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PREFACE

Dear colleagues,

radiation protection has an ambitious agenda to cover all exposure situations and all categories of exposure in a consistent way. For achieving this goal it is required to establishe new regulations and to harmonize the existing complicated systems of legislation for radiation protection.

Recently adopted Basic Safety Standardsof IAEA for the radiaion protection of workers and the members of the public, as well as, the publication of the new EURATOM Directive 2013/59, reflect the opportunity to implement in all European countries a coherent philosophy for the protection of exposed individuals taking into account the results of the research studies in all fields of ionizing radiation application and the increasing number of people involved in the use of ionizing radiation sources.

Before the implementation of the new proposals into the national legislation it is very important to discuss the main issues and changes proposed in all fields of application of radiation protection and to establish a dialogue on the main issues of the new recommendations.

The organizing and the scientific Committee of the XXXVI. Days of Radiation Protection submit to you the book of abstracts of the oral presentations and poster contributions, giving the possibility to exchange the opinions of the specialists in the given topics.

On behalf of all organizing institutes I should like to extent a very warm welcome to all participants and sincere appreciation for their contribution to the rich scientific programme.

We are also sure that the nice surrounding of High Tatras will also contribute to your pleasant stay at the conference.

We would like to thank all members of the organizing and scientific Committee for excellent work during the Conference preparation, and for the support of all sponsoring organisations and exhibitors.

Denisa Nikodemová

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RADIATION PROTECTION IN MEDICINE

Section I.

GENERAL ASPECTS AND NEW TRENDS OF RADIATION PROTECTION

ROLE OF THE IAEA IN ESTABLISHMENT OF THE INTERNATIONAL STANDARDS OF RADIATION PROTECTION

Miroslav Piňák

IAEA, Viena

The aim of the presentation is to highlight the existing challenges in radiation protection, and provide insight into the role of the IAEA in establishment of the radiation safety standards. It will, inter alia, cover from the following areas:1. global outreach of safety principles in radiation protection and safety2. IAEA and establishment of Safety Standards;3. IAEA Standards and national regulations;4. IAEA members states role in drafting and review of IAEA Safety Standards;5. existing, novel issues and challengesThe role of the IAEA is to establish fundamental safety objectives in radiation protection and safety following fundamental safety objectives, safety principles and concepts. The main aim of Safety Standards is to provide for the establishment of a system for protection of people and the environment from harmful effects of ionizing radiation. The requirements as included in the Safety Standards aim to assess, manage and control exposure to radiation so that radiation risks, including risks of health effects and risks to the environment, are reduced to the extent reasonably achievable.One of the novel feature adopted in the revised Basic Safety Standards (BSS) is the classification of exposures - planned, emergency and existing - each of them including several categories of exposure (occupational, public and medical), where appropriate.The revised BSS also addresses areas like exemption and clearance being particularly important in international trade and transport; significantly increases the number of requirements in medicine, in response to novel and/or expanding techniques in medicine using ionizing radiation; incorporates new regulatory limits for exposure to radon, and in protection of the lens of the eyes, as recommended by WHO and ICRP; newly introduces requirements for specific practices like, for example, airport security screenings; and addresses many other areas.While the principal approach to regulatory aspects in emergency exposure situation has not been significantly modified from the previous BSS version, the revised one, for example, strengthens the protection of emergency workers by setting the maximal dose that can be received during emergency response, and by putting emphasis on the principle of voluntary action in certain circumstances. The need for scientifically sound, administratively and legally recognized, and also practical and applicable regulations in emergency situations has also been recently surfacing in the view of Fukushima NPP accident.The presentation also describes the importance of outreaching of role of specialized international bodies and agencies cosponsoring organizations (FAO, IAEA, ILO, NEA, PAHO, WHO, EC and UNEP) in revision process and in implementation of the BSS, and importance and legal aspects of introducing BSS into the national regulatory frameworks.

RISK OF LEUKEMIA IN URANIUM MINERS

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Epidemiological studies among uranium miners have evidenced lung cancer risk in relation to radon exposure. Although leukemia is especially sensitive to induction by radiation, the assessment of leukemia risk in exposed populations is more complex as its incidence is substantially (more than 30 times) lower than that of lung cancer. So far, the significant association among uranium miners has been observed in studies of Czech uranium miners. The assessment of the risk is complex because the radiation risk in mines involves exposure to radon, external gamma radiation, and exposure to airborne long lived radionuclides arising from uranium ore dust. In contrast to radon measurements, the other two components were monitored much later in uranium mines. Recent follow-up of a Czech study of 10 000 uranium miners have resulted in 42 leukemia cases. The risk is evaluated in relation to cumulated equivalent doses from radon, long lived radionuclides, and external gamma. The mean equivalent doses to the red bone marrow in the entire study are 35 mSv from radon, 46 mSv from external gamma radiation, and 106 mSv from long lived radionuclides. Mean doses among leukemia cases are nearly twice. The excess relative risk per Sv (ERR/Sv) in this study 3.75 is statistically significant (p=0.008). This value is consistent with the leukemia risk observed in the Life Span Study among Japanese survivors of A bombing (ERR/Sv = 4).

This study was supported by the European Commission and the Czech Ministry of Education (project DOREMI GA 249689, 7G13001).

OCCUPATIONAL RADIATION EXPOSURE IN THE SLOVAK REPUBLIC

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Recently are 2 nuclear power plants in operation in the Slovak republic. Apart from nuclear facilities there are 450 licensed undertakings with monitored workers. The majority of the licensed undertakings are active in health care. In Slovak republic are five dosimetry services performing assessments on personal doses due to external exposure and two dosimetry services are approved to carry out monitoring of internal exposure. Dosemeters used for the monitoring of external individual exposure include: personal whole-body film dosemeters, thermoluminescence dosemeters (TLD) or optically stimulated luminescence dosimeters (OSL) for measurements of beta and gamma radiation; TLD for measurements of neutron radiation and TLD for extremities. The measured operational dose quantities are Hp(10), Hp(3) and Hp(0.07). Approved dosimetry service reports the measured dose data to the employers and to the Central register of occupational doses (CROD).
CROD were established on the Public Health Authority of the Slovak Republic in year 2001. The CROD assembles and processes the individual dose data related to the external and internal exposure from dosimetry services. CROD keep the records of individual doses of exposed worker until the worker attain the age of 75 years. Annually are monitored about 12 500 – 16 200 active workers. CROD registers in the whole history (2001 – 2013) more as 22 400 occupationally exposed workers. Information about the individually dose data are free of charge available for the respective worker, employers, radiation protection inspection, radiation protection officers, competent regional public health authorities, approved medical practitioners from occupational health services and also for competent authorities and central registers in European union countries upon the request. In compliance with the act No. 355/2007 the CROD issues also Personal radiation passports (PRP) to outside workers. CROD issued more than 5100 PRP since the October 2006.
Majority of individually monitored workers is active in the nuclear facilities (43 – 53 %), this group is followed by the health care workers (37 – 48 %). Based on the data registered in CROD it can be observed, that about 35% of individual effective dose lies below MDL and the distribution of doses has a stable trend for the last 5 years. Above 99,8% from all exposed workers with the individual effective dose below as MDL are active in the nuclear facilities (approx. 67% of the total NPP staff). The average effective dose of all monitored workers is about 0,90 mSv/y and 1,50 mSv/y for workers with doses over MDL. From long-term point of view the most highly average effective doses per one monitored worker were at the workplaces with the natural sources of radiation – traveler's guides in show caves, due to the radon radiation. The lowest average effective doses per one monitored worker were in the nuclear facilities. Another most highly average effective doses per one monitored worker were in the medical facilities (1,60 – 2,00 mSv/y). Most cases of exposed workers with higher doses can be observed also in the group of medical staff, mainly in the group of interventional radiologists and cardiologists (annual average effective doses in this profession group were from 5,50 mSv/y to 6,50 mSv/y). Highest contribution to the total collective effective dose exposed workers in Slovakia represented the collective effective dose of the medical staff. This contribution represented about 2/3 up to 3/4 from total collective effective dose and has an increasing trend (from 60% in year 2005 to 75% in year 2013). However, medical staff represented only 40% from total number of monitored workers. Highest increase of the collective effective dose during last decade was in the profession group of the cardiologist. Since the year 2002 to the year 2009 collective effective dose of the medical staff on the specialized cardiologist clinics increased three times. Beside the cardiology, the collective effective dose is increasing also in surgical radiology and in nuclear medicine.

PREPARATION OF THE NEW ATOM LAW IN THE CZECH REPUBLIC

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As it is in all fields of human activity also in the field of the use of ionizing radiation legislation changes during the time. State Officefor Nuclear Safety (SONS) has decided to develop a new atomic law, which should, after more than 15 years, replace Law no.18/1997 oll., as amended.The preparednewatomiclaw (Atomic Act) is primarily based on Recommendation No. 113 International Commissionon Radiological Protectionin 2007, which partially changesthe concept of radiation protection, which is now newly built on regulation of so-called exposure situations.The new draft of Atomic Act also responds to the experience with the application of current law and also a good level of radiation protection in the Czech Republic and applies so-calledgraded approach where certain activities are less important from the point of view of radiation protection and more strict requirements applies, eg. registration instead of license. During the preparation of the new law Directive No.2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation (which replaces four old Directives regulating radiation protection) had been adopted and SONSdecided to implement it in to draft of the new law. The most significant changes has brought new directive on the regulation of exposure to natural sources of radiation, non-medical radiation protection, outside workers protection and securityof sources.The effectiveness of the new law is designed from 1 July 2016.

CLUSTERED DNA DAMAGE INDUCED BY PROTON AND HEAVY ION IRRADIATION

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Ionizing radiation induces in DNA strand breaks, damaged bases and modified sugars, which accumulate with increasing density of ionizations in charged particle tracks. Compared to isolated DNA damage sites, the biological toxicity of damage clusters can be for living cells more severe. We investigated the clustered DNA damage induced by protons (30 MeV) and high LET radiation (C 290 MeV/u and Fe 500 MeV/u) in pBR322 plasmid DNA. To distinguish between direct and indirect pathways of radiation damage, the plasmid was irradiated in pure water or in aqueous solution of one of the three scavengers (coumarin-3-carboxylic acid, dimethylsulfoxide, and glycylglycine). The goal of the contribution is the analysis of determined types of DNA damage in dependence on radiation quality and related contribution of direct and indirect radiation effects. The yield of double strand breaks (DSB) induced in the DNA plasmid-scavenger system by heavy ion radiation was found to decrease with increasing scavenging capacity due to reaction with hydroxyl radical, linearly with high correlation coefficients. The yield of non-DSB clusters was found to occur twice as much as the DSB. Their decrease with increasing scavenging capacity had lower linear correlation coefficients. This indicates that the yield of non-DSB clusters depends on more factors, which are likely connected to the chemical properties of individual scavengers. This work was supported by ESTEC-Contract No.4000101677/10/NL/PA-NPI 120-2009, ESA project No. AO-7146 and by the Ministry of Education, Youth and Sports of the Czech Republic grant No. LD12008.

LASER-DRIVEN ACCELARATION AT ELI BEAMLINES– RADIOPROTECTION ASPECTS

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The international research centre ELI Beamlines, which is under construction in the village of Dolní Břežany near Prague, will exploit high power lasers of PW class to generate and accelerate beams of charged particles (up to tens of GeVs in energy). The beams will be used for both fundamental and applied research by experts from various scientific fields, includig biology, medicine, plasma physics but also dosimetry and radiation protection.

As laboratories operating lasers do not belong among the traditional “radiation workplaces”, there are no suitable specialized recommendations or standards available. Therefore, it is necessary to newly implement the existing general recommendations. Further, the generated mixed fields possess unique properties due to their production methods. As a result, the routinely used detection methods are not reliable or fail completely.

The paper presents the current status of the ELI Beamlines project and summarizes the problems, safety issues and scientific topics that facilities based on laser driven acceleration bring to the field of radiation protection.

IMPROVEMENT OF RADIOACTIVITY CHARACTERISATION BY CZT AND THIN PLASTIC SCINTILLATION DETECTORS AT NPP A1 DECOMMISSIONING

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Radiation situation at NPP A1, 37 years after accidental shutdown of the reactor, features by relatively high content of Sr-90 and transuranic elements (TRU) and dominant occurrence of Cs-137. The contamination is mostly distributed unevenly. High radioactivity in local spots of contaminations can be important source of uncertainty at their declaration by drum monitors used during the decommissioning. It was recommended within the frame of IAEA expert mission in subjected field at VUJE and JAVYS in 2012 to more intensively utilise selective in-situ measurements with help of small transportable CZT (Zinc activated cadmium tellurium) semiconductor detectors for direct measurements of Am-241 and Cs-137. In connection with the subject of decommissioning, stage II., it mainly concerns to spots of contaminations on concrete structures, active transitions in underground tanks but also mostly contaminated decommissioning material, e.g. wet liquid RW, sludge suspensions, sediments or soil. Advantage of CZT detectors is their small size and high detection sensitivity to detect low energy photons (e.g 60 keV of Am-241) even in the presence of the dominant Cs-137, it means on the high Compton radiation background of this RN (662 keV). The other TRU, but mainly the isotopes of Pu, can be consequently determined by recalculation on the basis of relatively constant ratios to the measured Am-241. For operative measurement of Sr-90, method of direct gammaspectrometry evaluation of beta and gamma spectra measured by 3mm thin plastic scintillator detector was adopted according to procedure developed at Kurchatov Institute, Moscow. The orderly higher active contamination spots are necessary, within the frame of decommissioning, to identify (e.g by monitoring of dose rates) then in-situ measure (CZT and betaspectrometry) and sequentially to declare their radioactivity. The matter is that the direct in situ measurement is much more accurate in opposite to RW standard drum monitor measurement where material (pieces) with orderly different radioacitivity is placed together into one drum. Improvement of characterisation at NPP A1 decommissioning was the topic of respective IAEA TCP project, as well. Aim of the presentation is to inform about the experiences on improvement of characterisation by application of the mentioned techniques with main focus on determination of: - detection efficiency for collimated CZT detectors and respective volume sources,- Compton radiation background of Cs-137 in the 60 keV area of Am-241, - MDA of Sr-90, Am-241 and Am-241/Cs-137 ratio on the high Cs-137 Compton background for selected point and volume sources,- (assessment) of the maximum measurable activities or dose rates for the mentioned RNs.

A NEW MULIDETECTOR PASSIVE NEUTRON SPECTROMETER FOR RADIATUION PROTECTION PURPOSE

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The neutron spectrometers for radiation protection purposes should :

- have a sufficient resolution,
- be sensitive in a large energy range from thermal (0,025 eV) up to relativistic neutrons (above 20 MeV),
- be insensitive to gamma background.

Presentation deals with a new multidetector neutron spectrometer for radiation protection purposes based on combination of moderating and threshold spectrometers. The moderating spectrometer consists of spherical polyethylene moderators of various diameters, with detectors 232Th, 235U and 237Np (neutron fission reaction) in its centers. The detectors 232Th, 235U and 237Np in free spaces have been used in the threshold spectrometer. The proposed multidetector neutron spectrometer uses 24 detectors.

Energy dependences of the moderating detector efficiencies were calculated by the Monte Carlo code MCNPX. To obtain the neutron energy spectrum a modified unfolding iteration procedure SAND II has been used. Properties of the multidetector neutron spectrometer for frequently occurring synthetic neutron spectra at nuclear reactors and around the calibration isotopic neutron source 241AmBe were verified by Monte Carlo simulations.

By using of solid state track detectors of fission fragments based on CR39 foils, the proposed multidetector neutron spectrometer for radiation protection purposes is enough sensitive for application in radiation fields where the calculated neutron dose equivalent rate is about 1 Svh-1 with uncertainties less than 7%.

Acknowledgment: The work was supported by the projects APVV-0-24 1-011.

CHALLENGES OF CHARACTERIZATION OF RADIOACTIVE WASTE WITH HIGH COMPOSITION VARIABILITY AND THEIR CONSEQUENCES FOR MEASUREMENT METHODOLOGY

Dušan Lexa

TechMart s.r.o.

Radioactive waste characterization is a key step in every nuclear decommissioning project. It normally relies on a combination of facility operational history with results of destructive and non-destructive analysis. A particularly challenging situation arises when historical waste from a nuclear research facility is to be characterized, meaning little or no radiological information is available and the composition of the waste is highly variable. The nuclide vector concept is of limited utility, resulting in increased requirements placed on both the extent and performance of destructive and non-destructive analysis. Specific challenges are illustrated on an example of the decommissioning project underway at the Joint Research Center of the European Commission in Ispra.

IS THE CURRENT SYSTEM OF THE QUANTIFICATION OF RADIATION EXPOSURE AND ITS MONITORING OPTIMAL?

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During the various applications of ionizing radiation and nuclear technologies, workers, patients and members of the general public are always exposed to a certain amount of radiation. The well-known main objectives of radiation protection consist of minimizing stochastic biological effects and avoiding as much as possible deterministic effects. To achieve an adequate level of protection of individuals, it is necessary to keep the exposure as low as possible below the upper acceptable levels expressed in terms of relevant dose limits. For this purpose the exposure has to be assessed by means of appropriate quantities and measured or monitored using adequate units. In order to estimate any harmful health impact caused by radiation exposure, many specific quantities have been introduced. A great number of these quantities adopted throughout the last 50 years or so as well as several different units, some of which can be attributed to more than one quantity, have led to confusions not only among the public but also among professionals who are engaged in various applications of radiation but are not necessarily experts in radiation protection. Since the quantities required for the quantification of exposure for the dose limitation are usually not directly measurable, other quantities which can be measured have been used instead. The relation of such quantities to dose limit quantities is not straightforward and may result in mistakes in interpreting the results of radiation monitoring.

The paper discusses the current state of quantification of exposure and points out some problems and inconsistencies regarding the definitions of some quantities used in radiation protection. Attention is paid in particular to the interpretation of the effective dose, equivalent dose, organ dose and other quantities needed for monitoring workers and workplaces. Special consideration is given to some contradictions related to the skin exposure of workers in nuclear medicine, where some ambiguous approaches are sometime applied to control and limit personal exposure.

THE NEWS AND INNOVATIONS IN RADIATION PROTECTION SYSTEMS AND EQUIPMENT

Marek Heteš

ENVINET Slovakia, a.s.

ENVINET as the part of the Nuvia Group is well known for the engineering supplies and services for the nuclear power. Nevertheless, the development, manufacturing and service of the radiometric systems, including unique manufacturing of the ionizing radiation detectors, supplemented by the specific equipment such as led-free shielding material and specialized software products has dominant and firm position in the company\\\'s portfolio.ENVINET continually reflects with the large scale of instrumentation and systems on the specific needs within the field of detection and measurement of ionizing radiation. The company provides comprehensive services covering the radiation protection requirements in the energy industry, health, education, science and research. Offered systems are flexibly adaptable to various scales – “on-the spot”, national and international, different conditions – “in-house” or terrain, and various modes - discontinuous or in-situ continuous measurements.The technique of the ENVNET\\\'s own development and production series is the result of the long-term experience in the nuclear power, and the co-operation with renowned research institutes, armed forces and first response groups. These traditionally include radioactive waste characterization instruments, numerous devices intended for terrain radiation survey and detection of the ionizing radiation, large scale of the plastic scintillators and NaI(Tl) detectors, digital analyzers, photomultipliers and preamplifiers, along with various types of lead and lead-free shielding.The automatic sample changer - NuLAB ASC100 stands for the news on the market, mirroring the great skill in the industrial automation and the experience in the radiation protection. The device represents advanced solution for high-resolution gamma spectrometry and is designed for automatic identification and quantification of radioisotopes in different types of samples.Daughter company Pico Envirotec continues the development of the new equipment, but also constantly innovates those already verified by practice. The compact and rugged design, easy operation, sensitive detectors and advanced software support made the products the essential part of radiation monitoring networks.ENVINET delivers innovative solutions also as the authorized distributor of renowned brands Thermo Fisher Scientific, ORTEC and Hidex. These are meeting the needs for faster and more accurate detection and identification while preserving simple handling.

STRONTIUM-90 IN MILK AND MIXED DIET IN THE CZECH REPUBLIC

Bartušková Miluše, Schlesingerová Eva

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Among various activities of National Radiation Protection Institute (SÚRO) monitoring of radionuclides in environment and food chain plays an important role. The monitoring takes place in frame of Czech Radiation Monitoring Network (RMN). Determinations of 90Sr are performed according to the monitoring schedule of RMN.Strontium 90 was released into environment during the tests of nuclear weapons in the fifties and sixties of XX. century and to some extent in 1986 owing to the Chernobyl accident. Strontium is a chemical analogue of calcium and accordingly when entering a mammal body, it behaves very much like calcium. A large portion of the strontium will accumulate in bone and like calcium it transfers to milk. Since the Sr uptake by the human body from milk is an important pathway for radiostrontium incorporation, milk and milk powder are good indicators of 90Sr content in human diet. Along with milk and milk powder, mixed diet samples composed of representative locally purchased food items according to food consumption statistics are also analysed for 90Sr.The analyses are made using oxalate precipitation method, when interfering radionuclides are removed by precipitation scavanging and after its ingrowth 90Y is separated and repeatedly measured by gas flow proportional counter. Strontium 90 activity is calculated as equal to 90Y activity in equilibrium.Time evolution of 90Sr activities in milk in Northern Moravia region (1988 present) and in Prague (1965 - present), in milk powder from the regions of the Czech Republic and in the mixed diet samples from the whole republic is presented on the poster. A very small increase due to the Chernobyl accident can be seen in milk (see Fig.2). After the ban of atmospheric tests the level of 90Sr has steadily been falling. The decrease is caused by radioactive decay and migration of the radionuclide in the environment. Due to this decrease activity concentrations in many samples have recently fallen under minimum significant activity (MSA) of the method. For example in cow’s milk we can see decrease from nearly 0.7 Bq/L in 1965 to < MSA = 0.06 Bq/L in 2014.FundingThis work was supported by the project funded by the Ministry of the Interior of the Czech Republic, identification code VF20102015014, and by the State Office for Nuclear Safety with the use of the database of Radiation Monitoring Network “MonRaS“.

UNIVERSAL VERY LOW ACTIVITY SHIELDING DEVELOPMENT AND PRODUCTION

Jakub Dvořák, Lukáš Džbánek, Markéta Koplová, Petr Okruhlica

VF, a.s., Černá Hora

In the field of liquid effluent monitoring realize VF company project FR-TI3/215 whose performance is under way in period from 2011 to 2014 in the framework Industrial research and development TIP announced by Ministry of industry and trade.

The study is based on the primary requirement the shielding element with low concentration of natural radionuclides of uranium, thorium and artificial radionuclides like cobalt etc. The secondary requirement is the price of the product compare to the lead standard elements. As the relevant requirement the manipulation with the material i.e. complex shapes production, moulding was analysed.

The outcome of this study is the material capable to use for moulding of the shielding element based on concrete with high amount of iron, the weight density up to 4.000 kg/m^3.

AEROSOL SAMPLERS INNOVATION POSSIBILITIES

Miroslav Hýža[1)], Petr Rulík[1)], Jan Surý[2)], Lukáš Skála[2)], Jaroslav Beneš[2)], Martin Fiala[2)]

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The growing demand for an early detection of increased levels of the artificial radionuclides in the atmosphere resulted in the design and fabrication of an aerosol sampler with automated spectrometric unit providing online gamma spectrometry above the aerosol filter. Study was performed with two types of high volume samplers- SENYA JL-900 SnowWhite (900 m^3/h) a SENYA JL-150 Hunter (150 m^3/h). This work gives results of the design optimization with respect to the detector type, geometry of measurement, remote control and spectrometric evaluation. ^{222}Rn and ^{220}Rn concentration fluctuations in the outdoor air are discussed with regard to the detection limit so the radionuclides expected after the NPP accident.

