NEWSLETTER

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EDITORIAL

The highlight of the 46th issue of the EAN Newsletter is an article on the collaboration between Norway and Russia for the clean-up of the Andreeva Bay legacy site (North West Russia). The project started in 2001 and involved the development of a set of scientific, practical and regulatory programs for radiation monitoring of the environment and workers, and emergency preparedness and response. The remediation work started in 2017 and continues today (**p. 2**).

The Italian ISS and INAIL present their reflexions on the implementation of the Euratom Directive 2013/59 in the Italian context when it comes to industries using NORM (**p. 9**) and how it fits with a 'graded approach' (a recurrent topic in EAN, see also **p. 20**). Regular readers of the Newsletter will be familiar with previous articles about the exposure of aircraft crew to cosmic radiation, and in this issue an analysis of the exposure of French aircraft crew in recent years is presented (**p. 11**).

In addition, the NERIS would like to present feedback from their 6th Workshop dedicated to the issue of "Operational and research achievements and needs to further strengthen preparedness in emergency management, recovery and response" (**p. 15**).

All in all, the articles in this Newsletter highlight how the ALARA principle is being tackled in a wide variety of circumstances including : legacy sites, NORM industries, cosmic radiation and post-accident situations.

We hope you will enjoy this Newsletter, which is made possible through EAN Members support.

The EAN Newsletter Editorial Board.
Sylvain Andresz, Julie Morgan, Fernand Vermeersch and Pascal Croüail
(P.S. do not hesitate to send your comments to the Board, cf. contacts **p. 21**).

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Theory and practice in the clean-up and the support of the supervision on legacy sites located in North-West Russia

N K Shandala[1], M K Sneve[2], A A Filonova[1], V A Seregin[1], P Strand[2], M P Semenova[1], K Siegen[2]

[1] State Research Center – Burnasyan Federal Medical Biophysical Center under FMBA of Russia, 123098, Zhivopisnaya str. 46, Moscow, Russian Federation

[2] Norwegian Radiation and Nuclear Safety Authority (DSA), 1332 Grini Næringspark 13, Østerås, Norway

Introduction

The most significant nuclear legacy site in the Russian Northwest is the former coastal technical base (CTB) of the Northern Fleet in Andreeva Bay, located 45 km from the Russian-Norwegian border. Release of radioactivity into the soil as well as uneven manmade contamination of the environment was caused by a radiation accident in 1982. Lack of proper maintenance of the infrastructure after operations at the CTB terminated led to the degradation of protective barriers and loss of containment of the storage facilities for spent nuclear fuel (SNF).

In 1999, the CTB status was redesignated as a site for temporary storage (STS) for SNF and radioactive waste (RW). At that time the environmental remediation began and a series of programs was implemented to set up the infrastructure for safe recovery of SNF from degraded stores storage and management of SNF. In accordance with progress on infrastructure improvements, plans were developed for large-scale operations at Andreeva Bay for SNF and RW recovery and preparation for transfer to PA Mayak.

Plans were divided into 3 stages:

1. SNF removal from the Dry Storage Units (DSU).
2. Removal of 6 spent fuel assemblies (SFA) from Building number 5.
3. Removal of RW accumulated during the previous operation of the site as well as other waste being generated at the stage of SNF removal.

In parallel with the above industrial projects, it was recognized as important to ensure safety through appropriate regulatory supervision; to update regulatory documents and procedures to be in line with latest developments in international recommendations and guidance, as adopted within the Russian regulatory framework, and to address the particular challenges associated with the complex legacy radiation situation.

2. Setting up of Regulatory Cooperation and Identification of Regulatory Priorities

In 2001 first discussions on cooperation between the State Research Center - A.I. Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency (SRC-FMBC) – technical support organization of FMBA of Russia – and the Norwegian Radiation and Nuclear Safety Authority (DSA, until 2019, the Norwegian Radiation Protection Authority, NRPA) in the field of radiation safety regulation at nuclear legacy sites at Andreeva Bay took place.

Work was set into the context of the long-term regulatory cooperation program and supported improved understanding of the radiation situation at STS Andreeva from a regulatory perspective and, in parallel, enhancement of the regulatory basis for operations at the site. Both parties decided from the beginning to take an innovative and holistic approach to the challenges associated with the STS. It was important to recognize the wide range of issues to be addressed in achieving effective and efficient regulatory supervision, to provide comprehensive protection of workers, the public and the environment. Priorities for regulatory attention were identified by carrying out an initial regulatory threat assessment [1].

Cooperation between SRC FMBC of FMBA and DSA continued further under an Agreement between the Ministry of Health and Social Development of the

Russian Federation and the Ministry of Health and Social Services of the Kingdom of Norway "On cooperation in the field of regulation of the safe use of atomic energy in conducting health and epidemiological supervision of radiation hazardous work" signed in 2008.

Several projects were implemented with the objective to ensure that remedial activity at Russian legacy sites and facilities is carried out within the framework of unified approaches to the radiation safety regulation, agreed with all interested countries. The outputs have included a range of drafted norms, standards, regulatory guides and procedures that address the unusual circumstances at the STS. They also include technical information on the radiation situation that supports independent evaluation of safety, as well as training and emergency exercises and the practical application of new technologies in challenging radiological situations.

In particular, work has been completed in the following key areas:

- Emergency preparedness and response.
- Operational safety and optimization.
- Site characterization and environmental monitoring. Detailed radiation survey at sites, territories and in the vicinity of the facility.
- Control of discharges and public exposure during remediation.
- Radiological Environmental Impact Assessment for: planned releases; accidents; transport; and treatment and storage of waste.
- Contaminated land management and support for long-term site restoration and waste management strategies
- Safety culture of the personnel and increasing their performance reliability in completion of hazardous operations.

As the regulatory framework for legacy management has been updated and improved, the next phase was to support regulatory supervision of their application.

3. Development and Application of Software

In the field of radiation safety and protection of the personnel, a software complex was created to reduce the uncertainty in assessments, speed the access to relevant dose information for work planning and optimize radiation exposure.

Andreeva Planner is one of the tools introduced on the site under the program, it is software for dynamic three-dimensional simulation of radiation-hazardous operations with visualization of the radiation situation in real time and dose calculation of work participants. The analytical capabilities of the developed software assists in the creation and simulation of different scenarios for radiation hazardous operations, as well as in calculating both individual effective doses of each of the virtual participants in the work and collective doses.

Another tool, EasyRAD is an information and analytical system of personnel radiation safety, providing structured data accumulation, data analysis and visualization of results. The system provides analytical tools to help in operational decision-making: building dose rate maps, exposure-based zoning of the areas within buildings and across the site, and occupational dose assessment.

Calculations in the EasyRAD software are based on the measured values of the ambient dose equivalent rate. The use of graph theory in EasyRAD helps to lay out routes for personnel movement, identify most suitable reference monitoring points, and plan the decontamination of road surfaces [2, 3]. The EasyRAD software system developed within the cooperation program. Its efficient algorithms for effective analysis of past and possible future radiation situations, provide clear benefits in radiation control planning for future hazardous operations, and in the context of emergency preparedness and response.

