STUK-B 206 / SEPTEMBER 2016

B

Radiation practices

Annual report 2015

Riikka Pastila (ed.)

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

STUK

STUK-B 206 / SEPTEMBER 2016

Radiation practices

Annual report 2015

Riikka Pastila (ed.)

STUK • **SÄTEILYTURVAKESKUS**
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Osoite/Address • Laippatie 4, 00880 Helsinki
Postiosoite / Postal address • PL / P.O.Box 14, FIN-00881 Helsinki, FINLAND
Puh./Tel. (09) 759 881, +358 9 759 881 • Fax (09) 759 88 500, +358 9 759 88 500 • www.stuk.fi

Translation. Original text in Finnish.

The following people were involved in preparing this report:
Ritva Bly
Santtu Hellstén
Hannu Järvinen
Sampsa Kaijaluoto
Anne Kiuru
Päivi Kurttio
Atte Lajunen
Maaret Lehtinen
Jukka Liukkonen
Teemu Siiskonen
Eija Venelampi
Petri Sipilä
Tommi Toivonen
Reijo Visuri

ISBN 978-952-309-337-9 (pdf)
ISSN 2243-1896

PASTILA Riikka (ed.). Radiation practices. Annual report 2015. STUK-B 206. Helsinki 2016. 37 pp. + apps. 12 pp.

Key words: use of radiation, radiation practices, safety licence, licence-exempt practices, inspections of the use of radiation, radiation sources, radioactive materials, radioactive waste, radiation doses of workers, natural radiation, non-ionizing radiation, metrological standards, regulation work, research, Finnish and international co-operation, information activities, services, abnormal events

Abstract

Some 3200 safety licences for the use of radiation were current at the end of 2015, including licences granted to dental X-ray practices (approx. 1600), which became subject to a licence on 1 September 2014. The use of radiation was controlled through regular inspections performed at places of use, test packages sent by post to dental X-ray facilities and maintenance of the Dose Register. The Radiation and Nuclear Safety Authority (STUK) conducted 599 inspections of safety-licensed practices in 2015. Over the course of the inspections, 726 repair orders were issued. Radiation safety guides were also published and research was conducted in support of regulatory control.

A total of over 10 800 workers engaged in radiation work were subject to individual monitoring in 2015, and nearly 69 000 dose entries were made in the Dose Register maintained by STUK.

In 2015, regulatory control of the use of non-ionizing radiation (NIR) focused particularly on lasers, sunbeds, radio appliances and cosmetic applications utilizing non-ionizing radiation. A total of 18 cases of sales or importation of dangerous laser devices were found in regulatory control. Seven on-site inspections of show lasers were conducted. Municipal health protection authorities submitted the details of the inspections of 17 sunbed facilities to STUK for evaluation and decision. In addition to this, four sunbed facilities were inspected on-site. In the market surveillance of wireless communication devices, 14 devices were tested.

In metrological activities, national metrological standards were maintained to the calibrations of the radiation meters for radiotherapy, radiation protection and X-ray imaging. STUK's metrological laboratory performed well in the measurement comparisons where STUKs results clearly fullfilled the acceptance criteria.. In external evaluations, the laboratory was found to comply with the requirements set for national metrological laboratories.

There were 98 abnormal events related to radiation use in 2015. Thirty of the cases dealt with the use of radiation in industry and research, 64 with the use of radiation in health care, and four with non-ionizing radiation. Furthermore, 755 events with an estimated lower safety significance were reported in regards to health care.

Contents

Management review

The Department of Radiation Practices Regulation (STO) of the Radiation and Nuclear Safety Authority (STUK) functions as a regulatory authority on the use of ionizing and non-ionizing radiation, conducts research in support of regulatory control in the use of radiation, and maintains metrological standards for ionizing radiation. Regulatory control involves safety licensing, approval and registration procedures, inspections of places where radiation is used, market surveillance and monitoring of workers' radiation doses.

In 2015, the general state of radiation practice safety was good in Finland. STUK collects information on radiation practices and keeps a close eye on the signals on which the reaction to the safety situation is based, in order to maintain its desired level.

New directive of the Council of the European Union on the basic safety standards for protection against ionizing radiation entered into force in early 2014. It must be implemented nationally within four years, and its regulations must be adopted in national legislation by 6 February 2018. At the beginning of 2015, the Ministry of Social Affairs and Health initiated the process of revising the Radiation Act. The revision of the Radiation Act is necessary in order to implement the new directive of the Council of the European Union on basic safety standards for protection against ionizing radiation, streamline the current Radiation Act and take all parts of the current Constitution into account. STUK has prioritized the revision of the Radiation Act as an important project. STUK also established a project for revising the Act, which produces draft texts for the Radiation Act and lower level statutes. The project involved the reorganization of human resources in order to ensure that the Radiation Act would be completed in the target schedule.

A total of 10 800 workers involved in radiation work were subject to individual monitoring in 2015. Of these workers, nearly 8000 were engaged in the use of ionizing radiation, while the rest consisted of nuclear power plant workers. In no case did the effective dose of a worker in 2015 exceed the annual dose limit or the five-year dose limit for workers.

In 2015, fewer abnormal events were reported to STUK than in the previous year. The decrease in reported events is primarily due to the new practice, according to which events with lower safety significance in the health care sector can be compiled together into specific categories and reported each calendar year. The number of such reported events was 755. The most significant of the reported events was one where a group of patients was X-rayed with an excessive radiation dose due to an equipment failure. The exposure of an individual patient was still substantially lower than the dose limit specified for an individual in the population, but the event was noteworthy due to it affecting a large number of people.

PET/CT scans, which utilize short-lived radioactive isotopes as tracers, are becoming more commonplace in health care. These scans are important particularly in the planning of cancer treatments and the monitoring of treatment impacts. New particle accelerators used to manufacture the isotopes are being commissioned in an increasing number of facilities. During the past year, a new accelerator laboratory was completed in Turku and new accelerators will be prepared for Kuopio and Helsinki in 2016. This area has been challenging from the perspective of STUK's regulatory control efforts due to personnel changes, but the transfer of know-how to the new experts has been successful.

Owned by VTT Technical Research Centre of Finland and located in Otaniemi, the most significant laboratory complex in Finland in terms of researching materials and focusing on radioactive materials is undergoing changes. New facilities will be completed at the VTT Centre for Nuclear Safety during 2016. Preparations for decommissioning the current facilities are underway. The decommissioning, including the processing of radioactive materials and contaminated materials, is new in Finland at this scale. STUK has made preparations for overseeing the change by tightening internal co-operation between various departments and reviewing the safety requirements related to the various operations with VTT.

STUK strengthened co-operation with the other authorities responsible for monitoring the transport of dangerous goods by means of participating in the meetings of a group of relevant authorities. In addition to this, a joint inspection was conducted with the Finnish Transport Safety Agency (Trafi) with regard to air transport.

Discussion around the suspected health effects of mobile phones and other sources of electromagnetic radiation was active. STUK replied to hundreds of inquiries concerning the topic from citizens via telephone and email. The regulatory control of non-ionizing radiation focused particularly on various consumer products based on the use of lasers and the control of the cosmetic applications of lasers. The increasingly open global sale of products across borders introduces challenges to safety control in this area. It is indicative of the situation that a higher number of unlicensed laser shows and non-compliant effect lasers were discovered.

The transition period for the Radiation Act amendment implemented on 1 July 2012 ended at the beginning of July 2015. This necessitates the sunbed service providers to appoint a responsible person to oversee that persons under 18 years of age are not permitted to use the sunbeds. STUK supervised adherence to the legal amendment through active monitoring and co-operation with health protection authorities and based on reports from citizens. Many self-service sunbed facilities continued their operations despite the legislative change, and the related regulatory control placed a considerable burden on STUK experts towards the end of 2015.

Over the course of the year, there was occasional congestion in licence and other application matters. However, the average processing time remained within the target range. In some cases, the maximum limit was exceeded due to a temporary resource shortage, mainly as a result of legislative work. The licence applications related to the reorganizations of the health care business sector were also more challenging than usual, which contributed to extending the processing times.

The operation of STUK's national metrological laboratory was found to clearly meet the requirements set for it. The evaluation was conducted by MIKES Metrology. To ensure high quality, STUK's metrological laboratory participates regularly in international measurement comparisons. The results for 2015 were good.

STUK participated in a number of European research projects, which resulted in, for example, new recommendations by the European Commission on the use of radiation in health care. STUK participated in an EU project (PiDRL) that prepared EU guidelines on reference levels for patient radiation exposure in the context of pediatric imaging and related measures. The reference levels for pediatric radiology issued in Finland are close to or lower than the average levels in other EU countries. The reference level curve method adopted in Finland is presented as an alternative in the EU guidelines. The EU guidelines will be published in 2016. STUK aims to increase research collaboration with Finnish co-operation partners for the purpose of ensuring access to up-to-date information and high-level expertise throughout the sector.

1 General

The expression “use of radiation” refers to the use and manufacture of and trade in radiation equipment and radioactive materials, and to associated activities such as possession, safekeeping, servicing, repair, installation, importing, exporting, storage, transportation and the process of rendering radioactive waste harmless. The expression “radiation practice” refers to radiation use and also to any activity or circumstances in which human exposure to natural radiation causes or is liable to cause detriment to health.

The expression “radiation” refers to both ionizing and non-ionizing radiation.

The regulatory control of radiation use and other practices causing exposure to radiation in Finland is the responsibility of the Department of Radiation Practices Regulation (STO) at STUK, while regulatory control of exposure to natural radiation excluding cosmic radiation is the responsibility of the Department of Environmental Radiation Surveillance (VALO) at STUK.

1.1 Principal key figures

The principal key figures for the use of radiation and other practices causing exposure to radiation are shown in Figures 1–4.

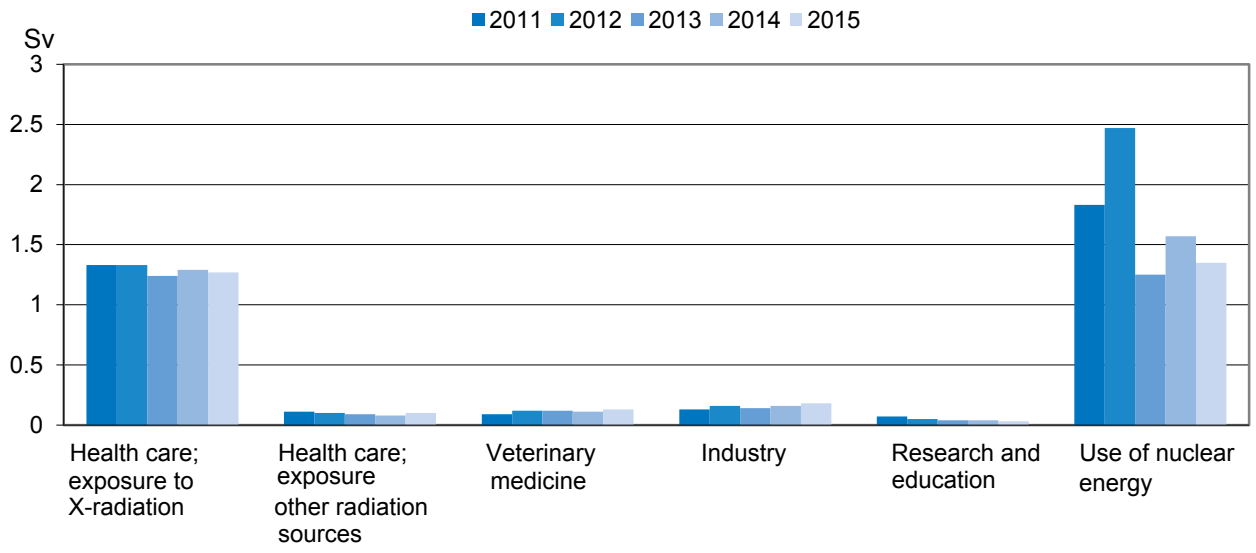

Figure 1. Combined doses ($H_p(10)$) of workers subject to individual monitoring by occupational category, 2011–2015. $H_p(10)$ values are generally (sufficiently accurate) approximations of the effective dose. One exception to this is the use of X-rays in health care and veterinary practices, in which workers use personal protective shields and in which the dose is measured by a dosemeter on the exposed side of the shield. The effective dose is then obtained by dividing the $H_p(10)$ value by a factor between 10 and 60. Besides the occupational categories specified in the graph, a small number of people subject to individual monitoring also work in the following fields: manufacturing of radioactive materials, installation/servicing/technical test operation, trade/import/export and services pertaining to the use of radiation and radioactive materials (see Tables 9 and 10 in Appendix 1).

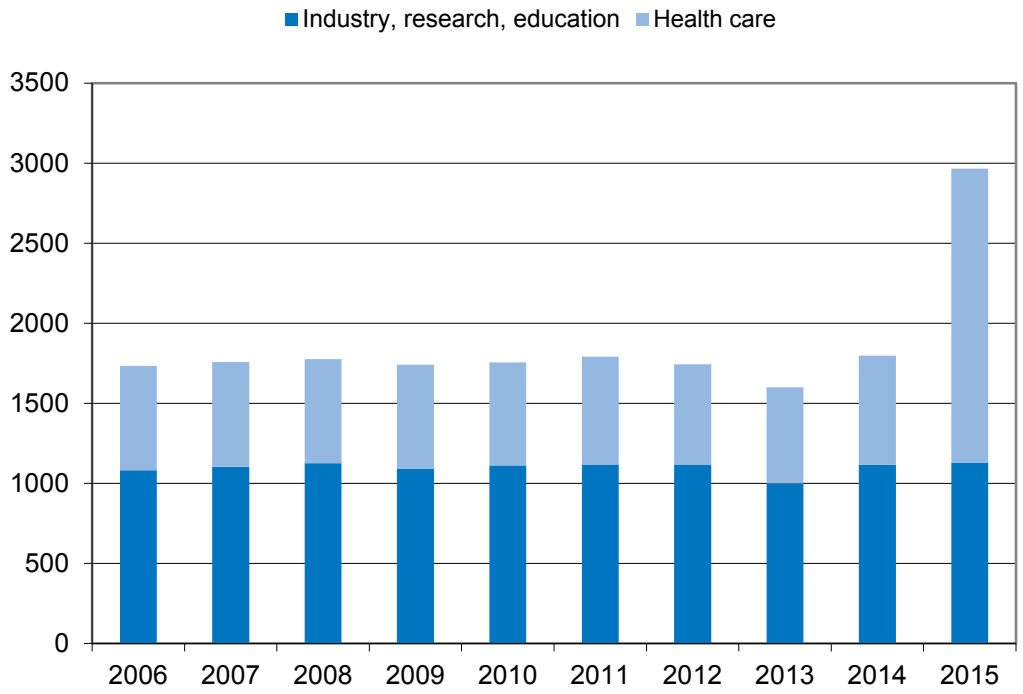

Figure 2. Current safety licences, 2006–2015. The increase in health care licences is due to the dental X-ray operations being changed from registered activities to activities that are subject to a licence.

