finne, NRPA, Norway
S12-O6	**Radon control in European countries -a RADPAR questionnaire study** Olli Holmgren, STUK Finland
S12-O7	**Comparison of two 222Rn exhalation rate measurement methods by study of Hungarian adobe building materials** Zsuzsanna Szabó, Eötvös Univeristy, Hungary
S12-O8	**Nordic re-parameterisation of the ECOSYS ingestion model** Kasper Andersson, Risø, Denmark
	Posters
S12-P1	**Assessment of the clearance options for NORM-waste** Merle Lust, University of Tartu, Estonia
S12-P2	**Radon measurements in Finnish workplaces during measurement seasons 2005-2010** Heikki Reisbacka, STUK, Finland
S12-P3	**Radiocesium in moose in Finland** Eila Kostiainen, STUK, Finland
S12-P4	**Assessment of doses to biota in the Baltic Sea** Iisa Outola, STUK, Finland
S12-P5	**External radiation doses to important organs in biota: Monte Carlo dose model calculations** Mattias Karlsson, Linköping University, Sweden
S12-P6	**STAR-Strategic Network for Intergrating Radioecology** Maarit Muikku, STUK, Finland

S12-P7	**Migration and plant uptake of 137Cs in six pasture soils after the Chernobyl accident 1987-2007** Klas Rosén, SLU, Sweden
S12-P8	**Radiocaesium in fungi in Pasvik, Norway** Johannes Nilssen, NRPA, Norway
S12-P9	**The Swedish Radiation Safety Authority's regulations on exemption and clearance of NORM waste** Ann-Louis Söderman, SSM, Sweden

15:45-16:30 **Coffee Break: Viewing of posters**

16:30 **2011 General Meeting of the NSFS**

THURSDAY, August 25th

08:15-10:10	**Session 13: Nuclear industry and technology** **Chair: Carl Göran Lindvall, Sweden**
S13-O1	**Developing an Information Barrier for verification in nuclear disarmament processes** Tore Ramsøy, IFE, Norway
S13-O2	**UK-Norway Initiative: Research into Managed Access of Inspectors During Warhead Dismantlement Verification** Steinar Backe, IFE, Norway
S13-O3	**Iodine and cesium release fractions in a Loss-of-Coolant Accident** Knut K.R. Eitrheim, IFE, Norway
S13-O4	**A review of a 14C model for dose assessment of releases from normal operation of nuclear facilities** Charlotte Lager, SSM, Sweden
S13-O5	**Clearance measurements of embedded pipes** Thommy I. Larsen, Danish Decommissioning, Denmark
S13-O6	**Industrial Radiography at Nuclear Power Plants** Birgitta Ekström, SSM, Sweden
S13-O7	**A Nordic approach to impact assessment of accidents with marine reactors** Ole Reistad, IFE, Norway
	Poster
S13-P1	**Preparing a WANO Peer Review within Radiological Protection at Forsmark NPP** Virva Nilsson, Forsmarks Kraftgrupp AB, Sweden

10:10-10:35	**Coffee Break: Viewing of poster**

10:35-11:40	**Session 14: Nuclear industry and policy** **Chair: Raimo Mustonen, Finland**
S14-O1	**Regulatory Approach to Radiation Protection in New NPPs** Veli Riihiluoma, STUK, Finland
S14-O2	**Estabilising on set of scaling factors from of measured activity concentrations** Jens Søgaard-Hansen, Danish Decommissioning, Denmark
S14-O3	**Reducing the discharges from Studsvik to the Baltic Sea** Ann-Christin Haegg, SSM, Sweden
S14-O4	**Qualified Experts for Radioactive Waste Management -the UK approach** Chris Englefield, Environment Agency, UK
11:40-12:05	**Closing Session** **Chair: Sigurður M. Magnússon, Iceland**
	Young Scientist's Award
	Transfer of Chairmanship to Denmark
	Closing remarks

End of Conference no later than 12:05

S1 - O1

Past, present, and future problems - are there any solutions?

VALENTIN, J.

Jack Valentin Radiological Protection, Öregrundsgatan 15, SE-115 59 Stockholm, Sweden, jack.valentin@telia.com

'Bosse' Lindell had to contend with several major challenges during his career: the establishing of nuclear power in Sweden, the development of medical radiation use, and the realisation that radon in houses could be a major problem, to mention just a few. Examples showing how he handled some of these problems, and how his close friends Dan Beninson and John Dunster handled some similar problems, indicate that the following factors were crucial to ensure success:

- genuine competence;
- mutual trust between regulators and licensees;
- respect for the views of others and an honest interest in the reasoning behind disagreeing views.

Today's challenges in radiological protection are different, but surprisingly similar to those that Bo Lindell and his contemporaries faced, including, e.g., nuclear new build and nuclear accidents, new modalities in radiation-based medical practice, and the realisation that non-ionising radiation could be a major problem. However, the loss of competence through generation changes in agencies and at operators adds a new dimension. To overcome this, we must remember old knowledge, and at the same time acknowledge the new knowledge provided by younger staff.

The details of future challenges cannot be predicted - if it were possible to discuss them in advance, they would not constitute challenges. However, while they may entail new and hitherto unknown technical aspects, they are unlikely to present any really new philosophical issues. Therefore, the solution to future challenging problems lies in expecting the unexpected, and being prepared to tackle it using the same tools as always - competence, trust, courage, and curiosity.

International Commission on Radiological Protection: Challenges and Opportunities in the Next 20 Years

Christopher H. Clement, CHP

Scientific Secretary, International Commission on Radiological Protection, 280 Slater Street, Ottawa, Ontario, CANADA K1P 5S9, sci.sec@icrp.org,+1 (613) 944-1918, www.icrp.org

The International Commission on Radiological Protection (ICRP) is an independent, international organization that advances for the public benefit the science of radiological protection, in particular by providing recommendations and guidance on all aspects of protection against ionizing radiation. The recommendations of ICRP form the basis of radiological protection standards, legislation, guidance, programmes, and practice worldwide. This is primarily through the system of radiological protection, most recently described in ICRP Publication 103, The 2007 Recommendations of the International Commission on Radiological Protection, and subsequent publications in the Annals of the ICRP. The system of radiological protection is based on scientific understanding, value judgement, and experience, all of which change over time. With this in mind, a few possible challenges and opportunities related to the system of radiological protection over the next twenty years are suggested and examined. This includes full implementation of the 2007 Recommendations, emerging evidence on non-cancer effects, evolving patterns of cancer morbidity and mortality, and individual radiosensitivity.

S2 - O2

Challenges in Radiation Safety from an International Perspective

CZARWINSKI, R.

International Atomic Energy Agency, P.O. Box 100, Wagramer Strasse 5,1400 Vienna, Austria, r.czarwinski@iaea.org

The use of ionizing radiation in medicine, industry and research is increasing remarkably throughout the world and is involving more and more complex systems. We are now facing a situation which offers challenges in radiation protection in a wide range of applications. Many factors influence this situation, such as the increasing globalization, which is escalating the importance of economic crosslinking, the global propagation of new and increasingly complex technologies, emerging diseases etc., not to forget factors related to terrorism. Radiation Protection Standards will have to take into account these factors and the international organizations must recognize their important role in the investigation of effects, in enhancing the harmonization of standards, keeping them state-of-the-art and in particular in supporting the comprehensive application of the standards in all areas. The international framework for radiation protection is based on a constellation of interacting organizations with different responsibilities, tasks and targets, based on the roles and mandates of several cooperating UN organizations and other international bodies.

The practicability of the radiation protection system depends not only on its' scientific stringency but also on the extent to which it is in line with accepted ethical values in society as well as with given political and social values. The global acceptance of radiation protection principles, such as justification, optimization and dose limitation as recommended by the International Commission on Radiological Protection (ICRP) is a good example. In particular in the medical area, the implementation of justification and optimization is a challenge. Ensuring that medical procedures are justified and optimized is vital, not least for CT and hybrid imaging examinations and in paediatric medicine. Keeping track of the increasing number of imaging procedures that individuals may undergo in relatively short time periods might be of benefit for this. Further research is also necessary to achieve sub-mSv CT for all applications. Overexposures, overuse of imaging and accidental exposures in radiotherapy are increasingly reported and have shown the need for cooperation between all involved stakeholders to increase radiation safety in medicine.

A further issue is the adequate consideration of the problem of cataracts, observed in particular with cardiologists. Recommendations for new equivalent dose limits for the lens of the eyes were published by the ICRP and incorporated in the revised International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS). This progressive step done by the IAEA just recently, requires particular efforts concerning the regulatory implementation of new and drastically reduced limits. In addition, there is still a need to evaluate the limits for members of the public.

The nuclear industry is also becoming increasingly globalized, as illustrated by the few limited industrial companies remaining worldwide, with the capability to build and serve high tech reactors. Specialized maintenance is likely to evolve into a competitive globalized business. A highly skilled workforce will become increasingly mobile. Comprehensive risk and safety assessments after the accident at TEPCO's Fukushima Daiichi Nuclear Power Plant will also have to be conducted and these will have an impact on the future radiation protection system. A proper control of the exposure of specialized workers has to be ensured and will become more and more complex. On the other hand, the availability of suitably qualified and experienced staff may become an even more important constraint and, if not appropriately followed up, lead to the employment of less-well trained and qualified workers – in which might weaken the safety culture. Therefore, capacity building for sustainable nuclear safety will have a critical role that goes far beyond the traditional approach to education and training.

There are further topical issues to highlight, such as the management of risks from low-dose radiation exposure (implications on dose and dose constraints when DDREF is changed), circulatory, vascular and other non-cancer effects of radiation, protection of the environment, emergency management and rehabilitation etc. Specific epidemiological research is necessary in order to strengthen the evidence base and the implication of practical implementation has to be more thoroughly assessed.

In order to face the current and future challenges in radiation safety effectively, an important issue is what tools to use. In this connection, communication plays a central role. The use of modern IT solutions, social media (high quality websites, Facebook, etc.) must be intensified in order to improve the information and involvement of stakeholders appropriately, and to transfer new knowledge. Communication is an essential element in safety culture, and this communication should be extended beyond the traditional stakeholders to also reach the general public effectively.

S3 - O1

The Changing World of Radiological Protection: Challenges and Opportunities from an NEA Perspective

Dr. Ted Lazo

The role of the OECD Nuclear Energy Agency is to assist member countries to better understand and effectively address safety issues related to the use of nuclear technology. In the area of radiological protection, this involves discussions of how international radiological protection recommendations should be developed and interpreted, and the ongoing assessment of the advancement of radiological protection science. This presentation will discuss the current status of both of these areas, and present the view of the NEA regarding the possible implications of ongoing trends and developments. The specific areas that will be addressed are developments in radiological protection science; developments in the management of low doses; the involvement of stakeholders in radiological protection decision making; the consequences of the Fukushima accident for radiological protection and emergency management; the implementation of new ICRP recommendations and of the revised International Basic Safety Standards; and implications for new nuclear build.

EPA's role in U.S. radiation protection: Past successes and challenges ahead

Michael Boyd, U.S. Environmental Protection Agency

The United States Environmental Protection Agency (EPA) was formed in 1970, largely as the result of widespread public alarm over the deteriorating quality of air and surface water and the fear that abandoned or poorly controlled waste sites would poison underground sources of drinking water. The environmental legislation that followed EPA's formation was characterized by openness, transparency, and opportunities for stakeholder involvement. These environmental laws were strikingly different from the laws controlling the use of radioactivity at that time. Many of the radiation protection programs in the United States can trace their origins at least as far back as the Atomic Energy Act of 1954 (AEA) and to the Federal Radiation Council (FRC) established by President Eisenhower in 1959. During the Cold War, the very stringent control that the government exerted over strategic radioactive elements such as uranium and plutonium influenced the control of all manmade radioactive elements. When EPA was formed, the U.S. Atomic Energy Commission (AEC) had the responsibility for both regulating and promoting the use of manmade radioactivity. This monopoly on controlling radioactivity began to change when the new EPA was given the authority, through an amendment to the AEA, to set "…generally applicable environmental standards for the protection of the general environment from radioactive material…" Also at this time, the duties of the FRC to "…advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards…" was transferred to the EPA Administrator. The FRC authority is for setting nonbinding radiation protection guidance, in the form of Presidential Recommendations, and the AEA authority is for setting enforceable environmental standards. Even though EPA sets the standards for radioactivity in the general environment, enforcement of these standards at facilities with radioactive material licenses is now the responsibility of the U.S. Nuclear Regulatory Commission (NRC), the agency that inherited the AEC's enforcement authorities in 1975. Over the years, with the passage of major new environmental legislation such as the Clean Air Act, the Safe Drinking Water Act, and the Comprehensive Environmental Response, Compensation, and Liability Act (known as Superfund), EPA gained additional standard setting and enforcement authority over radionuclides in air, drinking water, and soil. Before EPA, the Atomic Energy Commission held authorities now divided among EPA, NRC, the Department of Energy and others. Understanding this history provides insight into some of the challenges that still arise from these occasionally overlapping authorities. Since 1970, EPA has helped to reduce radioactive emissions to air and water and to clean up many of the contaminated sites left over from the Cold War era. As we look to the challenges of the future, now may be the time to set the U.S. on a path towards greater harmonization with the international system of radiation protection.

Challenges and Opportunities in Radiation Protection

Kenneth R. Kase

International Radiation Protection Association

The International Radiation Protection Association (IRPA) represents 17,000 radiation protection professionals worldwide. Today's challenges and opportunities focus on two major activities that have the potential to expose large numbers of people to significant radiation dose. These areas are medicine and nuclear power generation. Related to these activities is the need to provide well educated and qualified radiation protection professionals. In medicine the challenges arise from the increasing dose to patients and the potential for increasing and unmeasured doses to medical staff. Pertaining to nuclear power the challenges are to design power plants to adequately mitigate potential hazards and threats and to provide for appropriate management and recovery from release of radioactive material. These challenges are particularly critical in the developing world, but are also crucially important in the developed nations. The need to meet these challenges requires that radiation protection professionals be educated in medical physics on the one hand and nuclear engineering and physics on the other. The opportunities here are for the radiation protection community (IRPA and its Associated Societies) to collaborate with medical, medical physics and nuclear engineering societies, as well as medical service providers, equipment manufacturers and the nuclear industry to achieve the goal of educated and qualified radiation protection professionals for the future. To move forward IRPA has established a Working Group to draft a document for discussion on guiding principles for establishing a Radiation Protection Culture and plans to establish a Working Group to draft guiding principles for the Qualifications and Certification of Radiation Protection Experts.

Draft Revised EU BSS: Part I, Existing and Emergency Exposure Situations

JANSSENS A.

European Commission, Directorate-General for Energy, Radiation Protection Unit, EUFO 4157, L-2920 Luxembourg, augustin.janssens@ec.europa.eu)

The new Euratom Basic Safety Standards will update the current Directive 96/29/ Euratom and broaden its scope from two perspectives. Firstly, four other Directives (Medical, Outside Workers, High-Activity Sealed Sources, Public Information) will be incorporated. In principle this is a "recast" procedure within the overall policy of simplification of Community legislation. Secondly, the new Directive will cover all exposure situations, as defined in ICRP Publication 103. This results in requirements on domestic exposure to indoor radon and to building materials, and requirements on the protection of non-human biota, as part of overall environmental protection.

The paper will highlight some of the more important changes with regard to existing and emergency exposure situations, and focus on how they should be transposed into national legislation.

S4 - O2

New European Basic Safety Standards; Part II - Planned Exposure Situations

Kaare Ulbak

National Institute of Radiation Protection, Knapholm 7, DK-2730 Herlev, Denmark, ku@sis.dk

The European Commission have earlier this summer presented their draft revised Basics Safety Standards directive based on the recommendation from the Article 31 Expert Group taking into account ICRP Publication 103. The negotiations between the EU Member States and the Commission on the draft EU-BSS will take place the coming month in the Atom Questions Group of the Council. The paper will highlight some of the more important changes and challenges in implementation with regard to planned exposure situations, such as graded approach in regulatory control (exclusion, exemption, registration and licencing),occupational exposure (dose records), medical exposure (incorporation of the medical directive, accident prevention in radiotherapy) and deliberate exposure of humans for non-medical purposes.

Overview of the NKS-R programme and summary of ongoing activities

MYLLYMÄKI K.

Programme manager, NKS-R, Fortum Power and Heat, POB 100, FI-00048 Fortum, Finland, karoliina.myllymaki@fortum.com

NKS activities are sought and carried out under two broad research programmes. The NKS-R programme focuses on reactor safety and technology, whilst the NKS-B programme covers issues related to emergency preparedness and environmental issues. New NKS activities are sought under annual call for proposals for each programme and decisions on funding are made by the NKS board. The main aims of both the NKS-R and NKS-B programmes are to maintain and strengthen Nordic competence in the areas of nuclear safety and research and to develop close informal networks between scientists, workers and end users from the relevant Nordic authorities, organisations, industries and university departments that are concerned with the various aspects of nuclear safety and research.

With a total budget of 3.05 million DKK (409 k€), this year's NKS-R programme consists of seven activities, of which one is a continuing activity and six are new activities. The topics of this year's research are related to severe accidents, risk analysis, thermal hydraulics, organisational issues and safety culture and plant life management and extension. The projects bring together researchers and PhD students from universities and research centres in Denmark, Finland, Norway and Sweden.

Maintaining and developing Nordic expertise in nuclear research is important as several Nordic nuclear power plants are facing or undergoing modernizations and uprates. Furthermore the new builds planned in the Nordic countries create a demand for educated workforce in the nuclear field. The NKS-R programme aims at conducting research which is of interest for the end users, particularly encouraging the involvement of students and young scientists.

S5 - O2

An overview of the NKS-B Programme 2008-2011

GWYNN J.P.

NKS-B Programme Manager, NKS (Nordic Nuclear Safety Research), justin.gwynn@nrpa.no

With a total population of some 25 million people, and a common cultural and historic heritage, the Nordic countries have cooperated in the field of nuclear safety for approximately half a century. Informal networks for exchange of information have developed throughout the years, strengthening the region's potential for fast, coordinated and adequate responses to nuclear threats, incidents and accidents. NKS (Nordic Nuclear Safety Research) is a platform for Nordic cooperation and competence in nuclear safety, including radiation protection and emergency preparedness. The work is centred on nuclear power related issues and is divided into two main areas: Reactor safety (NKS-R) and emergency preparedness and environmental issues (NKS-B). The purpose of NKS is to carry out activities producing seminars, exercises, scientific articles, technical reports and other types of reference material, while special efforts are made to engage young scientists in this work. Activities are financed and supported by the Nordic authorities, research institutions, power companies, contractors and other organizations.

The aim of the NKS-B programme is to strengthen Nordic competence in the areas of radiological emergency preparedness, measurement strategy, technology and quality assurance, radioecology and the management of radioactive waste and discharges. Over the last four years (2008-2011) NKS has supported a total of 31 activities under the NKS-B Programme with a combined budget of 11.4 million DKK. Of these 31 activities, 16 activities were within the area of radiological emergency preparedness, 10 within the area of measurement strategy, technology and quality assurance, 3 within the area of radioecological assessments and 2 within the area of the management of radioactive waste and discharges.

Owners and Main Financiers of NKS
DK Danish Emergency Management Agency
FI Ministry of Employment and the Economy
IS Icelandic Radiation Safety Authority
NO Norwegian Radiation Protection Authority
SE Swedish Radiation Safety Authority

Additional funding provided by:
• Fortum Power and Heat Oy (Finland)
• TVO (Finland)
• IFE (Norway)
• Forsmarks Kraftgrupp AB (Sweden)
• Kärnsäkerhet och utbildning (KSU) AB (Sweden)
• OKG Aktiebolag (Sweden)
• Ringhals AB (Sweden)
• Fennovoima Oy (Finland)

International Gamma Spectrometric Assessment Exercises Using Simulated Spectra

DOWDALL M.[1], PÁLSSON S.E.[2] & UGLETVEIT F .[1]

[1]Norwegian Radiation Protection Authority, Grininæringspark 13, 1332,Østerås, Norway mark.dowdall@nrpa.no;
[2]Icelandic Radiation Safety Authority, Rauðarárstíg 10, IS-150 Reykjavík, Iceland.

Exercising is a key activity in ensuring effective emergency preparedness for nuclear and radiological emergencies. Gamma spectrometry is an important tool in this regard but may pose a significant challenge even to experienced analysts. The wide range of potential emergency scenarios makes it impractical to exercise with real sources but recent computational developments have facilitated computer simulation of gamma spectra of sufficient quality for exercising. The Nordic Nuclear Safety Research (NKS) has recently conducted three international exercises employing synthetic spectra to provide high quality training materials for enhancing the abilities of participating organisations. These exercise involved the analysis of a simulated HPGe spectrum from an air sample taken in the early phase after a major accident at a nuclear power plant, the analysis of gamma ray spectra acquired in response to malevolent acts involving different types of radioactive materials and mobile gamma spectrometry for location and identification of orphan sources and mapping fallout. Scenarios reflected realistic situations and spectra were generated using Monte Carlo simulation. All exercises were conducted under time constraints ranging from hours to days. Results for the exercises indicated some general areas of difficulty for participants in the areas of spectrum complexity, summation corrections, mother-daughter relationships and less commonly encountered isotopes. These difficulties impacted upon both qualitative and quantitative results. Many of the weaknesses observed in the results can to some extent be explained by lack of experience and exercising opportunities. This is an aspect which the NKS exercises were intended to ameliorate. This presentation will introduce the exercises, provide details of the scenarios and materials involved and discuss the exercises from the participants' point of view. The benefits and disadvantages of exercising with simulated spectra will be discussed and recommendations as to further activities will be presented.

Evaluation of the Radiological Emergency Field Operative Exercise, RE-FOX, taking place in Sweden 2012 with Nordic countries invited – Suggestion for a NKS-project.

FINCK R.R.

Swedish Radiation Safety Authority, 171 16 Stockholm, Sweden, robert.finck@ssm.se

In September 2012, the Swedish Radiation Safety Authority (SSM) plans to conduct a Radiation Emergency – Field Operative Exercise (RE-FOX). SSM has the intention to invite the Nordic Radiation Protection Authorities and other relevant Nordic organisations related to radiation protection to take part in the exercise. The exercise will be somewhat like the DEMOEX exercise that took place in Sweden in 2006 with Nordic participants, but with more scientific touch. The intention is to provide the opportunity to test and use different methods for radiation measurements. The exercise will probably include airborne gamma spectrometry, car-borne gamma spectrometry, measurements with portable equipment, sampling and mobile laboratory analysis. There will be different scenarios in the exercise, such as search of orphan sources, contaminated environment (using dispersed short lived radionuclides), a situation with a possible RDD, and maybe some decontamination experiments etc.

SSM would like to ask NKS to evaluate the results from the RE-FOX exercise and take initiative to a scientific follow-up of the methods and results. The main part of the follow-up is intended to be done in 2013. It could be performed in workgroups, workshops or in mini-symposia, much in the same way as was done by NKS after the RESUME 1995, RESUME 1999 and Barents Rescue 2001 exercises. SSM has reserved special funding for this follow-up that can be made available to the NKS work. SSM thinks that NKS is the right organisation for this follow-up. The very good experience from earlier NKS-work after exercises with Nordic participation speaks for this.

The responsibility will be divided into two parts. Part one is the SSM part. Planning and conducting the exercise will be the full responsibility of SSM. NKS is invited to take part in some of the planning meetings so that NKS can start the planning and the preparation of the follow-up work. Part two is the NKS-part. After the exercise, NKS is suggested to take the lead to evaluate the scientific parts of the exercise and conduct workshops and other relevant work. Finally NKS would organize the documentation of the results. The main part of this work is intended for the year 2013..

Radioecology and Radiation Emergency Preparedness in Iceland for 25 years – A Tribute to NKS

PÁLSSON S.E., Guðnason K. and Halldórsson Ó.