In 2017 work to improve the infrastructure was finished and it was decided to start the active phase to recover and remove non-damaged (normal) SNF from its degraded stores, and substantial transfers took place. Both Andreeva Planner and EasyRAD have been used since then to support optimization and wider management decision making and control exposure of workers to within the specially developed reference levels for these hazardous operations [4-5].
To ensure radiation protection of workers and the public during the process for extraction of SNF from DSUs and transport operations, regulatory review

has been carried out of the Environmental Impact Assessment (EIA). The proposed technological plan and safety justification for management of normal and abnormal SNF at STS Andreeva was analysed and approved following discussion and amendment. Regulatory documents on safe management of normal SNF have been developed on:

- Radiation monitoring.
- Planning of radiation hazardous operations.
- Implementation of the personnel protection optimization principle.
- Established reference levels.
- Selection of workers to carry out radiation hazardous operations.
- Arrangement of education and training of the personnel.
- Enhancing safety culture.

Radiation parameters have been checked during test removal of SNF and occupational doses assessed.
The radiation safety of STS largely depends on the professional reliability of the personnel involved in nuclear and radiation hazardous operations. In this regard, an important area of cooperation is the development and implementation into everyday practice of a hardware and software complex for monitoring the professional reliability of workers involved in SNF and RW management operations [6-8]. In the course of the work, four components of the system were developed: 1) periodic psycho-physiological examinations; 2) pre-shift monitoring / control; 3) support the training of the personnel in carrying out specific hazardous tasks; 4) professional selection / choosing of specialists. When developing these components, priority was given to contactless digital methods for assessing the psycho-physiological conditions of workers.

The system of personnel reliability monitoring has been successfully implemented in pre-shift monitoring and in training in hazardous operations. Testing has shown that the newly applied vibro-image data technique compares reasonably with conventional methods. The duration of this test is about one minute compared to 2-3 hours by conventional methods, which is a significant practical advantage.
Laboratory tests in SRC-FMBC have been carried out to assess the abilities of the students/testers to develop self-regulation skills. The relation between the parameters of electro-physiological signals with those of the speed and quality parameters of the trained activity has been revealed and described. The data obtained so far are preliminary, so it is reasonable for studies in this area to be continued. Moreover, a method for radiation safety culture assessment has been developed and internal assessment of such a culture at the STS Andreeva has been performed [6, 7].

4. Independent Monitoring and Field Work

For the successful implementation of the long-term process of regulating large-scale remedial activities at STS, a significant amount of complete and sufficiently structured information on the dynamics of the monitored parameters of the radio-ecological situation, as well as other associated data, is required. The environmental monitoring program has provided key data on the continuing situation regarding both chemical and radiological contamination and their dynamics. The receipt and accumulation of this information is carried out during radiation health physics monitoring. To structure radio-ecological information and analyze changes in the state of environmental contamination during remedial activities, information systems have been developed that include detailed stores of data on environmental media contamination [9].

Comparative analysis of the field work data allows representing the dynamics of changes at the facility, identifying areas of radioactive contamination of the environment, and optimizing monitoring studies. The current research results allow us to state that a change in the radiation situation at the Andreeva Bay facility is characterized by a positive dynamic in the reduction of manmade radionuclides as in environmental media, including the offshore sea area. Gamma dose rates over the site have changed little over the period of surveillance. The main changes in dose rate have been temporary and relate to identified planned operations, such as the installation of the biological shields at DSUs. Measurements of chemical forms indicate the potential for mobilization of Cs-137 and Sr-90; however, the results of time series monitoring indicate that contamination remains largely localized.

Analysis of groundwater samples from wells across the site indicate a range of chemical contaminants is present, with some contaminants being more than maximum permissible concentrations. Activity concentrations of Cs-137 and Sr-90 are also more than intervention levels in some samples. Both cytotoxicity and genotoxicity of groundwater samples has been demonstrated. However, the lack of double chromosome aberrations, frequently seen as radiation-induced biomarkers, indicates that chemical pollutants are likely responsible for the effects observed.

The analysis of fluctuating asymmetry of the birch leaves sampled on the site indicates a significant change in the state of plants. This could be due to their growing within the territory, but also because the site is on the edge of the species range.
Assessment of the Jaccard coefficient of floristic similarity in different areas indicates that species diversity across the site is small. Future changes to the coefficient could indicate a change in relative environmental quality, or just that they have evolved differently following the previous industrial or other disturbance. However, any such changes could be considered as a basis for further investigation as to the cause.

Continued monitoring will ensure that any changes to the radiation and environmental situation during continued SNF and RW activities are detected and any changes indicating ecological impacts detected, e.g. through changes in biodiversity indices.

5. Improvement of Emergency Preparedness and Response

To improve the emergency preparedness and response system at the STS Andreeva four emergency exercises have been held that have demonstrated the operation of controls and the emergency response system of Northwest Center for Radioactive Waste Management "SevRAO" and institutions under FMBA in case of a radiological accident [10, 11]. In combination, the exercises have improved arrangements for closer cooperation between operator and regulator when developing urgent decisions and recommendations on taking protective measures. In particular, the exercises tested:

- Expert assessment of the radiation situation and potential radiological consequences, to prepare recommendations for the management bodies, including the necessary counter-measures;
- Activation of the emergency preparedness system of FMBA in the region and, based on the findings of the exercise, to improve the preparedness of institutions under FMBA;
- Capabilities of forces and means of the responding bodies to the public of the region; and
- Procedure of the International Atomic Energy Agency (IAEA) and Scandinavian countries for notification of a radiological accident in real time mode in accordance with the current agreements at local, territorial and federal levels.

Results indicate that there is a high level of cooperation between emergency teams under FMBA and Rosatom, and preparedness of institutions under FMBA for medical care of injured persons. Valuable experience was obtained in the use of computer simulation methods for the purpose of radiation scenario and radiation situation assessment as well as visualization of radiation situation data and planning radiation hazardous operations with AndreevaPlanner and EasyRad. Representatives of many interested ministries and departments took part in the emergency exercises and special films were created for each exercise.

Based on the results of monitoring and assessing existing risks, special regulatory documents have been developed that consider the specifics of the facility at Andreeva Bay [12], that include:

- Requirements for the individual dose monitoring procedure;
- Requirements for radiation safety and protection of the personnel and population;
- Guidelines for the RW management including the very low-level waste category;
- Requirements for remediation of sites;
- Requirements for the radiation monitoring procedure in the vicinity of the facility;
- Requirements for monitoring of the environmental media etc.

Information from the regulatory program has always been shared widely with the international community, through participation in focussed collaborative discussions on legacy issues (e.g. at the

Nuclear Energy Agency Expert Group on Legacy Management [12]), workshops and conferences, and publication of program results in peer reviewed journals, e.g. [13]. A set of scientific and practical work in the field of regulatory supervision during the remediation of STS Andreeva was key input to the International IAEA Forum on the Regulatory Supervision of Legacy Sites (RSLS). The Forum has been successfully operating over the recent years as a platform for discussing the results achieved by IAEA Member States [14]. The results of the work have also been used as input to the task group of the International Commission on Radiological Protection (ICRP) that is addressing the application of the ICRP recommendations to existing exposure in areas contaminated by past activities.