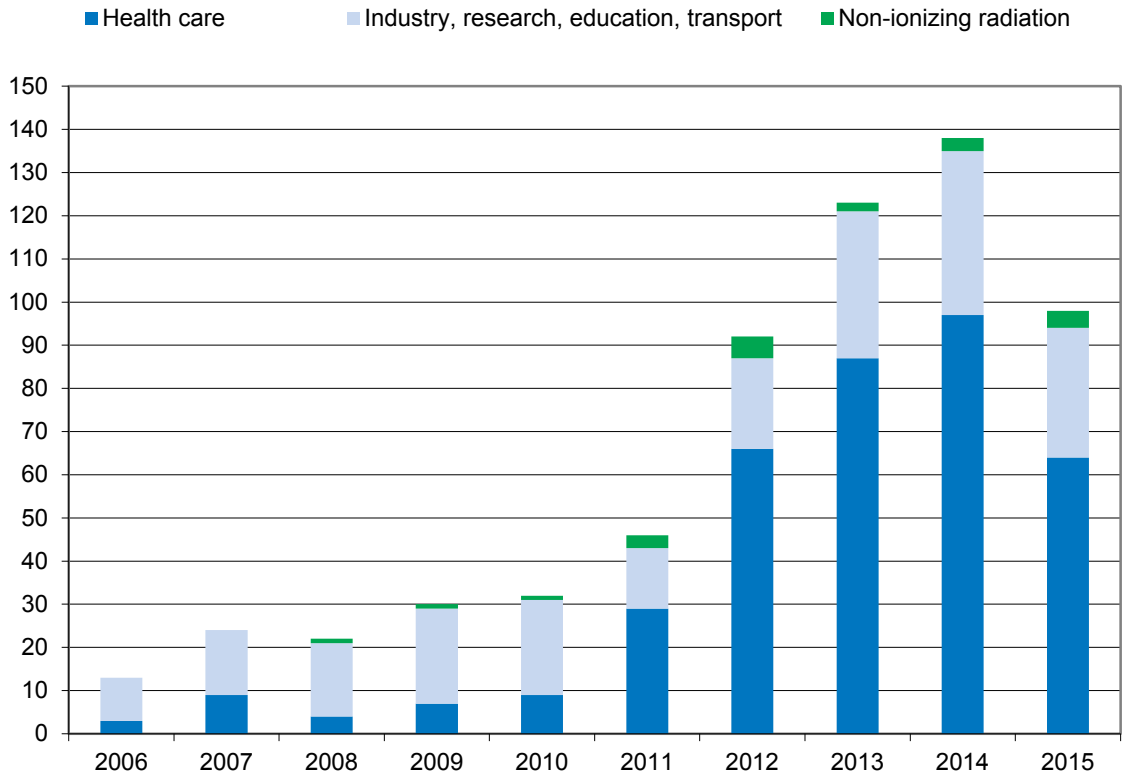

Figure 3. Abnormal events, 2006–2015.

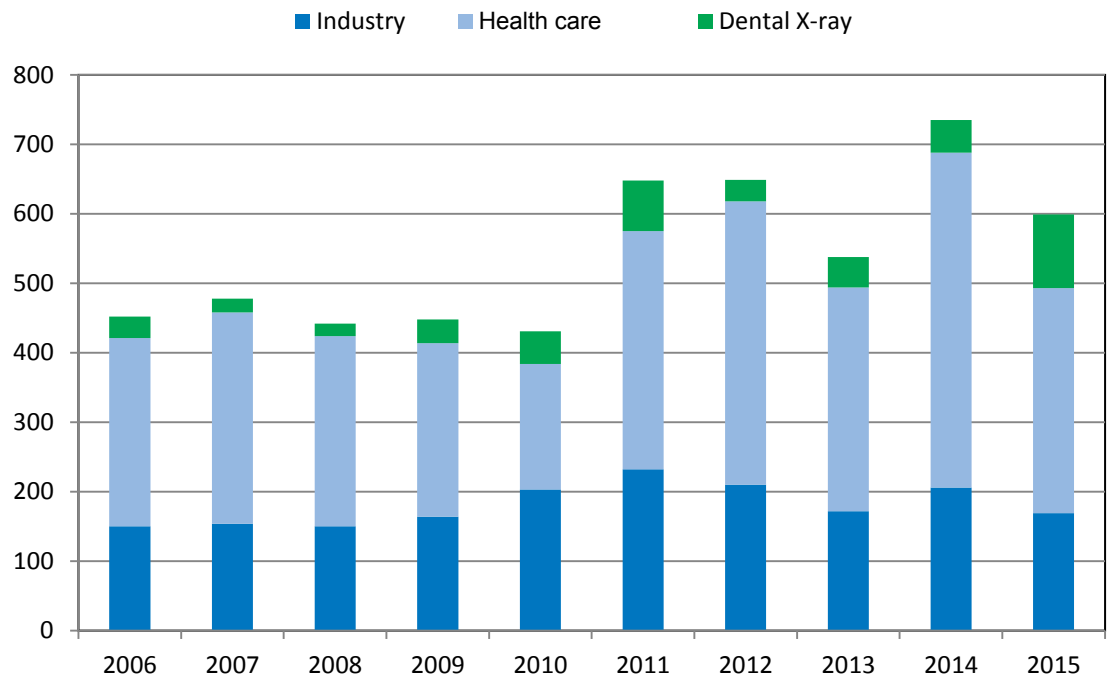

Figure 4. Inspections, 2006–2015.

2 Regulatory control of the use of ionizing radiation

2.1 Use of radiation in health care, dental care and veterinary practices

Safety licences

At the end of 2015, there were 1837 current safety licences for the use of radiation in health care (see also Figure 2) and 242 licences concerning veterinary practices. A total of 2253 licensing decisions (new licences, amendments to previous licenses and terminations of licences) were issued during the year. The numerical distribution of radiation practices referred to in these licences is shown in Table 1 of Appendix 1.

On 1 September 2014, conventional dental X-ray imaging was deemed to require a safety licence. After this, safety licences began to be issued to conventional dental X-ray practices. There are currently some 1600 dental X-ray practitioners.

The average time taken to process safety licence applications for X-ray practices in health care was 16.9 days. Roughly 4% of all licence applications were processed as urgent applications. Several applications were submitted to STUK only when it was time to take an appliance into use, and sometimes even after the appliance had already been taken into use.

Radiation appliances, sources and laboratories

Table 2 in Appendix 1 shows details of radiation appliances and sources, and of radionuclide laboratories used in health care and veterinary practices at the end of 2015.

X-ray practices, dental X-ray practices and veterinary practices

New diagnostic reference levels for patients' radiation exposure in the pediatric CT scans were set in 2015. At the same time, achievable dose levels in pediatric CT scans were adopted. The achievable dose level is more conducive to optimizing the reference level when using devices that enable sufficiently good image quality with lower dose levels by means of iterative image reconstruction, for example. The reference levels for CT scans of a child's body area have been issued as a reference level curve, which is a model developed in Finland that is suitable for applying reference levels especially in the context of small patient numbers. The model was recommended as a feasible method in the EU project (PiDRL) that prepared EU guidelines on reference levels for pediatric imaging and that also included STUK as one of the participants. In addition to this, the model will be presented in the ICPR's (International Commission on Radiological Protection) new recommendation regarding reference levels in radiological imaging, which is to be published in 2016.

X-ray equipment suppliers reported the X-ray appliances installed or reinstalled in health care practices in 2015 to STUK. The survey revealed one X-ray device that had not been issued a safety licence before the operations were started. In addition to this, 20 dental X-ray appliances that had not been reported to STUK were found in the survey. In connection to the inspections, STUK became aware of eight health care X-ray appliances lacking a safety licence. Safety licence applications were lodged for these devices.

In the spring, the guide "Oikeutus säteilylle altistavissa tutkimuksissa – opas hoitaville lääkäreille" (Justification in examinations involving exposure to radiation – a guide to treating doctors) was published in the STUK opastaa (Advice from STUK) series. The guide concerns the justification of X-ray and nuclear medicine examinations that utilize ionizing radiation. The guide has been presented via a newsletter, newspaper articles and training days.

In 2015, STUK received 35 reports on abnormal events related to X-ray practices in health care

(Item 2.8). The updated Guide ST 3.3 "X-ray examinations in health care", which entered into force in early 2015, aims to further specify the abnormal event reporting procedure. Incidents with lesser safety significance can be reported in annual summaries. A total of 755 of such events were reported.

A conference for medical X-ray technology experts was organized in April. The conference offered a comprehensive look at the current state of X-ray practices in health care from the perspective of the regulatory authority, as well as the division of responsibility and duties in radiological operations. In addition to this, STUK experts participated in several training events as lecturers and disseminated information on topical themes in professional magazines. In 2015, STUK sent out a newsletter aimed at radiation users in health care.

The practices of regulatory control were adapted based on a risk assessment. The regulatory control of X-ray practices was developed by implementing a new model for inspecting large service providers. The inspection model reduces the work load imposed on large responsible parties (party running a radiation practice) and provides an overview of the overall quality of the activities. Measurements of individual X-ray appliances were reduced, and the inspection focus was shifted more to the functionality of the quality assurance arrangements and the operating system as a whole. A regulatory control survey was introduced with regard to veterinary X-ray activities. The experiences of the survey were good, which means that it will continue to be used and its content will be developed further.

Nuclear medicine

Regulatory control of nuclear medicine

The inspections concerning nuclear medicine paid special attention to the performance of contamination measurements at regular intervals and always after work. Hand-and-shoe monitors were recommended for measuring the contamination of workers.

Development of regulatory control in nuclear medicine

The regulatory control of SPECT-CT and PET-CT devices was developed by preparing a guide on the use of computed tomography in nuclear medicine. In addition to STUK experts, the working group that prepared the guide included Eero Kauppinen (KSKS), Kirsi Timonen (KSKS), Virpi Tunninen (SatSHP), Eila Lantto (HUS), Jukka Schildt (HUS), Helena Kiiliäinen (VSHP), Kalle Sipilä (PSHP), Antti Sohlberg (PHSOTEY), Hanna Mussalo (KYS), Marko Seppänen (TYKS), Sampsa Turunen (HUS) and Pasi Korkola (TAYS) as well as equipment suppliers GE and Siemens. STUK also collected and published national data on PET-CT patient doses. The guide and the results of the dose analysis were presented at the Radiation Safety and Quality in Nuclear Medicine conference.

Based on the dose analysis, the effective doses caused by the radiopharmaceutical (F-FDG) in the most common examinations of metabolism in the brain, body and heart were, on average, higher (the average of the differences is 2.3 mSv) than the effective doses caused by a CT scan. The CT dose indices ($CTDI_{vol}$) were significantly lower than the reference levels set for conventional CT scans. The average of activities in full-body scans was also significantly lower than the reference level, but in brain scans the average and reference level were almost the same. More information on doses caused by radiopharmaceuticals will be provided in the report "Isotooppitutkimukset ja -hoidot Suomessa" (Nuclear medicine examinations and treatments in Finland) to be published in 2016.

Radioactive iodine treatment for cats

Radioactive iodine therapy for hyperthyroidism in cats (I-131 treatment) was initiated in Finland. Hyperthyroidism is the most common endocrinological disease found in cats. Radioactive iodine therapy is also suited to the treatment of thyroid cancer. The treatment practices must adhere to all other statutes concerning the use of unsealed sources. STUK has granted one safety licence for such operations.

Radiotherapy

Radiotherapy was provided at all five university hospitals, seven central hospitals and one private clinic to approximately 15 500 patients. Over the course of 2015, STUK conducted 10 commissioning inspections and 27 periodic inspections on radiotherapy equipment.

The comparative measurements between STUK and hospitals revealed the treatment dose accuracy of hospitals to be extremely good: the average difference in photon beams was 0.1% (standard deviation 0.6%) and in electron beams 0.5% (standard deviation 0.6%). The measurements did not reveal dose deviations that would compromise the safety of treatment.

In monitoring the accuracy of the patient dose in radiotherapy, the multi-field plans calculated using the dose calculation system were compared with the corresponding measurement results. Inspections of dose calculation systems that affect patient doses were conducted on more than 500 radiotherapy beams. The calculation accuracy of hospitals' dose planning programmes and the correctness of the input data were found to be extremely good. The highest observed deviations were lower than 3%.

Development of regulatory control in radiotherapy

The resources reserved for developing the regulatory control of radiotherapy were primarily allocated to the joint European research project MetrExtRT, which ended in June 2015. The project partners included leading European primary standards laboratories, including NPL, ENEA and PTB. STUK's contribution to the project focused on determining the characteristics of radiochromic film (Gafchromic EBT-3) and preparing the reading process best suited to film as well as developing a method for verifying the calculations of dose planning systems using comparative measurements. The work has been carried out in collaboration with the university hospitals of Tampere and Helsinki.

The method development has required the development and manufacture of several phantoms, particularly ones suited to electron radiation, as well as the study of film characteristics using measurements and Monte Carlo computation. The calibrations required for the study and the majority of the film irradiations were conducted in the national metrology laboratory, but the required high energy beam irradiations and dose planning were carried out in the radiotherapy unit of TaYS Central Hospital. In addition to STUK experts, the project involved a team of Italian physicists from ENEA.

Measurements were conducted to, for example, study the response of a new type of diamond indicator in electron and photon beams as well as the suitability of film for measuring dose distribution in combined photon and electron beams.

The results of the work were showcased in international conferences and scientific articles. The aim is to utilize them to produce new methods for measuring radiation and control measures for ensuring the continued high quality of radiotherapy.

Risk assessment in radiotherapy

The radiotherapy risk assessment method was published as a guide in the STUK opastaa (Advice from STUK) series and presented at the conference held by STUK in June 2015 in Helsinki. The guide is intended for radiotherapy centres. The appendix that can be downloaded from the STUK website serves as an independent risk assessment tool. Each centre is responsible for using the appendix for its own purposes, but the severity of harmful events has been assessed in advance to ensure a harmonized approach to the procedures. Risk assessment experiences and feedback on the guide will be collected at the following conference to be held in June 2016.

2.2 Use of radiation in industry, research and education

The use of radiation in industry, research and education also includes its use in services, installation and maintenance work, the sale and manufacture of radioactive materials, and the transport of radioactive materials.

Based on its inspection, STUK granted a commissioning licence to a Turku-based accelerator intended for isotope production. STUK issued statements related to radiation shielding also with regard to other particle accelerators intended for isotope production and related projects.

A report on the radiation safety of accelerators

used in research and isotope production was completed at the end of 2015. The report will be published in 2016, and the suggestions in it will be used to set specific requirements regarding accelerators.

STUK's regulatory control and inspection activities have revealed that certain trading companies of X-ray equipment and holders of X-ray equipment are not aware of the regulations and risks concerning the use of radiation. In industry and research, this has led to the use of X-ray equipment without an appropriate safety licence. Due to this, the possession and trade of X-ray equipment was subjected to a licence starting from the beginning of 2016. A notification letter was sent to responsible parties on the matter.