This investigation was supported by the project "MOSTAR", identification code VG20132015119, funded by the Ministry of the Interior of the Czech Republic.

NEW WEB INTERFACE FOR PERSONAL DOSIMETRY VF, A.S.

Jiří Studený

VF., a.s., Černá Hora

The lecture will introduce new functions and graphic design WebSOD – web interface Personal dosimetry Service VF. a.s. which will be updated in November 2014.

The new interface will have a new graphic design, intuitive control system and will be providing a range of new functions:

- Personal doses – display of personal doses from personal, extremity and neutron dosimeters including graphs, annual and electronic listings of doses
- Collective doses – display of group doses for selected periods of time
- Reference levels – setting and display of three refence levels
- Evidence – enables administration of monitored individuals – beginning, ending of monitoring, or editing the data of monitored persons and centers

Section II.
RADIATION PROTECTION FOR APPLICATION OF IONIZING RADIATION IN MEDICINE

RADIATION DOSES TO PATIENTS FROM NUCLEAR MEDICINE EXAMINATIONS

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The exposure of the population to ionizing radiation is rising rapidly, nearly exclusively due to increasing medical use of radiation, including diagnostic methods of nuclear medicine. In 2012 Public health authority of the Slovak republic (PHA SR) performed a survey about the population exposure from nuclear medicine procedures. The primary objectives of this survey were to assess the frequency of different nuclear medicine procedures, determine the average activities administered by nuclear medicine procedures and compare them with the national diagnostic reference levels and determine the annual collective effective dose to the Slovak population from nuclear medicine. The effective dose calculation was based on the methodology of the ICRP32, ICRP80 and ICRP106.

In Slovak republic are 11 nuclear medicine departments. The collected data of activities administered by different procedures correspond to 100 % of nuclear medicine departments. The total number of procedures included in the study was 36 250. The most commonly performed procedure was bone scintigraphy (35,9%), followed by lung perfusion and ventilation scintigraphy (17,0%), static and dynamic renal scintigraphy (13,0%), whole-body positron emission tomography of tumors with PET radiopharmaceuticals (11,6%), myocardial perfusion (8,8%), thyroid scintigraphy (6,2%), parathyroid scintigraphy (2,1%), scintigraphy of tumors (2,1%), scintigraphy of the liver and spleen (0,8%), brain perfusion (0,7%) and examination of the gastrointestinal system (0,3%).

The most commonly used radiopharmaceuticals were Tc-99m HDP or MDP for bone studies, F-18 FDG for PET studies, Tc-99m Tetrofosmin for myocardial perfusion, Tc-99m MAA for perfusion lung scintigraphy and for ventilation lung scintigraphy are used Kr-81m. Average activities administered for most frequently performed procedures were 368 MBq F-18 for PET studies, 750 MBq Tc-99m for bone scintigraphy, 115 MBq Tc-99m for lung perfusion scintigraphy, 140 MBq Tc-99m for renal scintigraphy, 605 MBq Tc-99m for parathyroid scintigraphy, 370 MBq Tc-99m for myocardial perfusion, 55 MBq Tc-99m for thyroid scintigraphy, 68 MBq Tc-99m for lymphoscintigraphy and 184 MBq I-123 for brain studies.

Based on the gathered data, the analysis of the nuclear medicine examinations was performed in order to estimate the typical effective dose of each type of examination as well as the collective dose of each group of examinations and their contribution to the total collective dose. The largest contribution to the collective effective dose from nuclear medicine examinations is from the use of Tc-99m radiopharmaceuticals (more as 90%) and from radiopharmaceuticals with isotope F-18. Radiopharmaceuticals with In-111, I-123 and Tl-201 have almost negligible contribution to the collective dose. Effective dose for most nuclear medicine procedures varies between 0.3 mSv and 12 mSv. The average effective dose from radiopharmaceuticals per examination determined in this study was 0,3 mSv for lung ventilation (Kr-81m), 0,7 mSv for renal scan, 1,0 mSv for thyroid scan, 1,2 mSv for renal scan, 3,6 mSv for bone scan, 4,6 mSv for myocardial perfusion (Tc-99m), 7,2 mSv for tumors (PET) and 12,6 mSv for myocardial perfusion (Tl-201). Bone scan are the biggest contributor to the collective dose of the population in the Slovak republic followed by whole-body positron emission tomography of tumors (PET/CT) and myocardial perfusion scintigraphy.

DIAGNOSTIC REFERENCE LEVELS AND POPULATION DOSE FROM DIAGNOSTIC RADIOLOGY

Leoš Novák[1)], Jaromír Uhlíř, Antonín Koutský, Petr Papírník[2)], Kateřina Daníčková, Martin Morávek, Dušan Olejár

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Currently valid diagnostic reference levels in the Czech Republic are not established on a basis of national dose survey. The values are adopted for some general radiography, fluoroscopy, dental, CT and mammography examinations from older British and European dose surveys. Therefore the values do not reflect the current situation in patient doses in the country. Thus a national dose survey in diagnostic radiology was carried out in the years 2012 and 2014. The group of "TOP 20" examinations identified in the European Dose Datamed project was chosen for the national dose survey. Typical patient doses for a standard sized patient (local diagnostic reference levels) and a description of standard procedures of the examinations were collected from a sample of university hospitals, public regional hospitals and private practices. The values of typical patient doses were expressed in terms of entrance surface air kerma and kerma – area product for general radiography procedures, volumetric computed tomography index and kerma – length product for CT examinations, mean glandular dose for mammography examinations and kerma – area product for fluoroscopy and interventional examinations. The typical doses from the hospitals were provided by a medical physicist responsible for the patient dose assessment in the hospital. Third quartiles of the dose distributions were used to propose new national diagnostic reference levels. The data from the survey were used also for an assessment of population dose from X-ray diagnostic procedures. Number of examinations was determined from the database of the biggest health insurance company VZP and the Czech Health Statistics Yearbook of ÚZIS. Typical effective dose for each of the TOP 20 examination was computed using a generalized conversion coefficient given in the Dose Datamed project report. Collective effective dose resulting from the TOP 20 exams was corrected to express collective effective dose from all X-ray exams by means of a coefficient given in the Dose Datamed II project report. The results of both diagnostic reference levels and population dose assessment were compared with current surveys conducted abroad.

DYNAMIC DIAGNOSTIC REFERENCE LEVEL (DDRL)

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Diagnostic Reference Level (DRL) is defined by the International Commission on Radiological Protection (ICRP) as a form of investigation level applied to an easily measured quantity usually the absorbed dose in air or tissue-equivalent material at the surface of a simple phantom or a representative patient.

The ICRP recommends the establishment of diagnostic reference levels as a tool for optimising the radiation dose delivered to patients in the course of diagnostic and therapeutic procedures.The Council of the European Union defines DRLs as dose levels in medical radiodiagnostic practices or in the case of radio - pharmaceuticals levels of activity for typical examinations for groups of **standard-sized patients** or standard phantoms for broadly defined types of equipment. These levels are expected not to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied.

In the Government Regulation of Slovak Republic No. 340/2006 are defined DRLs for standard-size patient as 70 kg weighing adult patient (currently is the average weight of patients in Slovakia higher and exceeds 80 kg)

Most radiological departments in Slovakia used in practice as tool for optimising of Radiation Protection (monitoring of the DRLs) the **DQC system** which compares and evaluates each performed exposures of all examined patients. In order to apply DQC procedure for all patients (not only for standard patient) we have introduced **Dynamic Diagnostic Reference Level (DDRL)** which takes into account the physical parameters (height and weight) of the patient as function of **BMI** (Body Mass Index).

The exponential of DDRL is based on the established DRLs for standard pacient and allows optimization for each patient in real time.

LOCAL DIAGNOSTIC REFERENCE LEVELS, APPROACHES AND COMPARE THE VALUES IN THE SOUTH BOHEMIA REGION IN VIEW OF RADIATION PROTECTION INSPECTOR

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This paper compares the value of local diagnostic reference levels(the LDRL)in health facilities of the South Bohemia Region. The work is motivated by questions of licensees, who would like to know their position in terms of the LDRL compared to other workplaces. Also by the activity of the inspector who can identify the problematic workplaces, where is necessary to increase attention to optimization, exposure, or justification. In connection with the ongoing internal audits in licensee workplaces the information about the status of the LDRL among others is current, motivating licensee to changes, optimization and verification of compliance with the recommendation of the National radiological standard of Ministry of Health.The data set is focused on radiographic examination for which National DRL(NDRL)are set out in the Decree No 307/2002 Sb., on radiation protection, as amended. The set of data can be expanded over time to include other examinations, for the NDRL has not been determined yet. Similarly, data were collected for radioscopic examination and CT examination. However there was identified the problem in comparing LDRL because of different magnitudes, which LDRL are given, resp. of incomplete summary of exposure parameters for their restatement and unification. For LDRL reported in kerma area product(KAP),there was found that the values are different until one order for the same examination. Probably due to a different mode settings for some KAP meters or bad transfer of area units. This was not commonly seen during the inspection. Licensees or inspector had not the feedback on the \"correctness\" because NDRL are in some case one order of magnitude higher. So that NDRL value was not exceeded. This discrepancy is necessary to clarify and identify the individual cause of the differences in values measured by KAP.The set of LDRL of individual workplaces also provides insight into the initiative of radiological physicists who are involved and provides the number of workplaces that can devise LDRL themselves. Individual licensees also differ in the approach to evaluation of LDRL and in the interest in the practical use of this value.

RADIATION EXPOSURE OF CARDIOLOGISTS' EYE LENSES DURING INTERVENTIONAL PROCEDURES

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Recently published studies have indicated a lower threshold of eye lens doses for developing cataracts than previously used. These studies have shown that the latency period responsible for cataract development depends on the absorbed eye lens dose. The recommendations of the ICRP, the new BSS of IAEA and the 2013/59/EURATOM Directive revise the old occupational limit of equivalent dose (150 mSv) to the new lower value of 20 mSv per year. Probably this value will be exceeded mainly during specific interventional procedures. The main aim of the present study was to investigate the received eye lens doses by monitoring and assessment of radiation load of cardiologists in the particular Cardiologic Healthcare Facility in Slovakia. The measurements were realized by using TLD located on the both sides of the protective lead glasses of five cardiologists during CA/PTCA procedures, performed in the period of 1 month. Evaluation of the dosimeters was performed by HARSHAW TLD 3500. Collected parameters of each individual examination were expressed in the quantity personal dose equivalent Hp(0,07). The whole body doses during the CA/PTCA procedures were controlled by RaySafe i2 dosimetry system, allowing the collection of real time radiation exposure of medical staff. Values of personal dose equivalent Hp(0,07) on the left eye lens (where we observed higher dose values), were extrapolated to annual doses and compared with the new eye lens limit. The comparison of the results (calculating the average annual dose from the gathered annual workload of each cardiologist) indicates that the new proposed limit for eye lens doses (20 mSv/year) should be exceeded. Important information comes from the results of RaySafe measurements, which refer to the fact, that although the whole-body annual doses obtained by the followed cardiologists doses not exceed the annual limit of effective dose, the equivalent doses to the lens of the eye obtained from TLD, reached the overflow value. Further specification of other interventional procedures, where monitoring of eye lens doses is necessary should be provided in the near future.

LABORATORY RECONSTRUCTION OF PERSONAL DOSES IN INTERVENTIONAL CARDIOLOGY/RADIOLOGY

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People working in interventional cardiology represent one of the most occupationally exposed groups. As recommended by the ICRP, these workers should be equipped with two personal dosemeters, one of them worn on the neck outside the protective collar and the second one on the trunk under the protective apron. It is proved that this double dosimetry method provides more precise estimate of effective dose. In connection with the new lower limit of the eye lens dose, the demands on the eye lens dose estimate increase. The aim of our experiment was to examine the relation between eye lens dose and the quantities $H_p(10)$,$H_p(3)$ or$H_p(0.07)$ measured with conventional personal dosemeters worn on neck and chest.

Irradiation conditions imitating the common operationof interventional radiology were created in the laboratory. The patient's body was substituted for a slab PMMA phantom (30 cm x 30 cm x 15 cm). An anthropomorphic Rando phantom representing a physician was clothed in a protective apron and a collar, with equivalent of 0.5 mm Pb for both. Three personal multicomponent whole-body thermoluminescent dosemeters (TLD), which allow to measure personal dose equivalents $H_p(10)$,$H_p(3)$ and$H_p(0.07)$, were fixed the Rando phantom, one on the collar on the neck and two on the chest over and under the apron. The use of the third dosemeter outside the apron, beyond the recommended double dosimetry, was motivated by the fact that the double dosimetry is not preferred in the Czech Republic yet. Moreover, a special TLD called EYE-D, measuring $H_p(3)$, was employed to determine eye lens dose. It was placed on the Rando phantom's temple in the proximity of the eye closer to the radiation source. The utilized PMMA slab phantom was irradiated with X-ray source with the quality RQR5 in four typical irradiation geometries, i.e. radiation beam entered the patient from the front, back, left and right side, which was simulated by the respective arrangement of both the phantoms towards the X-ray tube. The applied air kerma value at the slab phantom's surface was 50 mGy.

Relationsbetween personal dose equivalent values measured with the personal whole-body TLD and eye lens TLD were found. In the case of the personal dosemeter worn on the collar the results are: $H_p(3)_{eye}= 0.74H_p(0.07)_{neck}+ 0.04$, ($R^2= 0.965$), $H_p(3)_{eye}= 1.18H_p(3)_{neck}+ 0.02$, ($R^2= 0.978$) and $H_p(3)_{eye}= 1.01H_p(10)_{neck}+ 0.01$, ($R^2= 0.941$). A similar correlation was revealed also for the measurement on the chest over the apron: $H_p(3)_{eye}= 0.73H_p(0.07)_{chest}+ 0.002$, ($R^2= 0.975$), $H_p(3)_{eye}= 1.23H_p(3)_{chest}- 0.04$, ($R^2= 0.968$) a $H_p(3)_{eye}= 0.9H_p(10)_{chest}- 0.04$, ($R^2= 0.975$). These relations correspondwellwith results published abroad that were gained under real conditions, on the basis of evaluation of personal dosemeters worn by interventional radiologists. Our results support the opinion that interventional cardiology staff do notneed to beequipped with special eye lens dosemetersnecessary, particularly in cases, when protective goggles are used.

RADIATION BURDENS AND RISKS ASSOCIATED WITH NON-INVASIVE CT CORONARY ANGIOGRAPHY

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Non-invasive coronary CT angiography examination is one of the latest advances in imaging methods of the heart and surrounding blood vessels. Represents an alternative method of selective angiography, thereby increasing the importance of this examination. Due to technical progress and modernization in medical imaging methods, which use ionizing radiation, tends to increase radiation load of the population. Although coronary CT angiography examination is the indescribable benefit in the diagnosis of cardiovascular disease (especially coronary heart disease and vascular stenosis), we must not forget the potential risk of secondary tumors induced as a result of exposure to ionizing radiation.Since this is a relatively young and specific CT technology, we have conducted monitoring of the radiation load of patients undergoing CT coronary angiography examination method of retrospective gating, which included the quantification of calcium score. We conducted a retrospective study in which the aim is stating the radiation load on patient through effective dose. On the basis of the effective dose was determined the fraction of the additive risk of solid tumors as well as the fraction of additional risk of death from solid tumors induced by ionizing radiation by sex and age.Based on the 1078 made exposures, we can conclude that patients are exposed during the examination to relatively high doses of ionizing radiation. However, the heart muscle does not belong to the highly radiosensitive body, so we must take into consideration that the CT coronary angiography examination tends to increase the radiation load of other radiosensitive organs. For women it is especially breast tissue, which may increase the risk of induced breast tumors. The largest number of women who underwent CT coronary angiography were just women who belong to the risk group of women of breast tumors, ie Women aged between 50 and 70. In men it tends to increase the risk of the lung cancer.In this article we will discuss the need of optimizing the examination as well as taking into consideration of the gender, BMI patients and incurred additional radiation risk.

EXPERIMENTAL ASSESSMENT OF THE LOCAL SKIN EXPOSURE OF HANDS OF WORKERS AND ITS QUANTIFICATION WITH RESPECT TO RELEVANT REFERENCE LEVELS AND DOSE LIMITS

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During the various tasks associated with the preparation and administration of radiopharmaceuticals, the local skin exposure of workers on different locations of their hands show considerable variability. This fact was also confirmed by the preliminary results of mapping the exposure of the skin of hands using thermoluminescent dosimeters, which were placed at 12 different positions on the surface of the nail and palm side of a hand.The staff of two nuclear medicine departments, engaged in therapy using the solution 131I-NaI, was monitored. The results of measurements of the local skin exposure of the hand and its actual peak values for the individual workers varied and were found at various locations on hands. From the preliminary results of these measurements it was possible to conclude that this exposure could exceed not only the investigation level (3 cases) but also the dose limit for the skin of the hand (1 case). A worker with an estimated upper local skin exposure may receive the exposure at one or more locations exceeding 500 mSv/y. According to our results, it appears that there is a need for more detailed monitoring of the hands of workers in more departments in order to reliably map the current situation in the Czech Republic in this area. The paper was prepared with the support provided under the project SGS13 /161OHK4 / 2T/17 and CZ.1.07/2.2.00/28.0219.

A METHOD FOR SKIN HAND EXPOSURE BY POSITRONS DURING HANDLING OF 18F-FDG RADIOPHARMACEUTICAL

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By handling with radiopharmaceutical local irradiation of skin on hands of nearly 20% workers in nuclear medicine is likely to reach more than the legal dose limit for the skin. During syringe preparation and administration of positron radiopharmaceutical 18F-FDG to patients there are operations that can lead to hand irradiation by positrons. At present, there is insufficient data available about the positron exposure of the hands, which would serve as a basis for the optimization of procedures, including the preparation and administration of positron radiopharmaceuticals. This deficiency impedes the improvement of protective shielding of relevant tools against positrons and the availability of more accurate specifications of the distribution of local exposure of the skin of hands. Presented method of positron dose evaluation is based on pair of TLDs MCP-7 and MCP-Ns with different detection sensitivity to positrons and photons. Detection sensitivities of TLD MCP-Ns and MCP-7 were calculated by Monte Carlo code MCNPX 2.7 in units of skin dose equivalent Hp(0,07).Experimentally has been verified decreasing of skin dose by about factor 5 if positron source 18F-FDG in syringe, or infusion tube is shielded by a simple additional local shielding from 1mm polyethylene foil.

RADIATION LOAD OF WORKERS ON LINEAR ACCELERATORS

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Burden of health care personnel working on linear acceleratorsNew examination and treatment methods enable to reduce the number of health care personnel even in the case of increased numbers of examined patients. However, still open is the question of determining the effective dose delivered to health care personnel. The employment of several methods of evaluation of received dose at one workplace makes it possible to compare the accuracy and reliability of the respective types of measuring devices, as well as to point out the pitfalls of their use.At the St. Elizabeth Cancer Institute we compared the results of measurements of TL dosimeters, and OSL dosimeters at workplaces with linear accelerators.

FLUENCE COMPLEXITY IN IMRT FIELDS AND CORRELATION WITH GAMMA ANALYSIS

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Our previously published method for fluence complexity calculation in IMRT fields is based on portal dose images predicted by the Portal Dose Calculation algorithm in Eclipse (version 8.6, Varian Medical Systems) in the plane of the EPID aS500 detector (Varian Medical Systems). Fluence complexity is given by the number and the amplitude of dose gradients in a field. Now the method is validated with a set of 6 patients' plans. For each patient, 4 plans with different levels of complexity have been created, using the manual smoothing tools available in Eclipse. It has been found that fluence complexity calculated with our tool is in accordance with the level of manual fluence smoothing, with the number of monitor units, the behaviour of dose-volume histogram parameters and also with the results of gamma analysis after plan verification. Our method allows to estimate fluence complexity at the planning stage and thus potentially avoid measurement of complex plans, which do not often meet the verification criteria. With the help of our method, dosimetrists could recognize non-optimally smoothed dose distributions and perform some additional smoothing prior to verification. This would save time in the process. Furthermore, too complex fluences do not improve dose distribution and can cause errors due to complicated leaf sequencing. Fluence complexity is, however, systematically different for different patients, most likely depending on the site of treatment. Hence, particular limits for acceptable fluence complexity levels have not been established yet. This will be done in our future research, as well as careful testing of the new method for its use in clincial applications. This work has been supported by the SGS grant of the Czech Technical University in Prague no. SGS13/148/OHK4/2T/14.

EFFECT OF BREETHING ON THE RADIOTHERAPY OF LUNG CANCER

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We examined the breathing and his effect on accuracy of treatment dose delivery into treated volume. We focused on a special technique - extracranial stereotactic radiotherapy (ESRT), which is characterized by high precision of patient setup and fixation. However, since the respiration causes movements of the tumor in the range of several millimeters to centimeters, the tumor volume have to be extended by safety margins. In our work, we focused on the introduction of noninvasive respiratory control system using ExacTrac. Breathing was represented by a special marker placed on the patient's body. With 35 patients we had together 157 breathing exercises, in which we investigated the range of motion of the markers during a relaxed breathing, in a deep inspiration, and in a deep expiration. We have created a software that allows to display the movement of the markers as well as the reference values of relaxed breathing and inspiration. The patients were able to track the signal on a small screen and base on this feedback to regulate their breathing. The average reproducibility of the inspiration was 93.0 % with the feedback and 74.5 % without the feedback. For 16 patients we used dynamic CT scan to study the correlation between tumor motion and the movements of the markers (0.83 ± 0.17) and as a result we estimated the required internal margins for irradiation at shallow breathing and deep inspiration breath hold (DIBH) with and without feedback. In DIBH treatment situation the internal margin could be theoretically reduced by 3 mm with the feedback device. The standard deviation was rather large, and therefore the amount of margin reduction varies from patient to patient. We compared different irradiation techniques in terms of DVH and the consequent risk of complications (NTCP). Compared with the standard irradiation technique at shallow breathing, irradiation in DIBH without respiratory control reduced the volume of lung irradiated with 12 , 15 and 18 Gy and the average dose to the lungs by about 20 %. Applying reduced margins in DIBH with respiration control, this reduction was even increased to about 40 %.