Conclusions

A major achievement of cooperation over the years has been a significant reduction in the hazard at STS Andreeva, due to retrieval from the degraded old stores, emplacement in modern containers and transfer off-site of substantial amounts of SNF. The first substantial transfers of SNF took place in 2017 and it was acknowledged that international cooperation had resulted in the work being carried out safely and more quickly than otherwise possible. Continued progress with preparations for removal of remaining SNF is reported as being in line with or better than expected. The work is not complete and continues in the context of recovery and shipment of the more problematic degraded SNF.

The progress demonstrates the advantages of a stable long-term policy of hazard reduction and a strategy to implement it. Regulatory cooperation is a vital component, working within a flexible framework that makes it possible to address newly recognized challenges while still maintaining strict control over all risks.

Altogether 30 regulatory documents and procedures were developed and approved, giving comprehensive coverage of all radiation protection issues, including reconstruction and engineering work on site, personnel and environmental monitoring, emergency preparedness and response in case of accidents and overall improvement in safety culture. Innovative visualization tools were developed as well as techniques for monitoring personnel reliability. In addition, independent monitoring of the radiation situation and its dynamics was carried out. The experience gained during the remediation of STS Andreeva has helped to identify new relevant areas for improving regulatory supervision at other nuclear legacy sites. The cooperation between SRC-FMBC and DSA in the field of radiation safety regulation in STS Andreeva continues, based on the results of an updated regulatory threat assessment. The most recent developments have been reported in reference [15], alongside a description of how the work is linked to wider international cooperation.

■

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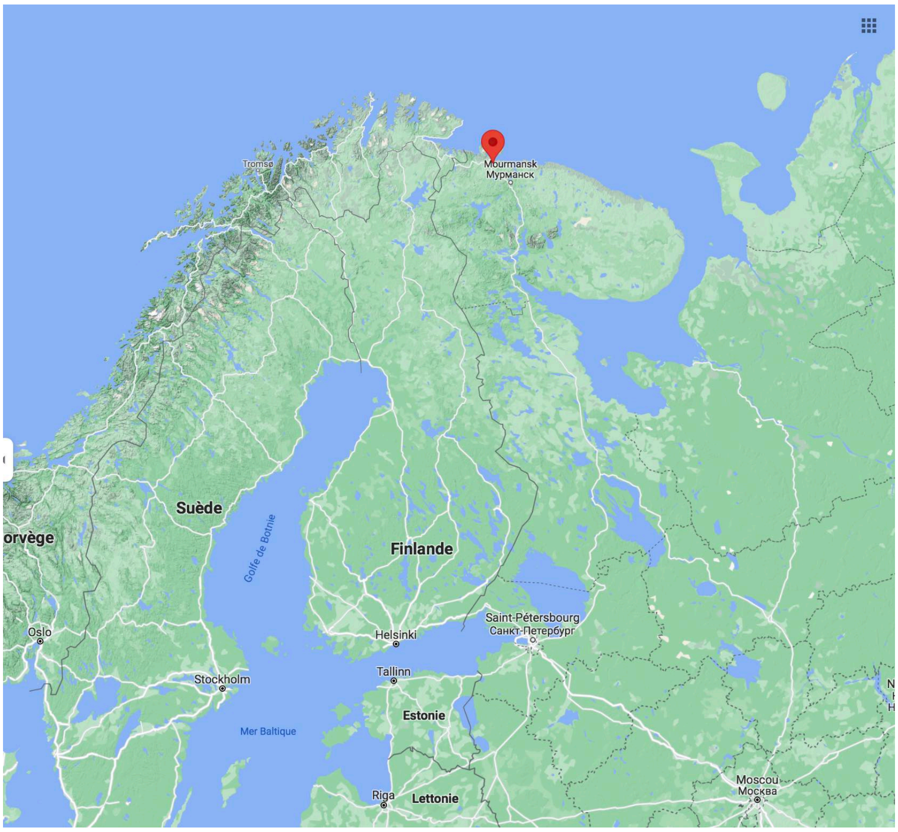

Location of Andreeva Bay, north-west Russia, © Google Maps

The Italian transposition of the EU BSS for NORM involving industries

Cristina NUCCETELLI
Istituto Superiore di Sanità (Italian National Institute of Health) - National Center for Radiation Protection and Computational Physics
Rome, Italy

Rosabianca TREVISI
National Institute for Insurance against Accidents at Work (INAIL), DiMEILA, Monteporzio Catone
Rome, Italy

Introduction

The Italian transposition of the 2013/59/Euratom Directive (Italian Legislative Decree 101/2020) was published on 12th of August 2020 and it went into effect on 27th of August 2020. Indeed, a short list of NORM involving industrial sector was already given in the Italian former legislation (the transposition of 96/29/Euratom Directive): the former list has been updated and extended in order to take into account the industrial sectors listed in Annex VI of 2013 EU BSS and Italian specific industrial activities.

In the Italian context, the list of activities is presented in Table 1. The most important new entries in the Italian legislation about NORM are:

1. General exemption and clearance criteria in terms of dose and activity concentration
2. Classification of NORM residues
3. Authorized landfills
4. Commodities

Table 1. — The list of the Italian industrial sectors and practices

Industrial sector	Class of practice
Coal-fired power plants	- Maintenance of boilers
Mining of ores other than uranium ore	- Extraction of granitoids (granites, ortogneiss, tuff, pozzolana, basalt, porphyry, lava)
Zircon and zirconium industry	- Processing of zircon sands - Production of refractories, ceramics and tiles - Production of zirconium oxide and metallic zirconium
Mineral processing and primary iron production	- Extraction of rare earths from monazite and of aluminium from bauxite - Extraction of tin, lead and copper - Processing of iron/niobium from pyrochlore ore of iron/tantalum - Use of potassium chloride as additive in metals extraction by fusion
TiO2 pigment production	- Management and maintenance of titanium dioxide production plants
Processing of phosphatic and potassium minerals	- Thermal phosphorus production - Phosphoric acid production - Production and wholesale of phosphate and potassium fertilisers - Production and wholesale of potassium chloride
Cement production	- Maintenance of clinker ovens
Production of thorium compounds and manufacture of thorium-containing products	- Production of thorium compounds and manufacture, management and conservation of thorium-containing products, in particular welding electrodes with thorium, optical components having thorium and nets for gas lamps
Geothermal energy production	- Maintenance of high or medium-enthalpy geothermal energy systems
Oil and gas production	- Oil extraction and refining, gas extraction, in particular to the presence of muds and scales in pipes and oil containers
Ground water filtration facilities	- Management and maintenance of facilities
Paper mill	*- Maintenance of pipes*
Cutting and sandblasting process	*- Plants using abrasive sands or minerals*

General exemption and clearance criteria

The general dose criteria for the exemption of practices from notification and/or for the clearance of materials from practices are reported in Table 2.

