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Radiation practices

Annual report 2017

Riikka Pastila (ed.)

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

STUK

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Abstract

A total of 3086 safety licences for the use of ionizing radiation were current at the end of 2017. 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 584 inspections of safety-licensed practices in 2017. The inspections resulted in 687 repair orders issued. In addition, radiation safety guides were published and research was conducted in support of regulatory control.

A total of 11 381 occupationally exposed workers were subject to individual monitoring in 2017 and 70 536 dose entries were recorded in the Dose Register maintained by STUK.

In 2017, regulatory control of the use of non-ionizing radiation (NIR) focused on lasers, sunbeds, radio appliances and cosmetic NIR applications. 22 cases of sales or import of dangerous laser devices were found through regulatory control. Fifteen on-site inspections of show lasers were conducted. Municipal health protection authorities submitted the details of the inspections of 31 sunbed facilities to STUK for evaluation and decision. In addition to this, six sunbed facilities were surveyed on the basis of STUK's own monitoring.

In metrological activities, national metrological standards were maintained for the calibration of radiation meters used in radiotherapy, radiation protection and X-ray imaging as well as the calibration of radon meters used for measurement of radon in air. In measurement comparisons, STUK's results were clearly within the acceptable range.

There were 112 abnormal events related to radiation use in 2017. Of these events, 25 concerned the use of radiation in industry and research, 84 the use of radiation in health care and three the use of non-ionizing radiation. In addition, 1085 events and near misses with an estimated minor significance for safety were reported for health care.

In 2017, nearly 7800 radon measurements at over 2000 workplaces were recorded in the national radon database. Radon concentrations detected in workplace measurements reported to STUK have decreased from the previous years. At conventional workplaces, the 400 Bq/m^3 radon concentration was exceeded at approximately 13 per cent of the measured workplaces.

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 of 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 2017, the general state of radiation practice safety in health care, industry and research was relatively good. No radiation use-related serious accidents or incidents impacting the safety of patients, employees or the environment were reported to STUK.

In 2017, the number of abnormal events reported to STUK increased slightly compared with the previous year: 105 abnormal events were reported in 2016 and 112 in 2017.

One abnormal event was associated with a fire. The fire broke out in the production facilities of an industrial plant. Dozens of radiometric measuring devices containing sealed sources were in use on the premises. Because of the duration and size of the fire, there was the possibility that the lead linings in the shields of the sealed sources could melt or the sealed sources could be damaged by high temperatures or collapsing structures. It was possible that radioactive material might escape from the sealed source as a result of such damage. Then radioactive material could easily spread across a wide area in firefighting water, for example. Particular attention was also paid to finding all the sealed sources and ensuring radiation safety during the clearing of the site of fire. The party running a radiation practice (hereinafter the responsible party) and the company responsible for the maintenance of the sealed source devices together wrote instructions for the safe handling and collection of the sealed source devices at the site of fire. All the sealed source devices were found, and the measurements carried out by the responsible party did not detect any increased dose rates or signs of leaks from sealed sources. The Safety Investigation Authority conducted an investigation of the fire. The Radiation and Nuclear Safety Authority contributed to the investigation by providing information.

Events with minor significance for radiation safety in the health care sector can be compiled into specific categories and reported each calendar year. Altogether 1085 such events were reported in 2017, compared with 998 in 2016 and 755 in 2015.

In 2017, altogether 15 377 workers were subject to monitoring of radiation exposure. Of these, 11 381 were subject to individual monitoring as occupationally exposed workers; nearly 7500 of them were engaged in radiation work and the rest in the use of nuclear energy. In Finland, the largest group of occupationally exposed workers, whose exposure rate is also the highest, is constituted by cockpit and cabin personnel working on airplanes, approximately 3600 people altogether. In 2017, there were no cases of the effective dose to a worker exceeding the annual or five-year dose limit set for workers. A collective dose of 14.65 Sv was recorded in the Dose Register in 2017 for all workers subject to monitoring of radiation exposure. Of this dose, 79% was recorded for flight personnel.

In 2017, the processing of safety licence applications and other applications was occasionally congested. However, the average processing time, 14.7 days, remained within the target range. In some cases, the maximum processing time was exceeded because of a temporary resource shortage, mainly as a result of legislative work. Reorganizations caused by the social welfare and health care reform are also reflected in applications for safety licences. Company acquisitions and the related reorganizations and responsibilities of the radiation user's organization have stirred a lot of discussion. Licence applications related to reorganization in the health care business sector were also more challenging than usual, which contributed to longer processing times.