VTT Technical Research Centre of Finland is building new facilities. This involves cleaning and decommissioning the old contaminated facilities and obtaining licences for the new facilities in accordance with the Radiation Act. STUK made preparations for overseeing these activities by tightening internal co-operation and reviewing the radiation safety requirements with VTT.

STUK arranged the 11th Conference on Radiation Safety in Industry in October in Helsinki. Key themes covered at the conference included security arrangements as well as the handling of abnormal events and learning from them.

STUK inspects the transportable radiation sources in accordance with its annual plan, as well as their use and transport arrangements, every three years. STUK sent a survey compliant with STUK's annual plan to the five largest transport service providers. The survey involved questions on the use of subcontractors, the radiation protection programme and management system. The response analysis is still under way. The companies will be contacted if the responses indicate that the applicable regulations are not being observed.

In 2015, STUK published a new guide on transport "Turvajärjestelyt radioaktiivisten aineiden tiekuljetuksessa" (Security arrangements for road transport of radioactive materials). The guide is aimed at both transport companies and safety licence holders, and it presents the requirements concerning transport security arrangements and provides examples of good practices. Copies of the guide were handed out in conjunction with inspections.

STUK strengthened co-operation with the authorities responsible for regulatory control of the transport of other dangerous goods by means of participating in the meetings of a group of relevant authorities. In addition to this, a joint inspection of air transport was carried out with Trafi (Finnish Transport Safety Agency).

Safety licences

At the end of 2015, there were 1128 current safety licences for the use of radiation in industry, research and education (see also Figure 2). A total of 577 licensing decisions (new licences, amendments to previous licenses and terminations of licences) were issued during the year. The average time taken to process safety licence applications was 15.3 days. The numerical distribution of radiation practices referred to in these licences is shown in Table 3 of Appendix 1.

Radiation appliances, sources and laboratories

Figure 5 shows the number of appliances containing radioactive substances used in industry, research and education for the last ten years. The number has remained largely the same for a long time.

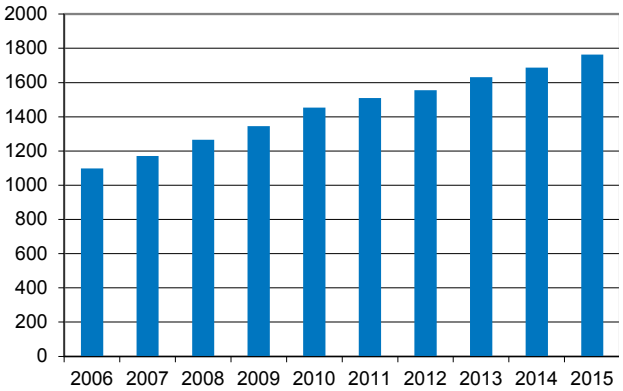

Figure 5. The number of appliances containing radioactive substances in 2006–2015.

Figure 6 shows the number of X-ray appliances in the last ten years. The number has almost doubled in ten years. Appliances containing radioactive substance have, to some extent, been replaced by X-ray appliances, in addition to which new scanning and analysis device applications have been introduced.

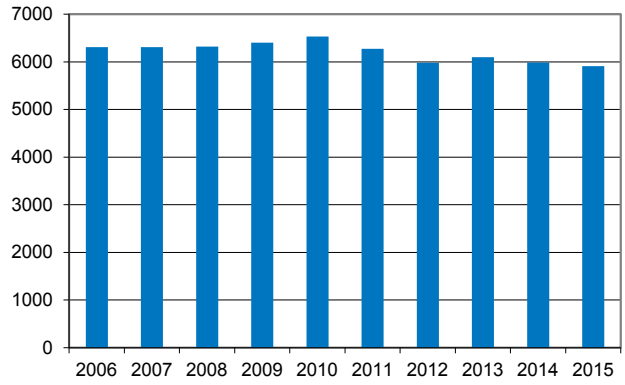

Figure 6. Number of X-ray appliances between 2006 and 2015.

Table 4 in Appendix 1 shows details of radiation appliances and sources, and of radionuclide laboratories used in industry, research and education at the end of 2015.

Table 5 in Appendix 1 shows details of radionuclides used in sealed sources.

X-ray appliance survey

At the start of 2015, STUK requested notifications from all vendors of X-ray equipment operating in Finland (44 vendors) concerning appliances sold in 2014 and their holders. These notifications revealed 14 responsible parties who did not have a licence for operating X-ray appliances. In addition to this, it was found that 14 licence holders had not notified STUK of their newly procured X-ray appliances. STUK issued the necessary orders to remedy the shortcomings discovered and controlled that a safety licence was applied for the use of all the aforementioned devices or that the devices were appropriately incorporated into an existing safety licence.

2.3 Inspections of licensed radiation practices

Health care, dental care and veterinary practices

In 2015, a total of 430 inspections were conducted on the use of radiation in health care and veterinary practices. Of these inspections, 334 were periodic inspections and 192 were commissioning inspections. In addition to these, 7 repeat inspections were carried out during the year. The number of veterinary x-ray practice inspections made was 61. These inspections resulted in 320 repair orders issued to the responsible parties. A further 8 appliances were also found that did not have the required safety licence for their use. In addition to this, the inspection revealed a few cases of inadequate radiation shielding in imaging rooms (typically the door frame). Seven doses exceeding the reference level were measured in the inspections.

There were approximately 1600 responsible parties engaged in dental X-ray practices in 2015. Patient radiation exposure due to dental X-ray imaging was measured in 1,002 intraoral X-ray appliances with testing equipment sent by mail. The average dose was 1.3 mGy. This dose corresponds to the dose on the surface of the cheek (Entrance Surface Dose, ESD) when imaging a tooth. The reference level of 2.5 mGy was exceeded in 53 imaging appliances. The reference levels for dental examinations were updated in 2014, as a result of which the reference level was exceeded more frequently.

In addition to this, STUK conducted on-site inspections of 106 panoramic tomography appliances used in conventional dental X-ray practices. The majority of the deficiencies observed during these inspections had to do with quality control, the appliance itself, its accessories or the correctness of registration information. Furthermore, doses exceeding reference levels were recorded on 7 panoramic tomography appliances.

After the inspections, radiation safety officers were sent a feedback survey asking for their opinion on the inspections. The majority of the respondents found the inspections to be useful and the issued repair orders to be justified. Some respondents wished that inspections could be booked further in advance. Respondents were satisfied with the contents and preparation speed of inspection reports.

Industry, research and education

Analysis regarding inspections in 2010–2014

In 2015, STUK prepared an analysis of the inspections conducted between 2010 and 2014. The aim was to determine the types of observations that the inspection yielded and how they were divided among the inspected responsible parties. Another goal was to locate the most common safety deviations.

A total of 1020 inspections of the use of radiation were carried out. These inspections revealed a total of 3345 safety deviations for which repair orders were issued. These deviations were found in 800 of the inspections (78% of the inspected responsible parties). No safety deviations were discovered in 22% of the inspections.

The majority of the deviations were shortcomings in the radiation sources used by the responsible parties (a total of 1018 inspection findings). The most common inspection finding related to a radiation source involved deficient device markings (a total of 526 inspection findings) or safety equipment, such as finger guards (a total of 163 inspection findings). The next most frequent finding involved lacking instructions concerning abnormal events (a total of 486 inspection observations). In 2010, 100 responsible parties were found to lack instructions concerning abnormal events. Four years later (in 2014), 56 responsible parties did not have such instructions. The third highest number of inspection findings was made with regard to issues relating to the operating organization (a total of 355 inspection findings). The majority of the safety deviations discovered in the inspections concerned the specification of the duties of the radiation safety officer responsible for the safe use of radiation or the arrangement of supplementary training.

Inspections in 2015

In 2015, 169 inspections were conducted at sites where radiation is used for industrial, research and education purposes. These inspections resulted in 406 repair orders. In accordance with the annual plan, periodic inspections are performed every 2–8 years depending on the category and extent of operations. In addition to this, radiation practices pertaining to new safety licences are inspected before operations are commenced or within a year of issuing the licence. In 2015, all new licences could not be inspected within a year of granting the permit. The date of the inspection is usually agreed upon in advance with the radiation safety officer.

One unannounced inspection of an industrial radiography practice was conducted in 2015. The deficiencies revealed by the inspection in radiation meters, for example, were so severe that the imaging operations were discontinued on-site. The matter was reviewed with the radiation safety officer and a representative of the responsible party's management.

After the inspections, radiation safety officers were sent a feedback survey asking for their opinion on the inspections. The majority of the respondents found the inspections to be useful and the issued repair orders to be justified. The respondents were particularly pleased that at the end of the inspection there was a review of the findings and the orders issued based on them. In some cases radiation safety officers reported that the inspection report did not arrive quickly enough following the inspection. The feedback on the inspections and the professional expertise of the inspectors was generally positive.

2.4 Importing, manufacture and exporting of radioactive substances

Details of deliveries of radioactive substances to and from Finland and of the manufacturing of such substances in Finland in 2015 are shown in Tables 6 and 7 of Appendix 1. The figures in the tables are based on data gathered from radiation safety licensees engaged in trading, importing, exporting and manufacturing.

The tables do not include the following information:

- Radioactive substances procured by responsible parties for their own use from other countries within the European Union, and consigned from said use to other European Union countries.
- Radioactive substances supplied to other countries via Finland.
- Smoke detectors and fire alarm system ion detectors containing americium (Am-241). Approximately 61 400 of these were imported with a combined activity of about 2.0 GBq. Approximately 50 smoke detectors with a combined activity of approximately 0.2 MBq were exported from Finland.
- Lamps and fuses containing radioactive substances imported to Finland. Some of these appliances contain small quantities of tritium (H-3), krypton (Kr-85) or thorium (Th-232).
- Unsealed radioactive sources imported to

Finland and exported from Finland. Based on activity, the most common unsealed sources imported were Mo-99, I-131, I-123, Lu-177, Br-82, Tl-201, P-32, Fe-55, In-111, Co-60, Sm-153 and Y-90.

2.5 Radiation doses to workers

A total of over 10 800 workers engaged in radiation work were subject to individual monitoring in 2015. Including doses below the recording level, almost 69 000 dose records were entered in the Dose Register maintained by STUK. This figure also includes the dose records of workers exposed to natural radiation – radon and cosmic radiation.

In no case did the effective dose of a worker in 2015 exceed the annual dose limit of 50 mSv or the five-year dose limit of 100 mSv. The combined doses ($H_p(10)$) to workers in the use of radiation were approximately 1.72 Sv and those to workers in the use of nuclear energy were approximately 1.35 Sv. The total dose in the use of radiation increased by 0.6% compared to the previous year. In the use of nuclear energy, the total dose was nearly 14.4% lower than during the previous year. The total dose in the use of nuclear energy varies considerably each year, depending on the duration of annual nuclear power plant servicing and the duties performed in servicing work at these facilities.

The highest $H_p(10)$ dose in health care was 24.7 mSv and it was recorded for a cardiologist. This dose is equivalent to an effective dose of approximately 0.8 mSv. The highest effective dose recorded in health care from a source other than X-radiation was 4.6 mSv, recorded for a radiographer working in a nuclear medicine department. The highest $H_p(10)$ dose in veterinary practice was 5.9 mSv, recorded for an animal keeper performing X-ray examinations. This dose is equivalent to an effective dose of approximately 0.2 mSv. The highest effective dose in industry was 8.3 mSv, recorded for an individual performing tracer tests. The highest effective dose in research was 4.2 mSv, recorded for a radiation worker using unsealed sources.

In some work tasks, such as in the handling of unsealed sources, workers are exposed to radiation unevenly. In such cases the dose to the hands, for example, may be considerable even if the effective dose is relatively small. A separate annual dose limit of 500 mSv has been set for skin, and workers use a so-called finger dosemeter to monitor radiation dose to the hands. In no cases did the dose to the hands of workers exceed the annual dose limit in 2015. The highest annual dose to the hands was 160.8 mSv measured for a laboratory technician. The largest doses to the hands have decreased significantly from the previous year. For nearly all workers handling unsealed sources the dose to the hands is less than 100 mSv.

Radon at workplaces

The Dose Register also records the dose information of workers exposed to natural radiation during their work, even though such workers are not classified as radiation workers.

The radon exposure of workers was determined based on radon measurements and the monitoring of working hours at workplaces in which the radon concentration exceeded the action level. Some of these workplaces were conventional workplaces, while others were sites located underground or in tunnels. A total of 26 workers, whose doses were recorded in the Dose Register, were subject to radon exposure monitoring over the course of the year. The largest effective dose to a worker as a result of radon exposure in 2015 was 8.1 mSv, recorded in the small-scale industry sector.

The number of workers subjected to individual monitoring due to radon exposure varies considerably from year to year due to possible high radon levels being discovered each year in previously unmeasured workplaces and variation in the amount of excavation and tunnelling work. In addition to this, workplaces undergo repair work, the success of which has an effect on the amount of radon exposure.

In 2015, a total of six responsible parties were obliged to organize radon exposure monitoring at their work sites. The total number of employees was 26, two of whom were in exposure monitoring only a part of the year. The distribution of the estimated effective doses in the workplaces included in the exposure monitoring is presented in Figure 7.

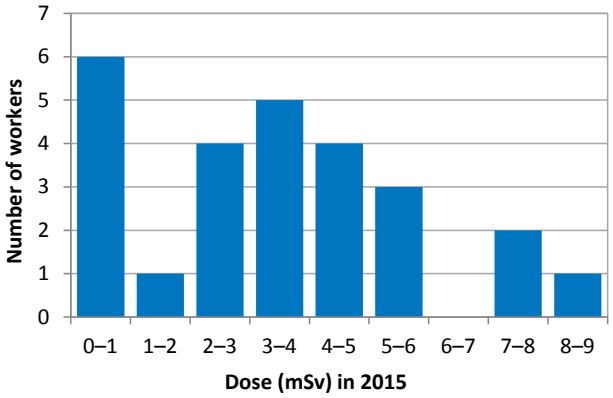

Figure 7. The distribution of the estimated effective doses in the workplaces included in the exposure monitoring.

The average of the effective doses of the monitored employees was 3.3 mSv while the median was 3.1 mSv. The highest effective dose was 8.1 mSv. At one site, use of the work space was discontinued immediately once the results of the first radon measurement were complete (3800 Bq·m^{-3}).

Cosmic radiation

The doses to the employees of six airlines were entered in STUK's Dose Register in 2015. The 2015 doses for one airline have not yet been received, but they will be recorded later, since the airline's dose calculation procedure has not yet been approved. In no case did the effective dose to an employee exceed the limiting value of 6 mSv stipulated in Guide ST 12.4. The highest individual doses of cosmic radiation recorded were 4.5 mSv to a pilot and 4.9 mSv to a cabin crew member. The average annual dose to pilots in 2015 was 2.3 mSv and that of cabin crew members was 2.4 mSv. The average doses over the period from 2011 to 2015 are shown in Figure 8.