Table 2. — General exemption and clearance criteria in terms of dose

	EU BSS	Italian legislation
Workers	1 mSv/y	1 mSv/y
Members of the public	1 mSv/y	300 µSv/y *

* For members of the public, the same dose criterion of 300 µSv/y of the former legislation has been maintained

The assessment of doses to members of the public takes into account pathways of exposure through airborne or liquid effluent, and pathways resulting from the disposal or recycling of solid residues.

Exemption and clearance levels

Exemption and clearance levels in terms of activity concentration were verified, considering scenarios from RP 122 II.

Table 3. — Values for exemption (ELs) for NORM in solid materials in secular equilibrium with their progeny

Radionuclide	Value for exemption (ELs)
Natural radionuclides from the U-238 series	1 kBq/kg
Natural radionuclides from the Th-232 series	1 kBq/kg
K-40	10 kBq/kg
Po-210 or Pb-210	5 kBq/kg

In all cases, the respect of values of ELs in Table 3 ensures the respect of Exemption and Clearance Level in terms of dose with two exceptions: road construction and disposal in landfills. For these scenarios, special ELs have been set at 50% of values reported in Table 3. Higher values are allowed if it is demonstrated that the general dose criterion for members of the public of 300 µSv/y is satisfied. Other exemption and clearance levels for specific conditions are:

- For oil sludge the exemption values are 5 times higher than the ones reported in Table 3 and 100 kBq/kg for U-nat, Th-230, Th-232, Po-210 or Pb-210 and 10 kBq/kg for Ra-228
- In case of incineration of residues, a scenario not considered in RP 122 II, the practice is exempted if it is verified that the general dose criterion for members of the public is satisfied, and also in cases where the radiological contents of different radionuclides are below the ELs.

According to the EU BSS, values for exemption are not valid to exempt the incorporation of NORM residues into building materials.

Solid Residues

The new law for the first time introduces a classification of NORM residues in the Italian radiological protection system. NORM residues are classified as exempted or not exempted based on their radiological content and/or the compliance with the dose criterion of 300 µSv/y. If they can be considered exempted, NORM residues can be disposed in conventional waste landfills, but the compliance with legislation about conventional waste management is required. However, notified practices need to be authorized for the disposal, reuse or recycling of exempted NORM residues. In Table 4 the scheme -based on graded approach- applied to NORM residue management is reported.

Table 4. — Classification of NORM residues

NORM residue (class)	Exemption Level (ELs)	Destination
Exempted residues	< 50% of ELs	NO restriction for any recycling or reuse and disposal in conventional waste landfill*
Exempted residues	Between 50% of ELs and ELs	NO restriction for any recycling or reuse and disposal in conventional waste landfill * if dose < 300 µSv/y

Not exempted residues	> ELs	Disposal in Authorized landfills

*compliance with legislation about waste management is required

Not exempted NORM residues can be disposed in landfills for hazardous waste according to Council Directive 1999/31/EC and European Directive 850/2018, if the following requirements are fulfilled:

- NORM residues have to be disposed in separated and dedicated cells
- natural or artificial geological barriers are present
- disposed residues are daily covered with clay
- full cells are closed with stable capping

However, for these landfills, to store not exempted NORM residues, it is mandatory that a preventive authorization is issued by the Prefect (the leader of an administrative area), after consultation with the local environmental and health authorities.

Commodities

As in EU BSS, the Italian legislation lists types of existing exposure situations. Among them it is included the exposure to commodities, excluding food, animal feeding stuffs and drinking water, incorporating naturally-occurring radionuclides.

Final remark

In summary, the scheme of the EU BSS Italian Transposition about NORM follows a «graded approach», as required by EU BSS. Indeed, in case of practices, procedure of exemption from notification is possible in two stage, i.e. firstly in terms of activity concentration and, if exemption levels in Table 3 are not complied, in terms of dose (see Table 2). Only in cases where the effective doses of workers and members of the public exceed the levels in Table 2, is notification required and the undertaker then has to adopt provisions about the protection of workers and of members of the public. Another graded approach application can be found in the introduction of NORM residue classification (see Table 4) and the institution of authorized special landfills which can accept not exempted NORM residues.

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Aircrew exposure to cosmic radiation – Data update from France

Sylvain ANDRESZ
Nuclear Evaluation Protection Centre (CEPN)
92260-Fontenay-aux-Roses, FRANCE

Introduction

In EAN Newsletter 36 (2015), the results of a survey on the regulatory approach to radiological protection of aircraft crews exposed to cosmic radiation was published [1]. The survey was also an opportunity to collect figures related to aircraft crew exposure, later referenced in International Commission on Radiological Protection (ICRP) publication 132 *Radiological Protection of Aircraft Crew against Cosmic Radiation Exposure* the [2].

In 2016, another EAN survey collected flight crew exposure data over the 2009-2015 period from 9 countries and the results presented in the EAN Newsletter 39 (2017) [3]. Differences in average and maximum exposures were explained by the type of flight destinations, notably a correlation between the exposures of the aircraft crew of a given country and the number of distant (i.e. non- European) and/or high latitude destinations reachable by direct flight from this country was established. The average exposures were decreasing in general, especially for French and German aircraft crew (numerous population). Finally; it was judged interesting "to *continue to monitor the exposure of aircraft crew and evaluate any changes observed during the next solar minimum (~2017–2021)*".

The purpose of this article is to provide an update on the aircraft crew exposure to cosmic radiation. The data from France have been used.

Result of the exposure of French aircraft crew to cosmic radiation

In October 2021, The French Institute for Radiation Protection and Nuclear Safety (IRSN) published the results of the individual monitoring of occupational exposure to ionizing radiation for the year 2019 [4]. Page 111-112 of the report show a synthesis of the exposure of the aircraft crew in 2019 (N=24 429) and indicate that other data are displayed in an interactive fashion on a dedicated website [5]. On this website, data associated to the exposure of the French aircraft crew for the 2015-2020 period are available and some of these data have been extracted and are presented in Figure 1.

From 2015 to 2019, the data reveal that the number of aircraft crew monitored has increased and, in parallel, the number of crew exposed between 1 to 5 mSv/y. The number of workers exposed > 5 mSv/y has notably increased over the years: it was 0 in 2015, 4 in 2016 and reached 91 in 2019. Nonetheless, their proportion to the total remain very limited (< 0.4% of the total). In 2020, all these numbers have dramatically fallen.

In addition, the IRSN's data have been used to calculate a "mean individual dose" (Table 1).

Table 1. — Mean individual dose of aircraft crew

Years	Workforce [5]	Collective dose (man.Sv) [5]	Mean individual doses^A
2015	19,565	38.65	1.98
2016	19,875	40.7	2.05
2017	22,600	46.9	2.08
2018	23,356	48.7	2.09
2019	24,425	53.44	2.19
2020	21,949	22.38	1.02

A Dividing the collective dose by the number of workers.

According to these calculations, the mean individual dose has also increased from 2015 to 2019, and then fallen in 2020.