Icelandic Radiation Safety Authority, Rauðarárstíg 10, IS-150 Reykjavík, Iceland, sep@gr.is

Conditions in Iceland are in many respects different from those in the other Nordic countries. Some aspects of the environment are more limited and others offer possibilities, as e.g. the utilisation of geothermal heat. But in spite of the differences, the cooperation with the other Nordic countries has played an important role in the developments in Iceland.

This can be seen in the development of radioecology and radiation emergency preparedness in Iceland. There the Nordic Nuclear Safety Research, NKS, played a key role. After the Chernobyl accident in 1986, preparations were made to establish a radionuclide measurement laboratory at the Icelandic Radiation Safety Authority. In 1989, the laboratory began working on gamma spectrometric measurements using an HPGe detector. Initially, the focus was on assessing the consequences of the Chernobyl accident in Iceland.

When the first results were presented at an NKS work group meeting in Helsinki in December 1990, they were 3-4 orders of magnitude lower than results from the other members.

This presentation will give examples of conditions in Iceland, many of which are very different from what can be found in the other Nordic countries. Understanding the roots of the differences encountered and discussing them in a Nordic forum has been instrumental in building up the understanding we have today. The NKS Nordic cooperation has thus been a key element in providing a better understanding of the Icelandic conditions. A key feature of the NKS work has also been the provision of an informal, friendly and supportive atmosphere of cooperation.

European population dose from radiodiagnostic procedures – early results of Dose Datamed 2

BLY R. [1], **JAHNEN A**[2]., **JÄRVINEN H.** [1], **OLERUD H.** [3], **VASSILEVA J.** [4] **AND VOGIATZI S**[5].

[1]*Radiation and Nuclear Safety Authority, STUK, Finland, Laippatie 4, P.O.Box 14, FI-00881 Helsinki, Finland, ritva.bly@stuk.fi*

[2]*Public Research Centre Henri Tudor, Luxembourg*

[3]*Norwegian Radiation Protection Authority, NRPA, Norway*

[4]*National Centre of Radiobiology and Radiation Protection, NCRRP, Bulgaria*

[5]*Greek Atomic Energy Commission, GAEC, Greece*

In the end of 2010 the European Commission launched the DOSE DATAMED 2 (DDM2) project (www.ddmed.eu) with the objective to collect available data on the doses from radiodiagnostic (x-ray and nuclear medicine) procedures in the European Union and to facilitate the further implementation of the "Radiation Protection 154. European Guidance on Estimating Population Doses from Medical X-Ray Procedures". According to the project specification, a database for population doses will be established for the purpose of systematic evaluation of results and to enable a continuous follow-up and up-date of population doses in Europe as well as trends in their development.

The data collection will be carried out by questionnaires. The purpose of the first general questionnaire is to survey the national regulatory frameworks and the status of implementation of the requirements for medical dose surveys and population dose estimations. The survey is open to 39 invited European countries 1-18 March 2011. The results of the survey will be used to review the status of implementation of national surveys for population dose in each Member State or other European country. A more comprehensive survey for the population dose data will be opened in May 2011.

In the NSFS conference the available data in Europe for assessing population dose from radiodiagnostic procedures will be discussed. The status of population dose estimations in Nordic countries will be compared to the whole European level. The first preliminary results of population dose estimations, performed in some countries, will also be discussed.

S6 - O2

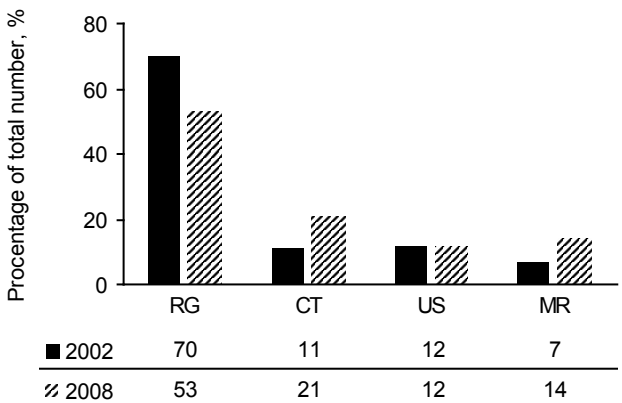
Trends in examination frequency and population doses in Norway, 2002 - 2008.

OLERUD H.M., FRIBERG E.G., WIDMARK A. & ALMÉN A.

Norwegian Radiation Protection Authority, P.O.box 55, NO-1332 Østerås, Norway,

hilde.olerud@nrpa.no

A new population dose survey in Norway anno 2008 gave the following key figures: 4,3 mill examinations (900 per 1000 inhabitants), 1.1 mSv/caput whereof 80% of the dose from CT. 23% of the examinations were done in private sector. Planar X-ray is reduced in number; ultrasound is about the same, while both CT and MR have doubled in frequency since 2002. The collective effective dose has however not changed since 2002. This is partly explained by technological advances in CT, but also the implementation of new radiation protection regulations since 2004, with increased focus on quality assurance and optimisation/diagnostic reference levels (DRL's).



The trends in use of conventional X-ray (RG), computed tomography (CT), ultrasound (US) and magnetresonance tomography (MR) between 2002 and 2008.

1. Børretzen I, Lysdahl KB, Olerud HM. Radiology in Norway – examination frequency per 2002, trends in time, geographical variation and population dose. StrålevernRapport 2006:6. Østerås: Norwegian Radiation Protection Authority, 2006. Language: Norwegian.
2. Almén A, Friberg EG, Widmark A, Olerud HM. Radiology in Norway anno 2008. Trends in examination frequency and collective effective dose to the population. StrålevernRapport 2010:12. Østerås: Norwegian Radiation Protection Authority, 2010. Language: Norwegian.

Frequency of Medical X-ray Examinations and Patient and Population Doses in Iceland in 2008.

Einarsson G.,

Icelandic Radiation Safety Authority, Rauðarárstíg 10, IS-150 Reykjavík, Iceland, ge@gr.is

Frequency of medical x-ray examinations have been investigated with collection of national data every 5 years and the latest collection, for 2008, has been used to assess patient doses and collective effective dose. In this report the results of this assessment will be presented.

National surveys on the frequency of medical diagnostic examinations have been done in Iceland every 5 years from 1993. The last one was in 2009 were data for 2008 was collected. IRSA has also since 1993 collected information about patient doses for medical examinations, with its own measurements at hospitals and clinics and dose data collection for all x-ray examinations. The methods used to assess effective doses from patient dose data, follow the guidelines presented in the EU report, RP-154 (2008). Data on patient doses for the most frequent x-ray examinations are presented with estimated effective dose (ED) and their contribution to the collective effective dose (CED). Data will be compared with information from older results.

The number of all medical diagnostic imaging examinations has increased by 35% from 2003, with an increase of 134% for MRI, 48% for CT and a decrease for Nuclear Medicine procedures by 42% and Angiographic- and Interventional procedures by 30%. Examination radiation doses are highest for CT examinations with an average dose of 7,2 mSv per/examination, which contributes about 75% of the CED.

Optimisation in diagnostic radiology – how EMAN can contribute to improvements

ALMÉN A., FRANK A. & LEITZ W.

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden, anja.almen@ssm.se

We need to have a broader view on optimisation in diagnostic radiology and find ways to improve communication. Actions are needed on different levels. One initiative on the Europe level is setting up the European Medical ALARA network (EMAN). One of the major tasks of the network is to serve as a meeting platform for different stakeholder and to initiate important measures to improve the situation. The achievements made so far by EMAN will be discussed.

The issue: Optimisation has been a fundamental pillar in radiological protection for a very long time. In diagnostic radiology optimisation is often described in a simplified and confined way; as a trade-off between radiation dose and image quality. Consequently, the scientific studies in the radiological protection community have dealt mainly with the "dose" to the patient and the "quality" of the images. The conclusions from such studies have not been widely applied in the clinic. And there is hardly any comprehensive approach to the issue in the clinical environment.

The reasons: One reason for these difficulties is the narrow minded view of the problem. The quality of the products (the outcome of the radiological examination) is influenced by numerous factors such as; equipment available and other types of resources in the clinic including competence, number of the personnel and finances. The optimisation process should also include the construction of the equipment and accessories, how the equipment is used etc. There is a lack of understanding of this process and what influences it.

The optimisation process: The whole process has to be mapped out in order to identify different important stakeholders involved such as; engineers constructing the medical equipment, health care providers, people in charge for purchases, health care professionals involved in setting up methodologies and evaluating the procedures in the clinic. Science in both medicine and technology are developing new features and solutions to medical problems and are also influencing this process. In addition, standards and regulations influencing design and use of technology have to contribute to the process. Within EMAN the entire process can be addressed involving relevant stakeholders.

Administrative Inspection of Danish X-ray Clinics

BJERKBORN A., FREDERIKSEN P.K., HØJGAARD B., WALTENBURG H.N.

National Institute of Radiation Protection, Knapholm 7, 2730 Herlev, Denmark, anbj@sis.dk

In August 2010, the National Institute of Radiation Protection (SIS) prohibited the use of all x-ray equipment in a private clinic in Copenhagen. On inspection, it had been found that the x-ray equipment did not fulfil the acceptability criteria. In spite of this, the clinic kept performing x-ray examinations for almost two months after receiving the letter of prohibition.

In Denmark, owners of medical x-ray equipment are required to appoint a medical physicist to take responsibility for the technical state of the x-ray equipment and to ensure that quality control is carried out in accordance with regulations. Following the case described above, where the responsible physicist played an important part, SIS made an administrative investigation of a sample of x-ray clinics. Documentation for quality control of the x-ray equipment was requested by mail or e-mail. This was a novel method for inspection of this type of facilities, as SIS normally makes physical visits to clinics.

The administrative investigation revealed large flaws in tests performed by external agents, such as x-ray manufacturers or retailers, as well as those performed by the responsible physicist. Physicists and engineers displayed poor knowledge of regulations and insufficient understanding of metrology and the treatment of measurement data. Clinic staff was often ignorant about the quality control system and unable to tell from the documentation of acceptance and status tests whether the x-ray apparatus was working properly or not. A closer description of typical problems and errors will be presented at the conference.

The administrative investigation has been a reminder of the importance of an efficient system for radiation protection in medicine, and that this system must also ensure the competence of the experts responsible for the technical aspects.

Patient organ radiation doses during treatment for aneurismal subarachnoigehaemorrhage

SANDBORG M., ROSSITTI S & PETTERSSON H.nd NILSSON-ALTHÉN J.

*Department of Medical Physics, Linköping University, University Hospital and CMIV, SE-58185 Linköping, Swednd, michael.sandborg@liu.s)*m.

The aim of this retrospective study was to estimate the radiation doses to fifty individual patients' risk orgad) during the treatment for subarachnoid haemorrhage (Sing. The imaging procedures comprise of computed tomography (CT) and 2D and 3D imaging during the interventional coilysm.

Equivalent doses to risk organs $H_{org,pha}$ were measured usie (Li_2B_4-) dosimeters in an anthropomorphic head phantom. The phantom was imaged using the same imaging protocol and imaging systems as with the patients included in this studd. The kerma-length product $P_{KL,pha}$ or kerma-area product $P_{KA,pha}$ for these phantom measurements were recorded. The hospital's Picture Archiving and Communication System (PACS) records were analyzed and the frequency of each imaging procedure for each patient was collected as well as the registered $P_{KL,pat}$ or $P_{KA,pat}$ for each imaging procedurs. The patient risk organ doses were finally computed by multiplying the conversion factors $H_{org,pha}/P_{KL,pha}$ or $H_{org,pha}/P_{KA,pha}$ with the individual patient's $P_{KL,pat}$ or $P_{KA,pat}$ for each procedure.

The results show ths. 82% of the patients made a good recovery or had moderate disability, 10% survived with severe disability and 8% died. The average fluoroscopy time was 38 min, the average P_{KL} was 7269 mGycm and the average P_{KA} was 286 Gycm2. The estimated average equivalent organ doses were as follows: brain 0.91 Sv (range 0.20-2.81 Sv), eye lens43 40 Sv (range 0..000.92 Sv), oral mucosa 0.07 Sv (range 0.02-0.19 Sv), thyroid 0.02 Sv (range 0.01-0.06 Sv) and salivary gland 0.23 Sv (range 0.06-0.63 Sv). The dose to the brain arises mainly (55%) from the interventional procedure and to a smaller extent from CT (45%) procedures. The eye lens dose arises mainly from C(7479%) and to a smaller exten(2521%) from the interventional coiling procedurr. The maximum eye lens equivalent dose found in this group of patients wa10.0 92 Sv, hence below but still close to the threshold for eye lens cataract (1.5 CTA. With the increased use of CT and other 3D imaging for patients treated for SAH, the risk for deterministic injuries, such as lens cataract, seem higher than the risk of late radiation effects such as Schwannoma or Meningis.

InWe concludesion, the risk for late radiation effects (cancer) is small compared to the risk of deterministic radiation injury (eye lens cataract) at our hospil.

Radiation dose in cardiac CT measured with TLD´s and compared with DLP.

FRIÐRIKSDÓTTIR H.Í.[1], MÝRDAL G.[2] & GUNNARSSON G.Þ.[1]

[1]Akureyri University Hospital, Eyrarlandsvegi, IS-600 Akureyri, Iceland, jshf@simnet.is [2]Landspitali University Hospital, Hringbraut, IS-101 Reykjavik, Iceland, gardar@lsh.is

The goal of the study is to reduce the radiation dose to patients fulfilling indication for prospective gating in cardiologic CT-examinations.

CTDI was measured in the 128-slice CT-scanner in Akureyri University Hospital (Siemens Definition AS) for controlling the CTDI-values on the operation console screen.

TLD measurements in a humanoid phantom were performed for both prospective gated and for retrospective gated examinations of thorax.

The displayed CTDI- and DLP values and the TLD-values were compared for both methods of gating.

CTDI- and DLP values were compared for actual patient examinations for prospective gating (15 patients) and for retrospective gating (15 patients).

The results of the measurements will be presented. Preliminary results indicate that examinations with retrospective gating give 2.5 to 3 times higher radiation dose to the patient than examinations with prospective gating.

Staff Doses in Interventional Cardiology

ANDERSEN T., HØJGÅRD B., BERG K., ROED H. & WALTENBURG H.N.

National Institute of Radiation Protection, Knapholm 7, DK-2730 Herlev, Denmark, tan@sis.dk.

The use of fluoroscopy guided procedures in cardiology is increasing and therefore the National Institute of Radiation Protection in Denmark (NIRP) would like to investigate whether the doses to the staff at Danish Hospitals are sufficiently monitored. Especially doses to the hands and eyes are of concern, because the staff is working close to the patient and the X-ray tube during the procedures. The project was carried out in cooperation with cardiology laboratories at two public hospitals in Denmark.

The staff is routinely monitored with film badges worn under the lead apron. In addition, the persons in the study wore an extra film badge placed on the shoulder above the lead apron. The effective doses to the staff were calculated using the dosimetric algorithm proposed by Niklason et al. Extremity doses were monitored by means of ring TLD dosemeters.

In total, data from 44 persons was collected. NIRP was also informed of the number of procedures each person had participated in.

Results:

The results show that the effective doses to the staff at the two cardiology departments are relatively low, even when the Niklason algorithm is used to include the doses to the parts of the body that are not covered by the lead apron. The annual dose limit of 20 mSv is far from being exceeded.

The doses to the eyes of the staff are below the current annual dose limit of 150 mSv, but if the recommendations to lower the dose limit for the eyes become a reality, the doses received by a part of the staff could be above the new recommended dose limit. This implies that the doses to the eyes of the staff at the cardiology departments should be followed closely in the future, for example by use of dosemeters placed on the shoulders above the lead apron. It might also be necessary to require lead glasses during fluoroscopy.

It was not possible to complete the monitoring of the doses to the hands of the workers with ring TLD dosemeters, because of the challenges of maintaining sterility. This part of the study was interrupted after a few days.

Changes in collective dose a result of underlying variations in frequency and dose

FRANK A., ALMÉN A & LEITZ W

Swedish Radiation Safety Authority, Stockholm ,SWEDEN anders.frank@ssm.se

Changes in collective dose between the year 2005 and 2008 have been investigated using a simplified method for the assessment of population doses from medical x-ray imaging [1]. The collection of data is restricted to a sample of representative hospitals for those 20 x-ray examination categories contributing mostly to the population dose. In order to calculate the collective effective dose from medical exposures the numbers of examinations have to be known together with the effective doses.

The Swedish national coding system was used to identify the 20 categories. From a sample of hospitals (around 20 % of the country) frequency data was collected from the radiological information system (RIS). Dose values were collected from national dose surveys and when not available from tabulated values in the guidance.

A comparison between the reported data from 2005 and 2008 is showing that the collective doses for plain radiography and fluoroscopy have decreased with 19% and 36%, respectively. This is due to a decrease of the number of examinations and a decrease of the mean dose values. The collective dose for CT and PTCA has increased during these three years with 30% and 8%, respectively, mainly because of the increased number of examinations. The mean dose values for CT have decreased slightly. The dose data for PTCA was available for 2008 in, the same value was taken for 2005.

For all examinations the dose per examination has decreased or remained unchanged, but the total collective dose increased with 8% from 2005 to 2008. This can mainly be attributed to the increased number of CT examinations.

1. European Commission. Radiation Protection No 154. European Guidance on the Estimating Population Doses from Medical X-ray Procedures. 2008.

Thermoluminescence dosimetry used as a postal quality audit in intraoral radiology

KELARANTA A.E.L., HAKANEN A.T.

STUK–Radiation and Nuclear Safety Authority, Laippatie 4, FI-00881 Helsinki, Finland, anna.kelaranta@helsinki.fi

Incident air kerma at the midpoint of exposure field is measured using thermoluminescence dosemeters (TLDs) as a postal quality audit in intraoral radiology. In addition to regular site visits, the postal quality audit is a part of STUK's Radiation Practices Regulation.

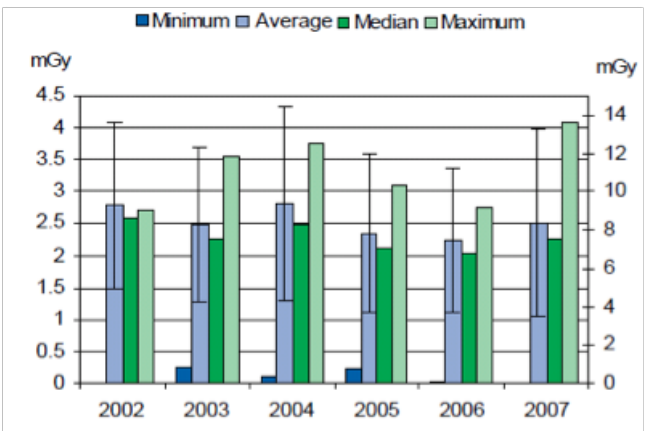


Fig.1. Incident air kerma per single dental bitewing exposure in Finland in 2002-2007. Maximum values have their own mGy-scale on the right side of the Fig. 1.

STUK maintains a registry for x-ray tubes/generators used in dental radiology. Formerly, TLD doses were calculated using a Microsoft Access interface connected to an SQL server database. In the future, TLD doses will be calculated using a WinTLD software which is a product of Mirion Technologies (RADOS) company. In the present survey, TLD calibration files/quality documentation from the years 1996-2009 were evaluated, and the parameters used in the dose calculations were either redetermined (energy correction coefficient) or adopted as a part of the forthcoming WinTLD configuration. ISO High Kerma Rate (H-series) x-ray spectra were set-up as a part of the work. Between 2002 and 2007, the average incident air kerma per single dental bitewing exposure was about 2.5 mGy. The expanded (k=2) uncertainty of the TLD measurements was 7.8%.

What about veterinarians' use of x-ray equipment? – Results from a nation-wide survey on the use of diagnostic x-ray among veterinarians in Norway.

SOLBERG M.

Norwegian Radiation Protection Authority, Grini næringspark 13, N-1361 Østerås, Norway, marie.solberg@nrpa.no

Norwegian Radiation Protection Authority (NRPA) has undertaken a study to assess veterinarians' use of X-ray equipment in Norway. The main objective was to study occupational exposure to ionizing radiation including attitudes toward and knowledge about radiation protection in veterinary clinics.

A web-survey among a large number of veterinarians throughout Norway was conducted. The Norwegian organization for veterinarians distributed the survey among their members and thereby enabled a large number of responses to be collected. In addition on-site data inspections at 13 veterinary practices were performed. The inspections included interviews, on-site inspections, verifications of compliance with regulatory requirements and in situ measurements of scattered radiation.

The web-survey was completed by 441 veterinarians, whereof 276 from 143 different veterinary practices, confirmed that they were using X-ray equipment. The results from the survey and inspections generally show satisfactory daily routines with regard to the use of X-ray machines, especially concerning occupational health aspects. However, nearly 50 % of the respondents were not familiar with the regulations. During the inspections, certain regulatory requirements were found to be less than satisfactory in most clinics. Such requirements included reporting the use of X-ray machines to the NRPA and the proper use of radiation warning symbols in rooms where X-ray equipment was used. About 50 % of the veterinarians who used X -ray equipment carried personal dosimeters. In addition measurements of scattered radiation from a single-exposure x-ray examination of a large dog were performed. From this the average occupational exposure in terms of ambient dose equivalent was found to be 2,5 μSv.

Web-survey is a very effective tool for assessing attitudes and practice within a large group. In combination with a smaller number of on-site inspections we managed to gain insight in and increase focus on veterinarians' daily use of x-ray equipment nation-wide.

Creating New Guidelines for CT Reference Dosimetry

HØJGÅRD B., ØBERG M. & WALTENBURG H.N.

National Institute of Radiation Protection, Knapholm 7, DK-2730 Herlev, Denmark, brh@sis.dk.

Objective:

The current national guidelines for measurement of diagnostic reference levels (DRLs) in CT are from 2001. They were intended for single slice CT, where the variation in technical parameters of scanning protocols was much more limited than in multi-slice CT. Thus, they are not detailed enough for the collected results to be compared. In order to systematize assessment of CT patient doses in Denmark, there was a need for updated guidelines that better reflected current practice. The guidelines should contain all the information needed to evaluate differences in patient doses reported for different scanners and from different diagnostic centres. As the use of CT is steadily growing, and the patient doses are high, it is important that there are precise and meaningful DRLs for optimizing CT protocols.

Method:

We have asked for resource persons with experience in CT to assist in the development of new guidelines. Around ten people from different professions (physicists, radiologists and radiographers) have volunteered, and more have offered their opinions on the subject via e-mail to the Institute. Several diagnostic centres have put themselves at disposal for the duration of the trial period.

The Institute has developed the basis for new guidelines including 16 technical parameters and 11 types of CT examinations and inquired about the most common indications for these examinations. The resource group has received a web-based questionnaire containing both qualitative and quantitative questions. The answers provide a direction for the definitive version of the guidelines, so that resulting in the collection of patient doses will be useful in practice. A few diagnostic centres will run a pilot project using the new guidelines in order to test the usability and comprehensibility. Unlike the current guidelines, the new ones are based on indications rather than exclusively the area of the body examined. Patient doses are to be collected for instance for ”CT, suspected lung cancer” rather than for the more general ”CT lungs”.

The new guidelines and the results from the pilot project will be presented.

Occupational dose of technical staff at radiotherapy simulation PET/CT studies.

CUTANDA HENRÍQUEZ, F. & VARGAS CASTRILLÓN, S.

Hospital General Universitario Gregorio Marañón. Servicio de Medicina Nuclear. Calle Doctor Esquerdo, 46. 28007. MADRID (Spain). francisco.cutanda@salud.madrid.org

Purpose of Study: To evaluate radiation exposure of technical staff involved in simulation procedures in a PET/CT unit. Technical staff carry out the most time consuming activities, such as positioning and marking of the patient, prior to radiopharmaceutical injection; nevertheless, radiographers from the Radiation Therapy department are in charge of the re-positioning of the patient for scanning, therefore they can be in close contact with a patient in several occasions during a simulation procedure.