The total number of workers in flight crews and their total dose were at the level of the previous year. The number of workers subject to individual monitoring of radiation exposure and their total doses are shown in Table 8 of Appendix 1.

Table 9 of Appendix 1 shows the number of radiation workers by field of activity subject to individual monitoring over the last five years. The combined doses to workers by field of activity are shown in Figure 1 (Item 1.1) and in Table 10 in Appendix 1. Table 11 in Appendix 1 shows the doses in 2015 to workers subject to high levels of exposure or of numerically large worker groups.

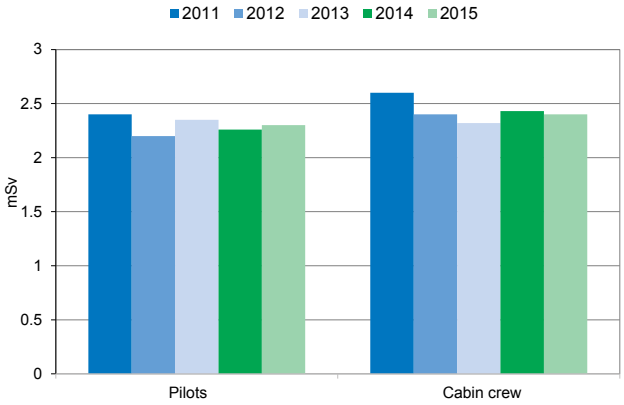

Figure 8. Average doses of flight crews in 2011–2015.

2.6 Approval decisions and verification of competence

Training organizations providing radiation protection training for radiation safety officers

In Guide ST 1.8, STUK has stipulated the minimum qualifications of the radiation safety officers who are responsible for the safe use of radiation. Training organizations that arrange training and competence exams for radiation safety officers must apply to STUK for approval to arrange such exams.

In 2015, new approval decisions to arrange exams and organize training for radiation safety officers were issued to seven training organizations. A total of 19 training organizations held valid approval decisions at the end of 2015. The approved training organizations are listed on STUK's website (www.stuk.fi).

Practitioners resposible for medical surveillance

STUK accredits the competence of medical practitioners responsible for medical surveillance of category A radiation workers. By the end of 2015, STUK had accredited a total of 450 doctors as medical practitioners responsible for medical surveillance, of whom 31 were accredited during the year under review.

Parties engaged in aviation operations

In 2015, STUK inspected three airlines. The inspections involved reviewing the companies' radiation safety procedures and issuing the necessary orders to change the practices in the event that they were found non-compliant.

Approval decisions of dosimetric services and methods of measurement

One dosimetric service was approved for operating as a service conducting individual monitoring measurements on radiation workers. The measurement methods used by the dosimetric service in question were approved at the same time. The approvals are valid for five years, after which they must be applied for again. In addition, a periodic inspection was conducted on one dosimetric service.

Approval decisions of radon measuring equipment

Three new approval decisions for radon measuring equipments were issued in 2015. A list of organizations with measuring methods that have been approved in accordance with the requirements of Guide ST 1.9 and that provide radon measurement services can be found on the STUK website. It is a condition of such approval that the measuring instrument is properly calibrated.

2.7 Radioactive waste

STUK maintains a national storage facility for low-level radioactive waste. The amounts of the most notable wastes held in the storage facility at the end of 2015 are shown in Table 12 of Appendix 1.

2.8 Abnormal events

Under Section 17 of the Radiation Decree (1512/1991), STUK must be notified without delay of any abnormal event involving the use of radiation that is substantially detrimental to safety in the location where the radiation is used or in its environs. The disappearance, theft or other loss of a radiation source such that it ceases to be in the possession of the licensee must likewise be reported. Any other abnormal observation or information of essential significance for the radiation safety of workers, other persons or the environment must also be reported.

A total of 94 abnormal events of the use of *ionizing* radiation were reported to STUK in 2015 (some of the abnormal events that occurred in 2015 were not reported to STUK until early 2016). Of these reports, 64 concerned the use of radiation in health care and 30 concerned the use of radiation in industry or orphan radiation sources. No abnormal events were reported in veterinary medicine. The numbers of abnormal events that occurred in Finland in 2005–2015 are shown in Figure 3 (Item 1.1), including abnormal events in the use of non-ionizing radiation, which are detailed in Item 4.7.

Abnormal events that occurred in health care X-ray practices and did not require immediate reporting in terms of their safety significance could, for the first time, be compiled and reported in an annual notification. Notifications on the year 2015 were received from 53 parties and they reported a total of 755 abnormal events. The annual notification differs from immediate reports in that it only lists the numbers of events falling under each respective event category. The numbers of abnormal events reported in annual notifications are presented in Table 1 by category.

The abnormal events in the use of ionizing radiation are presented below, grouped by use of radiation. More details are given of typical or significant events.

Abnormal events in health care

Abnormal events in X-ray practices

There were 35 abnormal events that were reported immediately. The most common reason for an abnormal event was equipment or system failure while the second most common reason was human error in the performance of the examination. Percentage-wise they represented 35% and 26% of the immediately reported abnormal events, respectively. Many of the abnormal events were related to a failure in the use of contrast medium during the imaging. For example, the contrast medium hose had come loose in the middle of imaging or the injection of the medium was timed incorrectly. The highest radiation exposure caused to a patient by an individual event was 14.5 mSv.

Table 1. Abnormal events reported in an annual notification for health care.

Exposed party	Type of abnormal event	Cause or contributing factor	Number of events per year
Abnormal events related to the referral			
Wrong patient	Referral written for the wrong person	Human error	16
		Human error, the high likelihood of errors in the referral system*) a contributing factor	1
Patient	Incorrect examination or anatomical object in the referral	Human error	187
		Human error, the high likelihood of errors in the referral system*) a contributing factor	12
	Another type of error in the referral		112
Abnormal events related to the performance of the examination			
Wrong patient	Wrong patient examined	The patient's identity was not verified before the examination	32
Patient	An incorrect examination was performed or an incorrect anatomical object was imaged	Human error during the performance of the examination	45
	Failed examination or an excess exposure related to the examination	Erroneous or deficient instructions	6
		Human error during the performance of the examination	81
Extraordinary exposure, other events			
Patient	Failed examination or an excess exposure related to the examination	Isolated case of equipment failure	127
		The high likelihood of errors in equipment, an auxiliary appliance or system*) as a contributing factor	50
	Examination repeated unnecessarily	No information available on earlier similar examination, or results from earlier examination not available	22
Patient and worker	Worker also exposed due to the abnormal event mentioned above (when the worker's exposure is not significant)		4
Worker	Worker exposure (when the exposure is not significant)		10
	Other event:		30
Unintended exposure of the foetus			
Foetus	Pregnant person exposed	The pregnancy is at such an early stage that it cannot be verified	1
		The possibility of a pregnancy was not considered before the procedure	2
A near miss that caused actions to be taken at the place of radiation use			
	When a more detailed report to the authorities is not considered purposeful		17

*) A high likelihood of errors refers to the poor usability of equipment or a system, allowing extraordinary radiation exposure to be caused by a human error that can occur easily.

Example event 1:
The automatic exposure control of the hospital's X-ray appliance malfunctioned, and the device took all images at the maximum values set for the system. The set maximum was suitable for heavier individuals but was three times too high for slim patients. The failure was observed in connection to quality control, but the equipment had already been used to image more than 600 patients, causing overexposure to some of them. The maximum effective dose to a patient was approximately 0.35 mSv. Children were not imaged with the faulty device.

Example event 2:
The CT device interrupted the imaging, which had to be repeated. This happened with two patients due to a device failure. The device was repaired after the first incidents and it functioned properly for a few days, but the fault recurred. The first patient was exposed to an extra dose of approx. 2 mSv while the second patient received an extra dose of less than 1 mSv.

Example event 3:
The ward had two patients with the same last name and first name. The patient transporter brought the patient to the X-ray department and the nurse checked the name from the ID bracelet. A stomach CT scan with contrast medium was taken of the patient. Later in the ward, it was discovered that the wrong patient had been scanned. The patient is estimated to have an effective dose of 14.5 mSv due to the unnecessary imaging.

In addition to the 16 categories specified in advance, the 755 events reported in the annual notification were divided into other events with minor significance in terms of radiation safety and into undefined near-misses. 43% of the reported events concerned errors in the referral, which could lead to erroneous imaging, as near-misses were also reported in this category. Individual equipment failures were reported in 127 cases, which means that, overall, the number of reported equipment failures of varying significance to radiation safety was substantially higher than in recent years. The incorrect patient was imaged in 49 cases, and a foetus was inadvertently exposed to radiation in three cases.

Abnormal events in nuclear medicine units

The nuclear medicine units in health care reported 27 abnormal events. In nine cases, the abnormal event was caused by an equipment failure, while in five cases the wrong radiopharmaceutical or a pharmaceutical of the incorrect activity level was administered to the patient. In three cases, an employee was contaminated by the radiopharmaceutical. In 20 cases, the exposed party was the patient and in seven cases it was an employee. The highest radiation exposure caused to a patient by an individual event was 17 mSv.

Example event 1:
When quality control phantom was being added into the imaging device, the needle came off the syringe, spraying some drops of radioactive Yttrium-90 on the imaging technician's upper body and face. The technician cleaned herself immediately after the incident until no levels above background radiation were found on her. The eyes, mouth and face of the technician were checked at an occupational health care clinic, but no abnormalities were found. The equivalent dose to skin was estimated to be approximately 50 mSv.

Example event 2:
Due to a faulty referral in a cardiac perfusion scan, the patient was administered the wrong tracer (Tl-201), which causes a higher radiation dose than the regular tracer (Tc-99m). The patient is estimated to have an extra effective dose of 17 mSv. The estimated dose was arrived at by deducting the dose of the scan with Tc-99m from the dose of the scan with Tl-201.

Example event 3:
The patient was provided with a 370 MBq I-131 capsule for treating hyperthyroidism. Due to the patient's difficulties with swallowing, the capsule was caught in his throat. In order to extract the capsule, an otologist was called who was able to remove some of it (140 MBq) by means of a fiberscope. The remainder of the capsule broke apart and dispersed in the pharynx. The otologist's hands were contaminated in the procedure but cleaning measures reduced the surface activity values to acceptable levels. Based on the reading of an electronic dosimeter, the doctor received a 19 µSv dose from external radiation.

Abnormal events in radiotherapy

Two abnormal events were reported with regard to radiotherapy, one of which concerned worker exposure during the maintenance of an afterloading device while the other involved an erroneous alignment in palliative radiotherapy.

Example event 1:

During the maintenance of the afterloading device, the source was being placed back in the device but the source had slid out of the shield prematurely. Two physicists and a maintenance engineer were exposed in the event. One of the physicists was exposed to a dose of 4 µSv whereas the other physicist and maintenance engineer received a dose of 2 µSv.

Example event 2:

Palliative radiotherapy was administered to treat a tumour mass clogging the lungs. The treatment was carried out by means of VMAT technology – 3 Gy · 10 treatment fractions. In treatment fractions 2–4, the treatment was aimed approx. 4–5 cm too low due to the lack of longitudinal offset. The radiotherapy was aimed two vertebrae too low although an orthogonal alignment had been performed before the treatment using a kV imaging. The first instance of treatment was performed correctly since the offset had been checked from the plan. Fractions 2–4 were aimed too low (3 Gy · 3). On the fifth time the chief physicist was asked to see why the alignment was unsuccessful. The lack of offset was discovered at this time. The treatment was then aimed correctly by taking the offset into account and positioning the patient appropriately. Due to the shape of the PTV (planning target volume), the 4–5 cm offset meant that, in treatment fractions 2–4, the radiotherapy missed the upper part of the PTV completely.

Abnormal events in industry, research and transport

Use of radiation in industry

In 2015, STUK received reports of 11 abnormal events concerning the use of radiation in industry. In five of the events, a worker was exposed to radiation emitted by a radiometric measuring appliance during maintenance because the radiation source's shutter had not been appropriately closed. In one case, a worker was exposed to radiation from a hand-held X-ray analyser. Two incidents where a person was inadvertently scanned occurred in the X-ray scanning of vehicles. One Pm-147 used in the quality measurement of paper was found to leak. In addition to this, one hand-held X-ray analyzer was stolen, and in one case it was discovered that a waste combustion plant had used sealed sources without a safety licence.

Example event 1:

A worker entered a silo to perform welding without the radiation source being sealed. The radiation source was Cs-137 at an activity of 1786 MBq. The distance to radiation source was approx. 3 metres, the wall thickness was 6 mm (steel) and the work lasted about an hour. Another person was positioned at the silo hatch a few metres further from the radiation source. However, the highest exposure was only about 10 µSv.

Example event 2:

The radiation source of the paper mill's basis weight meter – Pm-147 with an activity of 37 Gbq – did not function correctly in the coating measurement. During the measurements, it was discovered that the radiation source was damaged. STUK conducted an inspection at the paper mill. The rooms where the basis weight meter had been used and handled at the mill were checked thoroughly. The measurements indicated that the rooms were clean. The radiation source had only contaminated the inside of the source holder. The contaminated device, including the radiation source, was delivered to the manufacturer.

Example event 3:

In conjunction with the decommissioning of the radiation sources, it was found that a safety licence had never been applied for the sealed sources acquired for a waste combustion plant in 1995. However, the devices were appropriately marked and labelled the entire time. The sealed sources were delivered to a recognized installation.

Example event 4:

An X-ray analyser (45 kV) was stolen from the

responsible party's premises among other items. Interest groups were informed of the matter. To STUK's knowledge, the device was not found.

Industrial radiography

In 2015, STUK received four reports of abnormal events related to industrial radiography.

Example event 1:

The gamma source (Ir-192)used to image pipes was not completely retracted into the storage position and the imaging technician who quickly replaced the film received an extra radiation dose ($H_p(10)$ value 4.39 mSv). The imaging location was noisy, which is why the sound of the radiation alarm was not noticed in time.

Example event 2:

During pipe imaging, the two imaging technicians went over to examine the weld joint being scanned while the panoramic X-ray device in the pipe was on. Due to the high temperature, the workers had taken their jackets off, and the radiation alarms and dosimeters were in the jacket pockets near the control panel of the X-ray device. Since a radiation meter was also not used when approaching the pipe, the workers did not notice the elevated radiation level. One of the imaging technicians had a 0.8 mSv full-body dose.

Found radiation sources

Over the course of 2015, nine cases where the radiation monitoring devices of a metal recycling company or a steel mill had detected a radioactive material were reported to STUK. Cs-137, Co-60, Am-241 and Am-Be radiation sources were found mixed in with recycled metal. In three cases, the readings were caused by natural radioactive materials, such as radium. In addition to this, a weapon sight containing radium (Ra-226) was discovered among items delivered to the lost and found department of the police.

An Am-Be radiation source was found in a load of scrap metal in Sweden. The load originated in Finland. The source was not found in STUK's register and its origin is unknown.