Elements that can explain the trends

The aircraft crew are exposed to cosmic radiation, which is tempered by the atmosphere. The latitude also comes into play. The individual exposure increases with the time spent in the plane and the dose rate: the higher the altitude and/or the latitude, the higher the dose rate. Elevated solar activity can also decrease the ambient dose rate. The collective dose is influenced by the number of workers and their individual exposure.

The national company Air France made public several of its data reports on the web [7]. Notably, Figure 2 presents the number of passengers transported by the company: for short/middle range flights, for long flights and also the seat occupancy. From 2015 to 2019, these 3 indicators have increased. As more passengers are being transported, more workforce is needed on-board and need to be hired, increasing both the number of people monitored, their individual exposures (especially for those assigned to long-distant flight) and the collective dose of the workforce.
In 2020, the number of passengers transported dropped dramatically because of the restrictions of flight travel implemented in the context of the Covid-19 pandemic: less flights and less passengers, therefore less aircraft crew monitoring and diminution of their exposure.

The IRSN provided a focus on the 100 most-exposed aircraft crew for the 2015-2019 period in a stand-alone document [7] and concluded that the most exposed are crew (specially: pilot and steward/hostess) in big planes assigned to long-distant flights (USA, Asia in the French context).

But how to explain the notable increase of the exposure of the most exposed aircraft crew? According to IRSN in [7], the average time of flight of the most exposed aircraft crew has increased but "*slightly*" from 740 h/y in 2015 to 753 h/y in 2019. This is indeed a minor increase (+1.7 %) difficult to correlate with the significant increase in the number of crew exposed > 5 mSv/y. IRSN has acknowledged that the solar cycle could also play a role: the lower the solar activity, the higher the exposure from cosmic radiation (because the more energetic cosmic radiation coming from outer space are less deviated by the Sun magnetosphere). The solar activity follows an 11-year cycle and the solar activity was lower in the 2015-2019 period, in the second part of Solar Cycle 24 (the solar activity was higher from 2010 to 2015 in the first part of the cycle).

To confirm the IRSN's hypothesis, the SIEVERT-PN software [8] was accessed to calculate the dose received for different representative flight routes from 2014 to 2020 (Table 2. The average ambient dose rates have then been calculated (Figure 3). The SIEVERT-PN is used to calculate the dose of the aircraft crew reported to the Authority (but public can also used the tool). The result of SIEVERT-PN comes from modelling, validated every month by ground and on-board measurements [8].

Table 2. — Exposure (mSv) for different representative flight routes calculated with SIEVERT-PN.

	Dose from Paris to ...				
	Tokyo	**San Francisco**	**Washington**	**New York**	**Bueno Aires**
Flight Time	11h55	11h45	9h	8h35	13h50
2014a	0.0695	0.0744	0.0538	0.0508	0.0343
2014b	0.0611	0.0713	0.0517	0.0482	0.034
2015a	0.0764	0.0816	0.0594	0.056	0.0355
2015b	0.0727	0.0816	0.0561	0.054	0.0349
2016a	0.0787	0.0838	0.0595	0.056	0.0359
2016b	0.0855	0.0926	0.0644	0.0606	0.0368
2017a	0.0899	0.0998	0.067	0.063	0.0375
2017b	0.0931	0.1023	0.0688	0.0647	0.0376
2018a	0.0901	0.0979	0.0688	0.0631	0.0376
2018b	0.095	0.1038	0.0703	0.0661	0.0379
2019a	0.0967	0.1069	0.0715	0.0666	0.0381
2019b	0.0956	0.1075	0.0718	0.0666	0.0382
2020a	0.0991	0.1086	0.0723	0.0679	0.0383
2020b	0.1019	0.1017	0.0733	0.0688	0.0385

a= calculation made in January or February of the year;
b= calculation made in June or July of the year.

The flight total doses and the dose rates have clearly increased on the 2014-2020 period, especially those associated to the flights with the higher latitudes (to USA and Asia, which came near the North Pole) while the increase is less visible with the trans-equatorial flight (to Bueno Aires). All factors being equal, the only explanation to the overall increase of the ambient dose rates in planes is the diminution of the solar activity on this period.

Synthesis

As more passengers have been transported by flight from France in the last years, the aircraft crew workforce has increased in parallel. The collective dose, the mean individual doses and the number of workers exposed > 5 mSv/y have notably increased from 2015 to 2019. Different factors explain this general shift of the distribution of exposures toward higher values: more time spent in the air, especially for long-distant flights to North America and Asia, and a general increase of the ambient dose rate at high altitude related to the diminution of the solar activity over the period. In 2020, the severe diminution in the flight traffic because of the Covid-19 pandemic resulted in a drop of the number of people exposed and the magnitude of their exposure. Pandemic apart, and in application of the ALARA principle, careful planning of the flight schedule (ex. sharing the flight with the higher dose rate among the workforce) could result in a diminution of the dose (of the most exposed individuals).

■

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[8] SIEVERT is accessible at https://www.sievert-system.org/?locale=en

FIGURES. —

Figure 1. — Distribution of the exposure of the French aircraft crew from 2015 to 2020.

Figure 2. — Number of passengers for short, mid and long-range flights and seat occupancy.

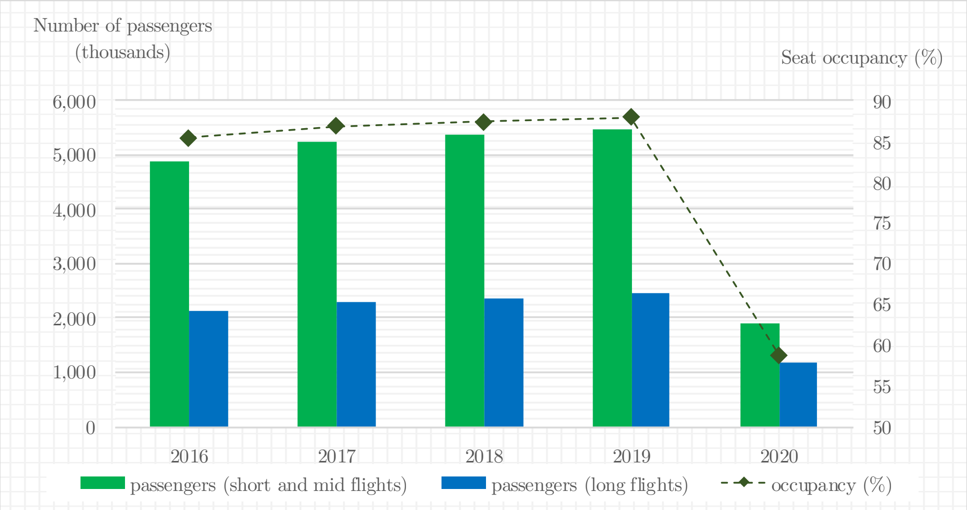
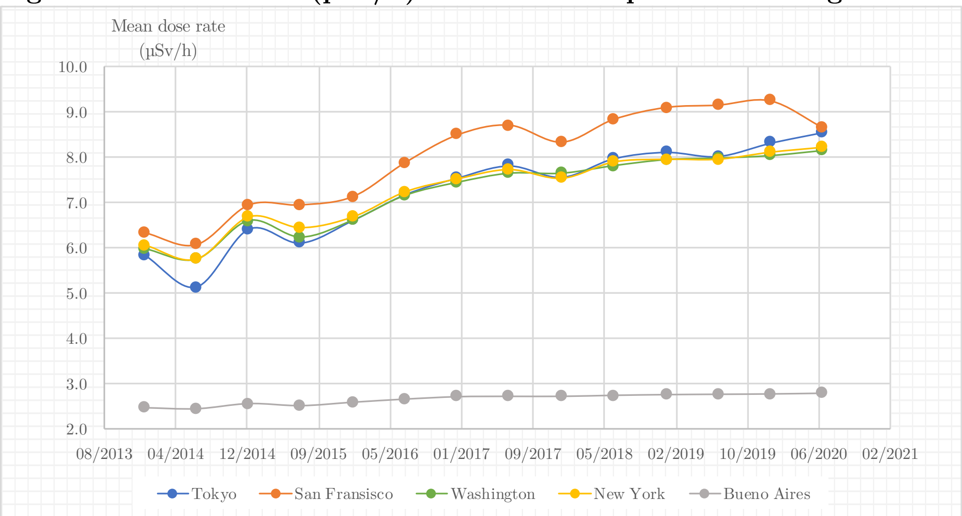