DOSIMETRY AND PLANNING AUDIT OF IMRT PROSTATE TREATMENT IN THE CZECH REPUBLIC WITH A PELVIC PHANTOM

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In 2013, the national end-to-end audit of IMRT prostate treatment with a pelvic phantom has been carried out in the Czech Republic. It has been performed by the NRPI on site and the participation was voluntary. All departments (17) where IMRT is used for prostate treatment participated. In total, 21 plans have been evaluated. Phantom with clearly defined structures that were the same for all departments has been used. There was a dosimetric and a planning part of the audit. The determination of absorbed doses with ionization chambers placed in the PTV and in the rectum and the comparison to the planned doses was performed. Planar dose distribution was verified with gafchromic film. Majority of departments were able to deliver the IMRT plan successfully. The dose to PTV measured with ionization chamber in the phantom exceeded tolerance level of 3% in 4 cases. The mean of measured to planned dose for PTV was 0.991 ± 0.004. In one case, the tolerance level for planar dose was significantly exceeded. Constraints used for planning, volumes calculation, and DVHs were analyzed. Homogeneity index and gEUD were calculated for PTV. Likewise, gEUD and NTCP were calculated for rectum and bladder. Ratio of gEUD to prescribed dose has been calculated. Dose-volume relationships have been evaluated considering QUANTEC. The influence of uncertainty in parameter a on the difference of rectum gEUD across departments has been estimated. CT numbers to RED conversion curves in the planning systems were verified. Homogeneity in PTV was outstanding for all plans. 95% CI gEUD was 71.6 – 83.5 Gy for PTV, 47.3 – 68.4 Gy for the rectum, and 28.0 – 49.5 Gy for the bladder. The ratio of gEUD to prescribed doses was between 0.96 and 1.03 showing weak point in the treatment process particularly in the meaning of target underdosage already in the planning phase. Verification of CT numbers to RED calibration revealed problems for lung insert (7 departments exceeded tolerance of 10%) and bone insert (2 departments out of tolerance limit). The audit highlights the aspects of IMRT dosimetry and planning that should be of special interest, particularly dose prescription, dose reporting, constraints for planning, DVH analyses, and dose verification. The audit has shown the common practice in the Czech Republic for IMRT prostate treatment and enabled the intercomparison for departments leading to the better practice. The work has been supported by project TAČR No.TB01SUJB071.

RADIATION PROTECTION SAFETY DURING INTERVENTIONAL PROCEDURES UNDER CT

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Interventional medical procedures under the CT fluoroscopy belong to the types of medical exposure with the higher radiation load of patients and medical staff. In connection with several cases when the hand doses were well above the limits, State Office for Nuclear Safety began to pay hihger attention to workplaces which provide these procedures. The poster shows the information about results of occupational exposure, the number of workplaces, their medical equipment and found out facts concerning the ways of radiation protection ensuring.

PRIORITIES OF RADIATION PROTECTION IN MEDICINE IN THE NEAR FUTURE

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The International Atomic Energy Agency (IAEA) organized in 2012 the „International conference on radiation protection in medicine“ with the aim to specify the actions mprooving the role of radiation protection in the healthcare. As the outcome of the conference 10 actions have been estimated and were identified as essential for harmonisation of radiation protection at international level. This initiative involves the proposal on strenghthening of the radiation protection of patients and health workers overall, attainment of the highest benefit with the possible risk to all patients, the full integration of radiation protection into healthcare systems, the dialogue with patients and public concerning the ratio of benefit to risk and the quality assurance of radiological procedures. In the poster there will be explained in more details the individual parts of this international call.

AN INDEPENDENT MONITOR UNIT CALCULATION BY COMMERCIAL SOFTWARE AS A PART OF A RADIOTHERAPY TREATMENT PLANNING SYSTEM QUALITY CONTROL

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An independent calculation of monitored units (MU) is supposed to verify that the treatment planning system (TPS) is an accurate part of the complex system for the delivery of a safe and effective treatment. Although TPS is subjected to the series of the acceptance tests and commissioning, some international recommendation (IAEA TRS 430) and task groups (AAPM Task Group 53 and 114) publish that these tests do not have to confirm any current and future clinical situations and they recommend implementing an independent MU calculation. Planning systems are subjected to the rapid evolution, they implement new complex technologies and therefore it is not possible to verify all potential future clinical scripts in advance. For the independent calculation of the monitored unit (MU) the commercial software RadCalc (Lifeline Software Inc., Tyler TX) was used as the choice of some available similar programs. The program was configured and used to verify the doses calculated by commercially accessible planning system Eclipse version 8.6.17 (Varian Medical System Inc., Palo Alto). This system is being used during the clinical running for the creation of the treatment plans. The results of each plan were compared to the dose phantom measurements by the ionization chamber at the same point in which the calculation were done (Eclipse, RadCalc) –in the izocentre. TPS is configured by the beam data (PDD and OAR). Those beam data were exported and afterwards the same data were imported to the program RadCalc. The consistent and independent data between TPS and RadCalc were gained by this process. The reference conditions were set the identical in RadCalc as in TPS, so the consistency between TPS and RadCalc output factors has been achieved (Collimator Scatter Factor: Sc, Phantom Scatter Factor: Sp). Those output factors were also measured by the ionizing chamber in the water phantom and compared with the TPS.

Based on the clinical data of the response to the doses, ICRU recommends ensuring the ability of dosimetric systems to deliver the doses with accuracy of at least 5%. Many factors, such as layout of anatomic structures, positioning of a patient, factors related to an accelerator (a dose calibration and mechanic parameters) cause random and systematic failures in a dose delivery. The source of some problems can be also caused by the system databases and relating information transfer; and the TPS containing besides other things other dose calculation algorithms.

The request of TPS accuracy must be designed in a sense of a complete uncertainty for a dose deliver to a patient. The uncertainty analysis relating to a radiotherapy treatment has shown that 3% accuracy in a dose calculation leads to a 5% accuracy in a dose delivery to a patient. It means that a medical physicist should be able to generate the TPS calculations with at least 3% accuracy. The calculation results are in a good agreement with compared literature. By the verification of a dose delivered to a patient the confirmation of each specific plan by ionization chamber in a phantom is understood, i.e. the use of commercially available measuring instruments or electronic portal dosimetry (EPID), so called patient-specific study. This method covers the system as a whole. The application of an independent MU calculation for this reason remains to be a question. Still above mentioned recommendations, which are based also on an extensive analysis of radiation accidents all over the world, determine that the verification of MU calculation is a useful and necessary step to guarantee the safety and accuracy of the treatment.

QUALITY ASSURANCE FOR MR STEREOTACTIC IMAGING FOR THREE SIEMENS SCANNERS

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Quality assurance of stereotactic imaging, especially with MRI (magnetic resonance imaging), is a complex issue. It can be divided in the basic verification and commissioning of a particular new scanner or a new scanning MRI protocol that is being implemented into a clinical practice and the routine quality assurance performed for each single radiosurgical case. The aim of this study was geometric distortion assessment in MRI with a special PTGR (Physikalisch-Technische Gesellschaft für Radiologie – GmbH, Tübingen, Germany) target phantom.PTGR phantom consists of 21 three-dimensional cross-hairs filled with contrast medium. Cross hairs are positioned at known Leksell coordinates with a precision of better than 0.1 mm and covering the whole stereotactic space. The phantom can be fixed in the Leksell stereotactic frame and thus stereotactic imaging procedures can be reproduced following exactly the same steps as for a real patient, including also the stereotactic image definition in the Leksell GammaPlan. Since the geometric position (stereotactic coordinates) of each cross-hair is known based on the construction of the phantom, it can be compared with the actual measured Leksell coordinates based on the stereotactic MRI. Deviations between expected and actual coordinates provide information about the level of distortion. The measured distortions proved satisfactory accuracy precision for stereotactic localization at 1.5 T Siemens Magnetom Avanto scanner, Siemens Magnetom Symphony scanner and 3T Siemens Magnetom Skyra scanner (Na Homolce Hospital, Prague). The mean distortion for these MR scanners for standard imaging protocol (T1 weighted 3D images) were 0.8 mm, 1.1 mm and 1.1 mm and maximum distortions were 1.3 mm, 1.9 mm and 2.2 mm, respectively.There was detected dependence of the distortions on the slice orientation and the type of imaging protocol. Image distortions are also property of each particular scanner, the worst distortion were observed for 3T Siemens Magnetom Skyra scanner.

IMPLEMENTATION AND BENEFIT OF THE DOSIMETRIC AUDITS IN RADIOTHERAPY

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The accuracy of the dose applied to the tumor tissue is an essential prerequisite for successful cancer treatment since it allows to reach the maximum dose in the tumor, with minimal damage to surrounding healthy tissue

Achieving this goal requires the introduction of a quality assurance program and uniform criteria for a medical procedure that leads to the highest accuracy of the dose applied to the tumor .

In the poster there are presented the results of the National independent correspondent audit of cobalt irradiation facilities in Slovakia. The results documented the significance of the dosimetry audits, and the possibility to reduce the uncertainties in the delivering of the precise treatment doses to the target volume.

POSTAL TLD AUDIT IN RADIOTHERAPY IN THE CZECH REPUBLIC

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The postal TLD audit in radiotherapy is an independent check of dose applied by radiotherapy centers. Our poster provides basic information on the methodology of dose determination within the TLD audit. An overview of different versions of the TLD audit that are focused on specific techniques in radiotherapy is given. We also present results of so called basic version of the TLD audit that is performed regularly for purposes of the State Office for Nuclear Safety. Moreover, results of intercomparison measurements organized by the IAEA (International Atomic Energy Agency), in which our laboratory takes part every year, are shown.The methodology of dose determination is based on TL measurement of LiF:Mg,Ti powder. The TL dosemeter (TLD) has form of a plastic capsule containing approximately 160 mg of this material. Before the TL reading, the powder of each particular irradiated dosemeter is divided into 9 identical samples by means of an accurate dispenser. The dosemeter response is given as average of TL responses of the 9 samples. The dose absorbed in water is computed from the TLD response by application of calibration factor and correction coefficients for elimination of energy dependence, supralinearity and fading of the TL material. The evaluation of the TLD audit is based on comparison of the dose measured by the TLD and the dose stated by a radiotherapy center. Relative deviation between these doses is calculated. Several versions of the TLD audit are available. The basic TLD audit is the most frequent. It consists of dose measurement under reference conditions of irradiation, and its frequency is at least once per two years for each clinically used beam. This TLD audit has contributed significantly to the improvement of the basic clinical dosimetry in the Czech Republic. Nowadays, most of the results are within the acceptance level of ±3%. Other more advanced versions of the postal TLD audit have been developed in the frame of research projects. They are focused on modern linear accelerators with multi-leaf collimators and modern treatment planning systems used for 3D conformal radiotherapy, stereotactic radiotherapy and IMRT. The advanced TLD audits consist in dose measurements under non-reference conditions, which reflect the common clinical practice more accurately. Some of these versions include film irradiation that enables to check selected parameters of the applied radiation fields.Our laboratory takes part in the IAEA intercomparison measurements every year. It verifies the accuracy of our TL measurements. It is based on dose determination using TLDs that were irradiated in the IAEA laboratory. The doses obtained are compared with the IAEA stated doses. Our laboratory has always succeeded in these measurements.

VERIFICATION OF CO-60 BLOOD IRRADIATOR MECHANICAL ENGINEERING DESIGN

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Aim of this work is to verify the mechanical engineering design of the blood irradiator (from view of radiation protection) and estimation of the field homogeneity in the irradiation chamber. To estimate the radiation field around the blood irradiator a modeling approach have been chosen and Monte Carlo code MCNPX has been employed. Fluence-to-dose conversion factor from ICRP-74 have been used for the annual dose equivalent evaluation. With this results, the shielding analysis has been performed in the context of occupation factor at the service staff work place and the current legislation requirements. In homogeneity of the radiation field has been estimated on the basis of isodoses in the water phantom (imitate the irradiator object, e.g. blood unit) placed in the irradiation chamber.The results have been further discussed with regards to the additional optimization (cost, availability of a sufficient number of resources, etc.).

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LINEAR ACCELERATOR AND MLC MONTE CARLO MODEL IN EGSNRC/BEAMNRC SYSTEM

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In radiotherapy (RT) the Monte Carlo (MC) method is used especially as a golden standard for comparison with measured data, modelling of a detector response or a treatment planning system (TPS) calculation. In last years, using of an IMRT technique has been rapidly increasing in developed countries and also in Czech Republic. Benefit of IMRT is strongly dependent on a precise treatment planning and accurate target volume dose delivery. Precise dose delivering is interwoven with IGRT and for dose distribution verification the phantom measurement is usually performed. However, this way of verification may not discover possible dose distribution discrepancy between TPS and a patient. MC modelling is suitable especially for this situation. Recently increased interest in this field can be noticed in foreign authors works. Although IMRT technique is commonly used in our country this topic is not investigated. The MC simulation for IMRT is based on a verified linear accelerator treatment head model. In our case the model of Clinac 2100 C/D (Varian Medical System) is created. EGSnrc/BEAMnrc code is used for MC modelling. This system is adjusted especially for RT simulation. The model can be divided into several subsections. It is necessary to know precise accelerator treatment head geometrical parameters (from a producer) and convert them to EGSnrc/BEAMnrc. Another step is entering electron beam parameters tuning which is fundamental for successful simulation. Electron beam parameters are energy(monoenergetic or gaussian distribution beam) and a spatial distribution (gaussian). Both are found by comparison of MC and measured quantities, which are sensitive to energy or spatial distribution changes, e.g. percentage depth dose, dose profiles for various depths and field sizes. Another task is to define EGSnrc inputs. This means mainly variance reduction techniques which can improve calculation statistics and save time but can also improperly influence the results. Last step is to define dynamic MLC which is indispensable for IMRT. First the geometric model of MLC is created and verified with static field measured data. Then dynamic component can be modelled. It is realized in BEAMnrc by control file containing leaves position coordinates. Number of particles running through each MLC configuration is calculated from dose to 1 MU determination. Whole linear accelerator model with dynamic MLC is necessary to verify using clinical measured data.

ESTIMATION OF SECONDARY NEUTRONS IN PROTON THERAPY

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Most of proton therapy centers for cancer treatment are still based on the passive scattering, in some of them there is system of the active scanning installed as well. The aim of this study is to compare secondary neutron doses in and around target volumes in proton therapy for both treatment techniques and for different energies and profile of incident proton beam.

The proton induced neutrons have been simulated in the very simple geometry of tissue equivalent phantom (imitate the patient) and scattering and scanning nozzle, respectively. In simulations of the scattering nozzle, different types of scattering filters and brass collimators have been used as well. 3D map of neutron doses in and around the chosen/potential target volume in the phantom/patient have been evaluated and compared in the context of the dose deposited in the target volume. Finally, the simulation results have been compared with published data.

This work was supported by RVO: 68407700 and Grant Agency of the CTU in Prague, grant No. SGS12/200/OHK4/3T/14.

DENTAL RADIOGRAPHY TEN YEARS AGO AND NOW: OVERVIEW OF RESULTS OF POSTAL TLD AUDIT

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Since 2002, regular postal audit in dental radiography organized by NRPI Prague belongs to basic radiography QA/QC tools in the Czech Republic. The measured parametrs are incident air kerma, field size, and exposure reproducibility. The overall quality of the dental radiograph is also assessed. Ten-year summary of the audit results is presented here.

Section III.
DOSIMETRY AND METROLOGY OF EXTERNAL AND INTERNAL EXPOSURE

PERSONAL DOSE EQUIVALENT MEASUREMENTS BY PERSONAL DOSEMETERS WITH BEAMS INCIDENT WITH A BIG ANGLE AND LOW ENERGY PHOTONS

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A programme to intercompare individual monitoring services for X-ray and gamma fields has been carried out in the Czech Republic. The programme was designed to test the performance of laboratories that provide individual monitoring services in these fields. Irradiation was performed in accordance with the ISO 4037 standard. Various types of dosemeters are used by monitoring services in the Czech Republic: film dosemeters, TLD and OSL dosemeters. An intercomparative programme has been organized on a regular basis by SONS, and the results have been comparable with the intercomparisons organized in Europe in recent years for all the dosemeters that are in use. In recent years it has been found unexpectedly that, in some cases, after one dosemetric system was replaced by OSL system in a certain workplace (mostly in a hospital department) the collective doses have increased. This finding led to a further series of intercomparison measurements, which proved that the problem was caused by photons with low energy and with beams incident with a very big angle and most probably with the design of the OSL dosemeters. The aim of this report is to bring the information about sensitivity of OSL dosemeters on angular irradiation.The setup for test of angular behavior of OSL dosemeters was the following. The dosimeters were irradiated with the same dose at specific angle (30°, 50°, 60° and 70°) energy N40 or N80. The dosimeters were placed on a water phantom 30×30×15 cm perpendicular to the beam axis. For exposure of each group of dosimeters phantom was rotated on specific angle from the beam axis. Phantom turned either in a horizontal plane (side irradiation) or in the vertical plane (irradiation from below). With this setup the dosimeters irradiated by energy N40 and by energy N80 was obtained, so the energy and angular dependence could be observed.The results of the tests show that OSL dosimetry systems authorized and regularly tested in the Czech Republic have outliers for the low energy region and for angles of 50 degrees and greater. With the highest probability, it can be stated that the evaluation proces does not determine the correct angle of exposure and due to the proper correction is not done. For a big angle of irradiation, the filters did not shield the dosemeters completely. These cases may have caused overestimations of Hp(10) in the special conditions occurring e.g. in interventional radiology and cardiology. The solution to reported problem is to change the evaluation SW or the system of the filters. The procedure to correct this problem is presented.

ACTIVITY MEASUREMENT OF ^{241}Am IN HEAD

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Size and shape, and the internal distribution of bone and soft tissue are different in human heads. This significantly affects the efficiency measurement of ^{241}Am in the human head, by a detector that is tense attached to the head. Therefore the calibration phantoms head device for in situ measurement of ^{241}Am should be constructed in considerable detail similar to the measured head. The construction of such calibration phantoms is difficult and according to our information nor sufficiently precise standard phantom head man is not yet made.

Presented new method of activity measurement of ^{241}Am in cranial bone is based on in-vivo gamma spectrometric measurements in position above head vertex. The spectrometer has been calibrated by a simple head phantom with well known ^{241}Am distribution in phantom of cranial bone. To calibrate the spectrometer a simple bone phantom of upper part of the skull (cranial bone) in the shape of a spherical layer in combination with Monte Carlo simulation of real size, form and internal structure of measured head has been used. Influence of internal structure of bone, soft tissue and sinuses has been evaluated by an unfolding of measured pulse spectra.

The proposed new method for in vivo measurement of ^{241}Am in the head was used for determination of ^{241}Am in head phantoms USTUR.

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WHOLE BODY COUNTER CALIBRATION AND DETERMINATION OF ^{241}Am BODY CONTENT

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Internal contamination of man by americium is relatively rare. It is possible at manipulations with americium in laboratory and at the production of AmBe neutron sources when safety measures are not fully keeped. The most probable contamination route is inhalation when the radionuclide is manipulated in powder form.Americium is distributed in body to all tissues. According a modification of ICRP biokinetic model by USTUR (1994) based on Am measurements of exposed persons, fractions of initial deposition are 45 % in skeleton (elimination half life 50 years), 25 % in liver (2,5 y), 20 % in muscles (10 y) and 10 % in other tissues (10 y). It is well known that concentration of americium is higher in trabecular bones (skull) as in cortical ones (long and short). It is deposited on a bone surface (both inner and outer), so the concentration in bones is dependent on a ratio of bone surface to bone volume.These facts are influencing reliable determination of Am in a body.The measurement geometry is choosed according the deposition of Am in a human body. The highest deposition is in skeleton and the second one in liver, lungs are the primary organ of contamination in case of inhalation.1. Liver – in this case there are a lot of interferences from deposit in near soft tissues, lungs and variable thick of tissues between liver and detector. Calibration phantom is relatively simple to make – water solution of Am in a shaped flask.2. Lungs – a large organ so the efficiency is relatively low and it is influenced by selfabsorption in ribs and sternum, interfering is also the deposit in liver and soft tissues. Phantom preparation is problematic due to complex geometry and density of lungs.3. Skeleton – ankle joint and bones of foot - the bone mass is large, the selfabsorption in bones is a problem, preparation of a realistic calibration phantom is difficult due to complex geometry and need of manipulation with radioactive materials (e.g. plaster).4. Skeleton – knee joints – the same problems as at ankle and interferences from muscles of thigh and calf. Phantom preparation is difficult due to complex geometry and need of manipulation with active materials (e.g. plaster).5. Skeleton – skull – temporal bone – very complex geometry and various soft tissues (face muscles, ears) are interfering. Phantom preparation is difficult due to complex geometry.6. Skeleton - skull – roof of the neurocranium (parietal and frontal bones) – consists from flat bones with low variations in thickness. Thin overlapping tissue makes the selfabsorption low. Preparation of phantom is much simpler as by other geometries. Thin (6 mm) phantom allow application of radionuclide water solution on both inner and outer surface and relatively homogeneous distribution in a phantom made from absorbing material, e.g. plaster.Use of real skull is complicated by a low ability of absorption of radionuclide solution. Our phantom is made from absorbent gauze and plaster what is adjusting the density and improving mechanical properties of the phantom.Simple and reproducible geometry enables simulation by a Monte Carlo code, enables to study influences of overlapping tissues with various thickness, influences of radionuclides present in overlapping tissues and in brain.

EARLY WARNING SYSTEM REALIZED BY ENIVNET A.S., DOMESTIC AND ABROAD

Jan Surý, Lukáš Skála, Pavel Holčák, Pavel Matoušek

ENVINET, a.s. Třebíč

Within recent years, research and development has expanded the portfolio of applied results in the field of early warning systems - both stationary and mobile standalone. Their implementation in different areas all over the world in different climatic conditions and their coincidence of possible communication interface software, databases, data collection and assessment of the radiation situations allow the users to respond to possible events and thus significantly affect the decision-making level for the preventive countermeasures including their utilization during radiation accidents. Some of the results will be presented during the presentation: • Implementation of monitoring stations in Varaždin, Velika Gorica, Sisak, Virovitica, Beli Manastir, Zadar, Knin and Ploče in Croatia 2014. Other locations such as Plitvice, Šibenik and Koprivnica are also considered. Radiometric monitoring station NuEM RAMS, dose rate from 10 nSv / h to 1 Sv / h. • Implementation of radiation monitoring stations in Warszawa, Żagáń, Wroclaw, Szczecin, Kraków, Lublin, Gdynia, Bydgoszcz, Rzeszów, Bartoszyce, Śrem, Świnoujście, and Ustka in Poland 2014-2015. Radiometric monitoring station NuEM RAMS, dose rate from 10 nSv / h to 9 Sv / h. Purpose of stations - for a radiation monitoring network in a given area and for integration into the networks of early warning system. Measurement by using smart probe with 2 (3) GM tubes according to a measuring range. Power supply from photo-voltaic panel for the standalone mode. Transmission of measured data is done by using a GSM network. Data are stored into database at a web server. • Early warning system in Latvia 2013-2014. 20 pcs of stationary spectrometric AGR or IGS type or equivalent stations, NaI (Tl) or LaBr detector for on-line identification of radionuclides based on integrated isotope base with at least 10 indicated radionuclides (K-40, Mo-99, Ru-103 Rh -106, Te-129, I-131, Te-132, I-133, Cs-134, Cs-137, and Ba-140). Objective - providing early warning in case of an increased radiation level. Automatic detection of individual radionuclides.

MODIFIED LIULIN DETECTOR CALIBRATION FOR ONBOARD AIRCRAFT DOSIMETRY MEASUREMENTS

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During their careers, aircraft crews are exposed to cosmic radiation more than people on the Earth's surface. Therefore, the exposure of aircraft crew to cosmic radiation is considered as occupational exposure in all EU member states, and even some non-EU countries. Routine dosimetry of aircraft crew is performed using computer programs based mainly on Monte Carlo simulations. Onboard dosimetry measurements are important for verification of the computational methods and for research. One of the detectors used for characterization of the radiation field onboard aircraft is active semiconductor detector Liulin originally developed for monitoring of cosmic radiation at the MIR space station. The output quantity of the measurement with the Liulin detector is the ambient dose equivalent H*(10) calculated with use of the absorbed dose D. This requires two calibrations. The purpose of our work was to develop one of these calibration methodologies converting the detector signal to the absorbed dose D independently of calibration performed at HIMAC facility in Chiba. The new calibration method is based on standard alpha radionuclide sources and replacement of the original PIN diode type S2744-08 with epoxy layer for the diode type S2744-09 without protective resin layer. The work reaches its conclusion by comparing the DSi results of Prague-Moscow flight, measured both by the Liulin detector with an original diode and standard calibration and the newly calibrated Liulin detector with the replaced diode.