Methods: A PTW 32003 ionization chamber along with a PTW UNIDOS electrometer and a Thermo SmartION survey meter traceable to PTB standards were used. Measurements were carried out for different diagnostic procedures (not only simulations) on 50 patients in a Siemens Biograph 6 machine. The patient was lying down on the couch and the point of measurement was at several distances and relative positions. Estimates were obtained on a "worst case scenario" basis, assuming the most complicated positioning technique. Staff rotation was taken into account.

Results: Estimates for staff dose, under worst case scenario assumptions, yield a maximum value of 1.30 mSv/year, but a mean value lies within the interval 0.90 to 0.80 mSv/year.

Conclusions: Dose to staff involved in simulation procedures in our PET/CT facility lies well below recommended annual limits. Staff rotation is a key element on keeping doses as low as reasonably possible. For staff working in the facility, the major radiation dose contributions are the ones involving preparation of the radiopharmaceutical and patient care when recently injected. At the time the patient is ready to be scanned, activity has decreased because of physical decay and bladder emptying.

Advice to refrain from non-medical ultrasound examinations of the foetus

DANESTIG SJÖGREN C . & LEITZ W.

Swedish Radiation Safety Authority, se 171 16 Stockholm,Sweden, catarina.

danestig.sjogren@ssm.se

The Swedish Radiation Safety Authority (SSM) has reacted to the increase of non-medical ultrasound (US) examinations of the foetus with the purpose to achieve images or videos "just for fun". Although US examinations are regarded as safe, there is a risk for harmful warming-up of the foetus, especially when non-professional personal is involved. There are also epidemiological studies showing neurological effects of US, an increased occurrence was found for left-hand boys who were irradiated prenatally with US.

With reference to the precaution principle SSM decided to start a campaign with the aim to prevent abuse of US. A letter was sent to all mid-wives in Sweden in which information was given about SSM:s concerns. The mid-wives were asked to pass this information to the pregnant women to whom they have early contact and thus to encourage them to restrain from souvenir images.

SSM is giving the following recommendations:

Diagnostic US shall only be used if the medical benefit is larger than the predictable harm. Only certified personnel with adequate training and education shall conduct US-examinations.

Diagnostic US shall not be used for taking images or videos of the foetus, neither for assessing the gender of the foetus on grounds others than medical.

DAP in Dental Panoramic and Chepalometric Examinations in Iceland.

Shimmyo D.Y., Einarsson G.

Icelandic Radiation Safety Authority, Rauðarárstíg 10, IS-150 Reykjavík, Iceland, dys@gr.is

The number of panoramic dental examinations and the level of patient doses for these examinations have not been studied in Iceland and with increased numbers of panoramic equipment in dental clinics, it is of value to evaluate patient doses and propose national reference dose values.

This paper will describe an investigation into the number of procedures and measurements of patient doses on all panoramic (panoramic and cephalometric-) equipment that is used in the country. The objective is to collect both information about the level of patient doses and number of procedures performed in one year and from these results propose national reference levels for these procedures.

There are 17 units in use (5 are digital) and 10 of these are also used for Cephalometric examinations (a.p. and lat. projections of the head). These units are located in 14 dental clinics.

Measurement of patient doses was done by measurements of DAP for the most relevant clinical settings of each x-ray unit. These measurements were done on all equipment.

Results of measurements on patient's doses, with estimate of effective dose and contribution to the collective effective dose will be presented. Although the numbers of measurements and equipment in this survey are

few, a reference dose will be proposed and compared with published DRL's in others countries.

S7 - O1

Guidance on internal audits and self-assessments: support to external clinical audits

ALANEN A.[2], JÄRVINEN H.[3], AHONEN A.[4], CEDER K.[4], LYYRA-LAITINEN T.[5], PAUNIO M.[6], SINERVO T.[7], AND WIGREN T.[1]

[1] *Tampere University Hospital, Finland*
[2] *Turku University Hospital, Finland*
[3] *Radiation and Nuclear Safety Authority, STUK, Finland, Laippatie 4, P.O.Box 14, FI-00881 Helsinki, Finland; hannu.jarvinen@stuk.fi*
[4] *Helsinki University Hospital, Finland*
[5] *Kuopio University Hospital, Finland*
[6] *Ministry of Social Affairs and Health, Finland*
[7] *Finnish Accreditation Service (FINAS), Finland*

High quality and good safety culture in the use of radiation in health care are ensured by systematic assessments of the quality of the practices, both by internal and external assessments. Internal audits and self-assessments are the most efficient and quickest way to evaluate the practices and to identify the areas where there is a need for development. In planning of the internal audits and self-assessments, it is of high importance to ensure that these will support the external clinical audits and vice versa. Therefore, both in internal audits and self-assessments, it is useful to select for assessments also topics which are expected to be assessed in external clinical audits.

The Finnish National Advisory Committee for Clinical Audit (NACA) is responsible for the overall coordination of clinical audits in Finland and has published several recommendations for the implementation of clinical audits. The latest recommendation (February 2011) provides basic guidance for internal audits and self-assessments, as supplementary procedures to the external clinical audits. The basic principles and the essential contents of this recommendation are reviewed in this paper.

Dose Measurements on Dental Tomographs and CBCTs

FREDERIKSEN P.K., BJERKBORN A., HØJGÅRD B. & WALTENBURG H.N.

National Institute of Radiation Protection, Knapholm 7, DK-2730 Herlev, Denmark, pkfr@sis.dk.

One of the assignments of the National Institute of Radiation Protection (SIS) is to inspect x-ray equipment at dental clinics.

Since the summer of 2010, SIS has measured the dose given to a patient from tomographs and Cone beam CTs (CBCT). Data presented in this study is for equipment that has been inspected according to routine procedures, i.e. after installation and then with 5 year intervals.

The patient dose was measured with a DAP meter that was attached to the equipment by either non marking tape or a belt. For a few tomographs it was not possible to attach the meter by these methods and consequently no dose was measured.

Doses have been measured for the settings routinely used by the clinic; i.e. for a 'standard' patient. These may vary for the same equipment used by different clinics. It is thus not the aim to compare performance of equipment from the same or different manufacturers at the same settings.

SIS has done measurements on 4 tomographs operating with film and 31 digital ones. 2 of the tomographs could additionally perform CBCT scans. One tomograph could only run in CBCT mode, and could then afterwards reconstruct 2D images from the 3D data.

For digital equipment, doses fall in the range from 3.12 to 18.68 $\mu Gy \cdot m^2$ with a mean value of 8.46 $\mu Gy \cdot m^2$ and median of 6.88 $\mu Gy \cdot m^2$.

For equipment using film and CBCT, dose ranges are from 6.34 to 32.65 and from 42.34 to 70.00 $\mu Gy \cdot m^2$, respectively.

Nordic survey on national management and requirements for use of dental Cone Beam CT

Friberg E.G., Leitz W., Waltenburg H., Tenkanen-Rautakoski P, Einarsson G.

Norwegian Radiation Protection Authority, P.O.Box 55, N-1332 Østerås, Norway, eva.friberg@nrpa.no

Introduction: Cone Beam CT (CBCT) has become a very attractive imaging tool within dental radiology, mainly because of its capability of providing cross sectional images and three dimensional reconstructions. However, CBCT are associated with higher doses and risks compared to traditional dental radiographic methods. Numerous vendors have started intensive and often quite aggressive sales campaigns for CBCT, yet the evidence-base for appropriate use is not yet strong. Countries with weak or no regulations for use of dental CBCT have experienced a rapid increase in the number of CBCT being purchased, mainly among dentists with no postgraduate qualifications or special expertise in radiology and radiation protection. There is evidence in the literature of inappropriate and excessive use of CBCT together with evidence of poor image quality because of insufficient attention to quality assurance and inadequate training of users. The aim of this work was to compare national management and requirements for dental CBCT among the Nordic countries to identify differences and similarities and to evaluate the need for establishment of common Nordic recommendations for dental CBCT.

Method: Detailed information on national management and requirements of dental CBCT among the Nordic countries were collected by use of a questionnaire distributed to all national radiation protection authorities.

Results: Major differences in management and requirements for dental CBCT were identified among the Nordic radiation protection authorities. No consensus regarding requirements for authorization, radiation protection officer, room shielding, classification of workplace, need for radiologists, medical physicists, image interpretation, CBCT operation, quality control, national diagnostic reference levels were found.

Conclusion: To obtain a harmonized management of CBCT among the Nordic countries and to ensure justified and optimized CBCT examinations there is a need for establishment of some common Nordic recommendations for dental CBCT.

External effects of an out patient PETCT facility.

Francisco Cutanda Henríquez[1], Silvia Vargas Castrillón[2].

[1]Hospital General Universitario Gregorio Marañón. Calle Doctor Esquerdo, 46. 28007. Madrid (Spain).
[2]Laboratorio de Metrología de Radiaciones Ionizantes. CIEMAT. Avda. Complutense, 22. 28040. Madrid (Spain).

Purpose of Study.

The aim of this work is to study the impact of a PET/CT facility on the community environment.

Methods.

A comprehensive radiation survey has been performed in the PET/CT unit at Hospital General Universitario Gregorio Marañón. Values obtained from this survey have been used to estimate dose for different profiles and different facility setups: a facility in a busy part of a city, with difficult access by car and another one with easy car access. The profiles are: facility staff, close relative (living in the same house), relative, member of the public.

Results.

Results for facility staff suggest some 3,6 mSv maximum dose for facility staff directly involved in performing the studies. Dose to relatives is below 50 µSv, and dose to public, even in an extremely unfavourable scenario, is well below natural background levels.

Conclusions.

The impact of a PET/CT facility on the surrounding area due to radiation is very limited, and it can be safely considered negligible.

Radiation doses 2001-2010 to staff working in a large PET and PET/CT department

HOLM S., SVALLING S., KLAUSEN TL, LOFT A.

Dept. of Clin.Physiology, Nuclear Medicine and PET, Rigshospitalet 3982, Blegdamsvej 9, DK-2100 Copenhagen Denmark

The PET centre at Rigshospitalet was founded in 1991 mainly as a research tool. The advent of PET/CT in 2001 fundamentally changed this. Today the centre has 4 PET/CT and 1 PET and #patients increased from 820 (2001) to 4884 (2010). The majority are cancer patients, imaged until recently with 400 MBq F-18 FDG in search of metastases or (~1000 patients) for planning of radiotherapy. The protection of the staff handling the radioactive patients (technologists and radiographers) always had a high priority and over time many measures have been taken to improve shielding and tools. In this abstract only whole body exposition is considered.

Staff is monitored by film dosimetry (National Institute of Radiation Protection) at 1-month interval and by electronic dosimeters (Rados 50/51/60). Previous studies presented at EANM congresses, have shown that 1) recordings by film, Rados (and TLD) are closely related in the PET rad. field 2) the precision of film dosimetry (0.1 mSv) makes it difficult to draw conclusions about small changes in procedures 3) the primary source for whole body dose is the handling of the radioactive patient in and out of the scanner, rather than dose drawing and injection and 4) patients for radiotherapy planning "cost" about double dose compared to standard imaging, due to the higher demands for precision in positioning and fixation. In Jan. 2010 automated injection was implemented, and since July 2010 a weight based injection scheme is used with a general reduction of 30 % in activity, maintaining the average scan time and image quality at the same time. The number of scans/month has been drawn from our RIS.

Average staff dose/scan decreased from 0.012 mSv (2001) to 0.009 mSv (2009), despite an increasing fraction of "therapy-scans" from 0 to 20%. Only in a few instances has a monthly dose exceeded our "intervention level" of 0.5 mSv and no one received 6 mSv in a year (maximum 5.6 mSv). Other staff groups (medical doctors, physicists, secretaries) in general receive 0 on their films. In the first half of 2010, the average was still 0.009 mSv /scan, but in 2nd half of 2010 it was reduced to 0.007 mSv/scan.

Despite an increase in #patients by a factor of 6, it has been possible to reduce staff dose per patient by 30% up to 2009. In 2010, a further reduction has been possible without compromising examination results.

Implementation of Radiation Measurement Criteria and Limits for Guidelines for Small Radioactive Spills at Landspitali University Hospital, Reykjavik.

GUDMUNDSDOTTIR V. , HALLDORSDOTTIR H., MYRDAL G.

Landspitali University Hospital, Hringbraut, 101 Reykjavik, Iceland, valdisgu@landspitali.is

This work came about when the authors were establishing response guidelines for small radioactive spills (diagnostic dose levels) of short lived beta and gamma emitting radioisotopes at LSH hospital. We observed an abundance of litterature but found this litterature dominated firstly by prevention measures, secondly by guidelines for laboratories and thirdly by instructions for large scale incidents. We set out to deliniate the appropriate methods of radiation quantification and limits to apply in the case of small spills involving doses of diagnostic levels occurring anywhere inside the hospital.

We propose measuring the dose rate (μSv/hr) and then estimating the activity of the spill in Bq/m^2 from these measurement using appropriate radiation source models; point source, line or surface. We discuss how the use of mixed models may be appropriate when a spill is unevenly distributed. We apply the mixed model approach to a practical example of a broken Tc-99m syringe in a hospital staircase where the contamination has spread in such a way that the point source model alone can no longer be used to assess the radiation.

From the dose rate the effective dose of external radiation from the spill is estimated using measurements of the spill geometry, activity, the time of exposure of the persons (public or workers) and a conversion factor from activity to dose rate.

From the available litterature on access restrictions due to surface contamination we deliniate the activity limits that determine access conditions to a contaminated area, inside and outside a laboratory.

We conclude a set of concrete measures and limits for the assessment of incidents involving small radioactive spills inside the hospital to be incorporated into our responce guidelines.

References: IAEA Tech-Doc 1162, Generic procedures for assessment and response during a radiological emergency, IAEA, Vienna, 2000. Advisory Committee on Radiological Protection, Report 7, Derived Working Limits for Surface Contamination, ACRP, 1993.

Interactive Web Services for Optimizing Nuclear Medicine

BLADH-JOHANSSON CARL, RICHTER SVEN, JÖNSSON HELENE

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden
Carl.Bladh-Johansson@ssm.se, sven.richter@ssm.se, helene.jonsson@ssm.se

For the Radiation Safety Authority (SSM) to monitor the development of nuclear medicine in Sweden and to calculate radiation doses to the population SSM annually collect information on the studies and treatments made. All data are saved in a database for compilation. Data are available for each hospital and all studies from 1999 to 2009. For each examination or treatment the number of patients and the medium activity are available for adults and for children.

On our web site it is also possible to calculate the radiation dose to patients from different procedures through the service "Doskatalogen". Radiation doses were determined different radiopharmaceuticals for adults, children and adolescents using Monte Carlo simulations. The calculations were made by persons involved in the ICRP and comply with data from ICRP.

Unfortunately, the page is only in Swedish, but an informed user can probably easily understand how to obtain the desired information.

An important purpose of disseminating information is to help hospitals in the optimization and modification of practices. The individual hospitals themselves can do a comparative analysis of information obtained through an interactive service that is available on our website, www.ssm.se. When doing a search the results can be saved in your own computer as an Excel file.

Link to isotope statistics: apps.stralsakerhetsmyndigheten.se / isotope / index_ nomenu.asp

Link to Doskatalogen: apps.stralsakerhetsmyndigheten.se/lpadoskatalog

Background

There are 32 nuclear medicine departments in Sweden. Cyclotrons and PET are found at four hospitals.

In the year 2009 approximately 105 000 examinations and 3000 treatments were made.

The collective dose for adults from diagnostic procedures was calculated to 360 manSv.

Action levels and guidelines for Swedish Armed Forces operations in radioactively contaminated environments

BOSON, J. & ULVSAND, T.

Swedish Defence Research Agency (FOI), SE-901 82 Umeå, Sweden, jonas.boson@foi.se

The aim of this project has been studying action levels for radioactive contamination. Which action levels apply today for the Swedish Armed Forces when operating in a possibly contaminated environment, and are these action levels relevant?

There are a number of documents dictating guidelines for Swedish Armed Forces operations in radioactive environments. Documents discussed here are those applicable for non-article 5 crisis response operations, such as Swedish military missions in Kosovo or Afghanistan. Key documents are NATO ATP 3.8.1 'CBRN Defence on Operations' and corresponding STANAG documents.

During initial studies performed by FOI and during a workshop held at the National CBRN Defence Centre in Umeå – with representatives from the Swedish Armed Forces, FOI and the Swedish Civil Contingencies Agency – some key issues were identified.

First of all there is considerable confusion about differences between guidelines, action levels and limits, as well as between action levels for different cases of radioactive contamination, i.e. contamination of personnel; working in a contaminated areas; and clearance of materials.

In addition to this, action levels presented in ATP 3.8.1 (which are similar to those given in IAEA Tecdoc 1092) appears to be unnecessarily low if applied to an emergency or other situation of limited duration.

In particular, work has focused on discerning the background to aforementioned action levels. Action levels stated in IAEA Tecdoc 1092 are, in fact, based on values calculated for radiation protection in a working environment. Application of these action levels in an emergency situation might lead to absurd consequences. The low values also raises questions as to whether they are readily measurably with handheld instruments.

Parallel to this work, experiments regarding instrument sensitivities have also been performed by FOI.

Officer on Duty at the Swedish Radiation Safety Authority

FRITIOFF K, FRANK A., FRIBERG J., HUBBARD L., HÄGG, A-C, LINDH K., LUNDMARK K., NILSSON T., STÅLNACKE C-G, WIEBERT A., ZIKA H.

Swedish Radiation Safety Authority, 171 16 Stockholm, Sweden, karin.fritioff@ssm.se

One of the tasks of the Swedish Radiation Safety Authority, SSM, is to protect people and the environment from the consequences of radiation accidents or incidents. Consequently, the Authority is on alert to deal with events such as an accident involving nuclear technology or an accident occurring during transport of radioactive material. As the Swedish Competent Authority within radiation protection and nuclear safety, the Authority first and foremost provides advice and recommendations to those dealing with the incident or accident.

The Authority therefore has a radiation protection officer on duty reachable 24/7/365 via the SOS Alarm Centre. In addition, a Swedish government ordinance from 2006 requires that a number of authorities in Sweden, including SSM, shall have an officer on duty in case of accidents. The officer is the official contact point at the authority in a crisis or accident situation. The officer shall have the competence to make a preliminary assessment of the situation in order to decide what the officer on duty individually, or together with an external actor, can manage and when SSM´s preparedness group, or the entire emergency organization, should be alerted. The officer also replies to, or forwards, requests about radiation protection resources and expert actions at a national and international level.

In this paper (presentation) we will discuss the different roles of the officer on duty: an advisor, a coordinator, the person initializing the emergency organization and its executive until the organization is settled. The paper will also present the background to the functions of the officer on duty at SSM and some real life examples for the officer on duty during the last years.

Use of deliberative stakeholder involvement in preparation of radiological emergency operating procedures at a steel mill

KOSKELAINEN M. O., & NUOJUA M.

Finnish Radiation and Nuclear Safety Authority and Unversity of Manchester, Laippatie 4, FI-00880 HELSINKI, Finland, markku.koskelainen@stuk.fi

Radioactive sources have many beneficial uses in medicine, industry, and agriculture, but when these sources are lost, misplaced, or stolen, they can have far-reaching consequences, especially if they enter the metal recycling chain.

To prepare for such events metals industry, have been equipped with monitoring capabilities and begun the process of preparing emergency operating procedures (EOPs). In a steel mill environment EOPs are essential for ensuring worker safety and preventing spread of radiological contamination.

The level of preparedness and implementation of EOPs varies from facility to facility, from no guidance to fully implemented and validated sets of procedures.

This article outlines a deliberative stakeholder process undertaken by a Finnish Blast Oven Furnace (BOF) operator to prepare EOPs for radiological incidents.

The procedure to prepare the EOPs begun with a consensus conference, where specialists were tasked to prepared the preliminary EOPs in accordance to international guidance. Capability building programmes were started simultaneously to provide the management and employees with a basic knowledge of radiation protection and risks associated with radiological accidents and incidents metal industry.

The preliminary EOPs were validated by the directors, management, and employees through an open stakeholder programme, and tested in an emergency exercise.

The deliberative stakeholder approach to EOP preparation showed a greater acceptance of the EOPs from the staff, and enabled the staff to gain ownership of the EOPs and make them functional for their respective roles.

RadiaCopter – UAS Gamma Spectrometry for Detection and Identification of Radioactive Sources

[1]GÅRDESTIG M; [2]KOCK P & [1]PETTERSSON H.B.L.

[1]Dept. of Radiation Physics, Linköping University and Linköping University Hospital, SE-581 85 Linköping, [2]Dept. of Medical Radiation Physics, Clinical Sciences, Lund University, SE-221 85 Lund, Sweden. magnus.gardestig@lio.se

The RadiaCopter is a measuring system for detection and identification of radioactive sources, carried by an Unmanned Aircraft System (UAS). This system fills a gap between existing systems of handheld detectors and full-size airborne systems as well as complementary to the car mounted detection systems.

The MD4-1000 (microdrones GmbH) is a quadrocopter (four rotors), called an AUMAV (Autonomous Unmanned Micro Aerial Vehicle) categorized as Unmanned Aircraft System (UAS) category 1B regulated by the Swedish Transport Agency. The drone carries up to 1200 g payload, which is well suited for holding a gamma spectrometric system.

The RadiaCopter combines high spatial resolution with good range. Opportunity to get close to the source gives high sensitivity with relatively small detectors and combined with an onboard camera it is also possible to visualize and determine the state of the source. The range makes it possible to cover larger areas during less time than hand-held systems, yet having the operator at safe distance. The RadiaCopter is intended to solve missions in customs, RN-threats, orphan sources or terrestrial data collection.

The regulations limit the search area to a radius within visual line of sight of the pilot. With three batteries the flight time is continuous with battery change and charging once an hour.

The system is operated either manually or by a specified GPS based route.

Detector data (dose-rate, γ-spectra) and GPS data is sent live to ground control.

A real-time statistical alarm method for mobile gamma spectrometry: combining binomial counting with a goodness-of-fit

KOCK P. & SAMUELSSON C.

Department of Medical Radiation Physics, Clinical Sciences, Lund University, University Hospital, SE-221 85 Lund, Sweden. peder.kock@med.lu.se.

In mobile gamma spectrometry source search operations, automated alarm algorithms can be of great assistance to the decision maker. Large search operations, where personnel can spend hours in the search vehicle, can be tiring. This calls for a computer-driven decision support system, i.e. alarm algorithm. Generally, the sensitivity of an alarm method is weighted against the false alarm rate. It has been shown in low-level radioactivity counting experiments that the actual false alarm rate can significantly differ from the desired level, even in a controlled laboratory environment. In the case of car borne mobile gamma spectrometry, this difference can result in erroneous conclusions about the presence of a radioactive source.

This article presents a new real-time method for inference about the presence of increased levels of radioactivity. The method is based on binomial counting statistics, combined with a multinomial Goodness-of-Fit (GOF). The combination of net counts in the Region of Interest (ROI) and the shape of the pulse height distribution within the ROI take into account not only the count rate but also the spectral information, allowing for better decisions about activity present.