The number of CT scans carried out in the health care sector has continued to increase, and the justification assessment and optimization of scans have become increasingly important. In 2017, particular attention was paid to the justification assessment of novel health care technologies that use radiation and, on the other hand, established technologies. The justification of new types of practices was discussed with several responsible parties in connection with changes to practices and deployment of new imaging practices.

The number of X-ray appliances in industry has increased considerably in the last ten years. The good news is that they have, to some extent, replaced appliances that contain radioactive material; the surveillance and decommissioning of such appliances is more challenging compared with X-ray appliances.

Owned by VTT Technical Research Centre of Finland and located in Otaniemi, the most significant Finnish laboratory that focuses on the researching of materials and handles radioactive materials is undergoing transformation. Decommissioning of the current laboratory facilities are underway. Some new premises were taken into use in 2017.

STUK carried out unannounced risk-based inspections related to the use of industrial radiography. These inspections proved to be useful. The inspections detected some shortcomings, and in one case the imaging practice had to be discontinued.

STUK collaborated closely with the other authorities responsible for monitoring the transport of dangerous goods by means such as participation in the meetings of a group of relevant authorities. In addition, joint inspections were carried out with the police, and a number of defects were detected.

Regulatory control of the use of non-ionizing radiation focused on providers of sunbed and beauty care services as well as laser shows.

STUK participated in three international research projects to improve the safety of X-ray diagnostics and radiotherapy. Methods for regulatory control and measurement of radiation practices in health care were developed through two projects included in the European Metrology Programme for Innovation and Research (EMPIR). In addition, the Academy of Finland granted funding for a project to develop advanced sensors for radiation measurement in X-ray diagnostics and radiotherapy. STUK signed a co-operation agreement with the Helsinki Institute of Physics.

In accordance with STUK's strategy, co-operation with universities and university hospitals was enhanced in 2017. Existing collaboration networks were reinforced, and new opportunities for research co-operation were actively surveyed. STUK has the initiative in promoting research co-operation, particularly in the fields of medical use of radiation and metrology. National architecture in radiological imaging was promoted in co-operation with the Ministry of Social Affairs and Health, KELA (The Social Insurance Institution) and the National Institute for Health and Welfare.

STUK aims to increase research collaboration with its Finnish co-operation partners in order to ensure access to up-to-date information and a high level of expertise throughout the sector. Research collaboration developed favourably. In addition, STUK participated in a number of European research projects with objectives such as receiving new recommendations from the European Commission on the use of radiation and obtaining research data necessary for Finnish users of radiation and regulatory control.

As the national metrological laboratory of ionizing radiation, STUK maintained relevant calibration and measurement methods for radiation dose quantities. The operations of STUK's national metrological laboratory were assessed and found to clearly meet the requirements set for it. To ensure high quality, the laboratory participated in regular international measurement comparisons. The comparison results for 2017 were good. Radiation meters were calibrated according to demand. In 2017, calibration services increased by 45 per cent compared with 2016.

The development of radiation safety regulations continued. STUK's contribution to the comprehensive revision of the Radiation Act was significant. The work was led by the Ministry of Social Affairs and Health. The revision is necessary in order to implement the EU directive concerning protection against dangers from ionizing radiation. The new Radiation Act is expected to come into force in 2018.

In spring 2016, STUK's premises were contaminated by radioactive cesium, and STUK requested the Safety Investigation Authority to investigate the incident. The Safety Investigation Authority's report was completed in March 2017. As a result of the incident and the recommendations resulting from the investigation, STUK revised its radiation safety guides (ST Guides) and control practices concerning the use of sealed sources. In addition, STUK commissioned a Master's thesis on the ageing on the sealed sources the results of which will be taken into account when preparing regulations pursuant to the new Radiation Act.

1 General

"Use of radiation" refers to the use and manufacture of and trade in radiation equipment and radioactive materials, and to associated activities, such as possessing, safekeeping, servicing, repairing, installing, importing, exporting, storing and transporting them, and the process of rendering radioactive waste harmless. "Radiation practice" refers to use of radiation and to any activity or circumstances in which human exposure to natural radiation (such as radon) is or may be hazardous to the health.

"Radiation" refers to both ionizing and non-ionizing radiation.

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

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.