DETERMINATION OF RADIOISOTOPIC CONTENTS OF HIGH-ACTIVE MATERIALS IN NON-STANDARD CONDITIONS

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The light-water research reactor LVR - 15, operated by Research |Centre Rez, serves as a source of neutrons for applied and basic research. One of the main areas of applied research is the influence of neutron radiation field on the physical and mechanical properties of construction materials used in reactor technology. Flat rigs are the facility used for the irradiation of the materials. The flat rigs, orthe reactor radiation rigs, are designed for placement and irradiation of large samples of construction materials in the reactorLVR-15 core. The samples inside the rigs are irradiatedin an inert atmosphereand at a constant temperature of 300°C according to customer requirements to theneutron fluence.

One whole reactor campaign is needed to achieve required value of neutron fluence in the rigs. Due to long-term irradiation in the neutron field and a relatively large sample volume,the total induced activity is very high and the samples become a strong source of radiation, mainly gamma radiation.Thehigh intensity of gamma emission complicates the handling, transport and subsequent use of the sample for the material properties testing.

The presented contributiondeals with the determination of a radioisotopiccomposition and the estimate of its activity.The determination is based on gamma spectrometry measurements. The purpose of the measurements was the determination of the main sources of radiation and the result was used to prepare a procedure for the handling, transport and testing of samples in the rigs.

Because of high gamma dose rate, it was not possible to do measurement near or inside the shielding container. Therefore, the measurement was made through the roof of storage building where the container was stored. The spectrometric measurement was done with a portable HPGe detector, a multichannel analyzer and a notebook.The efficiency correction, value from point of view the distance from the sample to the detector and absorption of radiation in the roof of the building,was made in estimate of activity.

NEUTRON RADIOGRAPHY FACILITY ON THE LVR-15 RESEARCH REACTOR

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Neutron radiography is imaging method used indirectly ionizing radiation. Its utilization is analogous to X-ray radiography but here there is significantly other sensitivity to different elements, it aims primarily for study of light elements in samples. Neutron source for neutron radiography is usually a research reactor. From 2011, new neutron radiography facility on the LVR-15 research reactor is developed with completion in 2015. The LVR-15 reactor is a light water moderated and cooled tank-type nuclear research reactor. It is situated in Research Centre Řež Ltd., in Řež near Prague. The nominal reactor thermal power is 10 MW and it is operated as a multipurpose facility. It offers services in many fields: material research, production of radioisotopes for medical and industrial purposes, irradiation of silicon single crystals, neutron activation analysis, boron neutron capture therapy, neutron diffraction etc.

The developed facility contains two radiography systems, which use two thermal neutron horizontal beams labelled as HK1 and HK3. Systems differ with dimensions of measured objects and space resolution. On HK1 larger samples can be studied on area with diameter of 10 cm and resolution of 100 μm. HK3 channel (microradiography) is assigned for small areas of a few cm^2 and resolution is a few μm. Pixel imaging detectors with high resolution are used for detection of thermal neutrons. In addition to classical 2D imaging, both systems will be able to do 3D imaging (neutron tomography) using positional equipment for sample rotation.

Radiation protection of facility operators is ensured by optimal filtration of the beam before the outlet to the measuring space, by outer shielding around the beam outlet, by automatic blockade of the beam shutter during work in irradiation space etc. With exception of sample fixing, majority operation (beam control, movement of a sample during measurement, data processing) can be done from remote computer, which also decrease received radiation doses. Commercial operation of the facility is planed from 2016 but basic neutronographic measurement can be made from 2013.

MONITORING OF THE LEVEL OF RADIOACTIVITY IN DIFFERENT ENVIRONMENTAL SAMPLES WITHIN THE SLOVAK REPUBLIC,THE COMMITTED EFFECTIVE DOSES RESULTING FROM THE INGESTION OF DIFFERENT AGE GROUPS FROM THE PUBLIC

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The Slovak Republic has established the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water, foodstuffs and soil and to ensure compliance with the basic standards as a member state of the European Union. Data from the monitoring are periodically published, evaluated and sended to the REM database of the European Community. Radioactive contamination of the Slovak Republic following the Černobyl nuclear accident has raised public concern about food safety. Many people are wondering whether the domestic food samples are safe to eat even 28 years after the accident.Based on monitoring data reported during period 2004 – 2013, 137Cs and 90Sr concentrations in fresh cow and sheep milk, whole diet, wild mushrooms, wild boar meat are evaluated. Resulting committed effective doses from annual consumption for the different age group and different foodstuffs are calculated. Discussion and conclusions are given subsequently.

ASSESSMENT OF MICRODIAMOND PTW 60019 DETECTOR AND ITS COMPARISON WITH OTHER DETECTORS FOR RELATIVE DOSIMETRY IN SMALL RADIOSURGERY FIELDS OF THE LEKSELL GAMMA KNIFE PERFEXION

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Purpose: Measurement of relative output factors (ROF) for the Leksell Gamma Knife (LGK) is not a trivial task due to strict demands of an accurate set up and small size of measured radiosurgery fields. The purpose of this study was to perform an assessment of a new synthetic single crystal MicroDiamond PTW 60019 detector (volume 0.004 mm3) for measurement of ROFs for 4 mm and 8 mm collimators for the LGK Perfexion. Small sensitive volume of this detector, near water equivalence and low energy dependence make it an attractive candidate for small field dosimetry. Results obtained in this study were compared with results measured by broad variety of different detectors and also Monte Carlo (MC) simulation. Method and Materials:MicroDiamond detector connected to PTW UNIDOS electrometer was positioned in ELEKTA spherical phantom and pre-irradiated to dose of 5 Gy. Measurements were performed in two different detector positions: 1) parallel with table axis, 2) orthogonal to table axis. Electrometer timer of 1 min was used to measure subsequently signal from 16 mm, 8 mm and 4 mm beams. Altogether ten measurements were performed for each of three collimator sizes. Results from MicroDiamond were compared with those obtained from various types of detectors used in the past by authors for measurement of LGK ROFs: i) two types of micro ion chambers: Exradin A16 (volume 0.007 cm3) and PTW 31016 PinPoint 3D (volume 0.016 cm3); ii) two types of diode detectors: IBA dosimetry PFD (diameter 2.00 mm, thickness 0.06 mm) and IBA dosimetry SFD (diameter 0.60 mm, thickness 0.06 mm); iii) three different film dosimeters: Kodak EDR2, Gafchromic EBT and Gafchromic MD-V2-55; iv) radiochromic gel dosimeter based on Turnbull blue dye (TB gel); v) alanine dosimeter (diameter 4.8 mm, thickness 3.0 mm) and vi) mini alanine dosimeter (diameter 3.0 mm, thickness 3.0 mm). All measurements were performed in the ELEKTA spherical ABS plastic phantom (160 mm diameter) except the measurements with TB gel. Home-made spherical PMMA phantom of diameter 160 mm was used for TB gel dosimeter measurements. MC simulation was done by using Geant4 for water as a phantom material. Results:Results of ROFs measured by MicroDiamond were 0.900 and 0.831 for 8 mm and 4 mm, respectively in detector parallel position and 0.903 and 0.830 for 8 mm and 4 mm, respectively in detector orthogonal position. Results are in a very good agreement with vendor recommended values 0.900 and 0.814. Overall the best agreement with vendor recommended values and MC is seen for measurements performed with film dosimeter, MicroDiamond and IBA dosimetry SFD diode detector. Other detectors appeared to have too large volume for this measurement, especially for the 4 mm collimator.Conclusion:New synthetic single crystal MicroDiamond PTW 60019 detector appears to be a very promising detector for relative output factor measurements in very small radiosurgery fields.

INNOVATIONS OF THE NRPI PRAGUE GAMMA AND X-RAY DOSIMETRY LABORATORY IN THE PERIOD 2008 TO 2014

Martina Vtelenská, Libor Judas, Jana Krchovová, Dana Kurková

State Institute of Radiation Protection, Prague

The NRPI gamma and X-ray dosimetry laboratory located in Prague serves as an expert dosimetry support for the inspection and supervision activities of the State Office for Nuclear Safety. Besides that the sources of radiation and the dosimetry equipment installed in the NRPI dosimetry laboratory are used for numerous experiments conducted by research groups at the NRPI. The innovations are funded by the State Office for Nuclear Safety, the Technology Agency of the Czech Republic, and the Ministry of the Interior.

These are the currently available radiation qualities:
Narrow-spectra beams N40 to N300 according to the norm ISO 4037-1. RQR2 to RQR10 beams according to the norm EN 61267, and derived beams RQA and RQT. Four 137Cs beams, with available air kerma rates ranging from 0,002 mGy/h to 500 mGy/h. Two 60Co beams with available air kerma rates from 2 mGy/h up to 500 mGy/h. The air kerma rates are traceable to the Czech Metrology Institute.

Principal dosimetry equipment:
Ionization chambers Exradin, Victoreen and Nuclear Enterprise, electrometers Keithley.

Accredited test procedures:
„SOP 09 - Determination of attenuation properties of materials by ionometric method in Isovolt Titan X-ray beams“ according to the EN 61331-1 Protective devices against diagnostic medical X-radiation, Part 1. „SOP 10 – Determination of air kerma and air kerma rate by ionometric method in Isovolt Titan X-ray beams and OG-8 irradiator beams“.

Further possibilities:
X-ray beams from 10 kVp up to 300 kVp with a wide range of Al, Cu, Sn, and Pb filtrations. Possibility to measure the energy dependence (N10 to 60Co) , temperature dependence (-50 to +50 centigrade) and angular dependence of the dosemeter response. Spectrometry of X-ray beams up to 150 kVp.

(LU,GD)3(AL,GA)5O12:CE SCINTILLATOR - A SHORT HISTORY

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Approximately ten years ago, Y3Al5O12:Ce (YAG:Ce) and Lu3Al5O12:Ce (LuAG:Ce) were the only relevant garnet scintillators. Advantages of garnets were decent light yield and energy resolution, excellent mechanical properties, high thermal conductivity and stability, and chemical stability, including non-hygroscopicity. On the other hand, YAG:Ce has low atomic number, therefore limited detection efficiency for photon radiation. Additionally, both materials suffer from high relative intensity of slow scintillation component, LuAG:Ce significantly more. Slow scintillation component is usually attributed to shallow traps connected to LuAl (YAl) antisite defects, which are introduced into the material due to high growth temperature, using e.g. Czochralski or Bridgman growth techniques.There are two approaches to solve shallow traps problem: 1/ production of material without traps, 2/ eliminating negative effects of traps. Lowering the growth temperature is adoption of the first approach. LuAG:Ce ceramics and epitaxial films are produced using temperatures several hundreds of K lower than necessary for melt growth. Indeed, these materials exhibit significantly lower intensity of slow scintillation component. However, light yield remained moderate.Second approach, so-called “band-gap engineering” uses partial/complete substitution of Lu (Y) by Gd and partial substitution of Al by Ga. Ga addition lowers the bottom of conduction band. Using proper concentration, traps may be buried inside the conduction band, thus eliminating possibility of electron trapping. Unfortunately, ionization of Ce3+ excited state becomes more probable. On the other hand, Gd addition increases the gap between conduction band and Ce3+ excited state, thus decreasing the probability of excited state ionization. Indeed, optimization of growth condition and composition lead to increase of light yield (> 50 000 photons/MeV), FWHM improvement (÷ 5 %), and significant decrease of slow scintillation component intensity. Luckily, such success is not limited only to melt grown bulk crystals, but was reproduced using liquid phase epitaxy also. (Lu,Gd)3(Al,Ga)5O12:Ce scintillator has still only a short history and it is possible that it will be further improved by co-doping, growth condition optimization etc.

X RAY SPECTRA MEASUREMET USING A CdTe DETECTOR.

Dana Kurková, Libor Judas

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Measurement of energetic spectra of ordinary clinical, technical, metrological and other similar x ray beams using semiconductor detectors meets two types of difficulties. First is the detection of high photon count rates of the X ray beams compared to the detector abilities. To reduce the photon counting rate on the detection system to an acceptable level a tungsten collimator disk, 2 mm thick with a hundreds of μm diameter circular hole placed in front of the detector in a precise geometrical orientation with respect to the X ray source must be used. The second type of difficultiesare spectra distortionsdue to (i) random summing, ii) escape effects, iii) carrier trapping, iv) Compton scattering, v) low detection efficiency), making the measured energetic spectra different from the physical energetic spectra. On the contrary to the common spectrometric tasks where the line spectra are in question, in case of xray spectrait is necessary to take into account its dominant continuous component, the bremsstrahlung, in its following mathematical processing.

X ray spectra were measured using aCdTe XR-100T detector (Amptek).

Spectra of N series were measured (according to ISO 4037-1:1996): from N60 to N150 for anode voltageof the tube 60-150 kV, realised by x ray tubeIsovolt Titan in dosimetric laboratory SÚRO, v.v.i..Two sets of spectra were measured–first without using the tungsten collimator kit of the spectrometer, in a distance of 7 m from x ray tube and low tube current andsecond using a tungsten collimator kit measured in a distance 1m from x ray tube focus and low tube current.

Elimination of random coincidences was achievedby reduction of counting rates on the detection system.

Further artefacts in measured spectra were compensated using an analytic response matrix. Response matrix was computed and subsequently applied in a program made in MATLAB.

We demonstrate a function of response matrix on both model physical spectra and measured spectra.

In consequence of mainly continuous character of measured spectra more parameters are needed for its description compared to the line spectra. Therefore we came up with additional parameters for characterization and mutual comparison of x ray spectra.

Project was supported by **Ministry of the Interior** project of the Czech RepublicMV-25972-2/OBV-2010.

ANGULAR DEPENDENCE OF TWO DIFFERENT (LiF based) EYE LENS TL DOSEMETERS

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The ICRP has recommended to lower the limit of the dose to the eye lens for occupationally exposed persons to a mean value of 20 mSv per year (averaged over 5 years, with a maximum of 50 mSv per year). This is the principal reason to seek new more accurate ways to estimate the dose.

In pursuance of European Union project ORAMED (Optimization of RAdiation protection for MEDical staff), a new kind of eye dosemeter, adapted to the measurement of the quantity $H_p(3)$ providing the eye lens dose estimation, was designed. It has a form of a plastic holder with a space to insert TLD covered with 3 mm thick layer of tissue-equivalent polyamide. With help of an elastic headband, the dosemeter is fixed with its TLD touching the temple close to the eye.The conventionally utilized detector is LiF:Mg,Cu,P round pellet. To calibrate the dosemeter, a new cylinder phantom and reference data were created within the project.

In the irradiation hall of the National Radiation Protection Institute in Prague, the eye lens dosemeterwas irradiated on the anthropomorphic Rando phantom's head using narrow X-ray beams N40 and N60. The aim was to examine the angular dependence of the dosemeter with regard to $H_p(3)$ quantity. Besides the above mentioned material LiF:Mg,Cu,P, the classic cheaper material LiF:Mg,Ti was employed. The experimental values of both types of TLD were compared to reference data. They both exhibit the similar angular dependence complying the $H_p(3)$ measurement. So it was proved that both kinds of detector may be equally employed in practice, under the conditions corresponding to the used radiation sources.

CALIBRATION OF THE WHOLE BODY COUNTER FOR MEASUREMENT OF ACTINIDES IN LUNGS

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Inhalation is the mainroute of intakeof radionuclidesintothe body duringan accidentinvolving arelease of radioactivesubstances. Therefore, measurement of radionuclides in lungs is important particularly in early stage after inhalation. In case of radionuclides with a high radiobiological efficiency, such as transuranium elements, an early estimate of the activityintake is essential. Such estimate can be done on the base of measurements in awhole body counter.

For purposes of in vivomeasurements, two whole body counters (WBC), intended for research purposes, monitoringduring normal and emergency situation,and for personal dosimetry service, are operated in SÚRO.One of them was upgraded in 2013 and 2014 and furnished with a new installation and detectors. Therefore, new calibration of the detection efficiency for the measurement of radionuclides in lungs was required.

Lawrence Livermore National Laboratory (LLNL) torso phantom was used for calibrations of the WBC detection system intended for measurement of transuranium elements in lungs. Thephantomcomprises three pairsof replaceablelungs;one pair withoutactivity, and two others withaddedactivity of ^{239}Puor^{241}Am. Considering the importance of the thickness and composition of the chest wall tissue for the attenuation of low energy photon radiation of transuranium elements in lungs, the phantom contains four additional overlayers of different thickness simulating muscle and adipose tissue in ratio 1:1.

Along with experimental calibrations of the WBC detection system using the physical phantom, Monte Carlo technique has been used for computational calibration.A voxel phantom has been created from CT scans of the LLNL torso phantom. The voxel model will be used for study of detection efficiencies in various measuring scenarios.

The new WBC detection system for in vivo measurements is introduced and a process and results of experimental and computational calibrations are described.

ESTABLISHMENT OF A CALIBRATION CHAIN FOR ACTIVITY OF 177LUTETIUM IN THE CZECH REPUBLIC

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The project Metrology for Radionuclide Therapy (MetroMRT) of the European Metrology Research Programme (EMRP) aims to improve the metrology of ionizing radiation in nuclear medicine. In the scope of the project, the first measurement with Lu-177 radionuclide was performed in Czech Republic, in cooperation of the Czech Metrology Institute (CMI) and the Department of Nuclear Medicine of Charles University 2nd Faculty of Medicine and Motol University Hospital in Prague. The following parameters of the gamma camera Symbia T were determined for Lu-177: calibration coefficient in point source geometry, scatter function, and scatter fraction. A recovery coefficient was determined utilizing the cylindrical Jaszczak phantom with cylindrical insets of different volumes. CMI also established the calibration chain for Lu-177 radionuclide in Czech Republic, from the primary standard of activity to calibration of well-type ionization chambers at end-user sites.

NEW RADIONUCLIDE SPECIFIC LABORATORY DETECTION SYSTÉM FOR METALLURGICAL INDUSTRY

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IJS, Institute Jožef Stefan Ljubljana
IST/CTN, EstradaNacional Sacavém
JRC-IRMM, Institute for Reference Materials and Measurements, Geel
MKEH, Magyar KereskedelmiEngedélyezésiHivatal,Budapest
NCBJ, Narodowe Centrum BadańJądrowych, Otwock, Świerk
PTB, Physikalisch-TechnischeBundesanstalt, Braunschweig
SMU, Slovak Metrological Institute, Bratislava
STUK, Radiation and NuclearSafetyAuthority Helsinki

One of the main outputs of the European Metrology Research Programme (EMRP) project „Ionising radiation metrology for the metallurgical industry" (MetroMetal) was the recommendation on a novel spectrometric detection system optimized for the measurement of radioactivity in metallurgical samples. The recommended system, prototypes of which were constructed at two project partner's laboratories, was characterized by using Monte Carlo (MC) simulations. Six different MC codes were used to model the system and a range of cylindrical samples of cast steel, slag and fume dust. The samples' shape, density, and elemental composition were the same as the ones of the calibration standards developed within the project to provide traceability to end-users. The MC models were used to calculate full-energy peak and total detection efficiencies as well as true coincidence summing correction (TCSC) factors for selected radionuclides of interest in the metallurgical industry: ^{60}Co, ^{137}Cs, ^{192}Ir, ^{214}Bi, ^{214}Pb, and ^{208}Tl. The MC codes were compared to each other on the basis of the calculated detection efficiencies and TCSC factors. In addition, a "Procedural guide for calculation of TCSC factors for samples in metallurgical industry" was developed for end-users. The TCSC factors reached in certain cases up to 32% showing that the summing effects are of high importance in the close measurement geometries met in routine analysis of metallurgical samples.

APPLICATION OF WHOLE SPECTRUM PROCESING METHOD FOR ANALYSING OF ENVORONMENTAL SAMPLES

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Worldwide used models for gamma spectroscopic analysis are based on the peak net area (PNA) method. PNA method uses just the information contained in full energy peak area and its usability for complicated scintillation spectra analysis is limited. Whole spectrum processing (WSP) method, based at the response operator matrix, uses information contained in whole spectrum and it is also capable to analyze complex spectra. Application of WSP method required appropriate response operator matrix for every application. Due to insufficient number of mono-energetic sources, it is not possible to create required matrix from measurement of detector responses. Complete operator could be obtained using scaling confirmatory factor analysis, where measured calibration spectra are described by analytical functions, which parameters are extrapolated to whole measured energy range. Appropriate description of changes in those parameters still require considerable amount of calibration sources. In case of high energy range or large volume measurements, where the number of appropriated calibration sources is even more limited, it is possible to calculate the detector response using Monte Carlo method. Our work is focused on calculating response matrix operator for 2” x 2” NaI(Tl) detector used for activity analysis of natural samples in Marinelli geometry using MCNP code. Analysis of collected spectra was performed using prototype of system BOB.

SPECTROMETRY OF THE MIXED FIELDS OF NEUTRON AND PHOTON RADIATION

Aleš Jančář, Zdenek Kopecký, Martin Veškrna.

VF a.s.

Spectrometric measurements of the mixed fields of neutron and photon radiation in the workplaces with the L-R-0 research reactor located in the ÚJV ŘEŽ and with the Van de Graaff accelerator, located in the ÚTEF laboratories Prague, are presented in this paper.

The experimental spectrometric measurements were performed using a newly developed digital measuring system, based on the technology of analog-digital converters with a very high sampling frequency (up to 2 GHz), in connection with organic scintillation detector, type BC-501A, and stilbene detector.

The results of experimental measurements show high quality of spectrometry mixed fields of neutron and photon radiation across the wide dynamic range of measured energy.

The presented result has been supported by the Technology Agency of the Czech Republic, within the project SPECTRUM, No. TA01011383.

DETERMINATION OF ^{129}I USING DISTILLATION METHOD AND LIQUID SCINTILLATION SPECTROMETRY.

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The conditions for effective distillation of iodine as a screening method for the determination of ^{129}I by liquid scintillation spectrometry were optimized. By distillation of iodine it is possible to achieve high-purity fraction without interferences needed for measuring ^{129}I for liquid scintillation spectrometer. Yields of separation were determined gravimetrically using $PdI_2 \cdot H_2O$. The environment that was found to be effective for distillation of iodine is made up of 1 - 2 mol·dm^{-3} HNO_3 together with 0.4 g of $NaNO_2$ as an oxidizing agent ($I^- \rightarrow I_2$). For testing of distillation, suitable apparatus for distillation of iodine was designed. The apparatus was connected to a vacuum box, which sucks iodine of the distilled solution. Then the iodine was captured in a solution of NaOH at a concentration of 1.5 mol · dm^{-3}. As part of the optimization methodology, it was found that the concentration of NaOH solution for adsorption I_2 (g) does not have any influence on the yields, as opposed to its volume, where it is necessary to use a maximum amount of NaOH in the holding flask for maximum adsorption of iodine. It was determined, that time needed for coagulation $PdI_2 \cdot H_2O$ is 24 hours and suitable time for distillation was 20 minutes. Optimized method for the determination of ^{129}I was applied for various matrices from NPPs in Slovak Republic. Values of ^{129}I for all analyzed samples were less than the minimum detectable activity (0.043 Bq). The separation yields were in the range (73.14 to 82.04)% and ^{129}I was measured on a liquid scintillation spectrometer TRI CARB 2900TR with high detection efficiency of 95% .