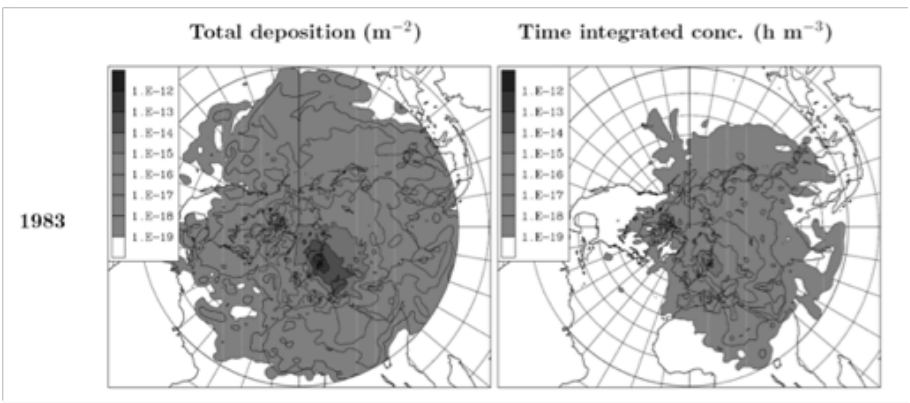
The proposed method is evaluated against four other real-time methods found in the literature through Monte Carlo simulations of point sources. Results show that the proposed method has a false alarm rate close to the desired rate, generally higher sensitivity compared to the other methods and that it performs especially well in the simulations where the background was poorly-known. The latter is the most important result in a mobile source search context, where the background level often is unknown and thus has to be estimated from previous measurements.

NKS NordRisk II: Atlas of long-range atmospheric dispersion model calculations

SØRENSEN J.H., LAURITZEN B., ASTRUP P. & KORSHOLM U.S.

Danish Meteorological Institute (DMI), Lyngbyvej 100, DK-2100 Copenhagen, Denmark, jhs@dmi.dk

Within the NKS/NordRisk II project "Nuclear risk from atmospheric dispersion in Northern Europe" an atlas of long-range atmospheric dispersion model calculations has been developed. The atlas describes risks from hypothetical long-range dispersion and deposition of radionuclides from 16 nuclear risk sites on the Northern Hemisphere. The atmospheric dispersion model calculations cover a period of 30 days following each release to ensure almost complete deposition of the dispersed material. The atlas contains maps showing the total deposition and time-integrated air concentration of Cs-137 and I-131 based on three years of meteorological data spanning the climate variability associated with the North Atlantic Oscillation, and corresponding time evolution of the ensemble mean atmospheric dispersion.



Annual mean of total deposition and time-integrated air concentration of unit release of elementary I-131 from the Leningrad Nuclear Power Plant.

RadiaDroid – Simulated Radiation Detection in Smartphones

GÅRDESTIG M & PETTERSSON H.B.L.

Dept. of Radiation Physics, Linköping University & Linköping University Hospital, SE-581 85 Linköping, Sweden, magnus.gardestig@lio.se

As a part of the Swedish preparedness for radiological or nuclear (RN) events, fire brigades, hospital emergency units and police departments in Sweden are equipped with detection instruments for radiation. The Swedish Civil Contingencies Agency, the National Board of Health and Welfare, the Swedish National Police Board together with the Swedish Radiation Protection Authority (SSM) have recently distributed a radiation detection instrument, the Intensimeter 28, a slightly modified AN/UDR-13 (Canberra Industries Inc, USA).

This contributes to the preparedness, but each partaker has only a few instruments at their disposal, which makes exercises with the real instrument limited in terms of instrument hours practicing. Exercises are important for the staff to be able to feel comfortable with the instrument and know how to interpret the readings. To carry out risk-free courses and exercises in fundamental radiation physics and the Intensimeter 28 as an instrument, a Smartphone (Android) application is proposed that simulates Intensimeter 28 in terms of functionality and response, such as booting, alarms, dose-rate, accuracy and cumulative dose.

This application, called RadiaDroid, has a twofold purpose; to teach (i) the handling of specific instruments, and (ii) the basic principles in radiation physics and radiation protection.

A set of tutorials guide the trainee through the inverse-square law, shielding and time of exposure, the three main principles of radiation protection. Specific tutorials to teach the specific instrument are also implemented.

Radiation is simulated with virtual placed sources indicated with its GPS coordinates (cf. Google Latitude), radionuclide and activity. The app calculates the dose-rate from chosen radionuclide and the distance using the gamma-ray doserate constant in free air. Alternatively, the user can choose a source directly in the app (GPS or distance) for individual training.

Challenges in the case of an incident during transport of spent nuclear fuel along the Norwegian cost

ELIASSEN K., HORNKJØL, S.

Norwegian Radiation Protection Authority (NRPA), P.O.Box 55, NO-1332 Østerås, Norway, karl.eliassen@nrpa.no

Over the last few years there has been an increase in transports of spent nuclear fuel along the Norwegian coast. The transports are part of the Global Threat Reduction Initiative (GTRI) which, among other issues, aims to reduce the use of highly enriched uranium (HEU) in civilian research reactors and to return spent fuel to the countries of origin.

The GTRI program was launched in 2004 and HEU has been shipped along the Norwegian coast for some years, but awareness was significantly raised in autumn of 2009 when MCL Trader passed Norway on its way from Gdynia in Poland to Murmansk in Russia. Since then there have been at least 5 more transports, and there seems to be a trend that these transports will be repeated with at least the same frequency as last year.

These transports represent a risk to Norwegian coastal waters as well as the Norwegian coast. The objective risk and the perceived risk is not necessary the same. There is no reason to believe that the transport regulations (IMDG code and INF code) are not followed. However, the fact that these shipments for security reasons are not notified officially, and that the ships involved often are quite small and have some negative stories connected to them, increases the public awareness. If a ship were to run aground off the Norwegian coast and/or sink, or an incident were to occur affecting the nuclear cargo, this would be a major challenge to Norway, independent of the size of a possible release. Examples from last year have also revealed other challenges related to these transports.

To be as well prepared as possible it is important for the Norwegian Radiation Protection Authority (NRPA) to have sufficient knowledge about these transports in advance, even if it is not possible to know e.g. the exact date. The NRPA have notification agreements with the Norwegian coastal administration and the Norwegian rescue coordination centre, which will secure an early warning if there is a transport of spent nuclear fuel in trouble outside the Norwegian coast.

The European platform on preparedness for nuclear and radiological emergency response and recovery (NERIS Platform)

MUSTONEN R., RASKOB W., NISBET A., SCHNEIDER T., LILAND A., DURANOVA T. and CROTEAU C.

STUK – Radiation and Nuclear Safety Authority, Laippatie 4, FIN-00880 Helsinki, Finland, raimo.mustonen@stuk.fi

European organisations that participated in the European integrated research project EURANOS (2004-2009) decided, at the end of the project, to create a unique European Platform on nuclear and radiological emergency response and recovery combining researchers, operational communities and relevant stakeholders, the so-called NERIS Platform. To date, 34 organisations have already joined the Platform. It comprises national and local authorities, technical support organisations, professional organisations, research institutes, universities and non-governmental organisations.

The first General Assembly of the Platform was organised in June 2010 in Helsinki. Two working groups have been created so far. The first working group on "the practical implementation of the ICRP-103 recommendations" aims to understand the implications of these recommendations and how they can be adopted into national systems. The group will also develop guidance on how to adapt existing Decision Support Systems RODOS and ARGOS to the new approach. The objectives of the second working group on "processes and tools for emergency and rehabilitation preparedness at community level" are to exchange experience on local-national cooperation and stakeholder engagement in developing emergency and recovery strategies. The second General Assembly was held in May 2011 in Paris. The drafts for the Vision and the Strategic Research Agenda (SRA) of the Platform were discussed and are at the moment under consultation of the Platform members.

Main structure of the NERIS Platform is described in its Terms of Reference (ToR) accepted in the first General Assembly. Membership of the Platform is open to all European organisations concerned with nuclear and radiological emergency response and recovery having expressed their interest in the activities of the Platform and having signed the Terms of Reference.

The presentation will describe the Platform and its operation and will focus on the first developments of the NERIS Working Groups.

Georeferenced data sharing during radiological accidents

PELTONEN T. & AMMANN M.

STUK - Radiation and Nuclear Safety Authority, P.O.Box 14, FI-00881 Helsinki, Finland, tuomas.peltonen@stuk.fi

A large part of the data produced during radiological accidents is georeferenced. This data must be shared and presented to the users in a usable, reliable, and secure manner. The paper presents the Web map component that has been integrated into the collaborative emergency management system of STUK and FMI, the Finnish Meteorological Institute. Data sharing is achieved in that system by providing access to models as web services, by using open standards and by feeding most data into a content management system. Data presentation is achieved by the mashup of the various data sources within an interactive Web map component. The Web map component is aware of the different data types that need to be dealt with. It has to deal with coverage (or gridded) data, which is typically produced by dispersion and dose models; with georeferenced images, for example in the form of rain radar images; and with feature data in form of trajectories (lines), GPS tracks (points), station measurements (points), or administrative units (polygons). Extensions to standard geographic data formats and toolsets are needed, however, because most data also have a time dimension (i.e. it is spatiotemporal in nature). The data is presented mainly in form of choropleth maps, but also contour plots, time animations, and time series plots are employed. Styling options, like colour scheme and scale, need special consideration in the context of emergency management, as stakeholders can be very sensitive about how risk and consequence assessments are portrayed. Data consumption is easy and unobtrusive. Any modern web browser is sufficient for online display, and the demands of video projectors and HDTVs are acknowledged. In addition, output can be optimised for handheld devices, and printing and image production is supported. Whenever there was a choice, we preferred open standards and technologies, like WMS, WFS, and file formats like KML and GeoJSON.

Alpha- and beta contamination of surfaces. Which levels of contamination are possible to detect with manual search?

HEDMAN A. & ULVSAND T.

FOI Swedish Defence Research Agency, Division of CBRN Defence and Security, Cementvägen 20, SE-901 82 Umeå, Sweden, angelica.hedman@foi.se

Measurement of alpha-beta activity on surfaces can be a cumbersome task. Results of a measurement vary depending on the velocity with which the probe is conducted over the surface, distance to the surface and characteristics and flatness of the surface.

Contamination limits are given in levels of Bq/cm^2 while the instrumental response are given in counts per second (cps), therefore a relationship between contamination and instrumental response needs to be developed. This relationship will be different for each type of instrument.

Measurements will be made with custom made equipment and computer program created for this purpose. All parameters are monitored and modified. The first instrument tested is Intensimeter 28 used by Swedish Armed Forces. It will be followed by other types of instruments. All are used with hand-held alpha/beta probes.

Sources used are Am-241, Ni-63, Tc-99 and P-32, i.e. alpha, beta and gamma sources of low, medium and high energies. Activity between 0.4 Bq/cm2 and 400 Bq/cm2 is placed on glass slides. The active area is 200 cm^2 (10 cm x 20 cm).

The results show the relationship between distance, velocity of the probe and degree of contamination.

Parallel with this work, there is a job that deals with contamination levels, which also has an abstract submitted to this conference.

Source preparation of Actinides and Polonium using coins

[1]E. Holm, [1]B. Lind, [2]M. Eriksson, [2]I. Levy, [1]G. Kinn

[1]Norwegian Radiation Protection Authority, Grini Næringspark 13, 1332 Østerås, Norway.
[2]IAEA-MEL, 4 Quai Antoine 1er, MC 98000 Monaco.

Electrodeposition of actinides such as Pu, Am,. U, Th is normally performed on stainless steel discs. Also platinum and copper has been used. Polonium sources are prepared by spontaneous deposition on silver, nickel and copper. World wide coins are generally manufactured by bronze, steel, copper plated steel, cupronickel, brass, alloys of Cu-Ni-Zn sometimes with Al.

The diameter varies between 16 and 25 mm and many of them fit into regular deposition cells such as liquid scintillation vials. The price of coins that can be used can be found for between 0.0012- 0.2 Euro i.e. cheaper than electro polished stainless steel discs (1 Euro). Usable coins are found in most countries.

We have electro deposited actinides on Norwegian (50 Øre), UK (1 Penny), Bulgarian (2, 5, and 20 Stotinka), Thai coins (50 satang and1 Bath). Deposition was done from an ammonium sulphate solution at pH2 with a current of 1 A during 2 hours. Polonium was successfully spontaneously deposited from a weakly acid solution onto a 1 bath Thai coin (cupronickel).The coins were measured with alpha spectrometry using ion implanted silicon detectors.

The result is generally very good. With high recovery and energy resolution between 25-40 keV (FWHM). A pulse height distribution of ^{242}Pu and ^{243}Am is shown in Fig.1. (5 Bulgarian stotinka, brass).

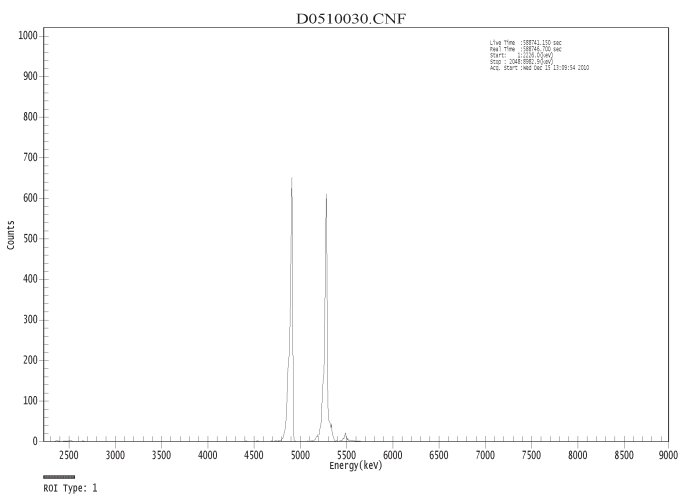


Fig. 1. Pulse height distribution of ^{242}Pu and ^{243}Am on Bulgarian 5 stotinka.

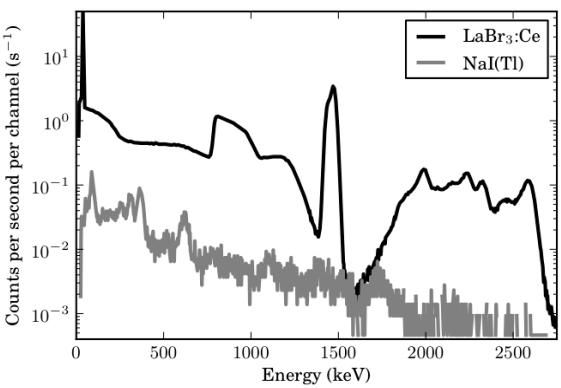
Using the LaBr3:Ce scintillation detector for mobile γ-spectrometry

NILSSON M. J. C., FINCK R.

Department of Medical Radiation Physics, Lund university, Lund, Sweden, jonas.nilsson.837@student.lu.se

Thallium doped sodium iodine (NaI(Tl)) detectors have for decades been the only viable option for portable high sensitivity γ-spectrometry. A possible replacement material which has characteristics superior to those of NaI(Tl), has only recently been made commercially available.

The new material, whch consist of cerium doped lanthanum bromide ($LaBr_3$:Ce), has a higher density and a higher light yield than NaI(Tl), but also has the drawback of being internally contaminated with ^{138}La and ^{227}Ac. This greatly affects the pulse height distribution as shown in the figure.



The figure shows the pulse height distribution of a measurement made with a 3''x3'' $LaBr_3$:Ce-detector in a well shielded low activity laboratory as well as a measurement with a NaI(Tl)-detector of the same size in the same environment.

Possible methods for compensating for the internal contamination were examined. Deconvolution as well as variations of simple background subtraction was used to reduce effect of the internal contamination when doing long measurements. For car borne applications, a "standard deviation display" was used to suppress the peaks caused by ^{138}La and ^{227}Ac in the pulse height distribution.

The work presented here shows that the higher resolution allows $LaBr_3$:Ce to successfully compete with the NaI(Tl) in a medium to high count rate environment. However, the internal contamination of $LaBr_3$:Ce makes NaI(Tl) better in a low count rate environment.

S8 - P8

A comparison between multiple car-borne gamma-ray measurements performed during two separate missions at the same route.

Lidström K., Nylén T

FOI Swedish Defence Researh Agency, Division of CBRN Defence and Security, SE - 901 82 Umeå, Sweden, kenneth.lidstrom@foi.se

The use of car-borne gamma-ray measurements has increased during the last decades. One of the challenges is to detect differences in nuclide specific gamma radiation levels during the mission. These results can today be visualized in real time and one of the used methods is to present the measured spectrums in rainbow format and classify the measured data in regions which are presented in specific colours.

This work has focused on the differences between missions, i.e. what changes can be detected between two, in time differentiated measurement missions at the same route. How much does the snow coverage invoke, how much can a road renovation with a new ground material invoke on the measured data etc. And then, how can a comparison between two different missions including several hundred pr thousands of measurement spectrums be performed and visualised.

Outlines of a content management system for emergency preparedness and response

AMMANN M., PELTONEN T. & LAHTINEN J.

Radiation and Nuclear Safety Authority, Laippatie 4, 00881 Helsinki, Finland, michael.ammann@stuk.fi

Computer support is needed to facilitate the emergency management process during nuclear or radiation accidents, and, since these events happen luckily rather rarely, computer support is needed for simulation, training and exercise purposes. Within Europe there are prominent decision support systems available today that tightly integrate measurements and models into a single package and provide comprehensive support during all phases of an accident. However, the systems we are aware of mostly lack the notion of collaboration, which is central to the emergency management process. Meanwhile, some European countries have adapted generic content management systems for information sharing purposes. Content management systems (CMS) were chosen because they excel at collaborative content management throughout the life cycle of documents. They provide out of the box functionalities for content classification, content syndication, user management, language translation, access control, workflow management, versioning, multichannel publishing, etc. Some of these have scalable feature sets and can, within limits, be adapted to the needs of the application domain at hand. However, there is another approach available to accommodate the peculiarities of the emergency management process: a generic web framework can be taken as a starting point for the development of a custom tailored application and readily available CMS functionalities can be added to it as needed. This is the approach we have taken at STUK, the Finnish Radiation and Nuclear Safety Authority. This paper outlines the content management functionality that is currently being added to STUK's emergency management platform. Our goal is to merge the functional areas of more traditional decision support systems with the collaborative feature set of content management systems into a usable, reliable, secure and extensible platform that fits into our actual emergency management process as neatly as possible.

The Danish CBRN Institute - joint civil-military terror preparedness

Carsten Israelson

CBRN, Denmark

In May 2010 a joint civil-military CBRN Institute was established under the Danish Ministry of Defense as the result of an agreement between the Ministry of Defense and the Ministry of Interior and Health. The Institute is manned with one RN expert.

The main responsibility of the CBRN Institute is to develop the CBRN preparedness in Denmark based on present and foreseen terror threats. This includes:

1) Establishing an overview of the present national emergency resources available in case of a CBRN attack.
2) Coordinate the Danish positions on CBRN matters in international organizations.
3) Coordinate the Danish input to and national implementation of the EU CBRN Action Plan.
4) Collect and distribute international research results within the CBRN area to relevant institutions and authorities in Denmark.
5) Facilitate collaboration between Danish and foreign industry and research institutions within the CBRN area.

Local-national forum for emergency and recovery strategies

EIKELMANN I.M.H. & LILAND A.

Norwegian Radiation Protection Authority, Emergency Preparedness Unit Svanhovd, NO-9925 Svanvik, Norway, Inger.Eikelmann@nrpa.no

The Norwegian Radiation Protection Authority and the County Governor of Østfold took an initiative to strengthen the county's preparedness within late phase emergencies after a nuclear accident/incident. We wanted to test a local-national forum where emergency and recovery strategies could be elaborated and cooperation mechanism explored, involving all actors that would be affected by radioactive contamination accidents/incidents. The idea was to arrange a thematic session where authorities and stakeholders at all levels and sectors were involved. The participants in the seminar included national, regional and local authorities, farmers associations, food industry, health sectors and others.

After some introductory sessions with presentations on radioecology, the emergency preparedness organisation and the responsibilities of the different authorities, there was a table-top exercise performed in smaller groups. The most important challenges identified in the discussions were the various roles and responsibilities for all involved actors and the need for sampling/analyses and recovery strategies.

The seminar brought up many questions and the need for a follow-up seminar to support the development of emergency plans in the local communities was evident.

The presentation will focus on important challenges for local preparedness and response and how the national authorities can assist the municipalities in improving their capabilities.

Swedish Armed Forces deployable R/N-laboratory

Michael Granström

Armed Forces, Sweden

The Swedish armed forces have three deployable analytical laboratories based on standard 20-foot container platforms. The laboratories are separate units, one for analysis of chemical agents (C-lab), one lab for analysis of biological agents (B-lab) and one for the analysis of radiological/nuclear agents (R/N-lab). The laboratories have been developed for use on national and international missions. Examples of such missions include local support during large-scale incidents and catastrophes as well as support in humanitarian operations.

The R/N-laboratory has equipment for analysis of samples from different matrixes. The analysis equipment comprises an electrical cooled germanium detector, a liquid scintillation counter, a filter/swipe reader and handheld instruments for detection of radiation. To a great extent, the analysis capacity is in accordance with the NATO standard for deployable laboratories, STANAG 4632, ed 1. The laboratory has participated in national preparedness exercises arranged by the Swedish radiation protection authority and also in two NATO arranged exercises.

Dimensioning of Norwegian nuclear and radiological emergency preparedness and crisis management

SELNÆS Ø.G.

Norwegian Radiation Protection Authority, PO Box 55, NO-1332 Østerås, Norway, Oyvind. Selnaes@nrpa.no

In emergency preparedness planning, it is always a challenge to form a preparedness that provides the best protection based on the resources available. Therefore, in March 2010, the Norwegian government decided on a set of six scenarios with different kinds of nuclear or radiological events in order to provide a basis for prioritizing needs and planning future development of nuclear and radiological emergency preparedness.

The scenarios qualitatively describe events with different consequences and each represents distinct aspects towards crisis management.

The six scenarios:

I. An event at a foreign radiological or nuclear installations that results in a large airborne release that may move into Norway and have consequences for larger or smaller geographical areas

II. An event at a Norwegian radiological or nuclear installation that results in a large airborne release

III. A local event in Norway or close to Norway with no relation to existing installations

IV. A local event that develops over time

V. A event with a large release to Norwegian marine environment or marine environment close to Norway, or a rumour or suspicion of considerable marine or terrestrial pollution

VI. A severe event abroad without consequences for Norwegian territory

The set is an important tool for public services, county governors, municipalities and other authorities involved in nuclear and radiological emergency preparedness. It raises consciousness on different needs in different situations regarding crisis management and provides a comprehensive approach towards emergency preparedness planning.

S9 - O6

SecurEau—Security and decontamination of drinking water distribution systems following a deliberate contamination

TURTIAINEN T., HAKALA S., VESTERBACKA P. & MUIKKU M.

STUK—Radiation and Nuclear Safety Authority, Laippatie 4, FI-00880 Helsinki, Finland, tuukka.turtiainen@stuk.fi

Emergency preparedness authorities and security scientists have identified drinking water distribution networks as a conceivable target of a deliberate, malevolent attack. In any event, disruptions in water distribution associated with damages in network structures incur discomfort and expenses. In worst case, agents that are injurious to health are used for contaminating water. SecurEau project addresses this issue by studying CBRN (Chemical, Biological, Radiological and Nuclear) agents.

STUK is one of the 12 European partners presently involved with the project. The main objective of SecurEau is to launch an appropriate response for rapidly restoring the use of the drinking water network after a deliberate contamination, specifically by:

- designing methods for identifying potential contaminants,
- modelling distribution of the contaminants inside the network,
- adapting and integrating various sensors in a surveillance system in an optimal configuration, and
- developing methods for decontaminating polluted drinking water networks and installations including neutralization of contaminated water and residues.

Investigation into adsorption/desorption of radionuclides carried out by STUK has given more insight into behaviour of radionuclides inside a distribution network. The chemical cleaning experiments carried out on laboratory scale have been encouraging—we have been able to efficiently decontaminate water pipe materials exposed to radionuclides with inexpensive and non-toxic chelating agents. A rapid screening method for detecting alpha-active radionuclides in water and biofilms has been validated. An overview of the outcomes and implications of our work will be discussed.