Figure 3. — Dose rate (µSv/h) for different representative flight routes



Feedback from NERIS 6th workshop

Eymeric LAFRANQUE
NERIS Coordinator
Nuclear Evaluation Protection Centre (CEPN)
92260-Fontenay-aux-Roses, FRANCE

On behalf of NERIS organisation

The NERIS Platform organised its 6th Workshop on 20-22 October 2021, by webinar. The Workshop gathered 85 participants and 24 presentations dedicated to the issue of "Operational and research achievements and needs to further strengthen preparedness in emergency management, recovery and response".

The final program and abstracts are available on the NERIS webpage (https://eu-neris.net/). Presentations will soon be made available. In addition, a SHARE/ALLIANCE/NERIS webinar on the offshore release of Fukushima Daiichi treated cooling water, was held on 20th October morning. The record of this webinar is available on the NERIS webpage (https://eu-neris.net/).

Session on “Operational aspects” source identification

Chaired by Johan Camps (SCK CEN, Belgium)

This session highlighted the importance of having the ability to perform independent source identification based on measurements and atmospheric transport modelling.

Piotr Kopka (NCNR, Poland) presented a probabilistic inverse model for the identification of continental-scale atmospheric contamination applied to the Ru-106 event in 2017. Atmospheric transport and dispersion modelling were performed using JRODOS MATCH.

Olivier Saunier (IRSN, France) presented the application of both cost function optimisation and Bayesian inference on the Se-75 release at the BR2 (SCK CEN, Belgium) in May 2019. The hourly Se-75 release was estimated, the inferred accumulated release matched with the Se-75 measured in the stack.

Spyros Andronopoulos (NCSR Demokritos, Greece) presented an application of the DIPCOT model with ERA5 numerical weather prediction data to the ETEX-1 tracer experiment. Retrieval of the source location and release were performed separately, with both corresponding well with the true ETEX-1 release.

Pieter De Meutter (SCK CEN, Belgium) gave an overview of the source reconstruction tool FREAR. He presented the ensemble used to study model uncertainty and its effect on source reconstruction, and the application to determine the release of Cs-137 during the wildfires in the Chernobyl Exclusion Zone in April 2020.

Operational aspects: from theory to practice

Chaired by Kasper Andersson (DTU, Denmark)

This session focused on operational aspects from atmospheric contaminant dispersion modelling to measurement capabilities, decision-support and dosimetry approaches for emergency management.

Hauke Brüggemeyer (NLWKN, Germany) described the competences and tools at the radiation protection competence center of the German federal state Lower Saxony for measurement and expert advice, with focus on emergency preparedness.

Fabio Alessio Vittoria (ENEA, Italy) provided an overview of the uncertainty connected to use of passive area dosimetry systems for environmental monitoring following a radioactive contamination event. This presentation reported on results from the EMPIR project ‘Preparedness’.

Christophe Gueibe (SCK CEN, Belgium) reported on results of ensemble forecasting and uncertainty estimation in connection with modelling of the accidental release of Se-75 in Belgium in May 2019.

Operational aspects: monitoring, chaired by Wolfgang Raskob (KIT, Germany)

Peder Kock (SSM, Sweden) reported on a monitoring exercise performed in Sweden that also included participants from many foreign countries to test common approaches and data exchange.

Lucian Ivan (CNL, Canada) presented a new atmospheric transport and dispersion model for multi-phase flows that can deal with different particles e.g. resulting from a detonation of a radiological dispersal device.

Luke Lebel's (CNL, Canada) presentation focused on the application of Operational Intervention Levels (OILs) for CANDU reactors, highlighting the difference between light water and heavy water devices.

Raymond Dickson (CNL, Canada) provided information on a field-deployable method for identifying particles that resulted from molten core-concrete interactions; important for getting a better insight into the status of the reactor core.

Session on “Holistic approaches to emergency and recovery management”

Co-chaired by Pascal Croüail (CEPN, France) and Catrinel Turcanu (SCK CEN, Belgium)

This session focused on stakeholder engagement and risk perception in emergency preparation and recovery management.
David Ferreira (APA, Portugal) discussed a trial of the ERMIN model for ranking and selecting the best countermeasures options, based on several accident scenarios in a steel mill. He underlined the importance in considering all relevant selection criteria and countermeasure effectiveness.

Catrinel Turcanu (SCK CEN, Belgium) presented findings from the CONFIDENCE project on a multi-method approach to investigate the range and nature of uncertainties faced by stakeholders, and their impact on decision-making. Results show the importance of communication on uncertainty for decision-making .

Robbe Geysmans (SCK CEN, Belgium) presented results from the ENGAGE project. He stressed that stakeholder engagement can be strengthened by acknowledging its contribution to improved decisions; acknowledging both formal and informal participation; and recognizing the value of bottom-up engagement.

Liudmila Liutsko (ISGlobal, Spain) illustrated the information material on the use of apps for measuring radiation, prepared by the SHAMISEN-SINGS project and targeted to various stakeholders. She showcased a data management plan for the use of apps at various levels, as well as ethical considerations.

Milagros Montero (CIEMAT, Spain) presented results of national stakeholder panels and a trans-national Delphi survey focusing in the transition phase, conducted in the CONFIDENCE project. This study collected stakeholders’ concerns and relevant criteria to plan strategic actions, and characterised various decision-making uncertainties in the transition phase.

Yevgeniya Tomkiv (NMBU, Norway) discussed a preliminary analysis of data from public opinion surveys in Norway and Japan addressing perception and attitude towards radioactivity in food after a nuclear accident. She highlighted the influence of perception on domestic origin of food products, and diverging opinions on the adoption of harmonized vs. food-/region-specific limits in food.