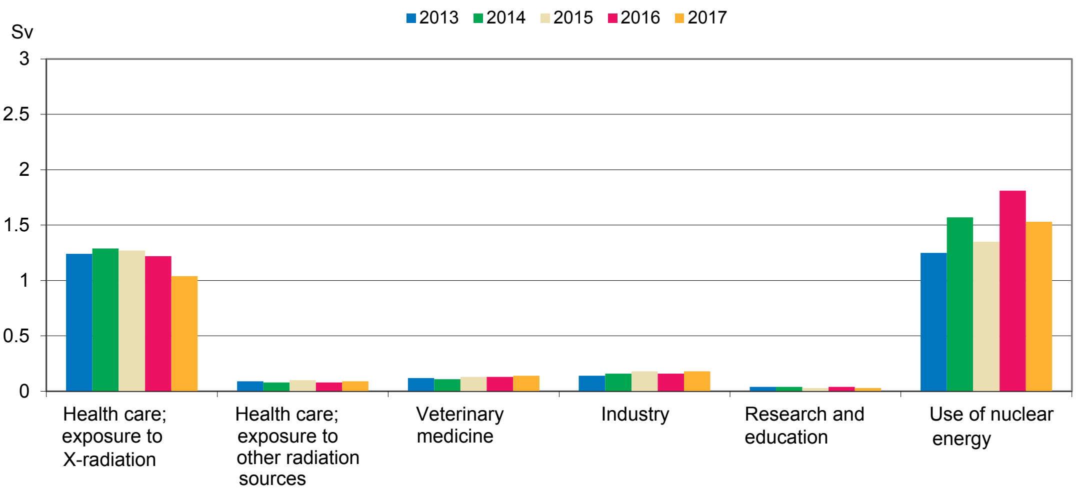

Figure 1. Combined doses ($H_p(10)$) of workers subject to individual monitoring by occupational category, 2013–2017. $H_p(10)$ values are generally (sufficiently accurate) approximations of the effective dose. An exception to this is the use of X-rays in health care and veterinary practices, in which workers 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. In addition to the occupational categories specified in the graph, a few people subject to individual monitoring 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).

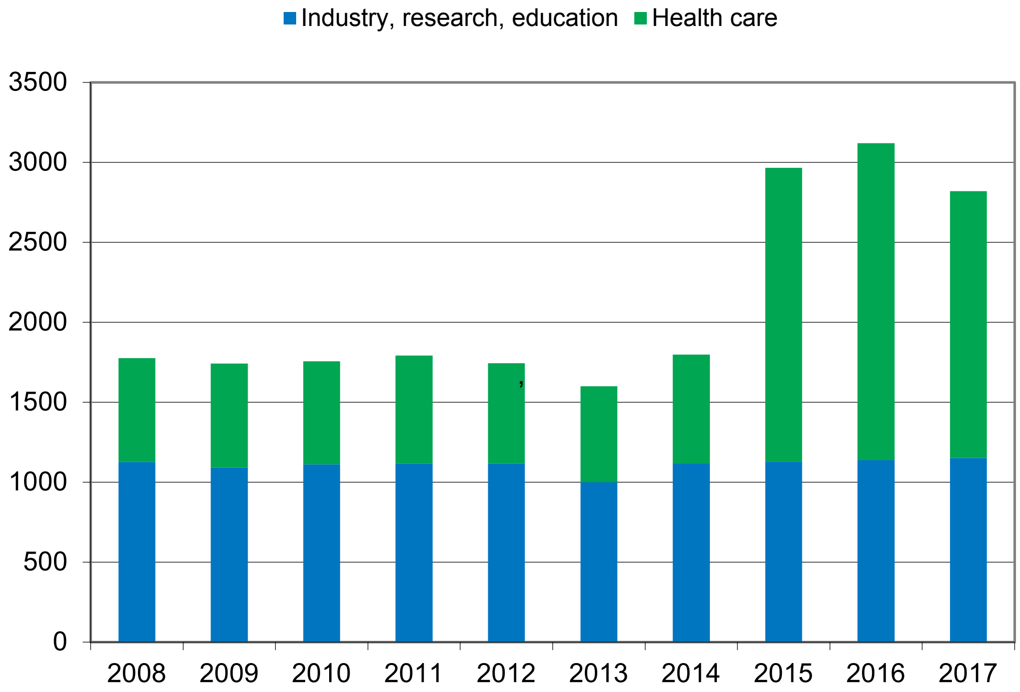

Figure 2. Current safety licences, 2008–2017. The increase in health care licences is due to the dental X-ray operations being changed from registered activities to activities that are subject to a licence.