SecurEau project is carried out under the EU's the Seventh Framework Programme for Research and Technological Development.

Aspects of dispersion of airborne radioactivity in a city centre

AGNETA H. PLAMBOECK, LAGE JONSSON, ERIK JOHANSSON, MATTIAS WALDENVIK

FOI, Swedish Defence Research Agency, Division of CBRN Defence and Security, SE-901 82 Umeå,

In case of dispersion of airborne radioactivity in a city centre a number of questions will prompt for an answer. While many questions can get their answers in due course of time based on results of tests and sampling, a good understanding of the quantitative effect of the dispersion will be very helpful, in particular in the early stage. In the following dose and dose rate estimates are presented for three scenarios including dispersion of radioactivity in a city centre. In one case the activity is released in an open place, in another from a roof and in the third case from a source on a street where the wind is blowing along the street. In each case, at specific positions, estimates are made of the dose from inhalation, contamination on skin and from external exposure i.e. radioactivity deposited onto ground, walls and roofs in the city centre. On the dispersion, and consequently the deposit pattern, recirculation behind tall buildings and diverted flow close to street-ends are found to have significant effects. Regarding the relative importance of contributions to the total dose it is found that inhalation could play a major role for long term effects while dose to skin dominates acute effects.

Key-words: Airborne radioactivity, radioactive dispersal, particulate dispersion, dry deposition, dry deposition velocity, contamination, dose, dose rate, city centre, urban area

S10 - O1

UV radiation induced processes in AlN and its potential application for solid state dosimetry

L.Trinkler*, B.Berzina

1 Institute of Solid State Physics, University of Latvia, Riga, Latvia

** Corresponding author: trinkler@latnet.lv*

UV radiation induced luminescence processes – photoluminescence (PL), thermoluminescence (TL) and optically stimulated luminescence (OSL) - have been studied in a wide band (6.2 eV) material AlN. High TL and OSL response makes this material potentially applicable for solid state dosimetry of UV radiation. Different forms of AlN material were used for investigation in similar experimental conditions - ceramics and nanostructures (nanorods and nanotips).

UV radiation induced luminescence properties in all forms of AlN are determined by recombination processes with participation of oxygen-related defects. In ceramics two types of oxygen-related defects are responsible for the main PL emission bands at 400 and 480 nm, excited in 220-260 and 270-380 nm, respectively. The same bands are revealed in TL and OSL emission spectra. It is found that the 400 nm emission band is connected with TL glow curve peak at 75 °C, while the 480 nm emission band – with a peak at 200 °C. It makes the 480 nm emission band more prospective for application for dosimetry needs, than the previously studied 400 nm band, because being bleached at higher temperature it is more stable and produces lower fading of the UV radiation induced signal during storage of the irradiated sample at room temperature. Besides the excitation region of this emission band falls into the UV-B region of Solar emission, which is a detection range of practical interest. Additional improvement of dosimetric properties was obtained by using oxygen ion implantation of ceramic samples, which caused the growth of the 480 nm emission band.

Similarly to the case of ceramics, in AlN nanostructures oxygen-related centres are responsible for two main luminescence bands at 380 and 480 nm, which are seen in PL, TL and OSL emission spectra. The peculiarity of the nanostructures is that all the observed luminescence processes (PL, TL, OSL) are excited mainly in the 200-210 nm region, which corresponds to the host lattice absorption. That may be explained by the smaller concentration of the defect centres and the more perfect structure of the host lattice of the nanostructures compared to ceramics. Tl glow curves are characterised with peak in the 70-90 °C region. From the dosimetric aspect AlN nanostructures are less prospective, because the UV radiation induced signal is lower, but fading rate is higher compared to ceramics.

Dose assessment after an historic intake of uranium

RAMSØY T., HAUGEN A-H., BACKE S. AND SIDHU R.

Institute for Energy Technology, P.O. Box 40, NO-2027 Kjeller, Norway, Tore.Ramsoy@ife.no

Institute for Energy Technology has for a number of years been producing UO2 pellets for use in the Halden Boiling Water Reactor and the JEEP II reactor at Kjeller. The pellets are produced from UO2 powder with an enrichment ranging from 4%-19%. The process involves several steps were there is a certain risk for uranium dust particles to form.

In a routine control of staff members in 2005 the presence of 234U, 235U and 238U in quantities far above the detection limit of 0.5 mBq/l was found. The isotopic ratio was consistent with low enriched uranium material.

The intake could not be related to any special incident in the laboratory. As neither the time of intake or if It could be attributed to acute or continuous was known, it was necessary to establish a series of measurements over a substantial time interval. The results of measurements of uranium in urine samples are presented in Figure 1.

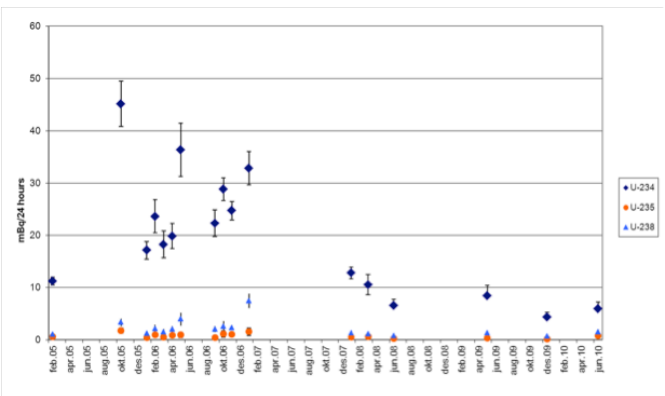


Figure 1 Measurements of Uranium in urine. Uncertainties refer to radiochemical analysis only

The employee left the pellet production laboratory in November 2006.

A manual interpretation of the data indicates a stable level of uranium up to the end of 2006 where the levels drop. This was deemed to be consistent with a continuous intake during his whole work period ranging from November 1991 to November 2006. Using ICRPs models for continuous intake through inhalation, the annual effective dose was estimated to 6.8 mSv.

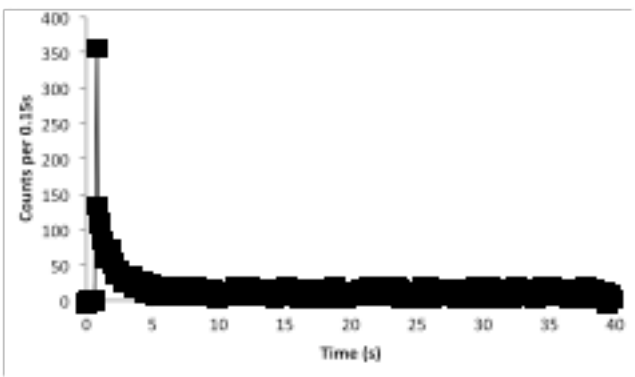
A new calculation using the computer code IMBA has later been carried out. The result from this calculation was in good agreement with the initial estimate.

OSL on Tooth Enamel - a Potential Emergency Radiation Dose Assessment Tool

GEBER T., MATTSSON S. & RÄÄF C.L.

Medical Radiation Physics, Department of Clinical Sciences Malmö, Lund University, Skåne University Hospital Malmö, 205 02 Malmö, Sweden, therese.geber@med.lu.se

A radiological emergency of any kind will necessitate dose assessment of potentially exposed people, in order to carry out proper remedial actions and medical treatment. In cases where non-radiological workers are involved, it is unlikely that the people in question would have carried personal dosimeters. Therefore other ways to estimate the absorbed dose is needed. To be able to retrospectively determine the absorbed dose of an individual from e.g. a sample of their teeth, would be of great use since they are individual and easy accessible. The current method for determining the absorbed dose in teeth is by electron paramagnetic resonance (EPR), which requires the tooth to be pulled out. For obvious reasons the avoidance of this would be preferable. Furthermore, EPR analysis of teeth requires magnetic and electrical fields, making it unsuitable for *in vivo* measurements. Optically stimulated luminescence (OSL) however, uses harmless light to stimulate electrons, which have been trapped following exposure to ionizing radiation. The stimulation leads to emission of light with intensity proportional to the absorbed dose.



OSL signal of a fragment of tooth enamel, stimulated during 40 s of blue light (λ=470 nm) stimulation upon irradiation in a ^{60}Co beam of 10.2 Gy.

The aim of this work is to investigate the OSL properties of parts of human teeth. A first step towards *in vivo* OSL on teeth has been initiated by testing the dose response of tooth material to gamma and beta exposure using a Risø TL/OSL-15 reader. Currently the minimum detectable dose, MDD, in teeth is relatively high (1-2 Gy). Another objective is therefore to optimize the readout procedure to achieve the highest luminescence yield and OSL signal per unit absorbed dose.

URANIUM IN URINE AND HAIR OF OCCUPATIONALLY UN-EXPOSED FINNISH PEOPLE

MAARIT MUIKKU, MARKETTA PUHAKAINEN, TARJA HEIKKINEN AND TAINA ILUS

STUK - Radiation and Nuclear Safety Authority, P.O. Box 14, FIN-00881 Helsinki, Finland

Uranium concentrations in the urine and hair of the occupationally unexposed Finnish population were determined using inductively coupled plasma mass spectrometry (ICP-MS). The age of the randomly selected participants ranged from 18 to 66 years. The mean concentrations of uranium in urine and hair were 0.016 µg/l and 0.216 µg/g, respectively. The mean uranium concentration in hair of the Finns was from three- to fifteen-fold higher than the values reported in the literature, while the mean uranium concentration in urine was similar to those measured elsewhere in Europe.

The observed large variation in the uranium concentrations in hair and urine can be explained by the variation in the uranium concentration in drinking water. In Finland the concentrations of natural uranium in drinking water have been observed to vary markedly depending on the location. Exceptionally high concentrations have been measured in private drilled wells in the granite areas of Southern Finland. A part of the measured uranium content in hair may also be due to external contamination, which may remain in the hair after the washing procedure. This proportion should be determined before using hair as a bioindicator of uranium exposure, especially when estimating occupational exposure.

Licensing of complex facilities other than nuclear power plants

CARL-GÖRAN STÅLNACKE, PETER BJÖRK and JAN LILLHÖK

Swedish Radiation Safety Authority, SE-17116 Stockholm, Sweden

The Swedish Radiation Safety Authority, SSM has now license applications coming up for several facilities outside the traditional domain that are by us considered and denoted -complex facilities;

- The European Spallation Source, ESS in Lund is going to be a very large proton accelerator driven neutron source intended for neutron based research. Its neutron production target will have a radionuclide inventory comparable to that of a research reactor but without fissile materials.
- Next door neighbour to ESS is MAX IV, a large synchrotron light source. This research facility will also house a linear short pulse facility and later on a XFEL (free electron laser).
- A dedicated medical treatment facility for proton therapy is under construction in Uppsala. (Kommunförbundet Avancerad Strålbehandling, KAS and Skandionkliniken)

These facilities present the biggest challenge ever concerning non-nuclear facilities at SSM and will involve several different departments and sections at the authority. The applications need to include information like that found in the PSAR (Preliminary Safety Analysis Report) used in connection to nuclear power plants. The legal base for licensing these kinds of facilities is today the Swedish Radiation Protection Act and the accompanying regulations issued by SSM that are somewhat different from those based on the Nuclear Activity Act. In parallel and apart from this licensing process there is an on-going work to merge these two laws into one in a near future.

The present regulations have not been very well adapted for this kind of “complex facilities” now addressed. A generic document has been worked out on how the necessary type of a review process can be structured to guide both the authority and the applicants.

This document is intended to address the overall occupational radiation protection and the protection of general public including also security aspects and emphasizing on identifying, in a break down structure, essential reviewing areas such as; building and facility design, accelerator and target design including components in beam guides, regulating and control systems, emergency preparedness, releases and environmental impact, dismantling, decommissioning and waste handling as well as organization, resources and management.

Radiation Safety Assessment of industry licensees

BYSELL C.

Swedish Radiation Safety Authority, Solna strandväg 96, SE-171 16 Stockholm, Sweden, camilla.bysell@ssm.se

The Swedish Radiation Safety Authority has about 1200 licensees within industries that possess and use radioactive sources. 15 licensees that uses sealed sources or X-ray equipment in their business were inspected in 2009 and 2010.

A Radiation Safety Assessment of industry licensees has been done based upon

- supervision
- injunctions
- incident reports
- information from manufacturers

The assessment was focused on three topics, namely

1. Observance of legislation and requirements
2. Radiation protection on site

   Based on the licensees radiation safety organisation
3. Probability that the licensee will continue to run the business in a safe manner regarding to radiation protection

   Based upon financial resources and competence

The purpose of the assessment was to gain a complete picture of how regulations are followed and implemented, see tendencies in the radiation safety, improve the supervision within the field and find alternative ways of supervision.

Radiation accident at a Swedish mining company

Peter Frisk, Jan Lillhök, Jan-Erik Grindborg and Petra Sjöström

Swedish Radiation Safety Authority SE-17116 Stockholm, Sweden, peter.frisk@ssm.se

In early December 2010 several workers at the Aitik mine outside Gällivare in Sweden were exposed to radiation from an X-ray machine. Seventeen workers were admitted to hospital. Personnel from different professional categories had during several days been working with troubleshooting and repairing of an X-ray machine, which is used for measuring metal content in ore. Some of the workers experienced fatigue, dizziness, nausea and irritated eyes, symptoms that can be signs of acute effects of irradiation. Later on it was shown that eight workers had been exposed to X-rays and that two of the workers might have been exposed to doses higher than the annual dose limits for workers stated in the regulations given by the Swedish Radiation Safety Authority (SSM).

SSM was contacted by the licensee when the company realised that repairing of the machine probably had been performed with the X-ray tube switched on. The day after SSM had been informed, a group of three inspectors from SSM travelled to Aitik. The inspectors interviewed the management and performed measurements of the radiation environment at the site. The inspectors met the treating physician and gave information to the affected workers. All affected workers were interviewed to collect further information about what had happened and radiation doses were estimated.

The investigation shows that the mining company might have been in non-compliance with the Swedish Radiation Protection Act and the regulations given by SSM. Therefore, SSM prohibited the licensee to repair and perform service on their machine and required more stringent routines. SSM has reported the event to a prosecutor to decide whether charges should be filed against the mining company for non-compliance with the Radiation Protection Act and SSM's regulations.

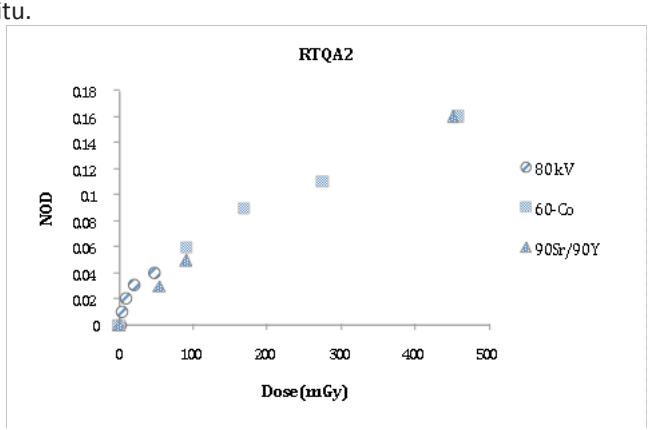
SSM has preliminary classified the radiation incident in the Aitik mine as a level 2 incident on the international INES scale. This scale classifies the safety significance of nuclear and radiological events involving ionising radiation.

Gafchromic film as a fast visual indicator of radiation exposure of first responders at a radiological or nuclear accident

ÖREN Ü., RÄÄF C.L., MATTSSON S.

Medical Radiation Physics, Department of Clinical Sciences Malmö, Lund University, Skåne University Hospital, SE-205 02 Malmö, Sweden, unal.oren@med.lu.se

Three types of Gafchromic films (XRQA, XRQA2 and RTQA2) have been studied to investigate their potential to be used as a visually readable dosemeter for persons acting as first responders in connection with radiological or nuclear emergencies. To evaluate the energy dependence of the dose response, two photon radiation sources were used: An x-ray unit (Mediel, Mölndal, Sweden), which operated at 80 kV and a 60Co-unit (Gammatron-3, Siemens, Germany), with primary photon energies of 1.17 and 1.33 MeV. Irradiations were also performed with high-energy β-particles using a sealed 90Sr/90Y source (EMax=2.27 MeV; Risø TL-15 reader, Risö National Laboratory, Roskilde, Denmark). The two most sensitive film types show a pronounced variation in sensitivity by photon energy and are therefore not suitable for use in cases of unknown photon energy exposures. The third film type tested (RTQA2), which is intended for quality control in radiation therapy has a sensitivity that is independent of the radiation quality, and is therefore considered as the most optimum for visual reading in-situ.



Dose-response curves of Gafchromic RTQA2 film irradiated with a x-ray system (80 kV), 60-Co (1.17 and 1.33 MeV) and a 90-Sr/90-Y source (Emax=2.27 MeV), respectively.

Tests carried out on a group of ten human observers showed that absorbed doses down to 40 mGy can be detected by the eye. Read by a portable densitometer, quantitative absorbed dose estimates down to 9 mGy could be achieved. The color change is obtained instantaneously, giving first responders immediate information about the presence of gamma and X-ray radiation.

Whole-body counters for measurement of internal contamination in Finland

Jussi Huikari, Maarit Muikku and Sauli Pusa

STUK - Radiation and Nuclear Safety Authority, P.O. Box 14, 00881 Helsinki, Finland
jussi.huikari@stuk.fi

STUK - Radiation and Nuclear Safety Authority has two whole body counters for measurement of internal contamination. Both counters use high purity germanium detectors. The stationary system is installed inside a 50 ton iron room and the mobile unit is built on a truck chassis. Both counters are used to assess the internal exposure of radiation workers and the exposure of the Finnish public. Up to now in the mobile unit, information of the location of the internal contamination has not been available due to measurement geometry. For this reason, a project was started to design and build a new counter in order to obtain location information and improve detection efficiency.

The location information is important for the radionuclides that are not homogenously distributed in the body, like freshly inhaled radionuclides by radiation workers and in the emergency situations when the intake path may not be so obvious. In addition, this new spectrometer gives more precise information about possible ^{131}I accumulation in the thyroid. Furthermore, lower detection limits for some specific nuclides (like ^{241}Am, ^{123}I) which emit only low energy (<200 keV) gamma rays will be achieved. Monte Carlo simulations exploiting MCNPX were used with voxel phantoms to guide the design process.

The mobile unit can also be mobilised in emergency situations and provides fast and reliable method for both screening and dose assessment purposes. This poster describes a design of the new mobile counter and presents measured and calculated results of detection limits and efficiency.

Uptake and retention of *per os* administered cobalt in human subjects

RANEBO Y., H. HOLSTEIN, HENRICSSON F., ROOS P. & RÄÄF C.L.

Medical Radiation Physics, Department of Clinical Sciences, Lund University, Skåne University Hospital, SE-205 02 Malmö, Sweden, Christopher.Raaf@med.lu.se

A potential radiation hazard to workers is inevitably introduced by the presence of radioactive cobalt in nuclear facilities, industry and nuclear medicine. The risks from internal exposure to radioactive cobalt, in terms of absorbed dose and late effects, can be estimated by kinetic models. To ensure reliable results, model parameters as uptake and retention must be as accurate as possible. We present here the results from a detailed survey and follow-up of orally administered cobalt substances in adult humans, its fate in the body and clearance behavior. The purpose has been to determine the accuracy in the prediction of the current models on the gastro-intestinal uptake, system tissue retention and excretion in the body from orally administrated cobalt.

Volunteer subjects have been given solutions containing ^{57}Co ($t_{1/2}$=272d) or ^{58}Co ($t_{1/2}$=71d). Both cobalt isotopes were in the form of cobalt chloride (CoCl2), for which the ^{57}CoCl-solution contained a carrier whereas the second solution was carrier-free. This enabled to investigate any influence from of a carrier on the gastro-intestinal uptake. The activity o the ingested portions were optimized to keep radiological doses at less than a fraction of the annual background dose (<0.35 mSv for each volunteer), while maintaining adequate counting statistics of the gamma spectrometric measurements of excretion samples. Measurements of in-vivo activities were performed by whole-body counter as well as imaging of organ uptakes by gamma camera were performed. Urine and feces samples were analyzed by high-purity germanium **(**HPGe**)** detector gamma measurements. To monitor the short-lived excretion phase after intake, with a biological half-life of about one day, urine and feces were collected for up to ten days, combined with gamma camera studies and whole-body counting. After this initial period, collection was performed a few times each week and during the last six months, a number of times each month. In addition, stable cobalt in urine and feces was measured by ICP-MS. Preliminary results show a very fast excretion and low gastro-intestinal uptake of ^{58}CoCl in a 43 year old volunteer (Fig. 1).

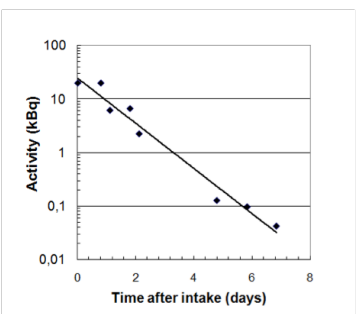


Fig. 1. Results from measurements of in-vivo 58Co content by whole-body counter showing an effective half-life of about one day from a per os intake of 20 kBq 58CoCl.

A study on PTW 10000, 1000 and 28 cc spherical ionization chambers.

VARGAS CASTRILLÓN, S., CUTANDA HENRÍQUEZ, F.

Laboratorio de Metrología de Radiaciones Ionizantes, CIEMAT, Avda. Complutense 22, 28040 Madrid, Spain, stvcastrillon@hotmail.com

1) Purpose

PTW 10000, 1000 and 28 cc spherical ionization chambers (32003, 32002, 32005) are widely used for radiation protection purposes in dosimetry laboratories and different radiation facilities with high quality requirements. When used in conjunction, the dose rate range covered varies from the order of μSv/h to Sv/h. A comprehensive study of these chambers was carried out, two chambers of each type were utilized. Settling behaviour, ion recombination, polarity effects, rotational symmetry and leakage currents were investigated. Stability tests, with a PTW Sr-90 check source and holder, were performed on a weekly basis during two months.

2) Materials and Methods.

Measurements were carried out with a PTW UNIDOS electrometer connected to the chambers by a PTW cable. Settling behaviour was studied for 30 minutes once HV was applied. Rotational symmetry was studied at 8 different chamber orientations. Two radiographs of each chamber were taken; for each orientation, chambers were rotated 90˚.

3) Results.

All chambers were found to be settled after 10 minutes. Within experimental uncertainty, the chambers were found to present rotational symmetry. No significant natural or radiation induced leakage currents were found. Stability tests showed random variations of less than 0.4% for all chambers. No significant polarity effects were found for PTW 32002 and PTW 32003; PTW 32005 shows a polarity effect at the highest dose rate. For each chamber type, ion recombination factors were obtained at two different dose rates.

4) Conclusions.

These chamber types present an excellent behaviour regarding all relevant features. They can be recommended for use on different high quality tasks, such as Cs-137 and Co-60 beam calibrations on SSDLs.

New perspectives for radiation protection concepts in the frame of sustainability

EGGERMONT G., HUGE J. & MAES F.

MEKO, University Brussels(VUB),Laarbeeklaan103,B-1090 Brussels, Belgium, Gilbert.Eggermont@vub.ac.be

A range of interpretations of the concept of sustainability is emerging in the field of technology, energy, environment and health policies. Up to now the system of regulation of exposure to ionising radiation pays few attention to sustainability assessment.

Major criteria for sustainable development are global responsibility, precaution, integration at different levels including trans-disciplinary science approaches, distributive equity, stakeholder participation and communication. Recently some of these aspects (ethical guidance, stakeholder engagement and radiation protection culture) received proactive attention at IRPA level.