ENERGY DEPENDENCE OF RADIOCHROMIC GELS FOR LOW-ENERGY PHOTON RADIATION

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The contribution summarizes the results of measurement of energy dependence of two types of radiochromic gel dosimeters on low energy photon radiation between 14 and 145 keV. The energy dependence was determined for two different types of gels – a well-known Fricke-infused xylenol orange ion indicator gel (FX gel) and a gel based on Turnbull blue dye (TB gel). Gel samples in PMMA cuvettes with a front wall replaced by a thin Mylar foil were irradiated at reference photon fields at the Czech Metrology Institute. Response of the irradiated gels was evaluated by UV-VIS spectrophotometry and by photographing with a 16-bit grayscale astronomical CCD camera. It was found out that the response of the TB gel is independent on photon energy down to at least 14 keV photons, while the FX gel is energy dependent for photons below roughly 50 keV.

SECTION IV.

EXPOSURE CONTROL OF NATURAL SOURCES OF IONIZING RADIATION AND RADON ISSUES

EXPOSURE DUE TO RADON IN HOMES – AN IAEA PERSPECTIVE

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The results of miner and residential epidemiology studies provide statistically strong evidence of harmful effects of exposure due to radon and its progeny. With the publication of the fifth edition of the International Basic Safety Standards, of the World Health Organization´s Handbook on Indoor Radon and new ICRP statement on radon, there is increased interest from the public health and radiation protection authorities on controlling exposure due to radon and its progeny.The IAEA Safety Requirements publication “Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards” sets out requirements on governments for control of existing exposure situations, which includes exposure due to radon. The types of situation that are included in the scope of existing exposure situations include exposure in workplaces for which the exposure due to radon is not required by or directly related to the work and for which annual average activity concentrations due to 222Rn must not exceed a maximum reference level of 1000 Bq/m3 annual activity concentration, as well as exposure in dwellings and in other buildings with high occupancy factors for members of the public for which the reference level must not exceed a maximum value of 300 Bq/m3. These requirements include: collecting data on the activity concentrations of radon in dwellings and other buildings with high occupancy by the public; providing information on exposure due to radon and the associated health risks; and if necessary, to develop an action plan for controlling public exposure to radon. The IAEA has developed a Safety Guide to provide guidance on developing the radon action plan: “Protection of the Public against Exposure Indoors due to Radon and Other Natural Sources of Radiation”. This presentation will summarize the information on the assistance that the IAEA is currently providing to IAEA Member States to develop radon action plans. These activities include the development of training material; the implementation of regional Technical Cooperation projects that include training courses and workshops; and the provision of expert missions to Member States to provide advice on the development of national radon action plans.

A PROPOSAL FOR THE EVALUATION OF THE EFFECTIVE DOSE TO THE POPULATION FROM NATURAL RADIONUCLIDES

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In assessing the impact of geographic location or sources of anthropogenic radionuclides on public health, it is important to be able to determine the effective dose from natural radionuclides as precisely as possible. In this paper, a complex method for determining the effective dose is presented. Calculation procedures for all major contributors to the effective dose are discussed: gamma radiation of soil and rocks, cosmic radiation, internal radiation, outdoor and indoor radon and thoron. Evaluation of the effective dose from indoor radon is of special importance. On the basis of our indoor radon measurements, a simple linear relationship was found between the concentration of radon in the soil air and indoor radon. This approach was applied to the conservative estimate of the effective dose from natural radionuclides in the vicinity of Mochovce.

THE STUDY OF RADON AND THORON CONCENTRATIONS IN RESIDENTIAL HOUSES IN THE LOCALITY OF ZÁHORSKÁ BYSTRICA

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Recent studies show that nearly 20 000 lung cancer deaths in the European Union each year are caused by exposure to radon and its progenies. Within the Visegrad countries (project of International Visegrad Fund No: 21120293), the initiative to carry out harmonized measurements of radon and thoron concentrations in residential houses emerged. We choose the locality of Záhorská Bystrica, where, based on previous measurements, there is increased risk of radon in residential houses from soil gas. In this paper we present the results of these measurements, seasonal variations of radon and thoron concentrations as well as the dependence of radon concentration on the type of construction materials and detector placement. The results show that in ~83% of cases radon concentrations are lower than 150 Bq/m3. However, in some dwellings radon concentration exceeded 400 Bq/m3.

INTERACTION OF RADON AND SMOKING AMONG CZECH URANIUM MINERS USING MODEL OF A THRESHOLD ENERGY

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Exposure to radon and smoking are among the most important factors influencing the risk of lung cancer. However, the joint effect of radon and smoking has not been sufficiently investigated so far. In this paper we will try to describe by means of a threshold energy model the mechanism of synergic effect of the aforementioned factors, and compare their influence on the risk of lung cancer. The model is based on the assumption that the inactivation of cells is caused by the excess of threshold specific energy z0 in the sensitive volume of the cell. Cigarette smoking causes, among others, an increase in the synthesis of the survivin protein that protects cells from apoptosis and thereby reduces their radiosensitivity. Survivin is therefore responsible for the increase of threshold energy z0, which in turn leads to the increase of lung cancer risk. A linear relationship between the threshold energy and the number of cigarettes smoked was assumed. The effect of smoking on radon exposure was evaluated for various groups of smokers that were defined by the degree of morphometric and geometric changes in the lungs induced by smoking and various degrees of chronic obstructive pulmonary disease. We simulate various scenarios of irradiation - short-term exposure, long-term exposure, as well as various smoking habits – smoker, exsmoker. The calculated values can be, to an extent, compared to the epidemiological analysis geometric mixture models of Tomásek, who statistically evaluated epidemiological data about lung cancer occurrence among miners working in Jáchymov and Příbram mines. From the results it follows that the correlation coefficient was particularly high. Although the approach outlined in this paper is only one of the many that strive to describe in detail the synergic effect of smoking and exposition, the used model can contribute to a more precise estimate of lung cancer risk in areas with various smoking habits.

RADON IN THERMAL WATERS AND RADON RISK IN CHOSEN THERMAL WATER SPAS IN V4 COUNTRIES – PRELIMINARY RESULTS.

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The territory of V4 countries is rich in thermal springs. Some boreholes reach a depth of 2000 m and temperatures up to 70°C. 222Rn concentrations in some thermal waters can exceed 1000 Bq/l, however this concentration is not constant. In V4 countries, there is a long tradition in using thermal waters in spa care. In thermal spas, radon is released from the water, and is transported along with its decay products into human respiratory tract, which is potentially harmful to human health. Thus, controlling the levels of radon concentration in thermal waters, homes and workplaces of spas is justified.The aim of this project (project of International Visegrad fund No.: 21320324) is the study of radon 222Rn concentration in thermal waters and in thermal spas in V4 countries. The measurements are carried out a few times during at least one year in order to observe seasonal variability. The obtained results will serve to determine annual effective doses for employees who spend ca. 8 hours a day inside spa buildings. It will be also possible to assess the effective doses for patients (users) of the pools with the highest registered radon concentrations. We carry out measurements in 3 existing thermal water spas in each of the countries: Slovakia, Poland and Hungary, and in 1 thermal water spas in the Czech Republic,according to choice of partners.

THE SIGNIFICANCE OF DETERMINING AIR EXCHANGE RATE IN DWELLINGS AND BUILDINGS TO CALCULATE THE INHALATION DOSE IN INDOOR AIR FROM OUTDOOR AIR CONTAMINATED WITH RADIOACTIVE MATERIAL

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Following the first part, in this paper on a real case of escaped radioactive matter in gaseous or aerosol form the significance of known the air exchange rate for a prediction of wasted inhalation doses to population is illustrated.

RELEASE OF NATURAL RADIONUCLIDES IN THE CZECH REPUBLIC - FROM WATER TREATMENT PLANTS WHERE WATER FROM UNDERGROUND WATER SOURCES IS TREATED

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Water treatment plants where water from underground water sources is treated are classified as workplaces where exposure to natural sources may increase significantly. Natural radionuclides contained in the raw water may be present in the sludge, filter cartridges and waste waters. A release of natural radionuclides from such workplaces into the environment is permitted only in the scope not exceeding clearance levels laid down in an implementing legal regulation or in the scope and under the terms specified in a licence issued by the State Office for Nuclear Safety (SONS).An increased occurrences of natural radionuclides can be found only in groundwater that were in contact with the geological environment with an increased incidence of radionuclides - members of the uranium and thorium decay series. The reason for exceeding the guidance levels for drinking water and bottled water is usually natural occurrence of uranium and radium isotopes.During water treatment when water from underground sources is used it is necessary to pay attention to the waste products that arise during process - water supply sludge, filter cartridges, waste water. Certain technologies used in water treatment plants are effective also for removing natural radionuclides. For example during removal of iron and manganese using filters with cartridges made from modified water sands the capture of radium isotopes occurs with efficiency up to 80%. Waterworks sludge is most often disposed by discharging into sewer or into the sludge lagoons. Wastewater is usually discharged into sewer or watercourses. The filter cartridges are disposed at landfill or regenerated. Some used sand filters containing radium may also serve as remediation materials - for example during the remediation of tailing ponds.Since 2010 in the Czech Republic is set hygienic limit 15 μg/l for concentration of natural uranium in drinking water due to uranium chemical toxicity. In many water treatment plants there are newly installed technologies for removing uranium from drinking water. Part of these devices are most often ion exchange resin filters that capture the uranium from the treated water. In the cartridges along with uranium other radioactive elements (eg. radium) are captured as well. The advantage of these technologies is that flushing is not required so no wastewater occurs. Used ion exchangers with higher content of uranium are processed in the chemical treatment of uranium ores, managed by DIAMO, state enterprise. The purpose of this post is to inform about issue involving release of natural radionuclides from water treatment plants and about rules that had to be be followed during process in order to protect people and environment against the adverse events of ionizing radiation.´

DEVELOPMENT OF THE METHODS FOR THE MEASUREMENT OF RADON EXHALATION FROM THE MATERIALS USED IN SUPERNEMO EXPERIMENT

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Study of neutrinoless double beta transformation of atomic nuclei is a current scientific issue. As it turns out, radon activity concentration is a non-negligible part of radiation background, which adversely influences the recognition of events which may arise as a result of the double beta decay. Elimination of radon in the filling of SuperNEMO detection system is an important prerequisite for the success of this experiment.Our goal is to be able to measure and evaluate the radioactivity of individual structural components and determine the radon exhalation from them. For this it is necessary to reduce the detection limits of the measurement methods. We constructed and tested a low-background plexiglass accumulation chamber for measuring radon exhalation from solid samples. The next aim is to design and test the accumulation chamber for measuring radon exhalation from large-volume samples. We also tested the possibility of replacing the scintillation detectors by the semiconductor detectors with a surface barrier, which, in combination with a large-volume accumulation chamber, could lead to additional reduction of the detection limit of radon concentration measurements. The developed methodology will be suitable in the field of radiation protection for the control of radon exhalation.

INNOVATIVE REFERENCE MATERIALS IN NORM AND TENORM INDUSTRIES

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Naturally occurring radionuclides are present in many natural resources. Industrial activities that exploit these resources may lead to enhanced potential for exposure to NORM in products, by products, residues and wastes. NORM industries produce large amounts of waste. Waste materials, generated form current and past activities, constitute a huge economic and ecological burden if they are not properly disposed of or reused. The radioactivity content of mineral feedstocks and process residues creates a need to control exposure to workers and members of the public. When such materials are being handled or processed, it is clearly necessary to determine the nuclides present and their activity concentrations as accurately as possible. However, traceable, accurate and standardised measurement method and systems, in particular for in-situ applications, are needed to decide on the re-use of waste materials without increasing costs whilst avoiding contamination of the environment and exposure to the public. This creates the need to develop reference materials to enable accurate and traceable calibration of measurement instruments. Ionising radiation measurement in the NORM industry currently focused on artificial radionuclides while a reliable measurement of natural radionuclides is required. Only when following conditions are met the NORM and TENORM industry facilities can be effective and safe for personnel, population and environment. The European Research Project JRP IND57 MetroNORM is perfectly suited for accurate and precise determination of hazardous NORM materials. Demanding tasks require proper evaluation of NORM materials for protection of health and minimization of danger to life and property. This project offers new and innovative calibration standards and reference materials (with total relative uncertainties lower than 10 %, k = 1) for lots of candidate materials including residue/waste from Ta/Nb ore processing residue/waste from phosphogypsum processing, coal ash of the type used in building, tuff of the type used in building, residue/waste from TiO_2 production, building aggregates, IONEX resin from water industry, $FeO(OH)/MnO_2$ sludge from water industry and oil wastes. All this will help to increase the production effectiveness and improve and optimize production technology in NORM and TENORM industries.

ALPHA SPETROMETRIC DETERMINATION OF 226RA IN WATER SAMPLES BY USING ION EXCHANGER MNO2-PAN

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A method for 226Ra preconcentration and separation from water samples using MnO2–PAN (polyacrylonitrile) ion absorber composite was proposed, optimized and verified. The optimization was focused on prevention of the destruction of MnO2–PAN composite absorber during radium elution from the column, testing of multiple use of the resin, influence of calcium concentration on radiochemical yields and application of the method for various types of water samples. Absorber was produced at Czech Technical University in Prague and now is also commercially available from Triskem International, France as MnO2–PAN Resin.This absorber with grain size (0.1-0.3) mm was used for 226Ra preconcentration from various types of water samples at pH = (6.5-7.0). Radium was eluted from the ion exchanger MnO2–PAN with 20 mL of 6.5mol L-1HCl at flow rate of 1.5 mL min-1. Samples were precipitated with Ba2+ to form Ba(Ra)SO4 microprecipitate for alpha spectrometry counting..The proposed method was applied to samples of natural mineral, mountain spring, drinking and natural healing waters from Slovakia, Slovenia and Czech Republic. Radium radiochemical recoveries were monitored by non-isotopic tracer 133Ba and they were in the range of (92 – 100) %. The obtained 226Ra activities in the analyzed samples were compared with the limit values set in Edict 528 of the Ministry of Health of the Slovak Republic in 2007 and no limit was exceeded.

EVALUATION OF NATURAL RADIONUCLIDES IN SELECTED REGIONS OF SLOVAK REPUBLIC

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Slovakian part of Western Carpathian is an area typical for very various geological structures. This fact is also reflected on values of natural radionuclide concentrations. Our paper was focused on evaluation and collection of data about activities of different natural radionuclides (uranium, thorium and potassium) and on the description of rocks which cause it. For research purposes were offered the results obtained from middle and eastern Slovakia which includes different types of rocks with various values of radioactive concentrations. Consequently these data were processed and shown by maps that represent the values of natural radioactivity in the studied areas. Moreover, the maps showed localities with lowest and highest radionuclide concentrations and create the basis for evaluation of the potential health risk, as a consequence of radiation exposure.

Section V.

RADIATION PROTECTION OF NUCLEAR POWER PLANTS, THEIR DECOMISSIONING AND WASTE MANAGEMENT

INDEPENDENT MONITORING OF THE RADIATION SITUATION AT BOHUNICE SITE

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Paper presents the main conclusions from the results of the monitoring of the radiation situation in the JAVYS site in the locality of A-1 for last calendar year (2013). The measurements of the radiation situation in this site compose of: • Continuous sampling of aerosols and fallouts in the ground layer of the atmosphere and the gamma spectrometric and radiochemical determination of artificial radionuclides, • Continuous measurement of external dose rates of gamma radiation • In-situ measurements and sampling of soils, • Sampling of biomarkers and their gamma spectrometric analysis. Measurements have been continuously carried out since 1992 and represent an independent assessment of the radiological impact of the activities carried out within the project.

PROPOSAL OF METHODOLOGY FOR TREATMENT OF SPECIFIC RADIOACTIVE LIQUID WASTE

Roman Strážovec[1)], Vladimír Nečas[1)], Martin Lištjak[2)]

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In the past decades of nuclear era the back end of nuclear power only addressed spent nuclear fuel (SNF) management and did not consider the issue of treatment and conditioning of radioactive wastes, their isolation from the environment or their final disposal. This fact was later proved to be the key issue, as the complexity of the design, materials, fuel type, method of handling of spent fuel, method of storage, two traffic accidents and improper construction of certain facilities for the storage of radioactive waste have become major causes of complicated radiation condition at Nuclear Power Plant (NPP) A-1. One of the most important conditions for ensuring radiation safety status of the A-1 was specific processing of liquid radioactive waste (LRAW) produced during its operation. These LRAW arisen during the storage of damaged spent nuclear fuel and during operation of nuclear units. In the past used liquid coolant of A-1 was contaminated with fission and corrosion products released from the fusion material, respectively with structural parts of fuel cells. Although actions to remove this LRAW have been implemented during the first phase of decommissioning, part of the liquid waste remains stored in the premises of the NPP A-1. At the present time arose the effort to process remaining waste with existing treatment facilities to form suitable for final disposal at the National Repository, which in some cases requires processing of smaller volumes over of waste over longer periods of time. Distinct character of these radioactive wastes (RAW) is in most cases based on significantly different chemical and physical composition, or significantly higher specific activity. Treatment and conditioning of these RAW requires searching for specific technical solutions. In some cases it is sufficient to solve only suitable fixing matrix and to use standard technological process of fixation, in other cases it is necessary to add specific technological process and which requires design and build new plants for fixing respectively solidifying. The paper describes in detail the possibilities of treatment and conditioning of RAW into different kind of matrixes and proposes new variant solutions for the safe storage of the final product in the Near Surface National Repository located in Mochovce.

RADIATION PROTECTION IN DECOMMISSIONING OF THE NPP V1

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JAVYS, a.s. Jaslovské Bohunice

What's new in decommissioning of the NPP V1? In 2014 the first stage of the decommissioning should be finished. The program of the first stage was characterized by decommissioning of the non-contaminated facilities and buildings (facilities and buildings out of the control area). However, during the first stage, two key activities were done during which radiation protection had to be especially supervised: BIDSF project - Treatment and Conditioning of Wet Historical Waste – Sludge and Sorbents in the operational tanks NPP V1 (the treatment has been the condition of the regulatory body for the ending of the first stage) and preparation of decontamination of both primary circuits NPP (without reactors). In the year 2015, the second stage of decommissioning should be started. Program for the second stage is broad and it includes fragmentation and treatment of activated parts of the primary circuits (reactors, their internal parts, shielding cassettes). Modification of the radiation protection equipment on the NPP site has been made by BIDSF projects. During the first stage, two basic projects have been done: C12 – Refurbishment of the radiation protection monitoring equipment and C-10 – Free release of decommissioning materials. The present state of monitoring systems, as the result of the aforementioned projects, and the first experiences are main part of this presentation. Another activity, which prepared basic conditions for an execution of radiation protection in the second stage of decommissioning, was the preparation of documents for the procurement of license for the second stage of decommissioning.

THE RADIATION SITUATION DURING DISPOSAL OF RADIOACTIVE WASTE ARISEN FROM V1 NPP STEAM GENERATOR DISMANTLING

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The decommissioning of nuclear power plants represents a complex of activities whose planning has to be realised in advance. As one of the most complicated activities it can be considered the dismantling of so called large components (in case of nuclear power plant with pressurised reactor these are reactor pressure vessel, reactor internals, pressuriser and steam generator). The dismantling of such parts is a difficult task not only from the perspective of their mass and geometric dimensions but also due to the activity content (induced activity or contamination respectively). To carry out the complex analysis of the dismantling process also the consequences of this process have to be taken into account (e.g. transport and final disposal of resulting radioactive waste). The dismantling of large components is in Slovak Republic an actual issue. This is because the nuclear power plant V1 in JaslovskéBohunice is currently in the first stage of the decommissioning process and the realisation of the second stage (involving dismantling of activated and contaminated components) is planned in years 2015-2025. From this reason it is necessary to evaluate the radiation aspects of each activity regarding the decommissioning process. The goal of the paper is to calculate and analyse the dose rates and obtained doses during disposal of radioactive waste in National radioactive waste repository in Mochovce

REGULATORY INSPECTIONS IN NUCLEAR POWER PLANTS IN THE FIELD OF RADIATION PROTECTION

Milan Hort, Dagmar Fuchsová

State Office for Nuclear Safety, Prague

State Office for Nuclear Safety executes state administration and performs inspections at peaceful use of nuclear energy and ionizing radiation in the field of radiation protection and nuclear safety. Inspections on radiation protection at nuclear power plants are secured by inspectors of the Department of Radiation Protection in Fuel Cycle, who work at the Regional centre Brno and České Budějovice. The presentation gives brief information on various types of inspections – planned or ad-hoc, routine inspections during plant operation or refuelling outages, or specialised inspections focused into various points of radiation protection – e.g. monitoring programmes, safety of radiation sources, regimes of radiation controlled area, control of effluents, clearance of radioactive substances, etc.

THE RELEASING PROCESS OF DECONTAMINATED METAL MATERIALS IN ÚJV Řež, a. s.

Josef Mudra

ÚJV Řež, a.s.

The main activity of Centre of Radioactive Waste Management is to treat the radioactive waste into the defined form for a radioactive waste repository. A part of the processed materials is possible to treat by decontamination and then meet the releasing limits for free release into the environment based on the principle of minimizing the volume of radioactive waste (RAW). Processing of treated RAW is performed by the unique methods and activities included e.g. power hydraulic shears, nibbler, plasma arc cutting, mechanical saw, etc. are used for segmentation. For decontamination are used e. g. High-pressure water jetting, chemical decontamination, ultrasonic bath decontamination, foam decontamination, abrasiveblasting etc. The radiation characterization and determination of correlation factors of difficult measure radionuclides are perfomed before using the decontamination methods. The correlation factor is ratio of activity of difficult measure radionuclides (pure alpha, beta, radionuclides such as 90Sr, 59Ni, 63Ni, 241Am, 239Pu, etc.) and gamma spectrometry measured radionuclides (e. g. 137Cs, 60Co, 152Eu, etc.). The correlation factors are determined for each waste stream with the same history (e. g. tanks, pipelines). These factors are used for calculation the activity of difficult measure radionuclides in the measured material which is not detectable by gamma spectrometry. The prepared material for free release into the environment is measured on the surface contamination and the specific (mass) activity. Both radiological measurements (surface contamination and specific activity) must be done under the Atomic Act and Decree No. 307/2002 Coll. Special measuring device (gamma spectormeter) for material measurement for free releasing material into the environment was developed by company ENVINET a.s. The device is operated by contractor of partner company. The expected amount of released material is about 150 tons, which is about 25 % of total amount of decommissioned technology in ÚJV Řež, a. s. The total measured amount material is 47,3 tons of metal material until this time. The total amount prepared for free release into the environment is 45,5 tons.

DEVELOPMENT OF METHODS FOR ASSESSMENT OF RADIONUCLIDES AROUND NUCLEAR POWER PLANTS USING ACCELERATOR MASS SPECTROMETRY

Ján Pánik[1)], Miroslav Ješkovský[1)], Jan Kaizer[2)], Pavol Povinec[1)], Martina Richtáriková[1)], Alexander Šivo[1)], Marek Zeman[1)]

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A Centre for Nuclear and Accelerator Technologies (CENTA) has been established at the Faculty of Mathematics, Physics and Informatics of the Comenius University in Bratislava comprising of a tandem laboratory designed for the Accelerator Mass Spectrometry (AMS) and Ion Beam Analysis (IBA). The 3 MV Pelletron accelerator is a key feature of the equipment which will enable to carry out state of the art research in physical, environmental, material, biological and medical sciences in collaboration with leading European and world laboratories. The laboratory is further equipped with two ion sources – Alphatros (RF source for H and He ions) and MC-SNICS source (target wheel with 40 positions for solid targets), and low and high energy analyzers of ions (all equipment of National Electrostatics Corp., USA). We shall discuss in detail development of methods for analysis of 14C around nuclear power plant in Jaslovské Bohunice, and present results of temporal 14C variations in atmospheric carbon dioxide and in tree rings collected at the monitoring stations in Žlkovce and in Bratislava. Spatial variations of 129I activity concentrations in seawater offshore of the damaged Fukushima plant will be presented as well.