In one case, an Am-241 radiation source was smelted at a steel plant. Due to the protective measures conducted, no radiation hazard was caused outside of the plant and workers were not exposed to radiation. The smelting of the americium source did not contaminate the metal that was being produced, because most of the americium exited as slag and combustion gas dust.

In addition to radioactive material, one instance of empty radiation source packages with radiation warning labels still attached to them were found in scrap metal.

Example event 1:

Some kilograms of radiating material (precipitate) were found in a small area of land in a scrap metal storage area. The sample taken from the precipitate was measured at STUK and found to contain natural radium (Ra-226) and small amounts of substances in the thorium series. Presumably, the precipitate originated from dismantled industrial process pipes that had, during use, accumulated precipitate and radium deposits which then dispersed in the scrap yard. The amount of radium was estimated to be lower than 3.4 Mbq. STUK issued a statement on the final disposal of precipitate containing radium, which stated that it can be disposed of in the industrial facility's waste collection area. The radium amount was low compared to the quantity of natural radium already in the waste collection area, and it will not cause environmental pollution or radiation exposure to humans after disposal.

Example event 2:

The radiation measurement gate of a metal recycling company triggered an alarm on a possible radioactive material in a scrap metal load. STUK conducted an inspection that revealed a metal flange about 20 cm in diameter, containing caesium (Cs-137). The dose rate on the surface of the flange was approximately 1.2 mSv/h, and the activity was estimated to be about 30 Mbq. No contaminations were found on the surfaces of the flange or other pieces of metal in the load. The radiating flange was delivered to a recognized installation, which found that a sealed source capsule containing caesium had been affixed in the middle of the flange. An original holder could not be found in Finland based on the markings on the capsule.

Disappearance of radiation sources

During an inspection of a responsible party's use of radiation, it was found that two Am-241

radiation sources (2.6 MBq and 370 MBq) were no longer in the company's possession. The fate of the radiation sources could not be determined despite search efforts. It is likely that the radiation sources have either been returned to the supplier or been recycled with electronic scrap.

Use of unsealed sources

One abnormal event related to unsealed sources was reported to STUK in 2015. The incident involved a worker's hand and clothes being contaminated with F-18 solution in connection to device maintenance. The worker changed his clothes and cleaned the easily removable part of the contamination off his hand. The skin of the worker's hand got a 12 mSv/cm^2 dose (dose limit 500 mSv).

Transport of radioactive materials

One abnormal event related to the transport of radioactive materials was reported to STUK in 2015. The case involved a package containing P-32 being erroneously delivered to a K-Market grocery shop near the intended hospital instead of the hospital itself. The K-Market staff informed the hospital that they had the package, and the hospital sent an employee to retrieve it. According to the clarification received from the party that handled the transport, the package was incorrectly placed on top of other pallet deliveries on board the vehicle. In transit, the package most likely fell into the roller cage that was on its way to the K-Market shop. The incident did not cause extra doses.

3 Regulatory control of practices causing exposure to natural radiation

The regulatory control of natural radiation (except cosmic radiation) was transferred to the Department of Environmental Radiation Surveillance and Emergency Preparedness on 1 June 2014. This section describes the regulatory control of natural radiation from the ground and related operations.

3.1 Radon at conventional workplaces

In 2015, STUK's alpha track radon measurements were used to conduct 2937 workplace measurements, which is twice the number of the previous year. Compared to before, a significantly higher number of radon measurements (n=485) conducted by other bodies were recorded in STUK's radon database. Fewer working-hour measurements of radon concentration were performed than in the previous year; STUK conducted 12 measurements, and 10 measurement results by other body were recorded in the radon database.

1313 inspection reports related to radon concentration were sent to conventional workplaces [a single inspection report covers more than one measurement point (location)]. The numbers of inspection reports sent to conventional workplaces and the orders issued are presented in Table 2.

At conventional workplaces, the 400 Bq/m^3 annual average radon concentration during work was exceeded at 248 measurement points and at two quarrying and construction sites. With regard to the instances where the action value was exceeded, STUK issued orders on additional clarifications and/or reductions of radon exposure. The employers' reports state that at the end of 2015, 421 employees worked in a space where the 400 Bq/m^3 radon concentration level was exceeded. Corrective measures were successfully implemented to reduce the radon concentration below 400 Bq/m^3 in 36% of the violating locations. STUK is controlling the process of lowering radon exposure at the remaining workplaces. The distribution of the radon concentrations of conventional workplaces stored in radon database is presented in Table 3.

If the radon concentration cannot be reduced even after corrective measures, a system to monitor radon exposure will be imposed on the facilities in question. Seven responsible parties (14 employers) have been under exposure monitoring in 2015. Employees of multiple companies can work on the premises of a single responsible party.

3.2 Radon in underground mines and quarries

Radon exposure in underground mines was inspected according to the set targets – the inspection interval is primarily two years. In addition to this, all long-term underground quarries reported to STUK pursuant to Section 29 of the Radiation Decree were inspected. Radon inspections were conducted on-site in five underground mines and 19 separate underground quarries or construction sites. The radon concentration was higher than 400 Bq/m^3 at two quarries and construction sites. At one of the sites, the radon concentration was successfully reduced through corrective measures, and at the other site, the working hours were short, which ensured low radon exposure.

3.3 Radioactivity of construction materials

STUK monitors exposure caused by natural radioactive materials contained by construction materials and other materials. The action level for radiation exposure caused by construction materials used for buildings to the population is 1 mSv a year. The number of monitoring measurements conducted concerning the radioactivity of construction materials meant for building production was 104, leading to the preparation of a total of 29 inspection reports.

According to the reports submitted to STUK, no cases of dose limits being exceeded were recorded. The activity measurements of construction materials have increased as a result of the EU Construction Products Regulation, which entered into force on 1 July 2013. The Construction Products Regulation makes the CE marking obligatory, also in Finland, in all construction products that enter the market and fall within the scope of the harmonized product standard. The harmonized product standards are drafted by the European Committee for Standardization CEN.

3.4 Radioactivity of household water

STUK monitors exposure caused by radioactive materials that occur naturally in water intended for human consumption. The dose caused by radioactive materials in household water may not exceed 0.5 mSv a year (dose ingested with food and drink). The radioactivity of household water was monitored at 26 sites, including waterworks and public premises. In one location, the radon concentration exceeded the action level, as a result of which the responsible party has taken measures to reduce the radon concentration in drinking water. The 0.5 mSv dose was not exceeded in any monitoring location. The natural radioactive materials in household water originate from the radioactive materials in the soil and bedrock which dissolve into surface water and groundwater.

3.5 Regulatory control of other natural radiation

STUK has been monitoring the radioactivity of the surroundings of the Talvivaara mine with regular samples taken 3–4 times a year. The monitoring has revealed elevated uranium concentrations of over 100 micrograms per litre mainly in the mine area's water systems, such as the opencast quarry and Salminen. Concentrations in the surface waters of water systems located outside of the mine area are so small that they do not pose any risk to people, animals or the environment as regards radiation protection. Such minor concentrations do not cause any adverse health effects in humans. Currently there are no restrictions related to radiation regarding natural products or foods harvested in the area. In addition to environmental surveillance, STUK has been involved in the preparation of various statements related to mining operations.

Table 2. The numbers of inspection reports sent to conventional workplaces and the orders issued between 1 January and 31 December 2015.

Required radon mitigation or working-hour radon measurement in the location	103
Required summertime measurement in the location in order to determine the annual average concentration	36
Required new measurement in the location	8
Chargeable reminder sent with regard to neglected repairs, measurements or notifications	19
Chargeable report sent (first one is free)	19
Total number of sent inspection reports	1313

Table 3. Distribution of the radon concentrations of conventional workplaces recorded in STUK's radon database and the estimated number of employees at the measured locations at the end of 2015. On the grounds of short working hours, monitoring was discontinued at 36 locations with a total of slightly over 100 employees according to the reports of the responsible parties.

Radon concentration *) Bq/m^3	Number of workplace measurements	Percentage of all workplace measurements (n = 3444) **)	Number of employees ***)
< 200	2872	83	10 672
≥ 200	572	17	1141
≥ 300	385	11	712
≥ 400	**248**	**7**	**421**
≥ 1000	62	2	96

*) If a summertime measurement was conducted at the measurement point, the table contains a calculation of the annual average radon concentration. If a measurement of radon concentration during working hours was conducted at the measurement point, the result was used instead of the alpha track radon measurement.

**) Dozens of measurement points were measured more than once. In 2015, there were 2937 measurement points.

***) The radon database includes 2033 measurement points for which the respective employers have reported numbers of employees. In total, 11 813 employees were reported. The employee numbers do not take into account work areas that have been reported to have no employees. Cases where employees have worked in high radon concentrations at some point of the year have not been taken into account if the radon concentration of the work area has been successfully reduced.

4 Regulatory control of the use of non-ionizing radiation

4.1 General

The expression "non-ionizing radiation" refers to ultraviolet radiation, visible light, infrared radiation, radio frequency radiation, and low frequency and static electric and magnetic fields. Coherent light, or laser radiation, is a special type of visible light. The use of non-ionizing radiation requires a preliminary inspection only in certain special cases, such as in the use of high-powered laser equipment in public performances. In other respects, the Non-Ionizing Radiation (NIR) Surveillance Unit of STUK conducts market surveillance for devices and practices that expose the public to non-ionizing radiation. Market surveillance is targeted at the following practices:

- sunbed services
- consumer laser devices
- wireless communication devices and high-powered radio transmitters causing public exposure
- cosmetic treatment devices that utilize non-ionizing radiation and their use in services.

In addition to regulatory control, STUK issues instructions on the application of the recommended values of low frequency electric and magnetic fields, stipulated by the Ministry of Social Affairs and Health Decree 294/2002, for example, for power lines, and approves the methods and instructions used in the inspection and regulatory control of the radio and radar devices used by the Finnish Defence Forces.

The work of the NIR Unit in regulatory control of the use of non-ionizing radiation between 2006 and 2015 is shown in Tables 13–16 of Appendix 1. The number of dangerous laser devices on the market was high, as in the previous years, but in 2015 the situation was found to be improving with regard to laser pointers. On the other hand, a higher number of unlicensed laser shows and non-compliant effect lasers were discovered. In 2015, STUK intervened in the sales of a dangerous device 18 times and in an unlicensed laser show three times. Numerous non-compliant radio devices were found on the market for the first time. The majority of these were cheap tablets sold by online retailers. As in the previous years, STUK received a large number of official statement and information requests from authorities concerning elctromagnetic fields. STUK was requested to issue statements on power line projects in particular.

In addition to carrying out regulatory control, STUK promotes the reduction of the harmful effects of UV radiation through active communication and participates as an expert in the discussion concerning the health effects of electromagnetic fields. Concerns related to mobile phone base stations and wireless networks have been particularly apparent in the inquiries made by citizens and information requests submitted to STUK.

4.2 Regulatory control of UV radiation devices

The regulatory control of sunbed devices and establishments takes place in co-operation with municipal healthprotection authorities, based on the amendment of the Radiation Act that was taken into force on 1 July 2012. Health inspectors audit the facilities as part of the regulatory control pursuant to the Health Protection Act, and submit a report on their findings to STUK for decision-making. In addition to this, STUK carries out its own inspections where necessary.

The transition period for the amendment (Radiation Act, Section 44) that prohibited self-service sunbed facilities ended on 1 July 2015. STUK supervised adherence to the amendment through active monitoring and based on reports from citizens. More detailed clarifications were requested from seven responsible parties and four operating facilities were inspected on-site.

Furthermore, the health protection authorities submitted the details of 17 inspections. (Appendix 1, Table 15). In five locations, the responsible person required by law was not present during all operating hours of the sunbed equipment. Severe technical deficiencies affecting safety were found in five locations while minor deficiencies were found in four locations. The most common deficiencies had to do with instruction manuals and timers. In addition to this, STUK was informed of an instance where a customer had burned a small area of skin in a sunbed. However, the inspection of the device revealed that the level of UV radiation met the applicable requirements.

4.3 Regulatory control of laser devices

The regulatory control of laser devices designed for private use is divided into market surveillance of traditional and online sales. In addition to this, the use of high-powered laser equipment in public performances is subject to regulatory control.

In market and on-site surveillance, STUK intervened in the sale or use of eight laser devices. Of these devices, seven were laser pointers, which all had deficiencies relating, for example, to type examination certificates and markings, and three devices were found to emit significantly higher power than the permitted 1 mW. Repair requests were issued regarding the markings, and the excessively powerful lasers were removed from the market. In one case, the inspection of a laser show revealed a high-power effect laser that did not have a lockable switch as necessitated by safety requirements. A notice was sent to the importer to remedy this issue in all corresponding products.

Webmasters of sites intended for consumer-to-consumer trade were sent 14 requests to remove a sales listing due to the excessive power of the laser pointer in question.

A total of seven laser shows were inspected on-site. In addition to this, 28 notifications were submitted to STUK on the laser shows arranged by responsible parties using approved laser devices. In the inspections, the security arrangements and the pointing of the laser beams were found to comply with the requirements in most cases. Table 13 of Appendix 1 contains a summary of the laser inspections.

4.4 Regulatory control of devices producing electromagnetic fields

STUK tested 14 products in the market surveillance of wireless communications devices (Appendix 1, Table 16), focusing on brands new to the Finnish market. The devices selected for testing consisted of phones and tablet computers. In addition to this, two TETRA phones intended for professional use were tested. The tested devices did not exceed the exposure limit, but the markings and documentation of several devices were deficient. Four devices had insufficient CE markings, which is why the processing of these devices was forwarded to the Finnish Communications Regulatory Authority.

Mobile phone base stations were monitored through a measurement campaign and safety analyses based on numerous reports from citizens. All base stations were found to be safe and installed in a compliant manner.

STUK tested the leak radiation of 10 microwave ovens as part of market surveillance measures. All appliances met the requirements set for them.

4.5 Regulatory control of cosmetic NIR applications

In the regulatory control of cosmetic NIR applications, the nail dryer control campaign was finalized, and he clarification of the requirements for tattoo removal lasers was continued in co-operation with the National Supervisory Authority for Welfare and Health and Regional State Administrative Agencies. Furthermore, a wider control campaign was planned, which will be implemented in 2016.

4.6 Other tasks

The number of statement requests to STUK on power line projects and land use plans near power lines remained high. A total of 11 statements were issued. In 2015, STUK also carried out a comprehensive analysis of exposure caused by radio devices used in work tasks and finished a report on the magnetic fields of indoor distribution substations.

Three statements were issued on other matters related to non-ionizing radiation. The topics were radar systems, laser devices and legislative projects in other administrative branches.

The effectiveness of regulatory control was improved through active communication. STUK took part in the campaign on the safety of online trade, which was coordinated by the Finnish Safety and Chemicals Agency (Tukes), and actively distributed information on the dangers of UV radiation, for example.