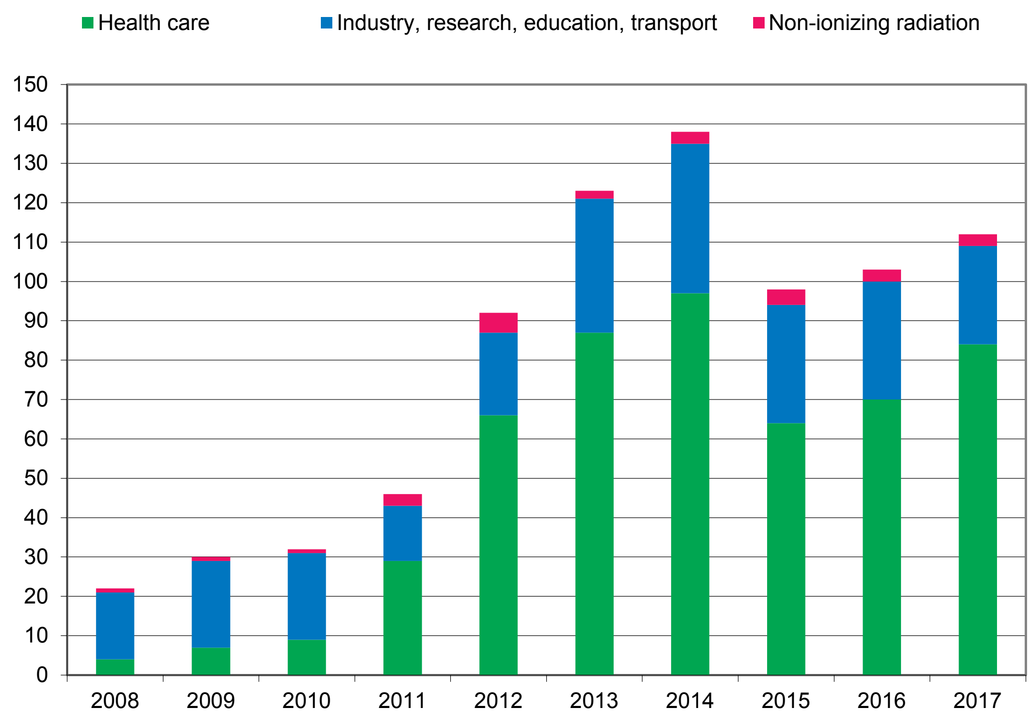

Figure 3. Abnormal events, 2008–2017.