PILOT EXEMPTION OF THE CONTROLLED AREA FROM REGULATORY CONTROL AT NPP A1 – LESSONS LEARNED

Alojz Slaninka, Martin Ličtjak, Ondrej Slávik, Ľuboš Rau

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The contribution includes the lessons learned within frame of the radiological characterisation of surface ground layer in the NPP A1 site of area approximately 60 m2 (9 x 7 m) that was a part of Controlled area. Aim of the characterisation was a demonstration that the area fulfils the requirements to exemption from Controlled area for purpose of decommissioning activities carry out within frame of II. stage of NPP A1 decommissioning project.The requirements on free release of materials into the environment were applied (e.g. 300 Bq/kg for single 137Cs). Radiological characterisation was performed by two independent methods; in situ scintillation gamma spectrometry and systematic sampling in regular grid followed by gamma spectrometry analyses in accredited laboratory of VUJE, Inc. (S-219). This improved the quality of monitoring and at the same time it enabled the inter-comparison of results obtained by both mentioned independent methods.Characterised ground area was partitioned to smaller subareas of 4 m2. At ground layer of 20 cm it means approximately 1000 kg of ground (in compliance with requirements on reference area at even activity distribution according to government regulation No 345/2006). An aver-age sample was taken from each of these subareas consisting of 5 particular samples from depth 0 – 10 cm. Also deep samples were taken from each subarea from depth 0 – 50 cm and analysed per 10 cm layers. In situ measurements were performed by metrologically cer-tified portable gamma spectrometry assembly with LaBr 1.5“x1.5“ detector and MCA InSpec-tor1000. 4 measurements in regular grid 1 x 1 m2 were performed on each subarea with counting time 5 min. and MDA137Cs ~ 100 Bq/kg. Detector was posited vertically to ground surface in height of 10 cm and in Pb shielding of 4 cm thickness. Contaminated ground layer identified by in situ monitoring and confirmed by sampling were removed. Then the next ground layer was monitored. This procedure was repeated until all contaminated layer were removed (max. depth 1,8 m toward surrounding in our case). The results of measurements showed that under appropriate conditions (sufficiently low radi-ation background, on interfering external sources) also the designed in situ method is effec-tive and reliable tool for contaminated ground layer identification. In addition the in situ method is more effective in terms of time and cost consumption on unit of monitored area. Per-formance of in situ method was 0,3 man.hour/1 m2 of monitored area (25 ground layer) against 4 man.hour/1 m2 by sampling method.It was demonstrated the criterions for area exemption based on the general criterions for free release of material lead to inadequate cost. From this arising the challenge to elaboration suitable methodology for area exemption containing acceptable criterions in terms of cost. One of possibility to decrease the monitoring cost is primary application of in situ method with application of sampling only on selected points for confirmation of in situ monitoring results.

FIELD EXPERIMENTS FOR STADY OF ATHMOSPHERIC DISPERSION OF RADIOACTIVE SUBSTANCES IN THE ENVIRONMENT

Petr Kuča, et al.

State Institute of Radiation Protection, Prague

Field experiments aimed at investigation into atmospheric dispersion of radioactive substances in the environment Abstract:Within the Czech Ministry of Interior Project „Research of advanced methods for detection, assessment and consequent control of radioactive contamination“ field tests have been performed aimed at study atmospheric dispersion of radioactive substances dispersed by a small-size explosion.The presentation is aimed at basic information on experimental configuration and conditions, as well selected results.This work is developed based on the results of the Czech Ministry of Interior Projects, ID VF20102015014 and VG20122015083.

DOSE RATES MONITORING USING A REMOTE-CONTROLLED ROBOT

Irena Češpírová[1)], Lubomír Gryc[1)], Jan Helebrant[1)], Eva Čermáková[1)], Petr Sládek[2)], Tomáš Jílek[3)], František Burian[3)]

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[3)] CEITEC – Ce

Within the research project MOSTAR was developed a little light dose rate meter based on a plastic scintillator which can be applied for remote measurements. Poster presents the results of measurements with this detector placed on a mobile robot. The measurement was carried out during a field experiment with dispersion of La-140 in Boletice and on a polygon in Třebíč where \'lost\' point sources were placed.This work was supported by the projects: MV ČR ID: VG20122015083 and CZ.1.05/1.1.00/02.0068 from European Regional Development Fund and by the Technology Agency of the Czech Republic project TE01020197 ”Centre for Applied Cybernetics 3”.

RADIATION MONITORING VEHICLE OF A NEW GENERATION

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[2)] ENVINET, a.s.

Within the research project MOSTAR was for needs of modern radiation monitoring vehicle proposed and realized inner transformation of ordinary car. Poster presents car-borne system with a basic spectrometry identification, determination of heading to source using by two detectors located on lateral sides of vehicle, dose rate logging and their mapping. Part of a monitoring vehicle is a semiconductor spectrometric trace for quick qualitative and quantitative evaluation of samples of living environment and other detectors for field measurement.“This work was supported by the project: MV ČR ID: VG20122015083”

ANTHROPOGENIC CONTAMINATION OF 236U IN THE ENVIRONMENT

Irena Špendlíková, Mojmír Němec

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Radionuclide 236U (T1/2 = 2.3.107 y) is produced from 235U by neutron capture (235U(n,γ)236U, σ = 95 barn). In the environment, the neutron production is very low, thus the values of natural 236U/238U ratio range from 10-10 to 10-14 and the amount on Earth is estimated to approximately 30 kg. Whereas, the neutron flux in reactors is incomparably high and the values of 236U/238U ratio goes up to 10-3. The amount of anthropogenic 236U is estimated to around 106 kg and due to human activities, namely nuclear fuel industry, the releases into the nature are not negligible. The 236U radionuclide can be used as a tracer of environmental processes, a neutron flux monitor, can carry a key signature to differentiate uranium sources (reprocessing activities, hot cell facilities etc.) and may be used in the uranium prospection. Comparing the ratios and amounts mentioned above, it is clear that the measurement of natural 236U can meet a number of challenging tasks.Recently, 236U has been involved in many environmental studies and several authors has already reported higher background contribution. This paper deals with the issues of anthropogenic contamination in sample preparation methods for 236U determination using Accelerator Mass Spectrometry, the analysis of possible inputs of contamination in these methods and various options to reduce this contamination.

LIQUID EFFLUENT MONITORING SYSTEM AND LIQUID SAMPLING SYSTEM LEMS

Jakub Dvořák, Lukáš Džbánek, Markéta Koplová, Petr Okruhlica

VF, a.s. Černá Hora

In the field of liquid effluent monitoring realize VF company project FR-TI3/215 whose performance is under way in period from 2011 to 2014 in the framework Industrial research and development TIP announced by Ministry of industry and trade.

The liquid effluent monitoring system is designed for the radionuclide activity concentration and parallel offtake the sample for qualitative and quantitative analysis of the radionuclides released to the surface waters and sewer systems.

The activity concentration measuring instrument is designed for using three different types of detectors. It is able to monitor activity concentration based on user pre-set level up to annual balance activity evaluation according selection of the detector.

The sampling instrument is designed for continuous and proportional sampling of contaminated liquid. Instrument samples to the transport container that are put to the radionuclide or chemical laboratory analysis.

The Instruments can work independently.

SUPPRESSION OF INTERFERING RADIONUCLIDES IN DETERMINATION OF ^{90}SR VIA CHERENKOV COUNTING

Soběslav Neufuss[1)], Mojmír Němec[1)]

FNSPE, Czech Technical University in Prague

The detection of 90Sr (half-life 28.9 a) as one of the nuclear fission products (yield > 5%) occurring in environmental samples is complex task. Detection of 90Sr can be done for example using liquid scintillation counting, proportional detectors or Cherenkov radiation counting. These methods can measure either 90Sr or its daughter product 90Y (half-life 64.1 h) or some of them measure their secular or defined equilibrium. Detection of 90Sr-90Y using Cherenkov counting appears as one of the prospective methods and can be successfully used for determination of 90Sr in samples. Main problem of this approach represents radionuclides with high beta radiation energy occurring in environmental samples which is required for Cherenkov radiation emission. These radionuclides e.g. 40K, 210Bi, 60Co, 234mPa might interfere with 90Y using for 90Sr determination. This paper describes possibly problems which might occur when the Sr-resin solid extractant for 90Sr separation is used and samples contain radioisotopes of lead which are members of natural decay chains. Radioisotopes of lead or their daughter products might follow pair 90Sr-90Y during separation process. For example 210Bi ($E\beta max$ = 1.162 MeV) as a daughter product of 210Pb is a member of uranium decay chain as such it is always present in environmental samples. Its chemical properties due to valency are similar to 90Y and it could follow 90Y during extraction. The separation of 210Bi from 90Y was tested from simulant solutions and for their determination Cherenkov counting and liquid scintillation spectrometry were used. Both were measured on HIDEX 300SL and TRIATHLER (both Hidex Oy, Finland) liquid scintillation counters.

VERIFICATION OF IRRADIATION CONDITIONS AT THE LVR-15 RESEARCH REACTOR FOR MONITORING OF LONG-TERM RADIATION DAMAGE OF CONCRETE SPECIMENS

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Research Centre Řež Ltd.

Most nuclear power plantshave a nominal design lifetime of up to 40 years but many plan to operate longer (60-80 years). In the USA there is a discussion about the conditions under which it would be possible to extend the licenses of BWR and PWR reactors up to 100 years. For this reason it is very important to monitor and predict the long-term degradation of construction materials used for nuclear power plants. Important materials are not contained only in pressure vessels and reactor internals but also in biological shielding (concrete parts of the units).

Informationaboutthe accelerated concrete aging especially irradiation conditions, neutron spectrum, or chemical composition of concrete are not sufficiently described in the literature. The conclusions are not clear and it is necessary to extend the database of experimental results, which will be used for better understanding of the effect of long-term radiation exposure on the basic material properties of concrete.

The aim of the experiments is to irradiate concrete specimens in the research reactorfor reasonable period of time (1-2 years), which corresponds to 80 years of operation of the nuclear power plant.It represents neutron fluence higher than 1×10^{19} n/cm^2 for neutrons with energy greater than 1 MeV. The ratio of the total neutron fluence to these fast neutrons should be approximately 20. The temperature of the concrete must not exceed 93°C (this also applies to the centre of the specimen).It would be good to maintain the temperature below 65°C which corresponds to the real operation power. At a temperature of 93°C a structural changes in the concrete occur.

The aim of the designed experiment was to test the possibility to irradiate concrete specimens under required conditions in the LVR-15 reactor. The experiment also allowed to determine the thermal conductivity of serpentine concrete. The thermal conductivity of the material is an important parameter for thermo-technical calculations. This value is significantly different for various types of concrete. Calculations for different levels of reactor power were compared with measured data (validation of thermo-technical calculations).

During the experiment the method of extracting and analysing the gases generated during irradiation was verified. A significant amount of gas is generated during irradiation. This gas must be regularly released,otherwise there is a risk of capsule damage due to high pressure.

The temperature of the specimens irradiated at higher neutron fluence during accelerated irradiation increases significantly.In order to not exceed the required temperature of 65°C another autonomous cooling system must be added.

DOSE RATE MONITOR FOR SEVERE ACCIDENT

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There was request from NPP V2 for installation of severe accident monitoring system – SAM including the control system SAM I&C. SAM I&C provides information to operational staff about NPP status during severe accident and allows the intervention for mitigation of accident consequences:− Provides information about the status and operation ability of particular SAM subsystems necessary to mitigation of accident effects or to stop its promotion. − Provides information about monitoring of reactor unit parameters needed to decision making for admission of strategies determined by SAMG.− Ensures the control of SAM action parts during SAMG strategies realisation.A part of own measuring circuits of SAM I&C is the monitoring system of radiation situation in the reactor hall. It is accident dose rate monitor of external gamma radiation based on monitor type GIM206K (MGPI Company) with measuring range 10-3 ÷ 105 Gy/h. Monitor is included into radiation monitoring system. Maintenance and service of monitor is ensured by radiation protection unit.GIM206K is designed to radiation situation monitoring in reactor hall during all stages of severe accident. Mechanical configuration and installation of detection unit ensures continuous operation including accident connected with hydrogen burning (the temperature of 1 500 oC can be achieved for a short term during hydrogen burning). Assembly of GIM206 monitor includes:− Ionising chamber KG50SEC (with sensitive volume of detection unit 0.1 dm3 and energy range of detected gamma radiation 0,06 ÷ 3,0 MeV),− Local processing and display unit „LPDU/IC“ - ensures detection unit signal processing, data processing and local presentation of measured data,− Internal and external cabling including fixation elements,− Junction box JB – provides the interconnection of the signals from measuring channel of accident monitor to cable connection into radiation monitoring control room and into SAM I&C. SAM I&C ensures the presentation of measured and status data in main control room and in emergency response centre.

Section VI.

APPLICATION OF RADIATION PROTECTION STANDARDS IN EMERGENCY MANAGEMENT

RADIATION ENVIRONMENTAL REAL-TIME MONITORING AND DISPERSION MODELING

Andrej Kováčik[1)], Ivana Bartoková[1)], Terézia Melicherová[2)], Jozef Omelka[1)]

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The system of real-time radiation monitoring provided by MicroStep-MIS is a turn-key solution for measurement, acquisition, processing, reporting, archiving and displaying of various radiation data. At the level of measurements, the monitoring stations can be equipped with various devices from radiation probes, measuring the actual ambient gamma dose rate, to fully automated aerosol monitors, returning analysis results of natural and man-made radionuclides concentrations in the air. Using data gathered by our radiation probes RPSG-05 integrated into monitoring network of Crisis Management of the Slovak Republic and into monitoring network of Slovak Hydrometeorological Institute, we demonstrate its reliability and long-term stability of measurements. Data from RPSG-05 probes and GammaTracer probes, both of these types are used in the SHI network, are compared. The sensitivity of RPSG-05 is documented on data where changes of dose rate are caused by precipitation. Qualities of RPSG-05 probe are illustrated also on example of its use in radiation monitoring network in the United Arab Emirates. A more detailed information about radioactivity of the atmosphere can be obtained by using spectrometric detectors (e.g. scintillation detectors) which, besides gamma dose rate values, offer also a possibility to identify different radionuclides. However, this possibility is limited by technical parameters of detector like energetic resolution and detection efficiency in given geometry of measurement. A clearer information with less doubts can be obtained from aerosol monitors with a built-in silicon detector of alfa and beta particles and with an electrically cooled HPGe detector dedicated for gamma-ray spectrometry, which is performed during the sampling. Data from a complex radiation monitoring network can be used, together with meteorological data, in radiation dispersion model by MicroStep-MIS. This model serves for simulation of atmospheric propagation of radionuclides escaping from nuclear facility and for estimation and forecasting of area contamination, concentrations of various radionuclides in different altitudes and dose rates. The radiation dispersion model can be also used for identification of unknown source of atmospheric radioactivity if it's used complementary with aerosol monitors in radiation monitoring network. Limitations and assumptions of this model are listed and results from its use in UAE are shown.

REFERENCE LEVELS FOR EMERGENCY EXPOSURE SITUATIONS (THROUGH THE ICRP AND IAEA OPTICS)

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In the paper, the ICRP and IAEA criteria for adoption of protective measures in emergency exposure situations are discussed. Using the ESTE Analyst code and presuming that IAEA criteria are fulfilled, distances for adoption of protective measures are assessed depending on the quantity of release.

PREPARE: PREPARING EUROPE FOR NUCLEAR EMERGENCY AND RECOVERY

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The PREPARE project that started February 2013 and will end beginning of 2016, aims to close gaps that have been identified in nuclear and radiological preparedness in Europe following the first evaluation of the Fukushima disaster. Among others, the project will address the review of existing operational procedures for dealing with long lasting releases, cross border problems in radiation monitoring and food safety and further develop missing functionalities in decision support systems ranging from improved source term estimation and dispersion modelling to the inclusion of hydrological pathways for European water bodies. In addition, a so called Analytical Platform will be developed exploring the scientific and operational means to improve information collection, information exchange and the evaluation of such types of disasters. The tools developed within the project will be partly integrated into the two decision support systems ARGOS and RODOS. This will be achieved through a collaboration of industry, research and governmental organisations in Europe taking into account the networking activities carried out under the NERIS-TP project. Furthermore, the NERIS Platform member organisations (so far 50 partners) will be actively involved in the development of the new tools.Important is also the engagement with Japanese scientists under the umbrella of the NERIS Platform and the NERIS-TP project. This collaboration will allow further insight into the Fukushima disaster and how this will be treated in the future.PREPARE combines 45 partners from universities, research organisations, operational emergency management centres, industry and NGOs, representing the key players in Europe. The work program comprises topics such as long lasting releases, source term estimation, model improvements, knowledge gathering and exchange of trustworthy information clearly driven from the observations during and after the Fukushima incident. PREPARE is a step forward in harmonisation of emergency management and rehabilitation preparedness in Europe as it provides tools and methodologies which are either used in national organisation and implemented in decisions support systems such as ARGOS and RODOS, but also involving non-governmental stakeholders to gather and disseminated trustworthy information.

IAEA NEW RECOMMENDATIONS IN THE AREA OF EMERGENCY PREPAREDNESS

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The poster is based on the latest recommendations of the IAEA safety standards relating to a response to an occurrence of radiation emergency situations. One analyzes how to implement the reference levels of the general criteria in the current practice providing an emergency preparedness in the Czech Republic. However, as the general criteria are represented by dose values, it is proposed to introduce the predetermined operational intervention levels (OILs). The operational intervention levels expressed in directly measurable dosimetric parameters along with the values of emergency action levels (EALs) represent a new direction in the area of emergency preparedness which streamlines a choice of suitable protective actions in the event of radiological accident. The poster also presents the draft how to apply the general system for an assessment of radiological health risks based on the block schemes connecting directly measured dosimetric values with the corresponding radiation health risks. The information was worked up based on the results of the Czech Ministry of Interior Project, MI - BV ID: VF20102015014.

LIGHT ARMOURED RECONNAISSANCE VEHICLE SYSTEM S-LOV-CBRN

Michal Tomek, Jaroslav Kareš, Pavel Čuda, Ota Fišera, Bohuslav Res

Military Research Institute, Brno

Light armoured reconnaissance vehicle system S-LOV-CBRN is intended mainly for CBRN reconnaissance and CBRN monitoring of areas of interest. The vehicle is designed to fulfil the missions according to military CBRN scenarios and to support effectively the first responders' teams during their response to the extent CBRN incident.The vehicle is equipped with a chemical (C) and a biological (B) detection system, as well as with a radiation and nuclear (RN) detection system consisting of the control unit with an internal dosimetric probe and of two external ones which are mounted on the right and left side of the vehicle. The external probes are collimated and shielded from radiation originating from the contamination of the vehicle itself. Measuring range allows measuring of very low levels of radiation from the level of background radiation, as well as high levels like residual nuclear radiation is. The basic measured quantity is the level of radiation, expressed in ambient equivalent dose rate of gamma radiation one meter above the ground. By computations (Monte Carlo method) and experiments correction factors were designed and implemented to correct evaluation of the radiation level. The neutron radiation is detected using semiconductor structures.The vehicle is equipped with a small reconnaissance vehicle (UGV) remotely controlled by the crew. UGV is intended for support of radiation and chemical reconnaissance. UGV is equipped with sensors for identification of selected chemicals as well as for detection of gamma and beta radiation. A beta probe is placed on the UGV's detection arm and is able to approach the object of interest. The measuring of beta radiation is supplemented by information about distance to the object and its image from camera.System S-LOV-CBRN is equipped with an automatic CBRN monitoring station (AMS). The AMS can be deployed in area of interest and configured so that it automatically monitors the CBRN situation, processes the information and sends the results to the field network in the form of the CBRN messages (ATP-45).System S-LOV-CBRN contains a portable beta and gamma detector which is intended for pedestrian survey.The vehicle was developed by the VOP-CZ and by the Military Research Institute (VVÚ, former VTÚO), which is responsible for the design and implementation of the CBRN technologies. A prototype of the vehicle successfully passed long-term tests and was introduced into the equipment of the Army of the Czech Republic.

THE SHIELDING PROPERTIES OF THE NEWLY DEVELOPED CONTAINER FOR TRANSPORT OF SAMPLES CONTAMINATED WITH CBRN SUBSTANCES

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A container for transport of environmental samples to the analytical laboratory is being developed as part of the development of system for collection and transport of samples contaminated with chemical, biological, radioactive and nuclear (CBRN) substances after CBRN incidents. The proposed system corresponds with current requirements of NATO publication AEP-66. The proposed container will meet the requirements of mechanical stability and tightness for the packaging of the chemical, biological and radioactive substances. Verification of shielding properties and satisfaction of requirements of radiation protection during transport of potentially relatively high active samples was the aim of this part of research. Publication AEP-66 recommends to collect radioactive sample with maximum value of equivalent dose rate (EDR) 10 μSv/h at a distance of 1 meter from the sample. Furthermore, the expected maximum volume of liquid sample in the container is 4 liters or 4 kg of solid samples (soil, meat etc.). Requirements of radiation protection are satisfied for value of EDR less than 2 mSv/h on the surface of the package and less than 0.1 mSv/h at a distance of 1 meter from the surface of the package. For the first approximation, the sample was assumed as a point source of radionuclide 137Cs. Value of equivalent dose rate 10 μSv/h at a distance of 1 meter corresponds to point source activity 140 MBq. The decrease of EDR of such source to the required level 2 mSv/h is achieved at a distance of 7 cm or by use of 3 cm thick lead shielding. This would imply either large volume or large weight of the container. Subsequently, radioactive volume source of contaminated soil and water with volume of 1 liter were simulated by the Monte Carlo method using MCNP software. Dependency of EDR decrease on the distance from the source was approximated by a function and decline of EDR to level of 2 mSv/h was found at a distance of about 3 cm from the source surface. These results, together with a wall thickness of the inner steel container, the inner lining and the outer transport package, give excellent assumption that the radiation protection requirements for the proposed container and transport package will be satisfied.

DISTRIBUTION OF Cs-137 AND Pb-210 IN THE DEPTH PROFILE FROM THE BOTTOM OF THE LAKE LAKA

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Lake Laka is a glacial lake situated in the National Park Šumava, below the mountain Plesna 1,096 meters above sea level. Wide range of vertical column samples of the lake bed was taken in cooperation with the Administration of the National Park and the Radiation Protection Institute mobile group in two sampling periods, October 2013 and March 2004. Additional samples of vegetation and soil were taken in the lake surroundings in October 2014. The paper is concerned with the measurement of activity concentration of Cs-137, remainder of the Chernobyl disaster fallout; and the activity concentration measurement of Pb-210 which represents naturally occurring radionuclides. Contents of both radionuclides were determined by gamma spectrometry measurements in 3 cm thick layers obtained by cutting the soil columns, and viewed primarily in the context of the depth profile.