4.7 Abnormal events

In 2015, STUK received four notifications of events caused by *non-ionizing* radiation that required immediate action. In two cases, high-power lasers were used at a public event without a licence. Based on the information received, the risk of eye injury was significant. The processing of the incidents is still under way. In the third case, an unlicensed high-power laser was used to indicate the target result at a sporting event. Based on the report issued by the user of the device, a significant hazard was not caused but further use in Finland will require an advance inspection by STUK. The fourth abnormal event was an incident where a high-power laser pointer was pointed at a passer-by. The incident was reported to STUK by the police.

The numbers of abnormal events between 2006 and 2015 are shown in Figure 3 (Item 1.1; see also Item 2.8 on abnormal events in the use of ionizing radiation).

5 Regulation work

Radiation safety guides

To achieve a standard of safety that complies with the Radiation Act, STUK publishes guides (ST Guides) for responsible parties that use radiation or engage in practices causing exposure to natural radiation. These Finnish language guides are also translated into Swedish and English.

The following guides were updated and published in 2015:

- ST 5.8 Installation, repair and servicing of radiation appliances
- ST 9.4 Radiation safety of display lasers.

The guide ST 12.3 "Radioactivity of household water" was abolished after the implementation of the EU directive on the radioactivity of water.

Other regulation work

The new Directive (BSS 2013/59/Euratom) on basic safety standards for radiation protection was approved on 5 December 2013. It must be implemented in national legislation by 6 February 2018. The radiation legislation will be updated in connection with the implementation. The Ministry of Social Affairs and Health established a steering group to coordinate the implementation of the new radiation safety directive and the comprehensive revision of radiation legislation in January. The ministry later set up subordinate working groups to process specific areas of the directive in March. The steering group and almost all of the sub-groups initiated their work.

STUK prepared drafts of the new Radiation Act sections for the groups to process in accordance with the STUK project plan. Towards the end of the year, the preparatory measures were consolidated in such a way that the core group, which is also responsible for preparing the decrees and binding STUK regulations issued by virtue of the Act, assumed the responsibility of the overall preparations. The goal was to ensure that the draft of the Radiation Act is completed by 29 February 2016, and it would already contain the texts for all chapters and sections. In addition to the BSS directive, the core group will consider the current radiation legislation and the recommendations of the IAEA. The steering group of the STUK project monitored the progress of the efforts in its meetings and addressed any needs to determine guidelines that emerged in the context of the preparations.

"Directive 2013/35/EU of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)" must be implemented by July 2016. In Finland, the directive will be implemented by a government decree, issued under the Occupational Safety and Health Act (738/2002) and drafted by the Ministry of Social Affairs and Health. STUK participated in the drafting of the decree as an expert at the request of the Ministry of Social Affairs and Health.

6 Research

The aim of research work conducted by STUK is to provide information on the occurrence and measuring of radiation, on its detrimental effects and how to prevent them, and on the safe and optimal use of radiation. Research supports the regulatory and metrological activities of STUK and the maintenance of emergency preparedness.

Research into the uses of radiation also seeks to improve knowledge and expertise in this field and to ensure reliable radiation measurements. Most research into ionizing radiation concerns medical uses of radiation and focuses on the radiation safety of patients. There is a growing need for research owing to rapid progress in examination and treatment methodologies. Research into non-ionizing radiation focuses on the exposure determination methods needed in regulatory control and the development of regulation.

STUK has been active in its efforts to expand the pool of competence in Finnish radiation safety research. STUK and nine Finnish universities established a consortium for radiation safety research coordinated by STUK in October 2015. Through co-operation, the aim of the consortium is to secure the continuation of high-quality radiation safety research in Finland. A national programme, which describes the key research needs, was prepared and published in June to serve as the foundation for the coalition. Possible project application opportunities that suit the parties involved will become available in early 2016. The Academy of Finland accepted the EURATOM programme among the H2020 programmes whose approved projects are eligible to apply for national funding from the Academy.

University and hospital partners were also encouraged to take part in international research consortia and funding application processes related to radiation safety and radiation metrology.

Research and development work was performed in the following projects:

EMRP European Metrology Research Programme

The EU-funded MetrExtRT project (Metrology for radiotherapy using complex radiation fields) concluded in 2015, and the goals of the project were reached. The initiative yielded a measurement method for verifying the dose calculation of electron radiation in radiotherapy. The method will be used in STUK's regulatory control activities, and Finnish radiotherapy clinics were involved in its development. The measurement method was tested at the STUK's national metrology laboratory.

The EU-funded MetroNORM project (Metrology for processing materials with high natural radioactivity) develops accurate, traceable and standardized methods for measuring natural radioactive materials that emit ionizing radiation in laboratories, radiation monitoring locations and the field. STUK is involved in the standardization of the calibration and reference samples prepared in the project and the production of a new measurement device to detect alpha radiation on various surfaces in field and laboratory conditions. The measurement device is also suitable for use in abnormal events where lengthy radiochemical sample processing is not required. For STUK, the project that will conclude in 2016 has been executed as planned.

STUK took part in the application process of the 2015 metrology research programme (currently named EMPIR). Approval for a project regarding perfusion imaging was received under the health theme. STUK is involved in the CT imaging portion of the project with the University of Helsinki.

Patient skin dose and staff doses in interventional radiology and cardiology

Together with Finnish university hospitals and central hospitals, STUK has performed measurements on the skin doses of patients and staff exposure in cardiological examinations and

procedures. In connection to this, the radiation exposure of workers closest to the radiation beam has also been measured. The measurements seek to determine the dependence of the exposure on the difficulty of the procedure and the characteristics of the patient. The results of the analysis will be used to update the cardiological diagnostic reference levels in 2016.

STUK also participated in EURADOS co-operation, which has involved developing a method for measuring patient skin doses in interventional radiology and cardiology. One goal is to study whether or not a joint European alarm limit can be set for skin doses to prevent patients from receiving skin damage.

Within the scope of the EURALOC project, STUK has measured the eye lens doses of cardiologists at three Finnish hospitals. STUK is also involved in determining the cataract risk among cardiologists.

Personnel well-being in magnetic resonance imaging work

Between 2011 and 2015, STUK participated in a research project coordinated by the Finnish Institute of Occupational Health and supported by the Finnish Work Environment Fund, the purpose of which was to create information and tools to improve the working conditions, comfort and safety of employees in magnetic resonance imaging work. The project was completed in November 2015. The most essential yield of the project was the publication of the guide "Henkilöstön työhyvinvointia edistävät toimintatavat magneettikuvaustyössä" (Actions promoting staff well-being in magnetic resonance imaging).

Other research activity

The CT-DEI project developed methods for characterizing the diagnostic image quality of CT equipment. A scientific review article was published on the results.

The results of the stopping power measurements of ^{12}C ions were analysed and a Master's thesis was written on the subject at the University of Jyväskylä. The scientific article is intended to be published in 2016. A Master's thesis was written on CT dosimetry and related calibration practices for the University of Jyväskylä.

7 International co-operation

Participation in the work of international organizations and commissions

Representatives of the Department of Radiation Practices Regulation are involved in several international organizations and commissions dealing with the regulatory control and the development of safety regulations and measuring methods in the use of ionizing and non-ionizing radiation, and in standardizing activities in the field of radiation, e.g. IAEA, NACP, EURADOS, EURAMET, ESTRO, ESOREX, AAPM, IEC, ISO, CEN, CENELEC, ICNIRP, EAN, EUTERP, HERCA, EURATOM/Article 31 – Group of Experts, WHO, UNSCEAR.

The Department of Radiation Practices Regulation is involved in the European Commission's PiDRL project, in which the aim is to prepare a recommendation on radiation exposure reference levels for pediatric radiological examinations and procedures. The first draft of the recommendation was completed, and it will be finalized for publication in 2016.

The Department of Radiation Practices Regulation trained Eastern European inspectors who arrived through IAEA.

Participation in meetings of international working groups

In 2015, representatives of STUK took part in meetings with the following international organizations and working groups:

- EURAMET's (European Association of National Metrology Institutes) annual meeting of contact persons
- Meeting of the Nordic Dosimetry Group
- Meeting of the Nordic group for medical applications
- HERCA (Heads of the European Radiological Protection Competent Authorities) and its working groups
- Annual meeting of EURADOS (European Radiation Dosimetry Group) and its working groups
- Meeting of ESOREX (European Study on Occupational Radiation Exposure)
- NORGIR meeting (Nordic Working Group on Industrial Radiation)
- EACA meeting (European Association of Competent Authorities on the transport of radioactive material)
- ICNIRP (International Commission on Non-Ionizing Radiation Protection)
- NACP Radiation Physics Committee
- Nordic Ozone Group (including UV questions)
- The Nordic radiation protection authorities' NIR seminar
- WHO EMF-project and InterSun Programme; international advisory group
- IEC TC 61 MT 16 meeting (sunbed standards)
- IAEA: Transport Safety Standards Committee
- IAEA: Radiation Safety Standards Committee.

8 Co-operation in Finland

Participation in the work of Finnish organizations and commissions

Representatives of STUK are involved in several Finnish organizations and commissions dealing with regulatory control of and research into the use of ionizing and non-ionizing radiation, and with standardizing activities in the field of radiation, such as the Advisory Committee on Metrology, the Radiation Safety Conference Committee, the Education Committee of Medical Physicists, Eurolab-Finland, SESKO and the Finnish Advisory Committee for Clinical Audit appointed by the Ministry of Social Affairs and Health, the Screening Committee, SOTERKO and the Environmental Intolerance Network. STUK experts take part in several meetings in the field of radiation in Finland every year, giving presentations and lectures in them.

Participation in meetings of Finnish working groups

During 2015, representatives of STUK took part in meetings of the following Finnish organizations and working groups:

- Subordinate working groups of the Ministry of Social Affairs and Health for the overall revision of radiation legislation
- The Screening Committee of the Ministry of Social Affairs and Health and the working group preparing the decree amendment working under it
- Environmental Intolerance Network of the Ministry of Social Affairs and Health
- SESKO SK 61 committee (safety of domestic electrical appliances)
- SESKO SK 106 committee (lectromagnetic fields)
- The Radiation Safety Committee of the Finnish Defence Forces (NIR matters)
- The Education Committee of Medical Physicists (radiation protection matters).

Finnish conferences arranged by STUK

STUK arranged the following conferences in 2015:

- A conference of medical X-ray technology experts was organized between 13 and 14 April in 2015 in Espoo
- Meeting of the Nordic Dosimetry Group with workshops (CT dosimetry, beta dosimetry) 14–16 April at STUK
- Radiotherapy physicists' conference 4–5 June 2015 in Helsinki
- 11th Conference on Radiation Safety in Industry 7–8 October 2015 in Helsinki
- Training event for persons conducting meter inspections 3 November 2015 at STUK
- Radiation safety and quality in nuclear medicine 10–11 December 2015 in Helsinki.

Other co-operation in Finland

STUK engaged in regulatory control co-operation with National Supervisory Authority for Welfare and Health (VALVIRA).

A STUK representative served as a member and secretary in the Finnish Advisory Committee for Clinical Audit (KLIARY) set up by the National Institute for Health and Welfare (THL) and funded by the Ministry of Social Affairs and Health (STM). KLIARY has sought to develop the current auditing procedure and published three new recommendations in 2015 concerning advanced audits on the use of radiation in health care. The recommendations and more information on the group's operations can be found on the group's website (www.clinicalaudit.net).

9 Communication

During 2015, STUK received, via its website and by phone, a number of questions from members of the public, radiation users, the media, and other parties interested in radiation. Most of the questions were related to non-ionizing radiation. Several interviews about current radiation topics were given to the media.

The harmful effects of UV radiation were actively communicated. On 9 April 2015, STUK took part in the UV press event, which was the 13th consecutive UV event arranged jointly by STUK, the Cancer Society of Finland and the Finnish Meteorological Institute. The topics of the event included skin cancer statistics, Finnish behaviour with regard to UV radiation and research of the material effects of UV radiation. The bulletin published on the event received wide media coverage and many reporters were present. Communication related to non-ionizing radiation was refined through the improvement of the materials published on STUK's website.

Press releases and online news articles were prepared in regulatory control of radiation practices with the following headlines:

- Even one step away from the patient being scanned affects the worker's radiation dose
- Knowledge of the risks does not reduce sun bathing
- Worker exposed to X-ray radiation
- Revisions of the Nuclear Energy Act and Radiation Act to increase STUK's authority
- Online shops located in faraway countries not covered by regulatory control and consumer protection arrangements
- STUK considers discontinuing the operations of MAP Medical Technologies Oy in Tikkakoski
- Hospital reports regarding hazardous situations help develop radiation safety
- Dental X-rays should not be avoided due to pregnancy
- STUK supervises the operations of MAP Medical Technologies Oy to improve the emission measurement system
- STUK and universities join forces for radiation safety research
- Safe online shopping requires attentiveness – also during Christmas.

In 2015, STUK published one newsletter aimed at health care professionals and two newsletters aimed at industry professionals engaged in radiation practices. The aim is to make the newsletter an integral part of communication.

The preparation of a guide concerning the safety of using radiation in cardiology was initiated in 2015 by establishing a working group including cardiology specialists from outside STUK (cardiologists, physicists and a radiographer). The guide is estimated to be completed in 2016.

10 Metrological activities

10.1 General

STUK serves as the national metrological laboratory for radiation dose quantities. STUK maintains national and other measurement standards to ensure the accuracy and traceability of radiation measurements carried out in Finland. STUK calibrates its own standards at regular intervals at the International Bureau of Weights and Measures (BIPM) or other primary laboratories. In the field of radiation metrology, STUK is involved in the work of the Advisory Committee on Metrology and the European Association of National Metrology Institutes (EURAMET). STUK also participates in the international equivalence agreement (CIPM–MRA), the implementation of which is coordinated in Europe by EURAMET, and in the network of secondary standard dosimetry laboratories (SSDL), which is jointly coordinated by IAEA and WHO.

Metrological activities are the responsibility of STUK's Radiation Metrology Laboratory for ionizing radiation and the NIR Unit for non-ionizing radiation. Metrology of ionizing radiation activity quantities is the responsibility of the Department of Environmental Radiation Surveillance and Emergency Preparedness (VALO) at STUK.

Maintenance of metrological standards and development work on irradiation apparatus and methods of measurement

Irradiation equipment and national metrological standards were maintained to the calibrations of the radiation meters for radiotherapy, radiation protection and X-ray imaging. The X-ray generators at the national metrology laboratory were replaced with new ones in 2015.

Meter and measurement comparisons

STUK took part in two EURAMET calibration comparisons related to patient dosimeters in x-ray diagnostics. The measured parameters included air kerma, kerma-area product, and the kerma-length product used in computed tomography. In both comparisons, STUK's results were excellent and they supported STUK's calibration activities well.

In 2015, STUK took part in the annual TLD dosimetry audit measurement of the absorbed doses of Co-60 gamma radiation (radiotherapy dose accuracy), which is organized by the IAEA/WHO for network of calibration laboratories. STUK's results deviated by 0.9% from the reference value and were therefore well within the action levels of the IAEA and the laboratory.