These rather new action rules are analysed and discussed in order to investigate current shortcomings of and perspectives for improvement of radiation protection and nuclear safety.

Particular attention is given to the ALARA principle as a precursor of precaution. Characteristics as complexity, uncertainty and ambiguity allow to reconsider options for present problems.

New cross cutting initiatives, created by international treaties such as the OSPAR and Aarhus conventions are challenging existing approaches in radiation protection. These initiatives aim at improving transparency and stakeholder involvement for a more sustainable decision support in the management of environmental and health effects. They question some implicit value judgements used in radiation protection expertise such as the information culture and the anthropocentric focus on the human health of the virtual average individual.

Assessment approaches for decision support, formalised at EU level such as environmental/strategic impact assessment (EIA and SEA respectively), are the precursors of upcoming sustainability assessment approaches. Such assessments allow to consider health impact assessment (HIA) systematically as well as distributive aspects and policy alternatives. Some cases are illustrating a broadening of the Justification concept.

S11 - O1

Health &Environmental governance is rapidly changing and oriented more and more by corporate interests, In radiation protection digitalisation of medical imaging and NORM industry are challenging regulation.

Meanwhile perception of lay men versus experts is polarising also in these fields. Experts are seeing their legitimacy questioned. A general need to focus awareness is coming up in radiation protection training.

Optimisation in nuclear risk management is vital and reconsidered in its cultural dimension but could be more supported by science based communication models such as RISCOM.

Risk assessment & management in the nuclear field should no longer be constrained by an isolated sectorial culture such as existing within the regulatory framework of the EURATOM treaty and projected in most national regulatory approaches but reflected as well in UNSCEAR and IAEA.

The new environmental concept for protecting a selection of fauna and flora species, being developed by ICRP, lacks adhesion among radiation protection professionals, nor is it adequate in the new dynamics of sustainability governance. An ecosystem approach considering different stress factors, such as being developed now for the atmosphere with regard to climate concerns, deserves more attention in nuclear regulation.

The dose paradigm and its application for overall risk indication is questioned while evidence for synergistic effects is increasing at different levels. The exposure reality in the environment, at the workplace, for the patient and the public is always a combined exposure requiring more holistic and coherent regulatory approaches.

Some additional qualitative instruments for sustainability assessment in the nuclear field will be presented which could enrich the world view of radiation protection professionals facing new technological challenges. As radiation protection tools offer a wealth of opportunities to other sectors, this could offer a win-win situation.

Is guidance in ICRP publications consistent on the application of reference levels?

HEDEMANN-JENSEN, P.

Danish Decommissioning, Frederiksborgvej 399, DK-4000 Roskilde, Denmark,

p.hedemann@dekom.dk

In ICRP 103, which has replaced ICRP 60, it is stated that no fundamental changes have been introduced compared to ICRP 60. This is true except that the application of reference levels in emergency and existing exposure situations seems to be applied inconsistently also in the related publications ICRP 109 and ICRP 111.

ICRP 103 emphasizes that focus should be on the residual doses after the implementation of protection strategies in emergency and existing exposure situations. If possible, the result of an optimised protection strategy should bring the residual dose below the reference level. Thus the reference level represents the maximum acceptable residual dose after an optimised protection strategy has been implemented. However, in ICRP 103 some inconsistent concepts have crept into the text, e.g. in paragraph 279 which states: *'All exposures above or below the reference level should be subject to optimisation of protection, and particular attention should be given to exposures above the reference level'.* A reference level for emergency and existing exposure situations is not an 'off-the-shelf item' that can be set free of the prevailing situation. It should be determined as part of the process of optimising the protection strategy. If not, protection would be sub-optimised.

If, in fact, all exposures above and below reference levels are subject to the process of optimisation, reference levels appear superfluous. It could be considered that if optimisation of protection below a fixed reference level is necessary, then the reference level has been set too high at the outset.

Up until the last phase of the preparation of ICRP 103 the concept of a dose constraint was recommended to constrain the optimisation of protection in all three exposure situations. In the final phase, the term 'dose constraint' was changed to 'reference level' for emergency and existing exposure situations. However, it seems as if ICRP 103 did not fully recognise that dose constraints and reference levels indeed are conceptually different.

The use of reference levels as they have been applied in radiological protection is reviewed. It is concluded that the recommendations in ICRP 103 and related ICRP publications seem to be inconsistent regarding the use of reference levels in existing and emergency exposure situations.

Teaching laymen an in depth understanding of ionising radiation

SAMUELSSON C.

Lund University, Dept. Med. Rad. Physics, University Hospital, SE 221 85 Lund, Sweden, christer.samuelsson@med.lu.se

Teaching laymen, e.g. emergency first responders, the subject of ionising radiation to such a level that they can handle instrumentation and take appropriate decisions on their own, is a real challenge. The initial refreshment lessons in basic calculations, atomic matter and physics are as a rule the easy part, but introducing the radiation concept is intricate. A lay person typically associates radiation with waves and what happens with these waves when they meet a body or a detector is obscure, at least for ionising radiation. Mistaking the radioactive substance for the radiation emitted is common. Our recommended pedagogic approach is to wait with the radiation concept and instead focus onto the particulate behavior of ionizing radiation particles, including photons. Particles are easy to visualize and the view of radiation as quantized rather than a continuous phenomenon, comes natural. With macroscopic particle collisions as a model it is now straightforward to describe collisions in matter by both photons and by real atomic particles. The outcome of fairly complicated interactions, e.g. Compton scatterings and escape in spectrometry detectors, the existence of the K-edge in a cross-section and so forth, is understood and makes sense to most of our nonprofessional beginners. The “particle approach” described, has been beneficial in the course “Measurement of photon and neutron radiation sources” educating crew members of Swedish Customs cars performing carborne gamma spectrometry.

Current problems of quantities in radiation protection and their possible solutions

J. Sabol,

Faculty of Biomedical Engineering, Czech Technical University in Prague, Czech Republic

The aim of quantities and units in radiation protection is to quantify biological effects resulting from the exposure of persons to ionizing radiation. These effects include stochastic effects which occur in exposed groups of individuals at low doses with certain probability, and deterministic effects which affect instantly exposed persons as long as their doses are above certain levels or thresholds. There are about 10 quantities for the assessment of stochastic effects with the main quantity being the effective dose, which cannot be measured directly and therefore one has to monitor other quantities and only then express the results in terms of this principal quantity. There is no such unified quantity for the quantification of the deterministic effects.

The paper discusses difficulties in the use and interpretation of so many quantities introduced for stochastic effects and emphasizes some mistakes in interpreting these quantities including the use of operational quantities such as the ambient dose equivalent. Since there is no general quantity for the estimation of deterministic effects where the type of ionizing radiations and exposed tissues or organs have to be taken into consideration, a new quantity – the deterministic effective dose - as a complementary quantity to the present effective dose reflecting stochastic effects has been proposed. In addition, it has been suggested to reduce the number of quantities currently in use in radiation protection in order to simplify their monitoring in regulatory control of radiation exposure in practice involving various radiation or nuclear based applications. Special attention is paid to the metrological aspects of these quantities.

S11 - O5

How the use of the concept “Dose Constraint” may help to lower annual individual doses

Virva Nilsson

Forsmarks Kraftgrupp AB, SE-742 03 Östhammar, Sweden, tel +46 173 821 33,

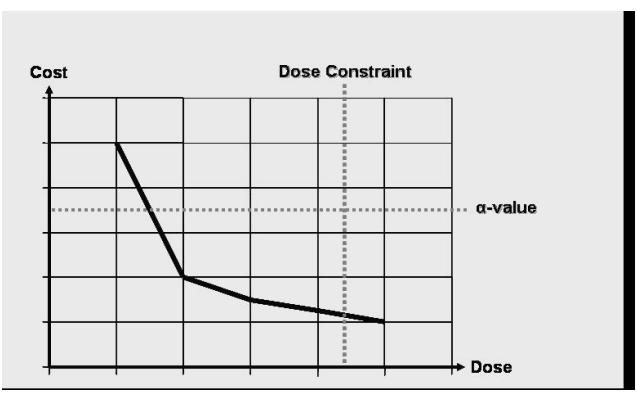
mobile +46 70 388 16 23, e-mail vpa@forsmark.vattenfall.se

In ICRP publication 103 the use of the concept “Dose Constraint” is emphasized. It will furthermore be an important ingredient also in the revised RP Basic Safety Standards from both IAEA and EU and will surely later on be reflected also in National Regulations.

At Forsmark NPP since many years the concept has been used in order to lower annual individual doses in the dose span 10-20 mSv.

This paper intends to show how the number of individual doses in the higher dose intervals has been lowered by actively using dose constraints in our ALARA-program and dose planning process.

Another important question will also be asked and discussed, namely should dose constraints only be considered for individual doses and not for collective doses?



Radiation Safety Assessment of licensees using with Open Sources

Holzwarth R. (presented by Helene Jönsson)

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden, richard.holzwarth@ssm.se

Between October 2009 and January 2011 The Swedish Radiation Safety Authority (SSM) performed 12 inspections of licensees working with open sources. The working areas of the licensees covered Research & Development (R&D) within private companies, academic related research and industrial process diagnostic measurements. Due to the fact that legislative and radiation protection requirements depend on the extent and nature of work the licensees were grouped in three categories of licensees:

- licensees performing extensive laboratory work
- licensees performing non-extensive laboratory work
- licensees performing industrial process measurements

Based on these three groups of licensees a Radiation Safety Assessment was carried out with focus on the following topics.

- Legislation and requirements: It is analysed to which extend licensees with comparable activities follow and respect legislation and requirements.
- Organisation of radiation protection on site: Focus is put on how radiation protection is organized at licensees with comparable activities.
- Safety culture: Based on personnel resources, economic resources and competence the conditions for continued working activities while applying sound radiation protection are evaluated

Purpose of the Radiation Safety Assessment was to identify areas of improvements within the topics mentioned above but also to further develop SSM's way of supervision.

Ethical guidance, stakeholder involvement and radiation protection culture in the Belgian Society for Radiation Protection

EGGERMONT G., SMEEESTERS P., SAMAIN J-P & HARDEMAN F.

Belgian Society for Radiation Protection (BVS-ABR), Hermann Debrouxlaan 40, B-1160 Brussels, Belgium, Gilbert.Eggermont@vub.ac.be

The Belgian IRPA affiliated organisation for radiation protection BVS-ABR (www.bvsabr.be) has set up guidance for ethical conduct and stakeholder involvement as required by IRPA. This was developed by a working group and submitted to the members for comments with final discussion and approval in the plenary meeting of the society.

Guidance is framed within the strategic objectives of the society and based on IRPA principles and on results of research and field inquiries integrating social research within the trans-disciplinary science of radiation protection. Participatory experiments at local and national level in nuclear waste decision making processes and with particular groups such as patients and workers have generated feedback of experience. Particular attention was also given to the modelling of risk communication as done in RISCOM.

The results of these exercises in generating guidance by a professional society are annexed in the paper while being illustrated by case references for present challenges in radiation protection (nuclear waste forum, round tables).

ALARA and radiation protection culture is discussed proactively with international IRPA representatives preparing IRPA13 in Glasgow, while building a bridge with safety & security culture as met in the field. Some definitions and proposals are put forward.

CEEPRA - Collaboration Network on EuroArctic Environmental Radiation Protection and Research

RISTO M.,[a] VAARAMAA K.,[b] KASATKINA N.,[c] NALBANDYAN A.,[d] PAATERO J.,[e] REINIKAINEN K.[f] & SOLATIE D.[a]

[a]STUK – Radiation and Nuclear Safety Authority, Regional Laboratory in Northern Finland, Lähteentie 2, 96400 Rovaniemi, Finland, maarit.risto@stuk.fi; [b]STUK – Radiation and Nuclear Safety Authority, Helsinki, Finland; [c]Murmansk Marine Biological Institute, Russia; [d]Norwegian Radiation Protection Authority; [e]Finnish Meteorological Institute; [f]Pöyry Finland Oy.

An international three-year programme of cooperation between the key authorities, research organisations and stakeholders in the Arctic regions of Finland, Russia and Norway has been launched in April 2011. The aim of the CEEPRA (Collaboration Network on EuroArctic Environmental Radiation Protection and Research) project is to establish an international cooperation network in order to improve nuclear safety, emergency preparedness, monitoring capabilities and risk assessments in this region.

The project will investigate long-term effects of potential nuclear accidents in the EuroArctic region and possible impacts on the region's indigenous population, terrestrial and marine environments, reindeer husbandry, the natural product sector, tourism and industries.

The current state of the region's radioactive contamination will be studied by examining environmental samples collected from the Finnish Lapland, Finnmark and Troms in Norway, the Kola Peninsula and the Barents Sea. The results will provide new information on the spread and accumulation of radioactive substances in the food chains in Arctic regions and possible risks.

The aim of the project is also to raise awareness and knowledge in the general public and stakeholders in the EuroArctic region with respect to the radioactivity-related issues, emergency preparedness and the regional status.

The project is funded by the European Union Kolarctic ENPI CBC and the Norwegian Kolarctic programmes.

NORM and other radioactive sources found in scrap metal yards in Sweden

SÖDERMAN A-L. & BREWITZ E.

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden, ann-louis.soderman@ssm.se

The Swedish steel and recycling industry do not allow any radioactive material to enter the steel process flow; there is a "zero tolerance" policy. The industry has increased the control of scrap metal the past two decades by installing portal monitors at scrap metal yards. In addition, some yards have detecting equipment in crane grips and transportation units. There are also a number of hand-held instruments.

Radioactive material is found among the scrap metal where it is impossible to establish the owner. More often than not these shipments come from municipal recycling sites, where anyone can get rid of anything without virtually any control at all. This paper will give examples of radioactive materials and sources detected and put a side at scrap metal yards in Sweden. In most cases the materials can be categorized as NORM, such as scale in pipes and different types of filters but also radioactive sources and pieces from instruments containing radium.

In the end the scrap yards have no one to charge for the costs for the management of the scrap and used to be left with the financial responsibility themselves. Today they can apply for money from SSM to cover the costs for the management and final disposal of the material. SSM receives special funding corresponding to EUR 100 000 per year from the Government, to cover the costs for the management and final disposal of non-nuclear waste from past practices and orphan sources. Another problem for the industry is the uncertainty whether the radioactive material will be accepted by Studsvik Nuclear AB which is the only Swedish licensed company that manages radioactive waste. Studsvik Nuclear AB recently decided that they no longer accept NORM, due to uncertainties regarding its final disposal. In many cases, NORM can be deposited of in landfills by specific clearance of the material.

Developing an Survey of the impact of enhanced natural radioactivity on human and natural environment

SIDHU R.S., RAMSØY T., HAUGEN A-H., BJERK T., MICHALIK B. AND WYSOCKA M.

Institute for Energy Technology, P.O. Box 40, NO-2027 Kjeller, Norway, Tore.Ramsoy@ife.no

The main goal of this joint Poland-Norway research project is to recognize and assess the radiation risk for people and for the environment from exposure to enhanced ionizing radiation caused by technologically enhanced natural occurring radioactive materials.

Three groups of NORM sites were chosen. In Poland, water holding pounds in connection with coal mining in Upper Silesia and the phosphogypsum waste dump in Wislinka have been studied. In Norway, a radiological survey around the disused niobium mine at Søve has been undertaken.

During production at Søve, uranium and thorium were concentrated in the slag that was dumped just outside the building where ferro-niobium was produced. Today the slag (600-1000 tonnes) is mixed with other materials and is partially covered. The present volume of the waste deposit is probably between 1500 and 2000 m3. In addition the areas around the mine are contaminated with niobium concentrate mixed with local soil.

Previous surveys have shown that the area containing slag components and the area with contaminated soil are contaminated with 238U and 232Th series radionuclides. The highest levels of 238U and 232Th measured in the slag are around 50-70 Bq/g.

New dose rate measurements in a grid of approximately 10 m x 10 m have been performed on areas not previously covered. Samples of slag, soil, biota, drainage water and lake water from contaminated and non-contaminated areas were also collected for analysis of radionuclides. Results from field measurements, radionuclide determination and speciation and leaching tests performed on slag and soil samples will be presented.

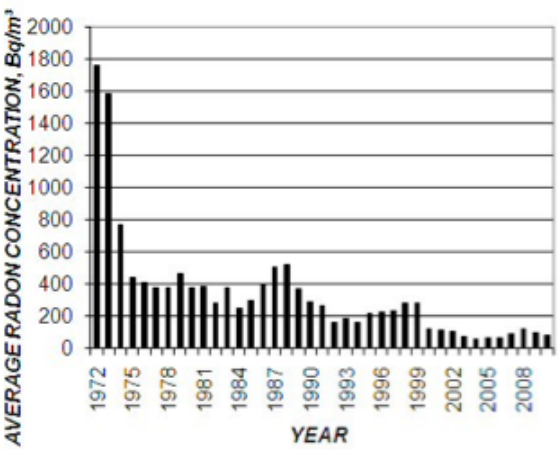
Radon in Finnish mines 1972–2010

AALLOS-STÅHL S.-M., VENELAMPI E., ANNANMÄKI M. OKSANEN E. & MARKKANEN M.

STUK - Radiation and Nuclear Safety Authority, Laippatie 4, 00880 Helsinki, Finland, siiri-maria.aallos-stahl@stuk.fi

Radon measurements in Finnish underground mines were started in 1972. In 1975, a limit for radon concentration was set at 1100 Bq/m^3. In 1992, an action level of 400 Bq/m^3 for radon, an average over the total number of annual working hours, was adopted. Since then regular radon inspections have been carried out in all underground mines.

In 1972 there were 23 operating underground mines in Finland. In 2010 there were 10 underground mines in operation, most of them being small in size. In 2002 a survey was done to determine the average individual and collective doses of mine workers between 1975 and 2001 (M. Annanmäki et al). In 2011 the same survey was repeated to determine the average individual and collective doses of mine workers between 2002 and 2010. In 1975 the mean effective dose for a mine worker was 3.5 mSv, by 1985 it had decreased to 2.4 mSv and by 1995 to 1.7 mSv. By 2001 the mean effective dose was below 1 mSv at 0.9 mSv and by 2010 0.6 mSv. The average radon concentration in the Finnish mines is 90 Bq/m^3 (results 2009-2010).



Average radon concentration (Bq/m^3) in Finnish mines 1972-2010

RADON PREVENTION IN NEW CONSTRUCTION IN FINLAND - A NATIONWIDE SAMPLE SURVEY IN 2009

H. ARVELA, O. HOLMGREN AND H. REISBACKA

Radiation and Nuclear Safety Authority - STUK. P.O. Box 14, FI-00881 Helsinki, Finland

The building code for radon prevention and the associated practical guidelines were revised in Finland in 2003 to 2004. Thereafter, preventive measures have become more common and prevention practices more effective. Consequently, indoor radon concentrations in new construction have been markedly reduced. In this study, the indoor radon concentration was measured in 1 500 new low-rise residential houses. The houses were randomly selected and represented 7% of houses that received building permission in 2006.

The average radon concentration of all houses measured, which were completed in 2006 to 2008, was 95 Bq/m^3, the median being 58 Bq/m^3. The average was 33% lower than in houses completed in 2000 to 2005. The decrease was 47% in provinces with the highest indoor radon concentration and 26% elsewhere in the country. In houses with a slab-on-ground foundation that had both passive radon piping and sealing measures carried out using a strip of bitumen felt in the joint between the foundation wall and floor slab, the radon concentration was on average reduced by 57% compared to houses with no preventive measures.

Preventive measures were taken in 54% of single family houses, and in provinces with the highest radon concentration in 92% of houses. Active prevention in areas with high indoor radon concentrations has reduced the regional differences in the radon concentration. Slab on ground is the prevailing type of foundation and necessitates careful radon prevention measures throughout the country. The most serious defects were observed in prevention practices in houses with walls made of lightweight concrete blocks that were in contact with soil. The foundation types with the lowest radon concentrations were those with a crawl space and a reinforced uniform floor slab.

Effectiveness of anti-radon measures in Norwegian homes, seven years after mitigation.

FINNE I.E., KOLSTAD A.K., RUDJORD A.L.

Norwegian Radiation Protection Authority, P.O. Box 55, 1332 Østerås, Norway, ingvild.finne@nrpa.no

During the National Action Plan against Cancer in Norway in the period 1999-2003, the Norwegian government subsidised radon reduction measures in approximately 1100 existing dwellings. In January 2010 about 450 of the homeowners were invited to participate in a study to determine the long-term effect of their remediation systems. In total 714 measurements were carried out in 352 existing single-family houses. However, only 273 dwellings had a complete data set from both pre-mitigation (1999-2003), post-mitigation (2003) and from 2010.

Comparing the pre-mitigation measurements with the post- mitigation measurements in 2003, the reduction of the mean radon concentration of the 273 dwellings was 70 %. Comparing the pre-mitigation measurements with the post-mitigation measurements in 2010, the reduction of the mean radon concentration was 60 %.

The measurements indicate slightly higher indoor radon levels in 2010 compared to 2003 and large variations in effectiveness of different anti-radon measures were found.

Radon control in European countries – a RADPAR questionnaire study

HOLMGREN O. & ARVELA H.

Radiation and Nuclear Safety Authority – STUK, Laippatie 4, 00880 Helsinki, Finland olli.holmgren@stuk.fi

Radon control methods aim at reduction of indoor radon concentrations in existing buildings and in new construction through remedial and preventive measures, respectively. This paper contains the analysis of the reduction efficiency of the current methods. The study arises from the EU project "Radon prevention and remediation" (RADPAR).

In addition to the reduction efficiency of different methods, status of radon remediation and prevention in each country was assessed based on a questionnaire study. The questionnaire was prepared and sent to all RADPAR partners in 14 European countries to gather national information about the current remediation and prevention techniques.

Radon control status varies to a great extent between different countries. The number of dwellings with elevated indoor radon concentration ranges typically from dozens of thousands to a million. The percentage of these houses already remediated is between 0 and 15 %. The number of houses where preventive measures in new construction have been applied varies from few to over 200 000.

The most efficient remediation method is the active sub-slab depressurization (SSD) and radon well, for which the reduction of radon concentration is typically 60–95 %. Other methods, such as sealing entry routes and improving ventilation, are less effective: reduction of radon concentration is typically 10–60 %. The efficiencies of prevention methods are analogous to those of remediation. Active SSD is the most efficient prevention technique. The efficiency of passive SSD is lower, usually 20–50 %. However, wide use of such systems can be recommended. Radon proof insulation of the base floor with a membrane and sealing pipe penetrations reduces radon concentration on average by 50%.

In particular, research data on current situation of radon prevention, i.e., the number of houses with preventive measures and the efficiency of the prevention measures, is currently still quite inadequate. Assessment of the techniques and also the surveys aiming at exploring the impact of remedial and preventive measures is greatly needed in order to promote the work at national level in Europe.

Comparison of two ^{222}Rn exhalation rate measurement methods by study of Hungarian adobe building materials

SZABÓ, ZS., SZABÓ, CS. & HORVÁTH, Á.

Lithosphere Fluid Research Lab, Department of Petrology and Geochemistry, Eötvös University, Pázmány P. s. 1/C, H-1117 Budapest, Hungary, zsszabo86@gmail.com

^{222}Rn and ^{220}Rn are responsible for 52% of the total annual effective dose to humans. Although the half-life of ^{220}Rn is short (55.6 s), it can enter indoor air from the walls of adobe houses. The main aim of this work is to test a ^{222}Rn exhalation rate measurement technique and to study ^{222}Rn and ^{220}Rn exhalation properties of Hungarian adobe building materials.