NERIS: THE EUROPEAN PLATFORM ON PREPAREDNESS FOR NUCLEAR AND RADIOLOGICAL EMERGENCY RESPONSE AND RECOVERY

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The NERIS platform was established in June 2010 to encourage European, national, regional and local authorities, technical support organisation, operators, professional organisations, research institutes, universities, and non-governmental organisations to co-operate and to facilitate access expertise and technology in maintaining competence in the field of nuclear emergency management and recovery for the benefit of European countries and citizens. 49 organisations are members of the NERIS Platform from 24 countries and 20 members are supporting organisations. The NERIS Association has been registered in August 2012 as a legal European Association under the French Law. It is operated by a management board of 10 members and the NERIS R&D Committee elaborates its strategic orientation. A secretariat is in charge of the technical administration (e.g. website - www.neris.net -, publication of 'Newsletters').

3 Working Groups have been set up:

- on „the practical implementation of the ICRP recommendations";
- on „processes and tools for emergency and rehabilitation preparedness at community level";
- on "Contaminated Goods".

Users group on decision support systems are also working under the umbrella of the NERIS Platform: the RODOS Users Group (RUG) and the "Handbook user group".
The NERIS Platform also supports the organisation of training courses on "Usage of the new products for supporting the management team" organised by VUJE, \"Preparedness and Response for Nuclear or Radiological Emergencies\" organised by SCK•CEN and "Late Phase Nuclear Accident Preparedness and Management" organised by CEPN.

The NERIS Platform is linked to research projects, managed by KIT:

- NERIS TP "Towards a self sustaining European Technology Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery".
- PREPARE project on innovative integrative tools and platforms to be prepared for radiological emergencies and post-accident response in Europe.

To set up a common reflection, cooperations have been established with European and international organisations: HERCA, ALLIANCE, CRPPH, ICRP and AIEA. To share issues on lessons learnt from the Fukushima accident, cooperation have been initiated with IGES (Institute for Global Environment Strategies) and with the Fukushima University.
The NERIS Platform is also involved in the steering committee of the EC Project OPERRA, aiming at structuring the research in the field of radiation protection at the Horizon 2020.
This paper will present the key components of the NERIS Platform and its objectives.

MAIN ACHIEVEMENTS OF THE EUROPEAN RESEARCH PROJECT NERIS-TP: TOWARDS A SELF-SUSTAINING EUROPEAN TECHNOLOGY PLATFORM (NERIS-TP) ON PREPAREDNESS FOR NUCLEAR AND RADIOLOGICAL EMERGENCY RESPONSE AND RECOVERY

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Having started in February 2011, NERIS-TP combined eleven leading research organisations in the nuclear emergency management area with four SMEs and four governmental organisations from 13 countries. One of the major achievements of the project was the further development, operation and management of the European Platform NERIS, which comprises now 49 members from Europe and Asia. Having successfully completed the project, it is now assured, that the NERIS Platform is self-sustainable and will continue operation for the coming years. The platform will play an important role in identifying future research needs at the European level. Such information is essential when defining future research programmes and prioritising radiation protection research in general as is on-going within Horizon2020. Further results can be summarised as major improvements of components of decision support systems in both inhabited and agricultural areas. Within the NERIS-TP project, several new computational tools have been developed ranging from an ICRP screening model, to improvements in the later phase modules and up to the capability to operate a DSS worldwide. In addition, preparedness at local/national level has been strengthened by setting up local/national fora, by developing tools that can be applied at the local level and also by integrating the experience gained in Belarus following the Chernobyl accident and in Japan following the Fukushima disaster.

Within the NERIS-TP project two major workshops have been organised. First, a workshop related to the practical implementation of the new ICRP recommendations and second, a final dissemination workshop at the end of the project. Furthermore, the training course "Preparedness for nuclear and radiological emergency response and recovery: Usage of the new products for supporting the management team", held in Trnava, Slovak Republic on 21 - 25 October 2013, national exercises promoting the newly developed tools have been conducted. Dissemination workshops and exercises have been conducted together with several national exercises testing the new products and providing feedback to the developers.

The NERIS ICRP Workshop, held in Bratislava, Slovak Republic in February 6-8, 2012, was organized by VUJE in cooperation with ICRP aiming to provide a forum for discussion and sharing of experiences on the implementation of the ICRP Recommendations. International, European and national perspectives were presented. 88 specialists from 51 organizations from 26 countries participated in the workshop. The final Dissemination Workshop "Strengthening the Preparedness at National and Territorial Level Using New Tools and Methods – Stakeholders Experiences", was conducted in Oslo from 22 to 24 January 2014. International organisations such as HERCA, EC DG Research, IAEA, OECD/NEA, and NGOs such as NTW (Nuclear Transparency Watch) and GMF (Group of European Municipalities with Nuclear Facilities) as well as representatives of the OPERRA project participated in the workshop and particular panels. 82 experts and stakeholders participated in the workshop, representing twenty countries. Notably, participants from Japanese organisations provided first feedback from the management of the consequences of the Fukushima accident.

Section VII.
BIOLOGICAL EFFECTS OF IONISING RADIATION AND ESTIMATION OF RISK FROM EXPOSURE

OCCUPATIONAL DISEASES IN URANIUM AND ORE MINERS RELATED TO RADIATION EXPOSURE IN THE CZECH REPUBLIC IN 2002-2013

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Dozens cases of disease of former or present uranium and ore miners are submitted to judgment as occupational diseases every year in the Czech Republic. Patients or attending physicians suggest that these cases are caused by occupational ionizing radiation. Only a part of these cases is qualified as occupational disease.

The term “occupational disease” is rather juridical term which underlies the right to financial compensation. The causal association with exposure to ionizing radiation cannot be indisputably verified by expert medical opinion. Most diseases in uranium and ore miners, which are proposed as occupational disease, are malignant tumors. The majority of judged cases are lung cancers from radioactive agents.

The lecture gives general information about all judged cases of occupational diseases in former uranium and ore miners in the Czech Republic in the years 2002 – 2013. In the period 2002-13 were 40-80 cases submitted to judgment as potential occupational disease every year.

The decision about occupational disease is derived from probabilistic approach based on estimation of probability of causation (PC) of irradiation on disease origin (e.g. methodical guideline No. 15, Ministry of Health Bulletin, part 9, 1998).

Only about third of these cases is qualified as occupational disease. Most frequent diseases were lung cancers. Nevertheless the rate of lung cancers acknowledged as occupational disease decreases during the last two decades. Non-melanoma skin cancers are on the second place. The rate of skin cancers increases. We can explain this fact by better diagnostics and by new method which allows more precious assessment of the skin dose. The method is used since 2005. Leukemias are on the third place (1 case in the year).

DOSIMETRY MEASUREMENTS WITH TIMEPIX IN MIXED RADIATION FIELDS

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Particles of cosmic radiation, and those used in hadron beam therapy, produce secondary particles when interacting with the target materials (spacecraft hull, atmosphere, beam-line components, and the human body). Created radiation field is composed of photons, electrons, muons, neutrons, fragments and primary ions with a large variety of energy spectra. Dosimetry measurement in such mixed radiation fields is therefore difficult and usually requires a combination of two or more detector types.We performed several experiments in mixed radiation fields with the semiconductor pixel detector Timepix to observe its capabilities of being used as a single dosimeter and spectrometer of the dosimetric quantities. For our studies, Timepix was exposed to three radiation fields in which it detected single particles, their positions, deposited energies and their time of arrival. The radiation fields were (1) proton therapeutic beam at Dubna, Russia, (2) CERN's high Energy Reference Field (CERF) facility at Geneva, France / Switzerland, and (3) heavy ion beams at HIMAC, Chiba, Japan. We compared the absolute values obtained with Timepix and other dosimeters and spectrometers, e.g. tissue-equivalent proportional counter (TEPC) Hawk, silicon detector Liulin, and track etched detectors. In contrast to these detectors, the advantages of Timepix are high energy and time resolution, large LET range, small size and short time needed for data evaluation. The limitation when using a USB 1 interface is a significant large dead-time, something which more current models have overcome with a USB 2 capability. One other limitation is the relatively small sensor volume coupled with the fact that the sensor volume is not tissue equivalent. This is however correctable on a track-by-track basis, given that the information is available. In this paper, we describe the Timepix evaluation methods of the dosimetric quantities and present the results of inter-comparison between different dosimeters. A good agreement was observed especially for LET spectra measured with Timepix and TEPC Hawk at CERF, LET spectra measured with Timepix and CR-39 at HIMAC, and energy deposition spectra measured with Timepix and Liulin in Dubna.

FAST NEUTRON DETECTOR USING A TIMEPIX DETECTOR

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The pixelated detector Timepix is an unique detector of ionising particles with high position sensitivity. It provides an additional information about the type of detected particle using pattern recongnition analysis of clusters created from affected pixels. A Timepix detector covered with polyethylene convertors of different thicknesses is presented as a real-time dosemeter for measuring dose equivalents in fast neutron fields of unknown spectra. The application of such a dosemeter could be found in the control rooms of nuclear power plants, in research accelerators or for neutron dose estimation in proton therapy centres. The way of creating such a dosemeter is to apply different weighting factors on the collected signal from identified recoiled protons under particular convertors. We are presenting the first results of such a dosemeter calibrated under monoenergetic neutrons in National Physics Laboratory. An energy of neutron beam is in range 0.5-16.5 MeV. The results are compared with simulated data.

RELATIVE BIOLOGICAL EFFECTIVENESS IN A PROTON SOBP

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Worldwide implementation of proton therapy to clinical practice requires detail knowledge of the effects of proton radiation to normal and tumor tissues. In proton therapy of cancer, a general value of relative biological effectiveness (RBE) 1.1 for all proton energies is applied for therapy planning. However, many experiments have shown that the RBE value is not constant along Spread-Out Bragg Peak (SOBP). Mainly at the distal edge of the peak, RBE values are increasing due to the higher linear energy transfer (LET) of the low energy protons. The goal of our study is to determine RBE values in clinical conditions of SOBP formed by active scanning proton beam. For experimental determination of relative biological effectiveness, we used cultures of normal neonatal dermal fibroblasts. Cell monolayers were irradiated on IBA cyclotron in the new Proton Therapy Center in Prague before, at the beginning, center and distal end of SOBP. The first results of clonogenic and micronuclei tests will be presented and discussed.

DEGRADATION OF POLYVINYLALCOHOL INDUCED BY GAMMA-RADIATION

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Degradation of pure Poly Vinyl Alcohol (PVA) and PVA doped with humic acids induced by gamma radiation was studied. Degradation changes were observed using ATR FT-IR equipment. Dehydration, double bond creation, and their subsequent oxidation were found out. Also, other degradation reactions occur simultaneously. Formation of C=C and C=O bonds is apparent. In contrast the presence of humic acids in the PVA sample showed stabilizing effect on PVA structure.

EFFECT OF IONIZING RADIATION ON THE ACTIVITY OF RESTRICTION NUCLEASES PVUII AND HINDIII

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The research is focused on the influence of the ionizing radiation on the activity of the restriction enzymes PvuII and HindIII. Enzymes PvuII and HindIII are restriction endonucleases of type II. These enzymes can be found in bacteria and they have a significant role in defense mechanisms of bacteria against viruses. They cleave DNA double helix at specific recognition palindromic sequences in the presence of cofactor Mg2+. PvuII cleaves the sequence CAG↓CTG and HindIII cleaves the sequence A↓AGCTT in marked places.Plasmid pcDNA3 has been used as the DNA substrate for the whole experimental study. It is 5446 base pairs (bp) long, circular DNA molecule and it contains three recognition sites for enzyme PvuII and one recognition site for enzyme HindIII. After the correct interaction of pcDNA3 with PvuII, we thus have three plasmid fragments with lengths 1069, 1097 and 3280 bp. When HindIII is incubated with this plasmid, we shall obtain the linear form of the DNA plasmid.The method for processing the cleaved DNA samples is the agarose gel electrophoresis. The activity of the irradiated enzymes decreases with increasing dose of radiation, because a part of the enzymes is deactivated due to induced radiation damage. To determine effect of radiation quality, samples were irradiated using proton and gamma sources. The results of our experimental study will be presented and discussed with respect to molecular structure of both enzymes and particular sites of radical damage influencing their function.This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic, project No. LD12008, and the Grant Agency of the Czech Technical University in Prague, grant No. SGS13/148/OHK4/2T/14.

GAMMA RADIATION AND CHICKENS

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In our work, we focused the effect of low doses of gamma radiation on metabolic parameters in chickens. In the first group of chickens we monitor changes of the concentration in glucose and cholesterol after whole body irradiation dose of chicken (3Gy). In the second group of chickens we studied the combined effect of radiation and intraperitoneal application solution of zinc chloride to changes of the concentration in glucose and total cholesterol. In the tissues of organisms are found only in a very small amount of microelements however are of particular importance in a number of enzymatic catalytic and regulatory processes. Zinc is found in all cells of the body. However, it is the highest percentage of zinc contained in muscle and bone cells. Resorption takes place in the small intestine, especially in the duodenum.For both groups of chickens, we performed analyzes on the 3rd, 7th, 14th, 21st and 30 day. Results and an overview of the work can be helpful in the peaceful uses of nuclear energy and in preventing diseases from exposure to radiation, but also in the case of the consequences after nuclear accidents.

PLASMID DNA IMAGED BY ATOMIC FORCE MICROSCOPY

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Radiation induced DNA fragment distribution seems to be missing information crucial for understanding of biological impacts of DNA clustered damages. First, the produced DNA fragments may interfere within pathways involved in repair of the clustered damages. Second, measurements of the clustered damages by conventional techniques are negatively affected by limits in fragments´ detection. Therefore, our project is aimed to characterization of radiation induced DNA fragment-length distribution by use of atomic force microscopy (AFM). In this contribution we introduce preliminary tests performed in laboratories of ESTEC (European space research and technology center). Several substrates for DNA plasmid AFM imaging were tested (glass, silicon wafer and mica), as well as fixing methods. The DNA on the substrates was imaged in the air with AFM in tapping mode; we will discuss optimal cantilever and scanning parameters. The AFM images have been started to analyze in order to a) distinguish plasmid forms of different conformation (supercoiled, circular, and linear) according to a level of plasmid DNA damage, since this information can be compared to conventional techniques such as electrophoresis; b) measure lengths of the linear forms.

RAPID ESTIMATION OF 239Pu, ^{241}Am AND ^{90}Sr IN URINE

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Comenius University, Faculty of Natural Sciences, Department of Nuclear Chemistry

This method uses column separations consisting of different commercial products Eichrom's Pre-Filter Material, DGA®Resin from Eichrom Technologies and AnaLig®Pu-02 gel, AnaLig® Sr-01 gel from IBC Advanced Technologies. Raw urine was acidified and passed directly through the resin columns. The method was successfully tested by adding known activities of reference solutions of NPL Alpha-Beta High 2005 to urine samples. The demonstrated linear model clearly proves that the residua fulfill the Gaussian model, without any autocorrelation and trend for intercomparison reference sample. By eliminating the co-precipitation techniques and the ashing steps to remove residual organics, the analysis time was reduced significantly.

Section VIII.

EDUCATION AND TRAINING IN RADIATION PROTECTION TAKES ACCOUNT OF NEW RECOMMENDATIONS OF EU, ICRP AND IAEA

EUROPEAN ACADEMY OF DECOMMISIONING

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Institute of Nuclear and physical Engeneering, Slovak University of Technology, Bratislava

Considerations about the European Decommissioning Academy (EDA)Vladimir Slugeň and Robert HincaInstitute of Nuclear and Physical Engineering Slovak University of Technology, Bratislava, Slovak RepublicAccording to analyses presented at EC meeting focused on decommissioning organized at 11.9.2012 in Brussels, it was stated that at least 500 new international experts for decommissioning will be needed in Europe up to 2025, which means about 35 per year.Having in mind the actual EHRO-N report from 2013 focused on operation of nuclear facilities and an assumption that the ratio between nuclear experts, nuclearized and nuclear aware people is comparable also for decommissioning (16:74:10), as well as the fact that the special study branch for decommissioning in the European countries almost does not exist, this European Decommissioning Academy (EDA) could be helpful in the overbridging this gap.For the first run of the EDA scheduled on 2014 we would like to focus on VVER decommissioning issues because this reactor type is the most distributed design in the world and many of these units are actually in decommissioning process or will be decommissioned in the near future in Europe.A graduate of the European Decommissioning Academy (EDA) should have at least bachelor level from technical or natural science Universities or Colleges and at least one year working experiences in the area of NPP decommissioning or nuclear power engineering. This study creates prerequisites for acquiring and completion of professional and specialized knowledge in the subjects:

- Decommissioning according to IAEA and EC Directives
- Nuclear physics and chemistry (Special laboratory exercises)
- VVER design
- Nuclear safety
- Decommissiong cost calculation and project management
- Legislative requirements for decommissioning
- Fuel cycle and spent fuel management
- Radiation protection (Special laboratory exercises)
- NPP decommissioning and radioactive waste treatment
- Contamination and decontamination technologies (On-site training)
- Strategy of back-end part of nuclear energy
- Storage of radioactive waste and deep repositories

The important part of the study will be also practical experiences based on laboratory exercises at universities, on-site training and demonstration at the NPP in Jaslovske Bohunice and 4 days technical tours at selected nuclear facilities in the Central Europe or Russia.The need to maintain and increase competent and qualified staff is a recurrent concern in the nuclear sector. In particular, in view of the growing decommissioning market, it can be expected that industry will involve new actors, including, in some cases, small and middle enterprices. The organisation of ad hoc training programs is also essential with a strong link to research and educational organisations.

OPPA PROJECT: MODERNIZATION OF PRACTICAL EDUCATION OF CTU FNSPE NUCLEAR ENGINEERING STUDENTS – TWO SELECTED EXERCISES

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The project under the title OPPA CZ.2.17/3.1.00/36038 “Modernization of Practical Education of CTU FNSPE Nuclear Engineering students” provides an opportunity to innovate existing exercises and set up new experimental exercises. The Department of Dosimetry and Application of Ionising Radiation has prepared or innovated the following exercises: The statistical character of radioactive decay; The anti-Compton spectrometer; n-γ pulse-shape analysis; 60Co-activity measurement by coincidence method; TL dosimetry and radiochromic films; and Time spectrometry as a coincidence substitute. We have selected two exercises for presentation here.The “Statistical character of radioactive decay” exercise demonstrates that the number of decays (or pulses) per unit of time is a random variable following a Poisson distribution. Thanks to MCS (multi-channel scaler) adopted five years ago, students have been able to perform a large number of measurements (10 000), and they obtain results with low statistical uncertainty. Our recent innovation is based on measuring the time between a randomly selected point in time and the arrival of the pulse. This time is also a random variable, but it follows a Pascal distribution. This exercise employs only a time-to-amplitude converter (TAC) and a multi-channel analyser (MCA) and some basic NIM modules. Nevertheless, the results are convincing.The students use a double-source method for GM detector dead-time (τ) measurement. The method is reliable if we assume a low count-rate, and non-cumulative and constant dead-time. However, there is a pedagogical flaw – the method lacks an illustrative nature. The student has to accept that the dead-time exists and is non-cumulative. Believing this, he obtains a system of 4 equations with 4 unknowns. The student calculates τ by solving these equations.We therefore decided to introduce a different method, which is based on time spectrometry. The students measure the time spectrum between two consecutive pulses using a delay line, a TAC, a discriminator, and an MCA. A clearly visible gap can be seen between time 0 and τ in the spectrum. Thus, it is obvious that, after the pulse, the next one cannot be detected for a certain time (τ); it is not just a matter of “believing”. Additionally, we show the students that the assumption of dead time constancy has only limited validity. Finally, the same experimental setup can demonstrate the existence of satellite pulses, if there is imperfect quenching.

THE VALUE OF EXCHANGE VISITS OF STAKEHOLDERS IN THE EDUCATION AND TRAINING PROCESSES IN THE AREA OF RADIATION PROTECTION AND SAFETY CULTURE

Tatiana Ďúranová, Jarmila Bohúnová

VUJE, a.s.

Exchange visits offer a bundle of benefits, well beyond just acquiring information. The value of exchange visits of stakeholders in the education and training processes in the area of radiation protection and safety culture is demonstrated on the activities performed within the EC projects NERIS-TP and PREPARE under the umbrella of the European NERIS Platform. The technical visits to the affected regions of Belarus close to Chernobyl NPP as well as Fukushima Mission 2013 on the FAIRDO and ISAP 2013 in Japan illustrate well the methods of wide range of stakeholders engagement and involvement in the area of radiation control and practical radiological culture and their benefit in the education and training process. These visits have created common understanding, relationships forged in the hardships of shared experience, commitments to new approaches, and friendships as foundation for future networking. Technical visits allowed Slovak stakeholders and Belorussian hosts to focus time and attention on a topic, learning deeply, sharing ideas, and assessing the relevance of new approaches in the area of the post-accident management and rehabilitation with the main goal of improvement both national and local plans for preparedness and recovery. The essential information came alive, in dialog, was detailed in response to specific queries, conversations were enriched by the perspective of distance and difference. The chance to look behind the scenes, to get acquainted with real people, understanding their problems and achievements have created inspiration to keep working and launch new initiatives in both countries. The shared experiences of all participants will contribute to the enhancement of nuclear or radiological emergency preparedness and post-accident recovery and will make the process of stakeholders involvement at all levels from local through regional to the national more complex, comprehensive and meaningful. The experiences from the process of overcoming the consequences of the Fukushima Daiichi nuclear disaster using the post-Chemobyl experience have confirmed the importance of the improvement both national and local plans for preparedness and recovery. The technical or study visits for education and training purpose are valuable in the process of enhancement of the radiation protection and safely culture.

EMERGENCY RESPONSE EXERCISE OF LABORATORIES EQUIPPED WITH GAMMASPECTROMETRY

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Seven laboratories equipped with semiconductor gamma spectrometry (HPGe detectors) are currently included in the Radiation Monitoring Network (RMN) in the Czech Republic. These laboratories have more than 30 spectrometric chains and approximately 20 \"experts\" and 70 \"users\" who would guarantee measurements during the radiological emergency (RE). The emergency exercise was carried out in 5 of them in 2014 (in 4 of them also in 2013). The aim was to test repeatedly their capacity in existing technical facilities and with current staff in the event of a RE and identify problems (bottlenecks) in the whole process from receipt of samples to entering the results into the central database of RMN. Duration of the exercise was 12 hours, due to the shortage of staff; work in one 12-hour shift is presumed during a RE, which the laboratories should be able to provide for 14 days. These exercise samples covered a wide range of commodities that would probably come to the laboratories during the RE (aerosol filters, sorbents for sorption of gaseous forms of iodine, fallout, surface and drinking waters, food chain components and soils). Some of the samples were previously spiked with 85Sr, 88Y and 40K (in the exercise these nuclides represented actual contamination that would occur in RE); liquid samples were spiked with 85Sr and 88Y and bulk materials with 40K.During the exercise almost 800 samples were analysed; in addition, the automatic gamma counter (GA) in Prague laboratory measured other 90 samples automatically during the night (samples were prepared during the day-shift). On the basis of the results the total measuring capacity of the laboratories of RMN CR was estimated at about 1300 samples per day. The main limiting factor of the capacity is the shortage of staff. The most overextended and most time-consuming parts of the whole process were identified, mistakes, errors and shortcomings of measurements were evaluated (in determination of the activities, in registration parameters of the sample, in manipulation with high activity samples) and the causes were analysed. As a result of this exercise and others that will follow the laboratories will optimize their emergency response procedures, validate them and establish control systems.The experiment highlighted the fact that the exercise of this type should be repeated periodically, not only because of changes in the technical laboratory equipment and staff, but also in order to practice routine of “emergency” processes.We extend our thanks to all workers and colleagues from participating laboratories for making the research possible. This work was supported by the project funded by the Ministry of the Interior of the Czech Republic, identification code VF20102015014.