11 Services

Calibration, testing and irradiation

Radiation meter calibrations and testing were performed on request. 114 radiation meter calibration, inspection and testing certificates and 36 irradiation certificates were issued. The number of samples irradiated was 612. Approximately 15% of the calibrations were performed for STUK's own instruments and samples. Figure 9 presents the development of irradiations and radiation meter calibrations and test quantities between 2003 and 2015.

The Non-Ionizing Radiation Surveillance Unit performed a total of two radiation meter calibrations and tests, along with seven safety assessments and radiation measurements. The service work of the NIR Unit between 2006 and 2015 is shown in Table 14 of Appendix 1.

Other services

The PCXMC computer application designed for calculating patient doses in X-ray diagnostics was further developed, and 63 copies of it were sold.

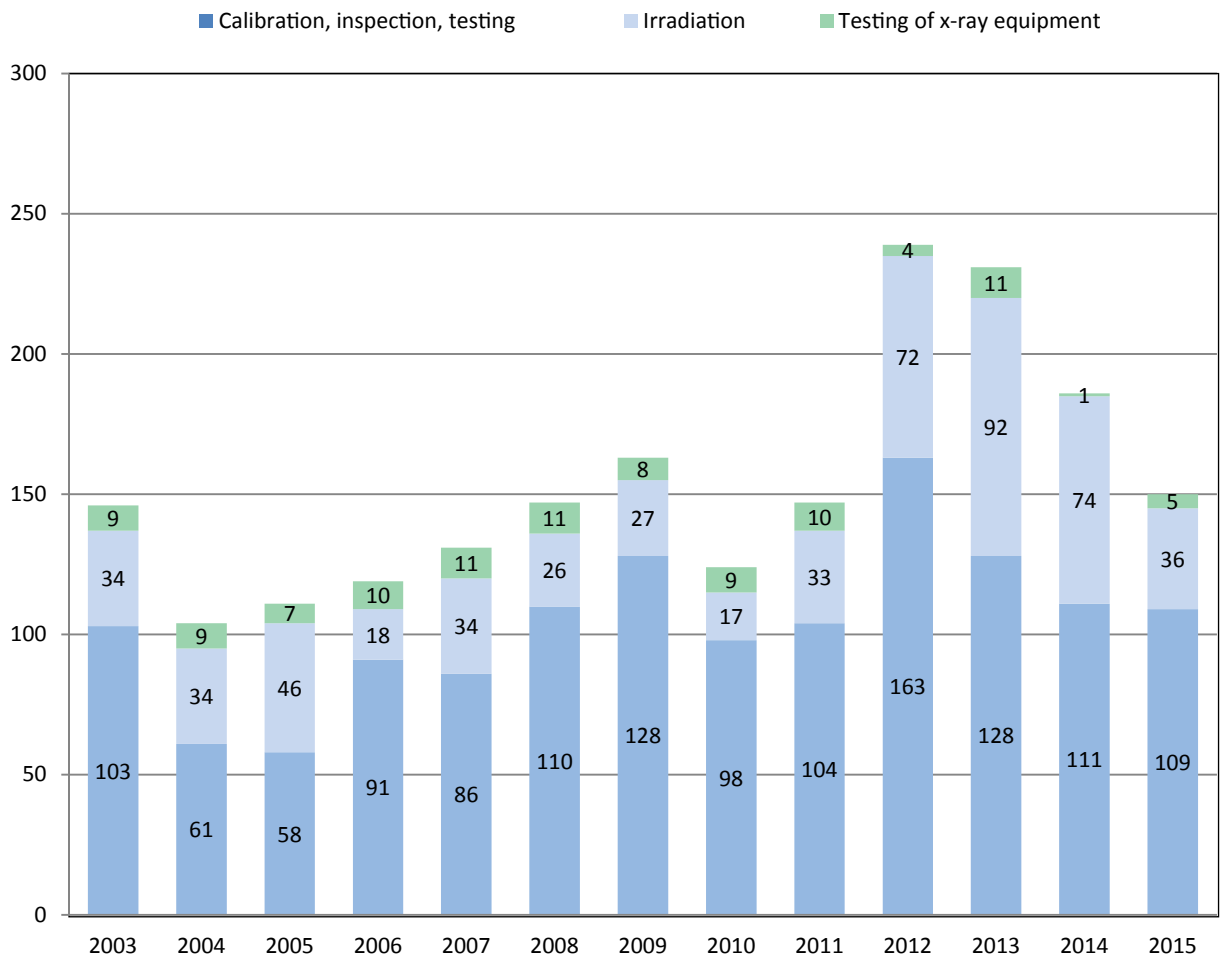

Figure 9. Numbers of irradiation certificates as well as radiation meter calibration, inspection and testing certificates provided as services between 2003 and 2015.

APPENDIX 1 TABLES

Table 1. Radiation practices in the use of radiation in health care and veterinary practices at the end of 2015.

Use of radiation	Number of practices
X-ray practices	305
Veterinary X-ray practices	242
Challenging X-ray practices	89
C-arm practices	82
Small-scale X-ray practices	1593
X-ray practices outside X-ray departments	51
Screening with X-rays	57
Use of unsealed sources	25
Use of sealed sources	24
Radiotherapy	13

Table 2. Radiation sources and appliances and radionuclide laboratories in the use of radiation in health care and veterinary practices at the end of 2015.

Appliances/Sources/Laboratories	Number
X-ray diagnostic appliances (generators)[*)]	**1575**
fixed conventional X-ray appliances	496
portable fluoroscopy appliances	262
portable conventional X-ray appliances	183
mammography appliances, of which	167
• screening mammography	87
• tomosynthesis	5
fixed fluoroscopy appliances, of which	108
• angiography	54
• fluoroscopy	29
• cardioangiography	40
CT-appliances, of which	121
• SPECT-CT	33
• PET-CT	15
CBCT appliances (other than dental imaging)	11
O-arm appliances	8
dental X-ray appliances (other than conventional dental imaging), of which	150
• CBCT appliances	82
• panoramic scanners	91
• conventional dental X-ray appliances	27
bone mineral density measurement appliances	61
other appliances	2
Dental X-ray appliances (conventional dental X-ray practices)	**5922**
conventional dental X-ray appliances	5262
panoramic scanners	660

Radiotherapy appliances	**141**
accelerators	45
X-ray imaging appliances	44
afterloading appliances	8
manual afterloading appliances	3
X-ray therapy appliances	1
radiotherapy simulators	16
sealed sources (check sources)	24
Sealed sources	**275**
calibration and testing equipment	265
attenuation correction units	6
gamma irradiators	2
other sealed sources in health care	2
X-ray appliances in veterinary practices	**368**
conventional X-ray appliances	281
bone mineral density measurement appliances	0
fluoroscopy appliances	2
intra oral appliances	71
CT scanners, of which	10
• SPECT-CT	1
• PET-CT	0
other appliances	4
Radionuclide laboratories	**36**
B-type laboratories	27
C-type laboratories	9

*) An X-ray diagnostic appliance comprises a high voltage generator, one or more X-ray tubes and one or more examination stands..

Table 3. Radiation practices in the use of radiation in industry, research and education at the end of 2015.

Use of radiation	Number
Use of sealed sources	570
Use of X-ray appliances	531
Installation, test operations and services	174
Importing and exporting of radioactive materials or trading in them	116
Use of unsealed sources	96
Use of particle accelerators	15

Table 4. Radiation sources and appliances and radionuclide laboratories in the use of radiation in industry, research and education at the end of 2015.

Appliances/Sources/Laboratories	Number
Appliances containing radioactive materials	**5911**
level switches	1907
continuous level gauges	1098
density gauges	973
weight scales	621
basis weight meters	475
appliances or sources used for calibration, testing or education	326
moisture and density gauges	112
particle analyzers	72
fluorescense analyzers	52
radiography appliances	37
other appliances	238

X-ray appliances	**1764**
fluoroscopy appliances	716
diffraction and fluorescense analyzers	514
radiography appliances	381
basis weight meters	45
other X-ray appliances	108
Accelerators	**26**
fluoroscopy	6
research	14
manufacturing of radioactive materials	6
Radionuclide laboratories	**121**
A-type laboratories	7
B-type laboratories	25
C-type laboratories	86
activities outside laboratories (tracer element tests in industrial plants)	3

Table 5. Radionuclides most commonly used in sealed sources in industry, research and education at the end of 2015.

Radionuclide	Number of sources
Other than high-activity sealed sources	
Cs-137	4056
Co-60	958
Kr-85	313
Am-241 (gamma sources)	319
Am-241 (AmBe neutron sources)	102
Pm-147	95
Fe-55	107
Ni-63	69
Sr-90	99
High-activity sealed sources	
Cs-137	51
Co-60	32
Am-241 (gamma sources)	9
Ir-192	7
Sr-90	5
Am-241 (AmBe neutron sources)	5

Table 6. Deliveries of sealed sources to and from Finland in 2015

Radionuclide	Deliveries to Finland		Deliveries from Finland	
	Activity (GBq)	Number	Activity (GBq)	Number
Ir-192	41 826	16	2347	16
Se-75	2220	1	311	2
Kr-85	1513	103	829	56
Fe-55	192	37	132	24
Cs-137	139	84	9	15
Pm-147	97	30	56	2
Ni-63	56	150	50	134
I-125	37	*)	- **)	-
Gd-153	8	14	-	-
Sr-90	8	15	6	10
Co-57	6	29	-	-
Am-241 (gamma- and alpha sources)	4	18	2	385
Ge-68	4	13	-	-
Co-60	1	5	< 1	1
others total ***)	< 1	6	< 1	2
Total	**46 110**	**521**	**3741**	**647**

*) The exact number of small sources of I-125 used in radiotherapy is not known.
**) The symbol "-" indicates no deliveries from Finland.
***) Nuclides: Po-210, Na-22, Ba-133 and Pu-238.

Table 7. Manufacturing of radioactive substances (unsealed sources) in Finland in 2015.

Radionuclide	Activity (GBq)
F-18	200 729
C-11	19 321
O-15	6700
Br-82	1577
others total*)	39
Total	**228 366**

*) Nuclides, such as: Cu-64, Au-198, Ru-103 and Mn-56.

Table 8. Number of air crew members subject to individual monitoring of radiation exposure and total dose of crew members (sum of effective doses) in 2011–2015.

Year	Number of workers		Total dose (Sv)	
	Pilots	Cabin crew	Pilots	Gabin crew
2011	1208	2423	2.85	6.23
2012	1182	2419	2.60	5.80
2013	1184	2596	2.79	6.02
2014	1213	2441	2.74	5.93
2015	1129*)	2485*)	2.60*)	5.96*)

*) One airline's data is missing.

Table 9. Number of workers subject to individual monitoring in 2011–2015.

Year	Number of workers in various sectors								
	Health care		Veterinary practices	Industry	Research and education	Manufacturing of radioactive materials	Others*)	Use of nuclear energy**)	Total***)
	Exposed to X-radiation	Exposed to other radiation sources							
2011	4320	1050	550	1209	742	22	79	3830	11 659
2012	3989	1083	582	1286	720	22	107	3676	11 341
2013	3953	1147	636	1329	727	20	125	3715	11 540
2014	3743	1243	653	1257	686	22	143	3621	11 197
2015	3631	1244	664	1371	649	26	142	3291	10 800

*) Sectors included: installation/servicing/technical test runs, trade/import/export and services.

**) Finns working at nuclear power plants in Finland and abroad and foreign workers working at Finnish facilities.

***) The figures shown in a certain row of this column is not necessarily the same as the sum of figures in other columns of the same row, as some health care staff are exposed both to X-radiation and other forms of radiation, and there are workers in industry who also work in the use of nuclear energy.

Table 10. Total doses (sums of $H_p(10)$ values) of workers subject to individual monitoring in 2011–2015.

Year	Total dose in various sectors (Sv)								
	Health care		Veterinary practices*)	Industry	Research and education	Manufacturing of radioactive materials	Others**)	Use of nuclear energy***)	Total
	Exposed to X-radiation*)	Exposed to other radiation sources							
2011	1.33	0.11	0.09	0.13	0.07	0.007	0.001	1.83	3.56
2012	1.33	0.10	0.12	0.16	0.05	0.007	0.001	2.47	4.23
2013	1.24	0.09	0.12	0.14	0.04	0.005	0.002	1.25	2.90
2014	1.29	0.08	0.11	0.16	0.04	0.019	0.007	1.57	3.28
2015	1.27	0.10	0.13	0.18	0.03	0.011	0.003	1.35	3.07

*) $H_p(10)$ values are generally (sufficiently accurate) approximations of the effective dose. One exception to this is the use of X-radiation in health care and veterinary practices in which workers use personal protective shields and in which the dose is measured by a dosemeter on the exposed side of the shield. The effective dose is then obtained by dividing the $H_p(10)$ values by a factor between 10 and 60.

**) Sectors included: installation/servicing/technical test runs, trade/import/export and services.

***) Finns working at nuclear power plants in Finland and abroad and foreign workers working at Finnish facilities.

Table 11. Data (H_p (10) values) on certain occupational groups in 2015.

Group	Number of workers	Total dose (Sv)	Average dose (mSv)		Largest dose (mSv)
			Workers whose dose exceeds recording level*)	All workers subject to individual monitoring	
Cardiologists and interventional cardiologists**)	211	0.65	3.6	3.1	24.7
Interventional radiologists**)	33	0.22	8.8	6.7	22.7
Radiologists**)	325	0.20	2.8	0.6	18.1
Consultant physicians**) ***)	296	0.06	1.5	0.2	6.4
Nurses**)	1111	0.05	0.5	0.1	2.2
Radiographers (X-rays)**)	1232	0.04	0.5	0.0	2.3
Radiographers (other than X-rays)	571	0.06	0.9	0.1	4.6
Veterinary nurses and assistants**)	404	0.09	1.0	0.2	5.9
Veterinary surgeons**)	249	0.04	1.2	0.2	5.2
Industrial material inspection technicians****)	556	0.12	0.7	0.2	6.3
Industrial tracer testing technicians	24	0.05	2.8	2.0	8.3
Nuclear power plant workers					
• mechanical duties and machine maintenance	661	0.47	1.2	0.7	8.1
• cleaning	203	0.14	1.2	0.7	7.9
• material inspection	182	0.13	1.1	0.7	4.3

*) Recording level is 0.1 mSv per month or 0.3 mSv per 3 months.

**) H_p(10) values are generally (sufficiently accurate) approximations of the effective dose. One exception to this is the dose sustained by these working groups. Workers engaged in the use of radiation (X-rays) in health care and in veterinary practices use personal protective shields, and the dose is measured by a dosemeter on the exposed side of the shield. The effective dose is then obtained by dividing the H_p(10) value by a factor between 10 and 60..