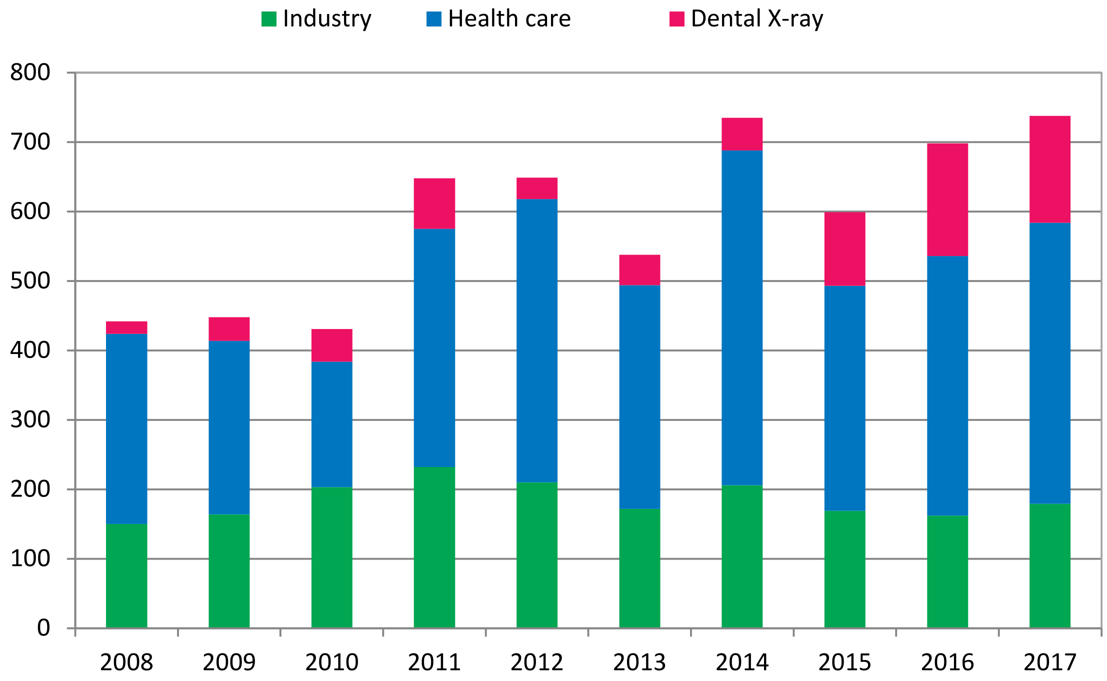

Figure 4. Inspections, 2008–2017.

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 2017, there were 1668 current safety licences for the use of radiation in health care (see also Figure 2) and 267 licences concerning veterinary practices. A total of 1090 licensing decisions (new licences, amendments to existing licenses and terminations of licences) were issued during the year. The average time for processing a health care safety licence application was 13.4 days. Table 1 of Appendix 1 shows the numerical distribution of the radiation practices referred to in these licences.

Radiation appliances, sources and laboratories

Table 2 in Appendix 1 shows details of radiation sources and appliances, and of radionuclide laboratories used in health care and veterinary practices at the end of 2017.

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

In 2017, STUK set new diagnostic reference levels for patients' radiation exposure in conventional X-ray examinations of adults. In addition, the update of the reference level for children's X-ray examinations was prepared and will be published in 2018.

STUK arranged the Radiotherapy Physicists' Conference and participated in the arranging of the Radiation Safety Conference. The Radiotherapy Physicists' Conference discussed the changes resulting from the revised legislation and held a one-day workshop on computational methods.

During inspections of X-ray practices in health care, STUK noticed doses exceeding reference levels on three different appliances. As a result of these, STUK issued repair orders for the inspected sites, requesting the responsible party to investigate whether a sufficient image quality could be achieved with a lower dose. The responsible parties were also required to make the necessary amendments to their imaging practices. In addition to these, in connection with regulatory control, STUK noticed doses exceeding the reference level on eleven dental panoramic tomography appliances and eight intraoral X-ray appliances. No radiation doses were detected in regulatory control that endangered the safety of an individual patient. Some appliances without a safety licence were detected in inspections. The responsible parties were told to immediately either apply for a licence or stop using the appliance.

STUK continued preparing a guide on the safe use of radiation in cardiology in collaboration with the Finnish Cardiac Society and experts specializing in the use of radiation in cardiology. The guide will be completed and published in 2018 in the Advice from STUK series.

STUK participated in the Kvarkki project for the implementation of national architecture in radiological imaging (the project for imaging material archiving run by the National Institute for Health and Welfare and KELA) by issuing statements and providing consulting with project plans. At the same time, specification of the characteristics necessary for the automatic collection of patients' radiation exposure data, included in the implementation of Kvarkki, was prepared, and efforts were made to include testing of the processing of patients' radiation exposure data in the testing of the archiving of imaging materials. STUK also participated in the project led by Valvira to revise the social welfare and health care licence and control process. The project is part of the "Licensing and Supervision" key project coordinated by the Ministry of Employment and the Economy. In addition, STUK participated in the 'Smart services and robotization' digitalization project that is led by the Ministry of Social Affairs and Health and falls within its administrative branch.

STUK participated in the Scientific Committee of the EUCLID project coordinated by the European Society of Radiology. The project aims to establish indication-based European reference levels for the most common CT scans, conventional X-ray examinations and interventional radiology.

STUK participated in the work of the Nordic Group for Medical Applications (NGMA) relating to the use of radiation in health care. In May 2017, the group arranged a workshop that discussed justification and reference levels. The group's annual conference in August 2017 discussed matters such as the automatic monitoring of patient doses, the practical implementation of justification assessment and the Nordic joint inspection (to be carried out in spring 2018). In addition, STUK participated in the activities of HERCA (Heads of the European Radiological Protection Competent Authorities).

X-ray equipment suppliers reported the X-ray appliances installed or reinstalled in health care practices in 2017 to STUK. The survey conducted found nine X-ray appliances for which a safety licence had not been applied before they were taken into use. In addition, a number of dental X-ray appliances not reported to STUK were found in the survey. In connection with the inspections, STUK became aware of eight health care X-ray appliances without a safety licence. Safety licence applications were submitted for these appliances.