COMPANIES PORTFOLIO

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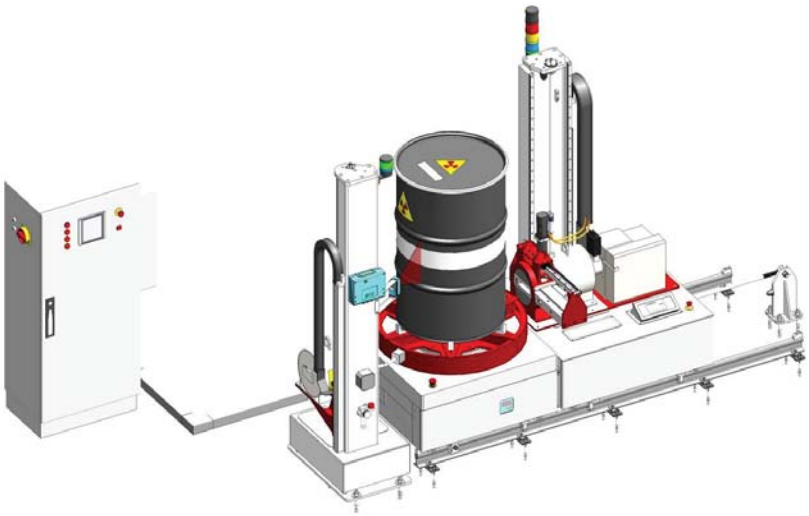

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Flexibilní řešení

Společnost VF je spolehlivým partnerem v oblasti radiační kontroly a ochrany. Partnerem, který **svým zákazníkům poskytuje flexibilní, technicky vyspělá a kvalitní řešení přizpůsobená na míru jejich potřebám**. Vysokou úroveň produktů a služeb nabízených společností VF zajišťuje tým odborníků se zkušenostmi s realizací řady různorodých projektů **v oblasti radiační kontroly a ochrany v České republice a mnoha dalších zemí po celém světě.**

Společnost VF disponuje kvalitním technickým vybavením, které jí umožňuje plnit vysoké nároky na kvalitu služeb a výrobků v oblasti radiační kontroly a ochrany za konkurenceschopné ceny. **Součástí technického zázemí společnosti jsou:**

- Technologické centrum pro aplikovaný výzkum a vývoj nových technologií, produktů a řešení v oblasti radiační kontroly a ochrany a následně zajištění sériové výroby zavedených produktů.
- Výrobní centrum zajišťující sériovou výrobu našich zařízení a kompletaci komplexních systémů.
- Akreditovaná metrologická laboratoř ionizujícího záření.
- Horká komora pro práci se zdroji ionizujícího záření vysokých aktivit.
- Školicí středisko pro předávání a výměnu zkušeností v oblasti radiační kontroly a ochrany.
- Realizační a servisní středisko, které zajišťuje realizaci projektů a poskytování servisních služeb, a to jak vlastních systémů, tak i systémů jiných výrobců.

Naši zákazníci:

- Jaderné elektrárny (Dukovany, Temelín, Bohunice, Mochovce, Paks, Kozloduy, Ignalina, Smolensk, Rovno, Fuqing, Fangjiashan, Lungmen, Metzamor, Atucha, Columbia).
- Přepracovatelské závody (Sellafield UK).
- Výzkumné ústavy (JRC Geel Belgie, ARC Seibersdorf Rakousko, UJV Rez ČR, IFJ Krakow Polsko, INRNE Bulharsko, KAERI Jižní Korea).
- Úložiště odpadů (Důl Richard ČR, Novi Han Bulharsko).
- Národní metrologické instituty (ČR, Slovensko, Litva, Bělorusko, Tádžikistán).
- Agentury pro ochranu životního prostředí (ČR, Slovensko, Rumunsko, Bulharsko, Makedonie, Pákistán, Čína).
- PET centra (Brno ČR, Bratislava Slovensko, Bydgoszcz a Kielce Polsko).
- Armáda a ministerstvo vnitra (ČR, Slovensko).
- Evropská komise, Evropská banka pro obnovu a rozvoj, IAEA.

Produkty a řešení společnosti VF

jsou rozděleny do následujících segmentů:

- Jaderná energetika a průmysl.
- Radioaktivní odpady.
- Zdravotnictví.
- Metrologie.
- Životní prostředí.

Zakázky realizujeme kompletně od zpracování studií, projektů a realizační dokumentace přes dodávku zařízení, vývoj a implementaci SW, instalaci a kompletní vyzkoušení systému na místě až po předání uživateli do provozu. Dále zákazníkům poskytujeme záruční a pozáruční servis.

Jaderná energetika a průmysl

Společnost VF je významnou mezinárodní společností v oblasti dodávek systémů radiační kontroly pro jadernou energetiku. Nabízíme kompletní řešení pro rekonstrukce i výstavbu nových bloků jaderných elektráren, pro výzkumné ústavy s výzkumnými reaktory, závody na přepracování paliva, úložiště radioaktivních odpadů a pro další zákazníky. **Nabízíme široký sortiment vlastních produktů i kompletní řešení systémů radiační kontroly a ochrany pro oblasti:**

- Monitorování pracovního prostředí a stavu technologie.
- Monitorování plynných a kapalných výpustí.
- Monitorování pevných odpadů.
- Monitorování osobních dávek a kontaminace na hranicích kontrolovaných pásem.
- Monitorování okolního životního prostředí.
- Přenosných přístrojů a laboratorních přístrojů pro měření vzorků.
- Kompletních měřicích, řídicích a informačních systémů.

Radiační kontrola a ochrana

Radioaktivní odpady a zdroje ionizujícího záření

V důsledku vyřazování dožívajících starších jaderných zařízení se dostává do popředí zájmu monitorování radioaktivních odpadů a jejich uvolňování do životního prostředí. Oblast radioaktivních odpadů a likvidace zdrojů ionizujícího záření se tak stává stále významnějším segmentem služeb a řešení.

Společnost VF nabízí pro tuto oblast řadu produktů zaměřených zejména na:

- Monitorovací systémy pro uvolňování radioaktivních odpadů do životního prostředí.
- Systémy pro radionuklidovou charakterizaci radioaktivních odpadů a stanovení prostorového rozložení aktivity.
- Informační systémy a databáze radioaktivních odpadů, výsledků měření, výpočty a limitování uložené aktivity, sledování pohybu kontejnerů s radioaktivními odpady.
- Projektování a výstavba horkých komor pro práci s vysokými aktivitami do 2000 TBq Co-60.
- Dodávky, výměny, manipulace a likvidace zdrojů ionizujícího záření.

Zdravotnictví

Zdravotnictví využívá zdroje ionizujícího záření pro nejrůznější diagnostické a léčebné účely. **Společnost VF nabízí zdravotnickým zařízením služby a řešení v oblasti radiační kontroly a ochrany, jako např. jsou:**

- Dodávky monitorovacích systémů radiační kontroly pro PET centra.
- Dodávky ozařovačů pro lékařské účely.
- Kompletní legislativní a technická podpora na pracovištích se zdroji ionizujícího záření (radiodiagnostická pracoviště, radioterapeutická pracoviště a oddělení nukleární medicíny).
- Metodickou podporu při tvorbě místních radiologických standardů a nastavení diagnostických referenčních úrovní.

Služba osobní dozimetrie

- Kompletní servis.
- Moderní technologie i design.
- Vysoká stabilita a citlivost.
- Jednoznačná identifikace.
- Odolnost proti vlivům prostředí.
- Operativní vyhodnocování.

Školicí středisko

Školicí středisko společnosti VF se zaměřuje na pořádání odborných školicích akcí, seminářů, kurzů a konferencí v oblasti radiační ochrany a ionizujícího záření.

Cílem Školicího střediska je zejména poskytnout kvalitní zázemí pro:

- Odbornou přípravu zaměstnanců VF.
- Setkávání s odborníky z průmyslu a jaderné energetiky.
- Celoživotní vzdělávání pracovníků ve zdravotnictví.
- Získávání zvláštní odborné způsobilosti pro práci se ZIZ.
- Spolupráci při odborném výcviku studentů vysokých škol.
- Poskytování prostoru i jiným společnostem a organizacím pro pořádání vlastních školicích akcí formou pronájmu.

Metrologie

Produkty a služby jsou dlouhodobě ověřené provozem vlastní laboratoře a zkušenostmi s realizací obdobných pracovišť v České republice i zahraničí.

Zaměřujeme se na následující produkty:

- Kompletní dodávky kalibračních laboratoří pro metrologické instituty, jaderné elektrárny, armádu a civilní ochranu, jejichž součástí jsou ozařovače, kalibrační lavice, řídící systémy a související technologie.
- Systémy pro měření a standardizaci aktivity radionuklidů, vhodné pro zavedení národních standardů aktivity.

Životní prostředí

Monitorování přítomnosti radioaktivních látek v životním prostředí má v portfoliu společnosti nezastupitelné místo.

Nabízíme především:

- Automatické monitorovací stanice pro sledování dávkových příkonů a koncentrace radioaktivních látek v ovzduší či vodách, přizpůsobené pro práci ve složitých venkovních klimatických podmínkách.
- Systémy předávání dat a informační systémy pro národní centra sledující úroveň radiace v životním prostředí.

VF, a.s.
Svitavská 588, 679 21 Černá Hora, CZ, tel.: +420 516 428 611, fax: +420 516 428 610, info@vf.cz

VF, s.r.o.
M. R. Štefánika 9, 010 02 Žilina, SK, tel.: +421 415 072 411, fax: +421 415 072 410, info@vf.sk

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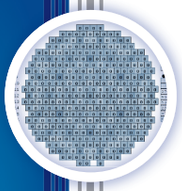
NUVIA GROUP

Společnost působící v oblasti jaderné energetiky, průmyslu, bezpečnosti a obrany, zdravotnictví a vědecko-výzkumných center.

INŽENÝRING, DODÁVKY A SLUŽBY PRO JADERNOU ENERGETIKU

VÝVOJ A IMPLEMENTACE SPECIALIZOVANÝCH SOFTWARE



RADIOMETRICKÉ SYSTÉMY A RADIAČNÍ MONITORING

LABORATORNÍ SYSTÉMY A TECHNOLOGIE

VÝROBA A SERVIS DETEKTORŮ IONIZUJÍCÍHO ZÁŘENÍ

AUTOMATIZACE V ENERGETICE A PRŮMYSLU

- Certifikace v souladu s mezinárodními standardy ISO 9001, ISO 14001, ISO 27001, ISO 20000-1 a OHSAS 18001.
- Postupy schválené Českým metrologickým institutem.
- Povolení Státního úřadu pro jadernou bezpečnost.
- Inovace založené na spolupráci se Státním ústavem radiační ochrany.
- Dlouhodobá spolupráce s ÚJV Řež, a. s., a Centrem výzkumu Řež s.r.o.
- Člen řídicího výboru LABONET – Mezinárodní sítě laboratoří pro charakterizaci radioaktivních odpadů organizované pod záštitou Mezinárodní agentury pro atomovou energii.
- Aktivní účast v EURAMET – Evropském metrologickém výzkumném programu pro nakládání s radioaktivními odpady.

Vybrané reference

- Radiační ochrana a radiometrické systémy pro jaderná zařízení a centra pozitronové emisní tomografie (PET).
- Charakterizace RAO z obou českých jaderných elektráren, uvolňování do životního prostředí.
- Provozování celostátní služby osobní dozimetrie autorizované k úřednímu měření v oboru dozimetrických veličin ionizujícího záření a neutronů.
- Vývoj nejmodernějšího stínicího materiálu bez použití olova.
- Inovace a výroba detektorů ionizujícího záření na bázi scintilačních krystalů NaI(Tl) a plastových scintilátorů (včetně projektu SuperNEMO).
- Vybavení staniček celostátní radiační monitorovací sítě a sítě včasného zjištění, technická a provozní podpora v režimu 24/7.
- Specializované informační systémy určené pro nakládání s odpady, evidenci jaderného paliva a jaderných materiálů.
- Vývoj a implementace informačního systému MonRaS pro činnost národního Krizového koordinačního centra.
- Spolupráce s Laboratoří jaderných problémů Spojeného ústavu jaderných výzkumů v ruské Dubně v oblasti optimalizace scintilačních detektorů.
- Vývoj systému charakterizace RAO a uvolňování do životního prostředí pro všechny ukrajinské JE.

ENVINET a.s., Modřínová 1094, 674 01 Třebíč, Česká republika, info@envinet.cz
ENVINET Slovensko, s.r.o., Piešťanská 8188/3, 917 01 Trnava, Slovenská republika, info@envinet.sk

www.envinet.eu

AFRAS Energo

AFRAS Energo s.r.o. je spolehlivým dodavatelem komplexních služeb v oblasti radiační ochrany. Navrhuje sofistikovaná řešení a spolupracuje s renomovanými výrobci zařízení. Ve všech svých aktivitách společnost využívá odborné know-how, nejnovější technické prostředky, měřicí zařízení a technologické postupy.

Investiční dodávky

- Realizace investičních projektů v oblasti radiačních monitorovacích systémů.
- Prodej přístrojů pro radiační ochranu, dozimetrických systémů, měřidel pro monitoring životního prostředí aj.

Inženýrské činnosti

Poradentství, technicko-obchodní řešení dodávek zařízení radiačních monitorovacích systémů pro realizaci investičních projektů.

Servis RMS

Komplexní zajištění údržby zařízení radiačních monitorovacích systémů v jaderných elektrárnách.

Společnost AFRAS Energo je výhradní zástupce firmy SAPHYMO na území ČR a Slovensko. Výrobky značky SAPHYMO jsou určeny pro radiační ochranu a kontrolu. Portfolio výrobků firmy SAPHYMO pokrývá široký záběr odvětví, jako je provozní dozimetrie, detekce záření a monitorování prostředí. Vyznačují se vysokou kvalitou a spolehlivostí. SAPHYMO je rovněž výrobcem portálových monitorů, určených pro detekci a měření radiace nákladu u vozidel a vlaků.

ADR
European Agreement

KOMPLEXNÍ RADIAČNÍ SERVIS

AFRAS Energo s.r.o.
JE Temelín – ATB 5
373 05 Temelín, Česká republika

tel.: +420 381 105 340
fax: +420 381 105 329

e-mail: info@afras-energo.cz
www.afras-energo.cz

Nejnovější spektrometry

GT-40, GT-40S Víceúčelový analyzátor záření gama

Aplikace

- Vyhledávání nerostů
- Průzkum nalezišť ropy a zemního plynu
- Geologický průzkum
- Geofyzikální mapování
- Určování obsahu K, U, Th a jiných zářičů v přírodním prostředí např. Cs-137, Cs-134
- Proměřování vrtných jader
- Monitorování životního prostředí

Vlastnosti

- Velmi citlivý 3x3" NaI(Tl) nebo 2x2" stíněný BGO detektor
- Precizní digitální DSP spektrometr
- Automatická stabilizace využívající přírodní pozadí
- Barevný, na slunci čitelný displej
- Jednoduché ovládání vícesměrovým ovladačem
- Bezdrátová komunikace přes Wi-Fi nebo Bluetooth
- Výsledky v reálném čase doplněné souřadnicemi z integrované GPS a hlasovým záznamem
- Kompaktní a robustní konstrukce

SR-10 Super identifikátor radionuklidů (RIID)

Aplikace

- Snadné vyhledávání zdrojů ionizujícího záření
- Citlivé měření dávkového příkonu
- Velmi přesné určení radioizotopů
- Možnost analýzy směsí různých zářičů
- Schopnost odhalení maskovaných zdrojů (terorizmus, pašování)
- On-line spolupráce s pokročilými analytickými systémy

Vlastnosti

- Velmi citlivý 2x2" NaI(Tl) detektor
- He-3 trubice pro detekci neutronů
- GM detektor pro měření vysokých dávkových příkonů
- Precizní digitální DSP spektrometr
- Automatická stabilizace využívající přírodní pozadí
- Pokročilý algoritmus pro vyhledávání a identifikaci radionuklidů

GEORADIS s.r.o.
Novomoravanská 321/41
619 00 Brno, ČR

e-mail: info@georadis.com
web: www. georadis.com
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1. inštalácie, údržby, opravy, prepravy, skúšky a prekládky rádioaktívnych žiaričov aj u zákazníka.
2. riešenie havarijných situácií a nehôd spôsobených stratou kontroly nad rádioaktívnym žiaričom.
3. odber ionizačných hlásičov požiaru, tranzitný sklad pre preskladnenie rádioaktívnych izotopov.
4. nakladanie s opustenými žiaričmi, rádioaktívnymi odpadmi neznámeho pôvodu a nepoužívanými rádioaktívnymi žiaričmi.
5. zmluvný servis defektoskopických zariadení a iných technických zariadení, v ktorých sa nachádza rádioaktívny žiarič. Predaj a servis zariadení pre defektoskopiu, likvidácia zariadení z ochudobneného uránu.

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JADROVÁ A VYRAĎOVACIA SPOLOČNOSŤ, A.S.
SPOLOČNOSŤ S NEZASTUPITEĽNÝMI ÚLOHAMI
V OBLASTI ZÁVEREČNEJ ČASTI JADROVEJ ENERGETIKY

javys

POSLANIE SPOLOČNOSTI

- prevádzkovanie, udržiavanie a vyraďovanie jadrových zariadení
- nakladanie s vyhoretým jadrovým palivom
- nakladanie s rádioaktívnymi odpadmi (RAO)

1. 4. 2006 začiatok výkonu činností
100 % akcií vlastní štát prostredníctvom Ministerstva hospodárstva SR

HLAVNÉ ČINNOSTI

- vyraďovanie jadrovej elektrárne A1
- vyraďovanie jadrovej elektrárne V1
- nakladanie s rádioaktívnymi odpadmi
- nakladanie s vyhoretým jadrovým palivom
- nakladanie s inštitucionálnymi rádioaktívnymi odpadmi a zachytenými rádioaktívnymi materiálmi
- úlohy v rámci prípravy nového jadrového zdroja

PRIORITY

- bezpečnosť
- kvalita
- ochrana životného prostredia

PRACOVISKÁ JAVYS, A.S.

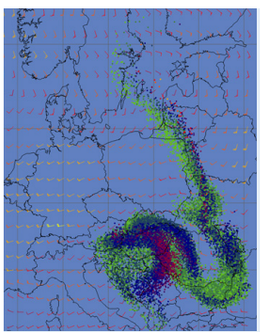
INTEGROVANÝ SYSTÉM MANAŽÉRSTVA

Jadrová a vyraďovacia spoločnosť, a.s., uplatňuje:

- systém manažérstva kvality ISO 9001
- systém environmentálneho manažérstva ISO 14001
- systém manažérstva BOZP OHSAS 18001
- systém manažérstva služieb IT ISO/IEC 20000-1

MicroStep-MIS

Monitorovacie a informačné systémy



RadMon – softvér pre radiačný monitoring

RadMon je softvér pre radiačný monitoring predstavujúci komplexné zákaznícke riešenia v oblasti kontinuálneho merania a vyhodnocovania príkonu dávkového ekvivalentu gama žiarenia, lokálneho i širšieho regionálneho významu. RadMon sa z technologického hľadiska i softvérovej architektúry pohybuje na veľmi vysokej úrovni. Softvér implementovala firma MicroStep-MIS aj na Úrade civilnej ochrany Slovenskej republiky.

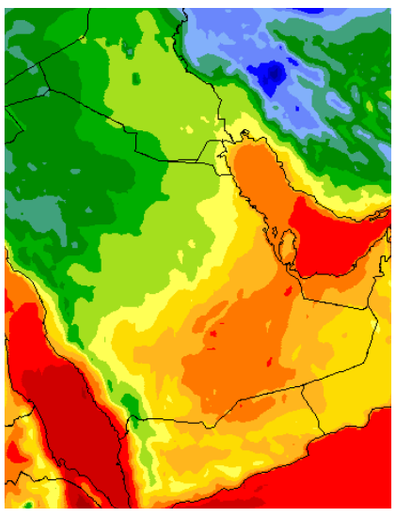
Radiačný monitoring pozostáva zo siedmich základných modulov: merací, konfiguračný, prezentačný, export dát, komunikačný, archivačný a alarmový.

Radiačná sonda RPSG-05

Vďaka širokému meraciemu rozsahu od **10 nSv/h** po **10 Sv/h** umožňuje sonda **RPSG-05** indikáciu minimálnych zmien, ako aj meranie extrémnych príkonov dávkového ekvivalentu gama žiarenia. V kryte tvaru valca, obsahuje sonda dva energeticky kompenzované Geiger-Müllerove detektory rôznej veľkosti a citlivosti.

Radiačná sonda je plne funkčná ako samostatné zariadenie pre trvalú montáž, ale i mobilné merania. MicroStep-MIS k sonde dodáva aj užívateľský softvér „RP Explorer“ zaručujúci komfortnú manipuláciu s dátami, ako aj exportovanie dát v rozličných formátoch.

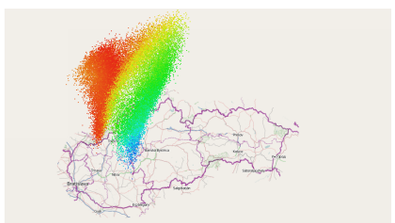
Sonda RPSG-05 potvrdzuje **špičkovú úroveň** certifikáciou podľa normy STN IEC 610117-1:2000.



Radiačná sonda typu RPSS

Sonda je určená na meranie príkonu dávkového ekvivalentu gama žiarenia v meracom rozsahu od 10 nSv/h po 1 mSv/h.

Sonda typu RPSS je **cenovo výhodná** a používaná na štandardné enviro merania.



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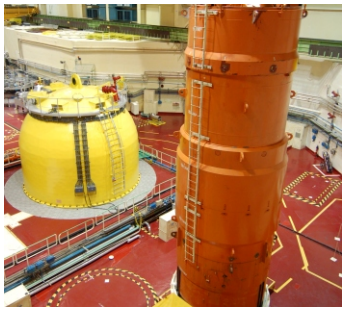
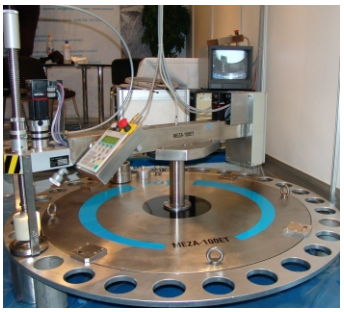
- PREDPROJEKTOVÉ ANALÝZY
- ŠTÚDIE REALIZOVATEĽNOSTI
- BEZPEČNOSTNÁ DOKUMENTÁCIA A PREDPISY
- VEDENIE PROJEKTOV
- FYZIKÁLNE A ENERGETICKÉ SPÚŠŤANIE
- HODNOTENIE ZARIADENÍ
- BEZPEČNOSŤ A SPOĽAHLIVOSŤ PREVÁDZKY
- PRÍPRAVA PERSONÁLU
- DIAGNOSTIKA
- UKONČOVANIE PREVÁDZKY
- LIKVIDÁCIA JADROVEJ ELEKTRÁRNE
- SPRACOVANIE RÁDIOAKTÍVNYCH ODPADOV
- VÝVOJ A NASADENIE MANIPULÁTOROV
- REKONŠTRUKCIA A MODERNIZÁCIA VYSOKONAPÄŤOVÝCH SIETÍ A ROZVODNÍ



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