Adobe samples were taken from settlements in three areas (SE-, NE-, and S-Hungary). ^{222}Rn exhalation rates were estimated by two different techniques, both using Al-accumulation chambers and RAD7 detectors. One technique (growth curve method) is based on measuring the growth curve of ^{222}Rn concentration in the chamber for ten days, and the other (equilibrium method) on measuring for four hours the ^{222}Rn equilibrium concentration after three weeks (about $5(T_{1/2})$) in the sealed chamber. The latter is faster for high number of samples. For the case of ^{220}Rn, only the equilibrium concentrations can be used ($5(T_{1/2})\approx5$ min). In addition, ^{226}Ra and ^{232}Th activities were determined by gamma-ray spectrometry, and grain size distributions were measured by wet sieving and laser grain size analyser.

The equilibrium method shows less ^{222}Rn exhalation rates but correlation (R=0.85) is found between the ratio of results and the degree of leakage. It is shown that when leakage is below $\alpha\approx0.005$ h^{-1}, based on the growth curve, the two methods give close results. ^{222}Rn and ^{220}Rn exhalation rates are similar (8±2, 7±2 s^{-1} kg^{-1}, respectively). The measured activities for ^{226}Ra, ^{232}Th (30±4, 26±5 Bq kg^{-1}, respectively) are close to the average values of Hungarian soil. Grain size distributions are peaked around 10-20 µm. Only a weak connection was found between the numbers of 10-20 µm particles and ^{222}Rn exhalation rates or between 0-10 µm particles and ^{220}Rn exhalation rates.

We conclude that a tightly gas proof circuit is required for the best estimation of both of the methods. Hungarian adobe is a potential ^{220}Rn exhaling building material, therefore indoor measurements are necessary to evaluate its effect.

Nordic re-parameterisation of the ECOSYS ingestion model

ANDERSSON, K.G.[1], NIELSEN, S.P.[1], THØRRING, H.[2], HANSEN, H.S.[3], JOENSEN, H.P.[4], ISAKSSON, M.[5], KOSTIAINEN, E.[6], SUOLANEN, V.[7] & PÁLSSON, S.E.[8]

[1]Risø DTU National Laboratory for Sustainable Energy, DK-4000 Roskilde, Denmark, [2]Norwegian Radiation Protection Authority, N-1332 Østerås, Norway, [3]Nord-Trøndelag University College, N-7729 Steinkjer, Norway, [4]University of Faroe Islands, Nóatún 3, FO-100 Tórshavn, Faroe Islands, [5]University of Gothenburg, S/U Sahlgrenska, SE-41345 Gothenburg, Sweden, [6]Radiation and Nuclear Safety Authority, FI-00881 Helsinki, Finland, [7]VTT Technical Research Centre, Espoo, FI-02044 Finland, [8]Icelandic Radiation Safety Authority, IS-150 Reykjavik, Iceland.

The NKS-B PardNor activity, which was finalised at the end of 2010, had the objective of generating parametric improvements for the ECOSYS model, which is essentially the ingestion dose model integrated in the two most widely used European decision support systems for accidents at nuclear installations - ARGOS and RODOS. In-line with recommendations from the originators of the ECOSYS model, one of the tasks of the Nordic work group was to customise the model for local use in each of the Nordic countries. This required identification of local parameters such as typical consumption rates of dietary constituents, animal feeding regimes, and seasonal crop development. Also new parameters for modelling of a series of important generic processes were identified, since it was evident that the ECOSYS parameterisation originating from the 1980's did not reflect the best knowledge of today. These processes included deposition to crops, soil and snow, natural weathering of contaminants on crops, leaching, fixation, desorption and resuspension of contaminants in soil, soil-to-plant transfer for different soil types, and transfer to meat and milk of farm animals.

ECOSYS model runs demonstrated that some of the generic parameter improvements actually changed estimates of contamination levels and dose contributions by orders of magnitude. Since the quality of European emergency consequence prognoses could thus be improved considerably, it is the hope of the work group that the parameters be integrated in ARGOS and RODOS to ensure justification and optimisation of intervention in the event of an emergency situation.

The presentation will give examples of ECOSYS parameter revisions and associated changes in consequence estimates.

S12 - P1

ASSESMENT OF THE CLEARANCE OPTIONS FOR NORM-WASTE

MERLE LUST

University of Tartu, Estonia, e-mail: merle.lust@gmail.com

The Sillamäe Metallurgical Plant was built in late forties. Target product was uranium, to be used for needs of Soviet nuclear program. From early 1970s has the plant introduced a new production line – rare earth elements. Rare earths were produced from loparite – rare earths, niobium, tantalum and NORM-containing ore. Later were rare earths produced from rare earth chloride mix [1]. Based on the radiation activity licence number 08/004 the plant is allowed to produce annually up to 48 tons of radioactive waste, which contains naturally occuring radionuclides (NORM-waste). The activity concentration of that waste has to be lower than 300 kBq/kg. At the moment the waste is storaged temporarily and the plant is looking for the possible solutions for the future management. One of the management options could be clearance of NORM-waste. Based on the Radiation Act of Republic of Estonia [2] the clearace of the radioactive waste is possible if:

- the public annual dose caused is lower than 0,01 mSv;
- the collective annual dose caused is lower than 1 manSv;
- in case of the NORM-containing material and waste the public dose caused has to be lower than 0,3 mSv.

For the assessment of the clearance options of NORM-waste it was taken into account that future radioactive waste arising is caused exclusively by the production process of Silmet [3].

Environmental Board allowed to use oil-shale in the construction process of Sillamäe harbour. Taking account that the activity concentrations and physical properties of oil-shale ash and the NORM-waste produced in Sillamäe are very similar, there is a clearance assumtion made that NORM-waste and oil-shale mix (110000 tons of oil-shale ash together with 48 tons of NORM-waste) could be used instead of oil-shale ash in the construction of the harbour, as the possible management option for the waste. The waste produced during the last years has average activity concentrations for U-238 and Th-232 respectively 98,8 Bq/g and 36 Bq/g.

The following dose assessment requirements and dose constraints and scenarios were considered in the assessment [4,5,6,7]:
1) transportation of NORM-waste;
2) inhalation of NORM-waste;
3) ingestion of NORM-waste;
4) fire in the waste management facilities;
5) doses to the harbour workers;
6) dose to the farmer, who lives and farms on the harbour area.

During the assessments programms used were: MicroShield TM 6.02, PRESTO-EPA and DanD. Based on the scenarions and assessments the assessment of the annual public and collective dose caused by using the oil-shale and NORM-waste mix in the construction of Sillamäe harbour was performed and as the result the conclusion was that the highest doses arise to the farmer, who lives and produces in the area. However, even in the case of the farmer the clearance requirement (annual dose lower than 0,3 mSv) is fullfilled with the probability of 95%. Additionally it can be easily proved that such kind of management option is the optimal solution for such kind and amont of the radioactive waste. Based on the assessments performed it was proved that in case using the NORM-waste and oil-shale ash mix on the construction of Sillamäe harbour, the clearance requirements for NORM-waste are fulfilled.

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Radon measurements in Finnish workplaces during measurement seasons 2005-2010

HEIKKI REISBACKA

STUK - Radiation and Nuclear Safety Authority

In Finland the action level for the radon concentration in inhaled air is 400 Bq/m^3 in workplaces where people are working regularly (1600 hours per year). The radon concentration means the annual mean of the radon concentration during working time. The mean radon concentration may be higher than 400 Bq/m^3, if the work is not regular. However, in schools, in day-care centres and in other public rooms radon concentration must be below the action level.

The responsible party, i.e. employers, ordered altogether 6340 radon measurements between 1.9.2005 and 1.11.2010. Passive alpha track detectors of STUK were used for these mainly two-month measurements. Private companies ordered 63%, municipalities ordered 30% and the government 7% of the radon measurements. 3900 measurements were classified by the type of measuring places. The average of radon concentrations for all measurements was 250 Bq/m^3, and the median was 83 Bq/m^3. The radon concentration of 400 Bq/m^3 was exceeded in 841 measuring points, and the concentration of 1000 Bq/m^3 was exceeded in 278 measuring points, respectively.

Radiocesium in moose in Finland

E. KOSTIAINEN, J. YLIPIETI

STUK – Radiation and Nuclear Safety Authority, P.O.Box 14, FI-00881 Helsinki, Finland

The level of radiocaesium contents in moose ((*Alces alces alces)* has been monitored annually in Finland during the period after the Chernobyl accident in 1986. The first radioactivity survey of Finnish moose meat was made in 1979. The nationwide mean ^{137}Cs concentrations in 1979 were 34.4 Bq kg^{-1} varying areally from 22.2 to 52.4 Bq kg^{-1}. In autumn 1986 the nationwide mean contents of ^{137}Cs reached 170 Bq kg-1 due to the 137Cs deposition after the Chernobyl accident. The mean 137Cs contents of moose meat in 1986 varied from 40 to 500 Bq kg^{-1} in the game management districts. Since 1986 the ^{137}Cs concentrations have decreased on average up to 50 percent until the beginning of 2000s. Samples of moose liver and kidney have also been measured to get information on the distribution of ^{137}Cs activity in moose organs. The ^{137}Cs concentrations in meat of Finnish moose in 2010 are below the level 600 Bq kg^{-1}, which level is recommended to be respected for the placing on the market of wild game (2003/274/Euratom). The aim of this study is to assess areal variation of the ingestion radiation dose from ^{137}Cs in moose meat after 1986.

Assessment of doses to biota in the Baltic Sea

OUTOLA I., VETIKKO V. AND SILOBRITIENE B.

Radiation and Nuclear Safety Authority (STUK), Laippatie 4, FI-00881 Helsinki, Finland, iisa.outola@stuk.fi

The Baltic Sea is one of the most contaminated sea areas with respect of ^{137}Cs and ^{90}Sr. Due to the slow exchange of water between the Baltic Sea and the North Sea and the relatively rapid sedimentation rates, radionuclides have prolonged residence times in the Baltic Sea.

To assess the doses to biota resulting from exposure to radionuclides from anthropogenic sources in the Baltic Sea, the ERICA tool was applied. ERICA Tool allows the estimation of dose rates to biota for different ecosystems for a set of default reference organisms or user-defined organism. Input data on radionuclide concentrations in biota and in media were obtained from HELCOM-MORS database complemented by additional measurements carried out by STUK.

Assessment was carried out for the major anthropogenic radionuclides: ^{137}Cs and ^{90}Sr but the dose resulting from the most important natural radionuclides such as ^{210}Po was also considered for a comparison.

The assessment was performed for the most contaminated areas of the Baltic Sea: the Gulf of Finland and the Bothnian Sea. Species that were considered included seaweed, fish and bottom living crustacean. Assessment was carried out for the present situation and also for the time of the Chernobyl accident.

Results revealed that the dose rates to the studied species were clearly below the screening level of 10μGy/h, indicating no significant impact of the anthropogenic radionuclides on these species. Of the radionuclides assessed, ^{210}Po contributed the highest dose.

External radiation doses to important organs in biota: Monte Carlo dose model calculations

KARLSSON M., STARK K., CARLSSON M. & PETTERSSON H.

Dept. of Radiation Physics, Linköping University, SE-581 85 Linköping, Sweden, mattias.karlsson@liu.se

Over the past decade, the interest to estimate absorbed doses to non-human biota has increased. Several approaches, dose models and tools have been developed, mainly to be used as screening tools for the assessor. Generally, these models contain several simplifications and assumptions which may affect their accuracy and little guidance exists for cases when the screening values are exceeded.

A graphical user interface (GUI) was developed for the general-purpose Monte Carlo code system MCNP5 aimed at in depth, site-specific analysis of exposure to biota, both in and on soil. The GUI offers large freedom of choice in defining exposure parameters, including the distribution of different radionuclides in the soil, the shape and size of the organism, compositions of soil and organism etc. Furthermore, the GUI facilitates the analysis of results by plotting the depth dose rate and presenting dose contributions from γ- and β-radiation.

The Monte Carlo dose models were validated with field measurements in a riparian wetland north of Gävle, Sweden, using thermoluminescence dosimeters in frog and worm phantoms. This area received a relatively high ^{137}Cs fall-out from the Chernobyl accident (~1 MBq/m^2). Additional validation was performed with phantom measurements with ^{40}K under controlled laboratory conditions. Results from the Monte Carlo model calculations were also compared with the ERICA assessment tool and the RESRAD-BIOTA code.

The measurements are expected to confirm the dose models constructed with the MCNP5 GUI. The intuitive structure of the GUI makes the advantages of the Monte Carlo method available also for those who have no prior experience of these kinds of calculations. User-friendliness is offered without compromising the accuracy of analysis.

The GUI allows detailed, site- and biota-specific evaluation of the radiological risk and may become an important tool for ecological risk assessment for contaminated sites.

STAR–Strategic Network for Integrating Radioecology

IKÄHEIMONEN TK., OUTOLA I. & MUIKKU M.

STUK – Radiation and Nuclear Safety Authority, P.O. Box 14, FI-00881 Helsinki, Finland, maarit.muikku@stuk.fi

With a renewed interest in nuclear energy and the scientific challenges related to the nuclear fuel cycle, the need for radioecological expertise is increasing worldwide. Concurrently, education related to radioecology has steadily declined, leading experts are approaching retirement, and funding for radioecological research is at a minimum in many European countries. To face this challenge and avoid further fragmentation, nine leading organizations established a Network of Excellence in radioecology, called STAR. The goal is to efficiently integrate important organizations, infrastructures, and research efforts into a sustainable network that contributes to a European Research Area in radioecology. To achieve this, a Joint Programme of Activities will be implemented covering integration and sharing of infrastructures; training, education and mobility; knowledge management and dissemination; as well as three key research themes (integrating human and non-human radiological risk assessments; radiation protection in a multi-contaminant context; ecologically relevant low-dose effects).

The coordinator, IRSN, is one of the largest radioecological research institutes in Europe. Three STAR partners are members of the High Level Expert Group on Low Dose Risk Research, ensuring that STAR will provide effective links to the wider community of low dose risk research. STAR will interact with other European and international research institutes in radioecology, radiobiology and ecology to produce the best research for addressing the key scientific challenges in radioecology. To address stakeholders' needs and policy questions, a strong link with end-users will be achieved via dedicated workshops, conferences and advanced dissemination tools. STAR will promote integration, networking and scientific excellence to benefit human and environmental radiation protection. A vital role of STAR is to develop a transition plan to sustainability that invokes a permanent management structure (the European Radioecology Alliance) and long term funding for radioecological research, infrastructure, training and education.

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Migration and plant uptake of ^{137}Cs in six pasture soils after the Chernobyl accident 1987 - 2007

[A]ROSÉN K*, [B]ÖBORN I, [A]PERSSON H & [A]GUTIERREZ VILLANUEVA J.L.

*[a]Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), P.O. Box 7014, SE-750 07 Uppsala, Sweden. *Email: Klas.Rosen@slu.se*

[b]Department of Crop Production Ecology, Swedish University of Agricultural Sciences (SLU), Box 7043, SE-75007 Uppsala, Sweden

This study comprises six pasture soils in central and northern Sweden which were strongly affected by the Chernobyl fallout in 1986. The aims of the study were (i) to investigate the vertical migration of ^{137}Cs during 20 years after the fallout, (ii) to determine the plant uptake of ^{137}Cs during that period, and (iii) to relate the mobility and bioavailability to soil properties and other environmental factors. The soil profiles were sampled at 5-7 occasions between 1987 and 2007. Corers were used to sample down to 60 centimetres depth. At each site three replicate profiles were sampled, each consisting of 5 bulked subsamples. The top 10 cm samples were sliced in 10 mm layers, and the 10-60 cm samples in 25 mm layers, before sample preparation and analyses.

21 years after the ^{137}Cs fallout the main part of the activity (61-97 %) was still present in the upper ten centimetres of the soil. However, there had been a significant movement from 0-5 cm to 5-10 cm and also further down in the profiles during the study period, e.g. in fen-peat soils and in a clay soil with high bio-turbation (e.g. earth worms). The migration rate as a whole decreased during the sampling period but varied considerably between the sampling occasions at each location. The mean migration rates were in the range of 0.2-0.5 cm year^{-1}. There was a clear decrease in plant uptake with time, the decrease was however greatest in the first years after fallout. In 2007 the transfer of ^{137}Cs to the vegetation was highest in an organic soil and in a gravely sandy loam in the mountain region and lowest in a clay soil. The plant uptake of ^{137}Cs was more related to the nutritional status of the soil than to the mobility as reflected in migration rate. The relation between migration rate, plant uptake and soil properties including soil mineralogy will be further explored. Preliminary results show that the differences in migration seem to be a product of soil properties, biological and hydrological factors at the individual locations.

Radiocaesium in fungi in Pasvik, Norway

NILSSEN J., MØLLER B., EIKELMANN I.M., HANSEN H.S.

Norwegian Radiation Protection Authority, Svanhovd emergency preparedness unit, 9925 Svanvik, Norway

Radiocaesium in the food-chain has been monitored in Norway since the Chernobyl-accident in 1986, and edible mushrooms have been included since the beginning. Although Finnmark county was spared for most of the fallout from Chernobyl, there is still some radiocaesium from the nuclear bomb tests in the 1950's and -60's in the area.

In 1993 NRPA started monitoring the level of radiocaesium in fungi in Pasvik, and from 2000, samples were collected and analyzed on a yearly basis. Edible mushrooms were sampled, and sorted by species, from the same area, and in the same month every year, before being analyzed at NRPA's laboratory at Svanhovd. All samples were analyzed fresh on a 3 inch NaI scintillation detector (1024 channels).

The level of ^{137}Cs in the fungi sampled from 2001 - 2010 varied quite a lot from one year to the next, and from one specie to the other with Red-banded Cortinarius (C. armillatus) containing the highest levels of ^{137}Cs, and Birch Bolete (Leccinum) containing the lowest levels. As the level of ^{137}Cs in fungi is influenced by so many parameters, e.g. soil properties, precipitation, sun-hours and the uptake mechanisms of Cs in the different species of fungi, it is very hard to estimate ecological half-life of ^{137}Cs in mushrooms. For one specie (Lactarius rufus) there even seems to be some connection between nickel in precipitation and level of ^{137}Cs, resulting in a negative ecological half-life, i.e. an exponential growth of ^{137}Cs rather than decay over the time period 2001 – 2010.

The Swedish Radiation Safety Authority's regulations on exemption and clearance of NORM waste

SÖDERMAN A-L. & JENSEN M.

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden, ann-louis.soderman@ssm.se

Naturally Occurring Radioactive Material, NORM, is under the authority's radiation protection regulation causing some natural activities to be regulated overly strict in some aspects. The presented regulations present appropriate levels of specific activities both for exemption of NORM and for specific clearance. Sweden has no industries with extensive use of NORM, which appears mainly in discussion about its proper management in connection with disposal or possible recycling.

The proposed regulations define exemption levels for NORM, in line with the preliminary ideas for the expected next version of the BSS preliminary ideas presented by the European Commission. For example, the exemption level is simply 1 Bq/g for any nuclide in the U-238 series, which is also the clearance level for bulk material. The regulations contain a restriction of < 100 ton ash per year, above which special regulations will be in force for management of ash from peat energy production facilities.

For disposal on municipal landfill and similar disposal sites, specific clearance levels are ten times higher than the exemption values in BSS, i.e. 10 Bq/g for nuclides in the U-238 series. Also certain products relating to alum shale, such as the shale itself and alum shale based concrete from demolished buildings, known not to exceed 3 Bq/g is allowed for certain construction purposes other than for buildings, such as road construction.

Developing an Information Barrier for verification in nuclear disarmament processes

RAMSØY T., BACKE S., JOHANSSON K., BJERK T., TORKILDSEN H-E., UL SYED, N., BÜRGER A., CURTIS D., DAY E., BUTCHER D., JONES M. AND RICHINGS A.

Institute for Energy Technology, P.O. Box 40, NO-2027 Kjeller, Norway, Tore.Ramsoy@ife.no

A joint United Kingdom-Norway initiative has been made to develop methods and tools that can be used by an inspection team to verify dismantlement of nuclear warheads. The project is divided into two major parts; the Managed Access Project and The Information Barrier (IB) system development.

During the dismantlement process, the inspecting team will have restricted access due to national security considerations and non-proliferation issues. Nonetheless, the inspectors will need to establish a chain of custody of the Treaty Accountable Item. The IB system will be a vital tool for the inspectors during the process.

The IB is basically an instrument designed to verify the presence or the absence of nuclear material in a closed container. The instrument measures γ-radiation emitted from the fissile material. The IB will, after a certain amount of data are collected, either flash a green light indication presence or a red light for absence of nuclear material.

The current version of the IB is aimed for use on a plutonium based fission warhead. The IB will be able to detect the presence of ^{239}Pu and also to determine whether the isotopic ratio between ^{239}Pu and ^{240}Pu is consistent with bomb quality plutonium. The presentation will discuss the spectroscopic methods to be used and challenges of developing a system that can be trusted both by the inspected party and the inspecting team.

UK-Norway Initiative: Research into Managed Access of Inspectors During Warhead Dismantlement Verification

BACKE S., REISTAD O., HØIBRÅTEN S., MYKKELTVEIT S., TISHAKOV P., WATERS C., CHAMBERS D., WHITE H., RUSSELL I., ALLEN K., KEIR D.

Institute for Energy Technology, P.O. Box 40, NO-2027 Kjeller, Norway, Steinar Backe@ife.no

The UK-Norway initiative is an ongoing collaboration between a nuclear weapons state and a non-nuclear weapons state which addresses technical and procedural challenges associated with a possible future nuclear disarmament verification regime. This has been a process of building trust and cooperation in an area which presents significant technical and political challenges to both parties.

In a future verification regime for nuclear warhead dismantlement, inspecting parties are likely to request access to highly sensitive facilities and weapon components. Such access will have to be managed carefully by the hosting party to prevent the disclosure of sensitive information, both in compliance with the Nuclear Non-Proliferation Treaty and in consideration of national security. At the same time, it will be incumbent on the inspectors not to gain proliferation-sensitive information.

This presentation highlights the outputs from the ongoing technical cooperation between the UK and Norway on managed access, including results from an exercise held in Norway in June 2009 and in UK in 2010.

Iodine and cesium release fractions in a Loss-of-Coolant Accident

EITRHEIM, K.K.R. , WALDERHAUG, T.P.

Institute for Energy Technology (IFE)/OECD Halden Reactor Project, P.O. Box 173, NO-1751 Halden, knut.eitrheim@hrp.no

A loss-of-coolant accident (LOCA) implies considerable damage to the core of a nuclear reactor and consequently the release of radioactive fission products. The safety analysis of a LOCA is defined in the various countries' regulations, e.g. as outlined in Regulatory Guide 1.183 (2000) issued by the U.S. Nuclear Regulatory Commission. In this guide, a fuel rod gap inventory of 5 % of both the total ^{131}I and ^{137}Cs fuel inventory is assumed to be available for instantaneous release. A further 25 % (BWR) or 35 % (PWR) of ^{131}I, as well as 20 % (BWR) or 25 % (PWR) of ^{137}Cs, is assumed to be released as the accident progresses. These release fractions are valid for LWR fuel with a peak burnup up to 62 MWd/kgU. The Halden LOCA test series addresses a number of issues associated with the behaviour of high burnup fuel in LOCA conditions. As fuel segments with very high burnup (80-90 MWd/kgU) are employed in some of the experiments, it is considered of interest to investigate the release of ^{131}I and ^{137}Cs as one of the objectives. As a consequence the following examinations are carried out as part of each test:

1. Estimate of activity inventory of fuel pre-LOCA using Origen software.
2. Determination of activity content in effluent loop water by gamma spectral analysis.
3. Determination of contamination deposited within loop piping by gamma spectral analysis.
4. Determination of post-LOCA ^{131}I and ^{137}Cs inventory in rod by gamma scanning.

The gamma scan analysis of the fuel itself has proved challenging, depending on the severity of the fuel relocation. Nevertheless, although these results are affected by uncertainties, they point to lower ^{131}I release for the fragmented high burnup fuel commonly employed in the experiments than specified by NRC.