Session on "Progress in supporting decision-making"

Co-chaired by Milagros Montero (CIEMAT, Spain) and Liudmila Liutsko (ISGlobal, Spain)

This session covered achievements, lessons learned and recommendations to improve decision-making. Challenges and future research needs were also outlined.

Marie Simon-Cornu (IRSN, France) summarized the methodology developed in the TERRITORIES project, for identification and assessment of the “fit-for-purpose” radioecological models used in post-accident recovery management. Quantification of uncertainties affecting model predictions was reported, with examples of application.

Kasper Andersson (DTU, Denmark) provided an updated overview of key issues on successful composition and implementation of recovery countermeasure strategies, from analysis made in the

CONFIDENCE project. He presented features in the European handbooks to be useful in MCDA.

Vanessa Durand (IRSN, France), reviewed recommendations formulated in the CONFIDENCE project to reduce uncertainties in decision-making processes raised in the national panels. A special consideration on the findings and outputs from the French stakeholders' panel was made.

Thierry Schneider (CEPN, France) reported on the new ICRP publication updating the framework for the protection of people and the environment in the case of large nuclear accidents, focusing on new issues considered: distinction of phases for exposure situations; selection of reference levels; consideration of non-radiological factors; co-expertise process in decision-making; stakeholder engagement; environment protection; preparedness for management and recovery.

Jérôme Guillevic (IRSN, France) presented recommendations and analysis of technical steps elaborated in the TERRITORIES project, to improve the consideration of uncertainties in different stages of the decision-making process in the management of the long-term phase.

Wolfang Raskob (KIT, Germany) accounted for the main achievements of the CONFIDENCE project and the needs for future research identified in the final dissemination workshop. He reported on key results, issues and challenges, ideas under research such as: simulation models, monitoring tools and operational use, stakeholder involvement, societal aspects and communication, decision-making and education and training.

■

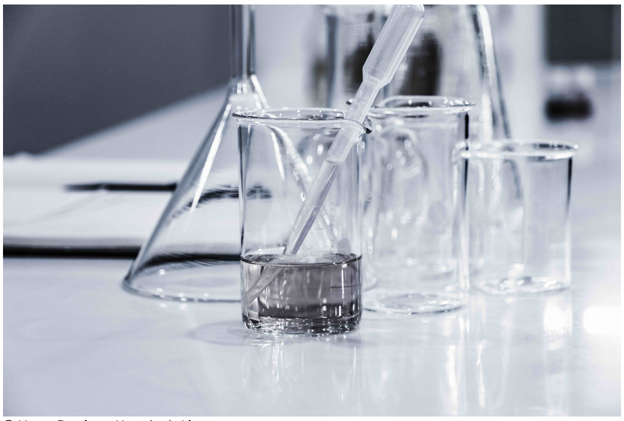
Did you know …

That RT-PCR testing was derived from nuclear detection techniques?

Adapted from *How is the COVID-19 Virus Detected using Real Time RT-PCR?* by Nicole Jawerth, IAEA, available on IAEA News.

Real time RT–PCR is one of the most widely used laboratory methods for detecting the Covid-19 virus. The term "RT-PCR" has almost entered into every-day language. But what is real time reverse transcription–polymerase chain reaction (RT-PCR)?

How does this work?
A sample is collected from the parts of the body where the COVID-19 virus gathers (ex. nose). The sample is treated with chemical solutions to remove proteins and fats and then extract only the ribonucleic acid (RNA). This extracted RNA is a mix of the person's own genetic material and, if present, the virus's RNA. A specific enzyme is added to convert the RNA into deoxyribonucleic acid, DNA. This is the 'reverse transcription' part of the process. They do this because only DNA can be copied — or amplified — which is a key part of the real time RT–PCR process for detecting viruses. Then additional short fragments of DNA that are complementary to specific parts of the transcribed viral DNA are added. If the virus is present in a sample, these fragments attach themselves to target sections of the viral DNA.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Originally, the method used radioactive isotope markers to detect targeted genetic materials, but subsequent refining has led to the replacement of isotopic labelling with special markers, most frequently fluorescent dyes.

The mixture is then placed in a machine that heats and cools the mixture to trigger specific chemical reactions that create new, identical copies of the target sections of viral DNA. The cycle is repeated over and over to continue copying the target sections of viral DNA, generally up to 35 cycles, which means that, by the end of the process, around 35 billion new copies of the sections of viral DNA are created from each strand of the virus present in the sample.
As new copies of the viral DNA sections are built, the marker labels attach to the DNA strands and then release a fluorescent dye, which is measured by the machine's computer and presented in real time on the screen. The computer tracks the amount of fluorescence in the sample after each cycle. When a certain level of fluorescence is surpassed, this confirms that the virus is present. The number of cycles needed to reach this level is also important to estimate the severity of the infection.

The 'conventional' RT-PCR (and conventional PCR also used to detect pathogen that carries DNA) results are only visible at the end of the reaction while real-time PCR provide the result during the cycling process. The real time RT–PCR technique is highly sensitive and provides results within as little as three hours, though conventional testing takes on average between six and eight hours. The potential for contamination or errors is also lower because the entire process can be carried out within a closed tube. It continues to be the most accurate method available for the detection of the COVID-19 virus.
However, real time RT–PCR cannot be used to detect past infections, which is important for understanding the development and spread of the virus, as viruses are only present in the body for a specific window of time. Other methods are necessary to detect, track and study past infections, particularly those which may have developed and spread without symptoms.
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Lorem Ipsum

Trenz Pruca

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THIS CAN BE YOUR ARTICLE

Do you have practices in ALARA to share?
change in regulation?
event to broadcast?
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Contact the Editorial Board

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Life of EAN and relationships with other networks

Working groups

Two EAN working groups have been set up in 2021:

1. *Review of the Implementation and the Dissemination of Recommendations and Conclusion of EAN Workshops* is analysing the impacts the EAN workshop could have had. A literature analysis and evaluation sheets distributed among the EAN members are the tools used in this task.
   Would you like to contribute by giving your feedback on the EAN workshop you participated in? Please contact the Editorial Board.
2. The EAN has constituted a group to analyse the application of the regulation for radon at the workplace and notably the application of the ALARA principle: *ALARA for Radon At Work*, A-RAW in which 10 countries are represented. The Working Group has elaborated a questionnaire to collect case studies on the application of the radon regulation at the workplace. The objectives are to address the challenges raised by the new regulation, identify potential pitfalls and also way to overcome and share good practices.
   The Working Group is also paying attention to work engaged by other organizations such as RadoNorm and HERCA on comparable subjects.

Hopefully, the results coming from these two working groups could be presented in 2022.

Recent EAN communications

October. The EAN participated to the ICRP *The Future of RP – Keeping recommendations fit for purposes* digital webinar 14 October-3 November. The live presentation '*The Graded approach for the radiation protection of the workers – Reflection from two European ALARA Network*' in session 3 was based on a brainstorming and a survey engaged to capture how the graded approach is understood and applied. The presentation is available on the EAN Documents and Publications section of the EAN website.