***) Including surgeons, urologists, orthopedists, neuroradiologists and gastroenterologists.

****) Exposure arising elsewhere than in nuclear power plant.

Table 12. The principal radioactive waste in the national storage facility for low-level waste (31 December 2015).

Radionuclide	Activity (GBq) or mass
H-3	38 099
Cs-137	2891
Am-241	2206
Kr-85	1714
Pu-238	1517
Am-241 (Am-Be)	604
Ra-226	235
Sr-90	219
Cm-244	148
Co-60	103
U-238 *)	1470 kg

*) Depleted uranium

Table 13. The work of the NIR Unit in regulatory control of the use of non-ionizing radiation in 2006–2015.

Year	Regularoty inspections	Decisions	Statements	Prohibitions of dangerous laser devices sold on the internet	Total
2006	48	1	7		56
2007	64	3	3		70
2008	67	5	6		78
2009	47	2	9	15	73
2010	55	3	9	31	98
2011	56	6	3	42	107
2012	53	0	15	43	111
2013	63	3	11	42	119
2014	53	2	23	41	119
2015	68	1	14	14	97

Table 14. The service work of the NIR Unit in 2006–2015.

Year	Calibrations and tests	Safety assessments and radiation measurements	Total
2006	17	7	24
2007	33	17	50
2008	46	24	70
2009	31	12	43
2010	36	13	49
2011	4	10	14
2012	8	16	24
2013	5	5	10
2014	6	8	14
2015	2	7	9

Table 15. Inspections of sunbed facilities in 2006–2015. In addition to STUK's own inspections in 2012–2015, also health inspectors of municipalities inspected the sunbed facilities in 2012–2015 and submitted reports of their findings concerning radiation safety to STUK for decision-making. In brackets there is the number of STUK's decisions. It was also investigated by requests for clarification from responsible parties, if their practices were in accordance with the requirements.

Year	Number of inspections
2006	25
2007	31
2008	26
2009	19
2010	16
2011	7
2012	6 (16)
2013	3 (40)
2014	1 (20)
2015	4 (17)

Table 16. SAR tests of mobile phones and other wireless devices in 2006–2015.

Year	Number of tests
2006	15
2007	15
2008	10
2009	15
2010	10
2011	5
2012	15
2013	11
2014	10
2015	14

APPENDIX 2

The electronic publication archive Julkari (julkari.fi) features STUK's serial publications in PDF format. Julkari also serves as a publication register. For this reason, only metadata is available for some publications.

The following publications were completed in 2015:

Scientific articles by STUK employees

Bly R, Jahnen A, Järvinen H, Olerud H, Vassileva J, Vogiatzi S. Collective effective dose in Europe from x-ray and nuclear medicine procedures. Radiation Protection Dosimetry 2015; 165 (1–4): 129-132. doi: 10.1093/rpd/ncv094.

Dabin J, Negri A, Farah J, Ciraj-Bjelac O, Clairand L, De Angelis C, Domienik J, Järvinen H, Kopec R, Maijer M, Malchair F, Novak L, Siiskonen T, Vanhavere F, Trianni A, Knezevic Z. Characterisation of grids of point detectors in maximum skin dose measurement in fluoroscopically-guided interventional procedures. Physica Medica 2015; 31: 1112–1117. http://dx.doi.org/10.1016/j.ejmp.2015.08.006.

Farah J, Trianni A, Carinou E, Ciraj-Bjelac O, Clairand L, Dabin J, De Angelis C, Domienik J, Järvinen H, Kopec R, Maijer M, Malchair F, Negri A, Novak L, Siiskonen T, Vanhavere F, Knezevic Z. Measurement of maximum skin dose in interventional radiology and cardiology and challenges in the set-up of European alert thresholds. Radiation Protection Dosimetry 2015; 164 (1–2): 138–142. http://dx.doi.org/10.1093/rpd/ncu314.

Farah J, Trianni A, Ciraj-Bjelac O, Clairand L, De Angelis C, Delle Canne S, Hadid L, Huet C, Järvinen H, Negri A, Novák L, Pinto M, Siiskonen T, Waryn MJ, Knezevic Z. Characterization of XR-RV3 GafChromic® films in standard laboratory and clinical conditions and means to evaluate uncertainties and reduce errors. Medical Physics 2015; 42: 4211–4226. http://dx.doi.org/10.1118/1.4922132.

Hourdakis Costas J, Büermann Ludwig, Ciraj-Bjelac Olivera, Csete Istvan, Delis Harry, Gomola Igor, Persson Linda, Novak Leos, Petkov Ivailo, Toroi Paula. Comparison of pencil-type ionization chamber calibration results and methods between dosimetry laboratories. Physica Medica: European Journal of Medical Physics. Published Online: October 21, 2015. DOI: http://dx.doi.org/10.1016/j.ejmp.2015.09.008.

Hourdakis CJ, Csete I, Daures J, Järvinen H, Mihailescu L-C, Sochor V, Novak L, Pedersen KM, Kosunen A, Toroi P, Denoziere M, Büermann L, Megzifene A, Einarsson G, Ferrari P, dePooter J, Bjerke H, Brodecki M, Cardoso J, Bercea S, Ciraj-Bjelac O, Compel J, Glavič-Cindro D, Ginjaume M, Grindborg J-E. Comparison of air kerma area product and air kerma meter calibrations for X-ray radiation qualities used in diagnostic radiology. Report on the EURAMET project #1177, identified in the BIPM key comparison database (KCDB) as EURAMET RI(I) – S9. Metrologia 2015; 52, Tech Suppl. 06024.

Jahnen A, Järvinen H, Olerud H, Vassileva J, Vogiatzi S, Shannoun F, Bly R. Analysis of factors correlating with medical radiological examination frequencies. Radiation Protection Dosimetry 2015; 165 (1–4): 133-136. doi: 10.1093./rpd/ncv041.

Kelaranta Anna, Ekholm Marja, Toroi Paula, Kortesniemi Mika. Radiation exposure to foetus and breasts from dental X-ray examinations: effect of lead shields. Dentomaxillofacial Radiology 2016; 45. Published Online: October 06, 2015.DOI: http://dx.doi.org/10.1259/dmfr.20150095.

Kelaranta A, Kaasalainen T, Seuri R, Toroi P, Kortesniemi M. Fetal radiation dose in computed tomography. Radiation Protection Dosimetry 2015; 165 (1–4): 226–230. doi: 10.1093./rpd/ncv097.

Lajunen A. Indication-based diagnostic reference levels for adult CT-examinations in Finland. Radiation Protection Dosimetry 2015; 165 (1–4): 95–97. doi: 10.1093/rpd/ncv087.

Pöllänen R, Turunen J, Karhunen T, Peräjärvi K, Siiskonen T, Wirta M, Turunen A. Novel equipment for in situ alpha spectrometry with good energy resolution. Health Physics 2015; 109(6): 601–605. doi: 10.1097/HP.0000000000000360.

Solc J, Dryak P, Moser H, Branger T, Garcia-Torano E, Peyres V, Tzika F, Lutter G, Capogni M, Fazio A, Luca A, Vodenik B, Oliveira C, Saraiva A, Szucs L, Dziel T, Burda O, Arnold D, Martinkovic J, Siiskonen T, Mattila A. Characterisation of a radionuclide specific laboratory detector system for the metallurgical industry by Monte Carlo simulations. Radiation Physics and Chemistry 2015; 116: 189–193. http://dx.doi.org/10.1016/j.radphyschem.2015.01.003.

Verdun FR, Racine D, Ott JG, Tapiovaara MJ, Toroi P, Bochud FO, Veldkamp VJH, Schegerer A, Bouwman RW, Hernandez Giron I, Marshall N, Edyvean S. Image quality in CT: From physical measurements to model observers. Physica Medica 2015; 31: 823–843. doi: 10.1016/j.ejmp.2015.08.007.

STUK's own serial publications

STUK. Oikeutus säteilylle altistavissa tutkimuksissa – opas hoitaville lääkäreille (Justification in examinations involving exposure to radiation – a guide to treating doctors). STUK opastaa/Maaliskuu 2015. Helsinki: Säteilyturvakeskus; 2015.

STUK. Sädehoidon riskinarviointi (Risk assessment in radiotherapy). STUK opastaa/Kesäkuu 2015. Helsinki: Säteilyturvakeskus; 2015.

Outola Iisa, Klemola Seppo, Venelampi Eija, Markkanen Mika. Rakennusmateriaalien radioaktiivisuus Suomessa. Ympäristön säteilyvalvonnan toimintaohjelma. (Radioactivity of construction materials in Finland. Environmental radiation monitoring action plan.) Ympäristön säteilyvalvonta/Maaliskuu 2015. Helsinki: Säteilyturvakeskus; 2015.

Pastila Riikka (toim.). Säteilyn käyttö ja muu säteilylle altistava toiminta. Vuosiraportti 2014. (Radiation practices. Annual report 2014.) STUK-B 189. Helsinki: Säteilyturvakeskus; 2015.

Pastila Riikka (ed.). Radiation practices. Annual report 2014. STUK-B194. Helsinki: Radiation and Nuclear Safety Authority; 2015.

Järvinen Vilma, Kaivola Mari, Ojanperä Anni, Tala Mika, Tarkkonen Tuula. Kyselytutkimus toiminnanharjoittajille säteilylainsäädännön uudistustarpeista (Questionnaire to responsible parties on needs to revise the radiation legislation). STUK-B 193. Helsinki: Säteilyturvakeskus; 2015.

STUK brochures / Other publications

Solatie Dina, Kallio Antti, Vaaramaa Kaisa, Venelampi Eija, Kyllönen Jarkko, Roos Per, Nielsen Sven P., Lauri Laura S., Holmstrand Marte Varpen, Mrdakovic Popic Jelena, Pettersson Håkan, Pelkonen Mila, Rasilainen Tiina, Leppänen1 Ari-Pekka. NORM-related Mining in Nordic Countries: Legislation, practices and case studies. NKS-350. NKS-Nordic Nuclear Safety Research, September 2015.

Radiation safety guides

Finnish language

Säteilylaitteiden asennus-, korjaus- ja huoltotyö. Ohje ST 5.8. (Installation, repair and servicing of radiation appliances. Guide ST 5.8.) STUK (25 September 2015).

Laserien säteilyturvallisuus yleisöesityksissä. Ohje ST 9.4. (Radiation safety of laser displays and shows. Guide ST 9.4.) STUK (30 April 2015).

Swedish language

Röntgenundersökningar inom hälsovården. Direktiv ST 3.3. (X-ray examinations in health care. Guide ST 3.3.) STUK (8 December 2014).

Installation, reparation och underhåll av strålningsalstrande apparater. Direktiv ST 5.8. (Installation, repair and servicing of radiation appliances. Guide ST 5.8.) STUK (25 September 2015).

Tillämpning av maximivärdena för strålningsexponering och beräkningsgrunder för stråldosen. Direktiv 7.2. (Application of maximum values for radiation exposure and principles for the

calculation of radiation dose. Guide ST 7.2.) STUK (8 August 2014).

Beräkning av stråldos från intern strålning. Direktiv ST 7.3. (Calculation of the dose caused by internal radiation. Guide ST 7.3.) STUK (13 June 2014).

Hälsokontroll av arbetstagare i strålningsarbete. Direktiv ST 7.5. (Medical surveillance of occupationally exposed workers. Guide ST 7.5. STUK (13 June 2014).

English language (translations)

Warning signs for radiation sources. Guide ST 1.3 STUK (9 December 2013).

X-ray examinations in health care. Guide ST 3.3 STUK (8 December 2014).

Application of maximum values for radiation exposure and principles for the calculation of radiation doses. Guide ST 7.2 STUK (8 August 2014).

The dose register and data reporting. Guide ST 7.4 STUK (8 December 2014).

Medical surveillance of occupationally exposed workers. Guide ST 7.5 STUK (13 June 2014).

Radiation safety of laser displays and shows. Guide ST 9.4 STUK (30 April 2015).

APPENDIX 3

ST GUIDES PUBLISHED BY STUK. SITUATION AS OF 30 APRIL 2016.

General guides

ST 1.1 Safety in radiation practices, 23 May 2013
ST 1.3 Warning signs for radiation sources, 9 December 2013
ST 1.4 Radiation user's organization, 2 November 2011
ST 1.5 Exemption of radiation use from safety licensing, 12 September 2013
ST 1.6 Operational radiation safety, 10 December 2009
ST 1.7 Radiation protection training in health care, 10 December 2012
ST 1.8 Qualifications and radiation protection training of persons working in a radiation user's organization, 25 January 2016
ST 1.9 Radiation practices and radiation measurements, 17 March 2008
ST 1.10 Design of rooms for radiation sources, 14 July 2011
ST 1.11 Security arrangements of radiation sources, 9 December 2013

Radiation therapy

ST 2.1 Safety in radiotherapy, 18 April 2011

Diagnostic radiology

ST 3.1 Dental X-ray examinations in health care, 13 June 2014
ST 3.3 X-ray examinations in health care, 8 December 2014
ST 3.8 Radiation safety in mammography examinations, 25 January 2013

Industry, research, education and commerce

ST 5.1 Radiation safety of sealed sources and devices containing them, 7 November 2007
ST 5.2 Use of control and analytical X-ray apparatus, 26 September 2008
ST 5.3 Use of ionising radiation in the teaching of physics and chemistry, 4 May 2007
ST 5.4 Trade in radiation sources, 19 December 2008.
ST 5.6 Radiation safety in industrial radiography, 9 March 2012
ST 5.7 Shipments of radioactive waste and spent fuel, 6 June 2011
ST 5.8 Installation, repair and servicing of radiation appliances, 25 September 2015

Unsealed sources and radioactive wastes

ST 6.1 Radiation safety when using unsealed sources, 2 March 2016
ST 6.2 Radioactive wastes and discharges, 3 October 2014
ST 6.3 Radiation safety in nuclear medicine, 14 January 2013

Radiation doses and health surveillance

ST 7.1 Monitoring of radiation exposure, 14 August 2014
ST 7.2 Application of maximum values for radiation exposure and principles for the calculation of radiation doses, 8 August 2014
ST 7.3 Calculation of the dose caused by internal radiation, 13 June 2014
ST 7.4 The dose register and data reporting, 8 December 2014
ST 7.5 Medical surveillance of occupationally exposed workers, 13 June 2014

Veterinary medicine

ST 8.1 Radiation safety in veterinary X-ray examinations, 20 March 2012

Non-ionizing radiation

ST 9.1 Radiation safety requirements and regulatory control of tanning appliances, 1 July 2013 (in Finnish)
ST 9.2 Radiation safety of pulsed radars, 2 September 2003 (in Finnish)
ST 9.3 Radiation safety during work on masts at FM and TV stations, 2 September 2003 (in Finnish)
ST 9.4 Radiation safety of laser displays and shows, 30 April 2015

Natural radiation

ST 12.1 Radiation safety in practices causing exposure to natural radiation, 2 February 2011
ST 12.2 The radioactivity of building materials and ash, 17 December 2010
ST 12.4 Radiation safety in aviation, 1 November 2013