A review of a 14C model for dose assessment of releases from normal operation of nuclear facilities

LAGER C., XU S., NORDÉN M., HÄGG A-C., ANDERSSON P.

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden, charlotte.lager@ssm.se

In 2001 Swedish nuclear power companies reported revised dose assessment models for releases of radionuclides during normal operation, e.g. a process oriented ^{14}Cmodel (POM^{14}C) was reported. The dose assessment was reviewed and accepted by the authority with one exception – the ^{14}C model. The authority did accept the use of the model but no formal review was performed. In this paper a review methodology is applied on POM^{14}C. Firstly, reproduction of a selected calculation case was performed to get an understanding of the model. Secondly, a brief literature review of biosphere models used for ^{14}C was conducted to obtain an overview of various approaches used in dose assessments for release of gaseous ^{14}C from normal operation of nuclear facilities. Through reproduction of the calculations flaws in the quality assurance (QA) of POM^{14}C was found. Examples are such as missing parameter values and unclear model description. Except the QA problems, we found that in principle POM^{14}C can be applied reasonably well to predict the activity level of ^{14}C in crops. However, the use of POM^{14}C implies unnecessary modelling for the case reported in the dose assessment. A transparent and robust dose assessment can be made by using literature values or measured data for the final yield, calculate ^{12}C concentrations in the crop and the ^{14}C content in the crops can then be calculated from the average ^{12}C/^{14}C ratio in the atmosphere. The brief literature review of existing models indicates that the choice between dynamic and equilibrium assessment models is of particular interest, raising the issue as to whether dynamic models are useful and/or necessary. A further study is planned with the objective to identify what is needed for further development of dose assessments of releases from normal operation of nuclear facilities.

Clearance measurements of embedded pipes

LARSEN T.I., & HEDEMANN-JENSEN P.

Danish Decommissioning, Frederiksborgvej 399, 4000 Roskilde, Denmark, tla@dekom.dk

The decommissioning of the nuclear facilities at Risø, Denmark, involves decontamination of six hot cells with subsequent clearance. During operation from 1964 to 1989 the cells were used for examination of spent fuel and handling of irradiated cobalt pellets. Thus the cells are contaminated with actinides, fission products and ^{60}Co. The concrete block contains roughly 350 m of embedded pipes with diameters ranging from 50 mm to 300 mm and several pipes are bended or curved. None of the pipes may be removed from the construction so clearance measurements are required to be performed on-site using a detector inside the pipes.

A market survey showed that no detectors were perfectly suited for measuring low levels of contamination in non-straight pipes of varying diameters, as both low sensitivity and means of calibration pose a problem. Passivated Implanted Planar Silicon (PIPS) detectors were chosen for the pipe measurements because they are sensitive to both α- and β-radiation, it is straightforward to discriminate between the two types of radiation and they come at a relatively low cost. Calibration is a problem, though, as detectors and calibration sources are plane and pipes curved. However, a conservative approach is adopted, by which the measured contamination is overestimated. The paper describes the calibration procedure and presents the results of preliminary tests of PIPS detectors of different sizes. Further, it describes the technical setup and how compliance with the clearance criteria will be tested.

Industrial Radiography at Nuclear Power Plants

EKSTRÖM B., ADDO N., BYSELL C., ERIXON S., FRITIOFF K., GOTLÉN K., LARSSON N. & de LUELMO S.

Swedish Radiation Safety Authority, SE-171 16 Stockholm, Sweden, birgitta.ekstrom@ssm.se

During the last years several incidents with industrial radiography have occurred at Nuclear Power Plants (NPPs) in Sweden. Therefore the Swedish Radiation Safety Authority (SSM) decided to inspect the activity with industrial radiography in 2010 at all three sites with reactors in operation. During the inspection the Authority also reviewed the work of the licensee for the industrial radiography. SSM was especially interested in how the NPP and the executing company cooperated before, during and after the radiographing work. An industrial radiography activity in a NPP differs from other radiography activities because one normally works in an environment with dose rates above background and sometimes with high dose rates.

Almost all industrial radiography actions in a NPP during an outage are classified as "open radiography" in accordance to SSMFS 2008:25 (The Swedish Radiation Safety Authority's Regulations and General Advice on Radiography). During the outage normally several people not involved in the radiography are working day and night close to the radiography working area. It is important to limit the access so that no unauthorized people can enter the area with radiation from the radiography equipment. That is one reason why it is essential that NPP and the radiography company cooperate in radiation protection issues.

During the inspections SSM had two teams working, one team for the NPP and another team for the radiography company. The two teams had close contact for comparing the information which was received during the inspections.

The views about how the cooperation in reality was performed sometimes differed among the personnel from the NPP and the radiography company.

The outcome from these inspections can be summarized as follows:

- Cooperation in radiation protection issues is essential and could be strengthened and start at an early stage
- Pre-job-briefing and post-job-debriefing are good tools for improving radiation protection
- The instructions for the working procedures could be more clearly written and in more detail in order to avoid misunder¬standings
- Improvements are needed to follow valid procedures and instructions
- Experience feedback could be strengthened
- Improvements are needed to ensure that the foremen have the regulated adequate education
- Earlier proposed corrective actions should be implemented

The Authority is presently following the implementation of the corrective action programs of the NPPs and the radiographing companies.

A Nordic approach to impact assessment of accidents with marine reactors

REISTAD O.C., HUSTVEIT S., PALSSON S. E., HOE S. & LAHTINEN J.

Institute for Energy Technology, Instituttvn. 18, N-2007 Kjeller, ole.reistad@ife.no

This paper summarizes the effort to date to establish a joint Nordic approach to impact assessments of accidents with marine reactors. Various assessments of potential releases related to real and hypothetical accidents involving naval reactors varies from no release at all to an overall release of 200 x 10_{15} Bq, similarly from collective effective dose commitment on 25,000 manSv after a hypothetical accident with releases to air, to 97 manSv for sunken vessels. Thus, this effort has included a review of impact assessments made for both releases to air close to settlements and release to the high seas. The results indicate that significant releases may occur, though having lower risk for contamination and implementation of counter-measures than publicly assumed. An initial conclusion is, that due to large-scale dismantlement of early generation vessels in Russia, all nuclear-propelled vessels presently operating in the neighboring waters to the Nordic countries have similar properties regarding accident risks and release mechanisms. The main group of vessels is submarines, potentially equally divided between Russian and US submarines due to the continued high presence of the US Navy together with reduced sailing time in the Russian Navy. The main exception is Russian nuclear-propelled surface vessels. Considering the fact that neighboring countries may soon embark upon construction of a new generation of marine reactors, there is a need to systemize the approach for assessing possible consequences of accidents in relation to all relevant installations, also floating power reactors. The main area for large-scale improvements is emergency preparedness, in particular when considering the systematic approach to this area in Canada, experiencing regular port calls from US, UK and French nuclear-propelled vessels. Of the Nordic countries, only Norway allows similar visits in certain ports.

Preparing a WANO Peer Review within Radiological Protection at Forsmark NPP

VIRVA NILSSON

Forsmarks Kraftgrupp AB, SE-742 03 Östhammar, Sweden, tel +46 173 821 33
mobile +46 70 388 16 23, e-mail vpa@forsmark.vattenfall.se

The World Association of Nuclear Operators, WANO, was established in 1989 and unites operators from more than 440 nuclear power plants operating in 35 countries/areas. WANO conducts its activities through Regional Centres placed in Atlanta, Moscow, Paris and Tokyo. There is also a London office which provides oversight and support for the regional centres.

Each Regional Centre manages WANO's four main programmes - Operating Experience, Peer Reviews, Professional and Technical Development and Technical Support and Exchange.

The goal of the Peer Review Programme is to support each WANO member in improving the safety and reliability of the member´s nuclear facilities.

In a peer review, a WANO team (about 20 people) are invited by a utility to spend two weeks at a plant observing plant personnel performing their jobs, conducting interviews and reviewing documentation. One week of preparation for the team precedes the review.

A peer review can examine a plant's performance in the following functional areas:

- Organisation and Administration
- Operations
- Maintenance
- Engineering Support
- Radiological Protection
- Training and Qualification
- Fire Protection
- Chemistry
- Operating Experience
- Emergency Preparedness

The peer reviews can also review areas that typically cross several organisational lines, such as :

- Safety culture
- Human performance
- Self-evaluation
- Industrial safety
- Plant status and configuration control
- Work management
- Equipment performance and condition

The review team consists of highly qualified staff from WANO members throughout the world who have extensive practical experience in the areas they review. They bring together knowledge and experience of operating plants in different countries, and make an objective assessment of the operations of the plant against best international practice. During the review, the team notes strengths that may be useful to other plants, and areas in which improvements can be made to enhance safety and reliability at the host plant. The team focuses on the workers performing their day-to-day tasks, as this is where operator success lies. The result is a confidential report to the utility identifying the strengths and areas for improvement. This confidentiality ensures full, open discussion between the review team and the management of the plant reviewed. Members of the team also benefit from the review process: they bring back good ideas and practices to their own plants.

This paper discusses preparing a peer review and the guidelines for radiological protection at a nuclear power plant in general as well as the process of identifying the gap between the guidelines and the plant practice.

Regulatory Approach to Radiation Protection in New NPPs

RIIHILUOMA V. ; VILKAMO O. ; ALM-LYTZ K.

STUK Radiation and Nuclear Safety Authority Finland, PL 14, 00881 Helsinki

Radia¬tion and Nuclear Safety Authority (STUK) reviewed the utility Teollisuuden Voima Oyj's (TVO) application for the Construction Licence of the Olkiluoto 3 nuclear power plant unit in 2004 – 2005. Based on this review STUK prepared its statement on safety together with a safety assessment report of the new plant to the Government.

By virtue of the Nuclear Energy Act (990/87) and the Government Decree on the Safety of Nuclear Power Plants (733/2008), STUK issues detailed regulations, YVL Guides, concerning the safety of nuclear power plants. Several YVL Guides deal with radiation safety (site, abatement of releases, worker radiation protection, emer¬gency arrangements, etc).

STUK has continued reviewing the detailed design during the construction of the new plant unit. STUK also carries out periodic inspection. The paper will discuss some radiation safety related requirements in the design of a new Finnish NPP and their implemen¬tation in the licensing documentation. Also some future aspects concerning regulatory work will be dealt with.

For the moment Olkiluoto 4 and Fennovoima 1 reactor projects are preparing readiness for construction licence applications.

Establishing one set of scaling factors from a series of measured activity concentrations

SØGAARD-HANSEN, J. & LARSEN, T. I.

Section of Radiation and Nuclear Safety, Danish Decommissioning, Frederiksborgvej 399, DK-4000 Roskilde, Denmark, jens.soegaard@dekom.dk

For clearance measurements it is possible, under some circumstances, to calculate the activity concentrations of difficult-to-measure radionuclides from the measured activity concentration of a key nuclide that is more straightforward to measure. This is done by multiplying the activity con-centration of the key nuclide by scaling factors. In cases with many objects to be measured, it is preferable to have only one set of scaling factors to be used for all the objects.

The paper explains a method for establishing a single set of scaling factors from a series of activity concentration measurements on samples from the former Hot Cell facility at the Risø DTU site in Denmark. This facility has mainly been used to examine spent fuel samples and is contaminated with fission products and isotopes of uranium and transuranic elements.

It is shown that the distribution of the measured activity concentration ratios can be described by normal distributions. It is discussed how to identify and deal with outliers. Conservative values of the activity concentration ratios to be used as scaling factors in the clearance measurements on objects from the Hot Cell are calculated from the normal distributions. Un-certainty values are assigned to the scaling factors.

Reducing the discharges from Studsvik to the Baltic Sea

HAEGG, ANN-CHRISTIN SVANTE ERNBERG, CHARLOTTE LAGER, MARIA LÜNING

Swedish Radiation Safety Authorithy, SE-17116 Stockholm, Sweden ann-christin.hagg@ssm.se

In 2009, HELCOM published an assessment over the radioactivity in the Baltic Sea (1). Data presented in the report indicate that the discharges of radionuclides from the Swedish nuclear facility Studsvik were higher than from other nuclear facilities in the Baltic Sea drainage area. However, the doses to man and the environment were still well below the authorised dose limits given in the Swedish regulation concerning discharges from nuclear facilities (2). In 2009, SSM decided to carry out an inspection at the Studsvik facility in order to find out whether or not the facility was fullfilling the other requirements in the discharge regulation (2). The result of the inspection was that the companies had to take measures in order to do so. For example, they had to improve their knowledge about the sources of the discharges and take suitable measures in order to reduce the discharges as low as reasonably achivable using the best available technique. SSM is following the implementation of the measures taken by Studsvik AB and AB SVAFO and SSM belive that they will result in lower discharges to the Baltic Sea in the future.

The paper will describe the SSM regulations concerning discharges and discuss the measures taken by the two companies, as well as how to decide whether optimisation and best available techinique are being applied – or not.

(1) HELCOM 2009, Radioactivity in the Baltic Sea, 1999-2006 HELCOM thematic assessement Balt. Sea Environ. Proc. 117

(2) SSMFS 2008:23 Strålsäkerhetsmyndighetens föreskrifter om skydd av människors hälsa och miljön vid utsläpp av radioaktiva ämnen från vissa kärntekniska anläggningar

Qualified Experts for Radioactive Waste Management – the UK Approach

CHRIS ENGLEFIELD[1]; ANGELA WRIGHT[2]; ADAM STACKHOUSE2, LINDA PEAKE[3].

[1] Environment Agency, [2] Scottish Environment Protection Agency, [3] Northern Ireland Environment Agency

Implementation of the Basic Safety Standards (96/29/EURATOM) in the UK has been achieved by the use of separate legislation for personnel safety and environmental protection, most of which originated 60 years ago.

For personnel protection in the workplace the Qualified Expert role is fulfilled by the Radiation Protection Adviser (RPA). This role has been defined and in operation for many years with enforcement by the Health and Safety Executive.

The environmental regulators have required employers to use a specialist adviser on radioactive waste management for several years but it is only recently that the UK has defined the role of the Radioactive Waste Adviser (RWA) following a formal consultation in 2010 by the Regulatory Bodies (the environment agencies for England and Wales, Scotland and Northern Ireland).

The foundation of the proposals (to be started in 2011) is a syllabus of relevant knowledge and a scheme defining appropriate levels of experience that together describe the level of competence expected of the Radioactive Waste Adviser. The development of the syllabus has been led by the regulators but with the UK Radiation Protection profession working with them.

In addition, the regulatory bodies have proposed an implementation scheme that will largely be run by the profession, with a light touch from the regulators. An independent body will certify the competence of all RWAs but the employer will still have to decide if any individual is suitable for their own circumstances. Appropriate credit will be given for people who already have RPA status, to minimise bureaucracy.

The proposals will be applied to nuclear licensed sites as well as to other users of radioactive materials.

This paper will outline the expectations that the regulators have of RWAs and the employers that they advise and how implementation is progressing. The arrangements lend themselves to the transition to the Radiation Protection Expert (RPE) proposed for the new BSS.

Austria

Renate Czarwinski	International Atomic Energy Agency

Belgium

Gilbert Eggermont	VUB/BVS-ABR
Toon Meeuwsen	CANBERRA

Canada

Christopher Clement	ICRP

Czech Republic

Jozef Sabol	Faculty of Biomedical Engineering

Denmark

Annika Bjerkborn	Danish National Institute of Radiation Protection
Bent Lauritzen	Risø DTU, Technical University of Denmark
Birgitte Hinge	Regionshospitalet Viborg
Britta Højgaard	National Institute of Radiation Protection
Carsten Israelson	The CBRN-Institute
Finn Physant	NKS
Hanne N. Waltenburg	National Institute of Radiation Protection
Jens Havskov Sørensen	Danish Meteorological Institute (DMI)
Jens Søgaard-Hansen	Danish Decommissioning
Kaare Ulbak	National Institute of Radiation Protection
Kasper Andersson	Risø DTU National Laboratory for Sustainable Energy
Lars Thorbjørn Jensen	Glostrup Hospital
Leif Scherbe	Imec ApS
Mette Oehlenschlaeger	National Institute of Radiation Protection
Per Hedemann-Jensen	Danish Decommissioning
Peter Kaidin Frederiksen	Statens Institut for Strålebeskyttelse
Peter Møller	SIS
Steen Hoe	DEMA
Stine Groth-Pedersen	Indkøb & Medicoteknik, Region Midtjylland
Sven Nielsen	Risø DTU
Søren Holm	Dept. of Nuclear Med. and PET
Thommy Larsen	Danish Decommissioning

PARTICIPANTS

Estonia

Merle Lust	Tartu University

Finland

Anna Kelaranta	University of Helsinki, Department of Physics
Arvi Hakanen	STUK - Radiation and nuclear safety authority
Dina Solatie	STUK - Radiation and Nuclear Safety Authority
Eila Kostiainen	STUK - Radiation and Nuclear Safety Authority
Hannu Järvinen	STUK - Radiation and Nuclear Safety Authority
Heikki Reisbacka	STUK - Radiation and Nuclear Safety Authority
Iisa Outola	STUK - Radiation and Nuclear Safety Authority
Jarkko Ylipieti	Radiation and Nuclear Safety Authority
Jori Halonen	Doseco Oy
Jukka Laaksonen	STUK
Jukka Lehto	Laboratory of Radiochemistry, University of Helsinki
Jussi Huikari	STUK
Kaisa Vaaramaa	STUK
Karoliina Ekström	NKS
Maarit Muikku	STUK - Radiation and Nuclear Safety
Maarit Risto	STUK – Radiation and Nuclear Safety Authority
Markku Koskelainen	STUK
Michael Ammann	Radiation and Nuclear Safety Authority
Mika Markkanen	STUK - Radiation and Nuclear Safety Authority
Olli Holmgren	STUK - Radiation and Nuclear Safety Authority
Olli Vilkamo	STUK - Radiation and Nuclear Safety Authority
Raimo Mustonen	STUK - Radiation and Nuclear Safety Authority
Ritva Bly	STUK - Radiation and Nuclear Safety Authority
Siiri-Maria Aallos-Ståhl	STUK - Radiation and Nuclear Safety Authority
Tarja K. Ikäheimonen	STUK - Radiation and Nuclear Safety Authority
Tirre Hentinen	Doseco Oy
Tuomas Peltonen	STUK - Radiation and Nuclear Safety Authority
Tuukka Turtiainen	STUK - Radiation and Nuclear Safety Authority
Veli Riihiluoma	STUK
Wendla Paile	STUK
Ted Lazo	OECD Nuclear Energy Agency

France

Kenneth Kase	International Radiation Protection Association

Germany

Hartmut Schulze	GNS Gesellschaft fuer Nuklear-Service mbH

Hungary

Zsuzsanna Szabó	Eötvös University

Iceland

Daniel Yoshio Shimmyo	Icelandic Radiation Safety Authority
Elísabet Dolinda Ólafsdóttir	Icelandic Radiation Safety Authority
Garðar Mýrdal	Landspitali University Hospital
Guðlaugur Einarsson	Icelandic Radiation Safety Authority
Kjartan Guðnason	Icelandic Radiation Safety Authority
Óskar Halldórsson	Icelandic Radiation Safety Authority
Sigurður Emil Pálsson	Icelandic Radiation Safety Authority
Sigurður M. Magnússon	Icelandic Radiation Safety Authority
Valdís Guðmundsdóttir	Landspitali University Hospital
Þorgeir Sigurðsson	Icelandic Radiation Safety Authority

Latvia

Laima Trinkler	Institute of Solid State Physics, University of Latvia

Luxembourg

Augustin Janssens	European Commission

Norway

Anders Widmark	Norwegian Radiation Protection Authority
Anna Nalbandyan	Norwegian Radiation Protection Authority
Ann-Helen Haugen	Institute for Energy Technology
Bård Olsen	Norwegian Radiation Protection Authority
Elis Holm	NRPA
Eva Godske Friberg	Norwegian Radiation Protection Authority
Hilde Merete Olerud	Norwegian Radiation Protection Authority
Inger Margrethe Eikelmann	Norwegian Radiation Protection Authority
Ingvild Engen Finne	Norwegian Radiation Protection Authority

PARTICIPANTS

Johannes Nilssen	NRPA
Justin Gwynn	NKS
Karl Eliassen	Norwegian Radiation Protection Authority
Knut Kjærand Rø Eitrheim	Institute for Energy Technology (IFE)
Kristine Wikan	Norwegian Radiation Protection Authority
Maria Larsson	Norwegian Radiation Protection Authority (Nrpa)
Marie Solberg	Norwegian Radiation Protection Authority
Mark Dowdall	Norwegian Radiation Protection Authority
Ole Harbitz	NRPA
Rajdeep Singh Sidhu	Institute for Energy Technology
Steinar Backe	Institute for Energy Technology
Tor Wøhni	NRPA
Tore Ramsøy	Institute for Energy Technology
Øyvind Gjølme Selnæs	Norwegian Radiation Protection Authority

Spain

Francisco Cutanda Henríquez	Hospital General Universitario Gregorio Marañón

Sweden

Angelica Hedman	FOI Swedish Defence Research Agency
Anja Almén	Swedish Radiation Safey Authority
Ann-Christin Haegg	Swedish Radiation Safety Authority
Annhild Larsson	Göteborgs universitet/Fastighetavdelningen
Ann-Louis Söderman	Swedish Radiation Safety Authority
Ann-Louise Eksborg	Swedish Radiation Safety Authority
Birgitta Ekström	Swedish Radiation Safety Authority
Britt-Marie Rolén	Swedish Radiation Safety Authority
Camilla Bysell	Swedish Radiation Safety Authority
Carl Bladh Johansson	Strålsäkerhetsmyndigheten
Carl G Lindvall	Barsebäck Kraft AB
Carl-Göran Stålnacke	Swedish Radiation Safety Authority
Charlotte Lager	Swedish Radiation Safety Authority
Christer Samuelsson	Lund University
Christer Solstrand	Oskarshamn NPP
Conny Welander	Barsebackkraft AB
Dan Josefsson	Radiation Physics Department
Eirik Gundersen	gammadata instruments ab

Erik Johansson	FOI
Håkan Pettersson	Dept of Radiation Physics, Health Faculty
Hanna Holstein	Medical Radiation Physics, Lund University
Helena Ragnarsdotter Westerlund	Swedish Radiation Safety Authority
Helene Jönsson	Swedish Radiation Safety Authority
Heléne Wijk	Swedish Radiation Safety Authority
Helmuth Zika	Swedish Radiation Safety Authority
Ingrid Öborn	Swedish University of Agricultural Sciences (SLU)
Ingvor Svantesson	Swedish Nuclear Fuel and Waste Management Co
Jack Valentin	ICRP (former scientific secretary)
Jonas Boson	Swedish Defence Research Agency, FOI
Jonas Nilsson	Lund university
Karin Fritioff	Swedish Radiation Safety Authority
Klas Rosén	SLU, Department of Soil & Environment
Magnus Gårdestig	RadiationPhysics/County Council of Östergötland
Marie Karlsson	Dept of Radiation Physics, Health Faculty
Mattias Karlsson	IMH, Division of Radiological Sciences
Micael Granström	Swedish Armed Forces deployable R/N---laboratory
Michael Sandborg	Dept of Medical Physics
Peder Kock	Medical radiation physics, IKVL, Lund University
Peter Frisk	Swedish Radiation Safety Authority
Robert Finck	Swedish Radiation Safety Authority
Stefan Isaksson	gammadata instrument ab
Therése Geber	Lund University
Thomas Ulvsand	FOI, CBRN Defence and Security
Tore Halse	Linköping University
Ulla Hansson	Astra Tech AB
Ünal Ören	Lund University
Virva Nilsson	Forsmarks Kraftgrupp AB

United Kingdom

Adam Golightly	Tracerco

USA

Mike Boyd	EPA