RadoNorm

RadoNorm — Managing risks from radon and NORM

The RadoNORM project is gaining momentum. The 1st annual meeting was held 6-7 September, presenting the objective and progress of the 8 Working Package. The first day was intended for RadoNorm members only, while the other day was open to RadoNorm stakeholder (which EAN is) and discussed how stakeholders can help tuning the project activities.

Then, the RadoNorm project in collaboration with RICOMET-2021 held a workshop "*Beyond scientific disciplinary boundaries: the future of radiation protection research and practice?*" (8 September) which focused on benefits and pitfalls in multidisciplinary research and also how to include citizens in research.
Programme on both workshops and more info can be found starting from the webpage; https://www.radonorm.eu/

ISOE

ISOE — Information System on Occupational Exposure

After several postponements, the next ISOE International Symposium organised by CEPN and ASN is planned **21-23 June 2022**.
The programme of the symposium is under construction. Check the ISOE Website for the latest information.

Other meetings in sight

- International Conference on Individual Monitoring of Ionizing Radiation (IM2022) and Neutron and Ion Dosimetry Symposium (**NEUDOS-14**), 25-29 April 2021, Krakow, https://imneudos.jordan.pl
- **IAEA NORM X** 2022
  9-13 May 2022, Utrecht, https://normx2022.com
- **IRPA** 6th European Congress on Radiation Protection, 30 May-3 June 2022, Budapest, *https://akcongress.com/irpa2022/*
- **ICRP 2021+1**, 7-10 November, Vancouver, https://icrp.org

Contacts

European ALARA Network Contact Persons

AUSTRIA
Franz KABRT
Osterreichische Agentur fur Gesundheit und Ernahrungssicherheit GmbH
Spargelfeldstraße 191, 1220 WIEN
Tel.: +43 (0)5 0555-32922 |
E-mail: franz.kabrt@ages.at

BELGIUM
Fernand VERMEERSCH
SCK•CEN
Boeretang 200, 2400 MOL
Tel: +32 14 33 28 53; Fax: +32 14 32 16 24
E-mail: fvermeer@sckcen.be

CROATIA
Mladen NOVAKOVIC
Radiation Protection Authority – EKOTEH Dosimetry
Vladimira Ruzdjaka 21, 10000 ZAGREB
Tel: +385 1 604 3882; Fax: +385 1 604 3866
E-mail: mlnovako@inet.hr

CZECH REPUBLIC
Jan KROPACEK
State Office for Nuclear Safety,
Syllabova 21, 730 00 OSTRAVA
Tel: +420 596 782 935; Fax: +420 596 782 934
E-mail: jan.kropacek@sujb.cz

DENMARK
Kresten BREDDAM
National Institute for Radiation Protection
Knapholm 7, 2730 HERLEV
Tel: +45 44 54 34 63
E-mail: krb@sis.dk

FINLAND
Maaret LEHTINEN
Säteilyturvakeskus – Radiation Practices Regulation
Laippatie 4, 00880 HELSINKI
Tel: +358 9 75988244 Fax: +358 9 75988248
E-mail: maaret.lehtinen@stuk.fi

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ISSN 1270-9441
c/o CEPN
28, rue de la Redoute
F-92260 Fontenay-aux-Roses
http://www.eu-alara.net

FRANCE
Paul LIVOLSI
Institut National des Sciences et Techniques Nucléaire, Commissariat à l'Energie Atomique (CEA/INSTN),
17 rue des Martyrs 38054 GRENOBLE Cedex 9
Tel: +33 4 38 78 39 27; Fax: +33 4 38 78 51 01
E-mail: paul.livolsi@cea.fr

FRANCE
Pascal CROÜAIL
Nuclear Protection Evaluation Centre),
28 rue de la Redoute 92260 FONTENAY-AUX-ROSES
E-mail: pascal.crouail@cepn.asso.fr

GERMANY
Ulrike Kulka
Bundesamt für Strahlenschutz,
Ingolstädter Landstrasse 1, 85764 OBERSCHLEISSHEIM
E-mail: UKulka@bfs.de

GREECE
Sotirios ECONOMIDES
Greek Atomic Energy Commission
P.O. Box 60228, 15310 AG-PARASKEVI
Tel: +30 210 6506767; Fax: +30 210 6506748
E-mail: sikonom@eeae.gr

ICELAND
Geislavarnir Ríkisins
Rauðarárstigur 10, 150 REYKJAVIK
Tel: +354 552 8200; Fax: +345 552 8202
E-mail: ge@gr.is

ITALY
Cristina NUCCETELLI
Istuto Superiore di Sanità – Technology and Health Department
Viale Regina Elena 299, 00161 ROME
Tel: + 39 06 4990 2203; Fax: +39 06 4990 2137
E-mail: cristina.nuccetelli@iss.it

IRELAND
Hugh SYNNOTT
Environmental Protection Agency,
Office of Radiological Protection
3 Clonskeagh Square, Clonskeagh Road, DUBLIN 14
Tel: +353 1 206 69 46; Fax: +353 1 260 57 97
E-mail: h.synnott@epa.ie

NORWAY
Malgorzata SNEVE
Norwegian Radiation and Nuclear Safety Authority
Regulatory Cooperation Programme,
Grini næringspark 13, 1361 Østerås, P.O. Box 329, 0213 OSLO
Tel: +47 95 171 14 49
E-mail: Malgorzata.sneve@dsa.no

SLOVENIA
Selma FIJULJANIN
Slovenian Radiation Protection Administration
Langusova 4, 1000 LJUBLJANA
E-mail: Selma.Fijuljanin@gov.si

SPAIN
Arturo PEREZ MULAS
Consejo de Seguridad Nuclear
Justo Dorado 11, 28040 MADRID
Tel: +34 91 346 02 62; Fax: +34 91 346 03 16
E-mail: apm@csn.es

SWEDEN
Petra Hansson
Stralsäkerhetsmyndigheten,
17116 STOCKHOLM
Tel: +46 8 799 44 38
E-mail: Petra.Hansson@ssm.se

SWITZERLAND
Stefan ROESLER
Centre Européen de Recherche Nucléaire (CERN)
Groupe Radioprotection, Unité Santé, Sécurité et Environnement
Esplanade des Particules, P.O. Box 1211 GENEVA 23
E-mail: Stefan.Roesler@cern.ch

SWITZERLAND
Nicolas STRITT
Swiss Federal Office of Public Health,
Radiation Protection Division,
3003 BERN
Tel: +41 31 324 05 88; Fax: +41 31 322 83 83
E-mail: nicolas.stritt@bag.admin.ch

THE NETHERLANDS
Folkert DRAAISMA
NRG
Utrechseweg 310 B50-West,
6812 ARNHEM
E-mail: draaisma@nrg.eu

UNITED KINGDOM
Julie MORGAN
UK Health Security Agency, Chilton
DIDCOT – OX11 0RQ
Tel: +44 1235 825301
E-mail: julie.morgan@phe.gov.uk