In 2017, STUK received 84 reports on abnormal events related to X-ray practices in health care (item 2.8). Incidents with minor significance for safety can be reported in annual summaries. A total of 1085 such events were reported.

Nuclear medicine

Similar to the previous year, the inspections concerning nuclear medicine paid particular attention to the performing of contamination measurements at regular intervals and always after finishing work. Hand and foot contamination control devices have been recommended for measuring the contamination of workers. After several years of recommending, nuclear medicine units have started acquiring these devices. Contamination measurements are carried out and their results documented more frequently than before. Despite this, contamination has often been detected in inspections, as well as radioactive rubbish in places where such rubbish should not appear.

Transports of radioactive materials to and from nuclear medicine units have been inspected in collaboration with the police. Transport inspections have mainly been carried out in connection with normal inspections of locations in which radiation is used, without notifying the transport company in advance. Shortcomings in transport arrangements have been detected in these inspections, and the police has imposed a fine on the driver in these cases. No significant defects have been detected in transport-related procedures at hospitals.

The increase in PET/CT scans is reflected in the purchasing of equipment and the initiation of scanning practices at new locations of use.

Radiotherapy

Radiotherapy was provided at all five university hospitals, seven central hospitals and one private clinic to approximately 16 000 patients. In 2017, STUK conducted three commissioning inspections and 47 periodic inspections of radiotherapy equipment.

The comparative measurements between STUK and hospitals revealed that the treatment dose accuracy at hospitals was very good: the average difference was 0.1% in photon beams (standard deviation 0.3%), 0.3% in electron beams (standard deviation 0.5%) and 0.7% in afterloading sources (standard deviation 1.0%). The comparative measurements did not reveal any dose deviations that would compromise the safety of treatment.

When 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 550 radiotherapy beams. The calculation accuracy of the dose planning programmes of hospitals and the accuracy of the input data can be considered as very good. No deviations of over three per cent were detected.

In 2017, an advance statement was issued on the structural radiation shielding of a boron neutron capture therapy station. The device will be installed in 2018 and used for the administration of treatments similar to those administered using the FIR-1 reactor in Otaniemi, Espoo. However, a nuclear reactor will not be needed to produce radiation; neutrons are produced in a particle accelerator.

STUK used procedures systematically developed through the prior EMRP project in the regulatory control of novel radiotherapy accelerators and radiotherapy methods (FFF, or flattening filter free technique). The development work was continued with respect to the evaluation of the reliability of the measurement methods. The metrology research programme project RTNORM, launched in 2017, particularly focuses on improving the reliability of radiotherapy dosimetry.

2.2 Use of radiation in industry, research and education

Safety licences

At the end of 2017, there were 1151 current safety licences for the use of radiation in industry, research and education (see also Figure 2). A total of 523 licensing decisions (new licences, amendments to existing licenses and terminations of licences) were issued during the year. The average time for processing a safety licence application was 15.9 days. Table 3 of Appendix 1 shows the numerical distribution of the radiation practices referred to in these licences.

Radiation appliances, sources and laboratories

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

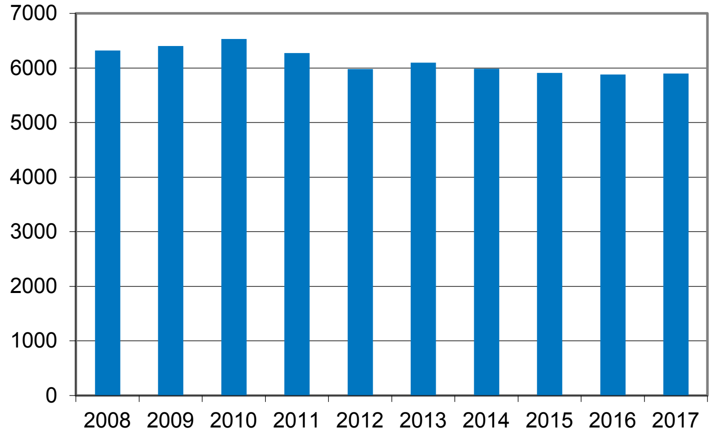

Figure 5. Appliances containing radioactive materials, 2008–2017.

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 appliance applications have been introduced.

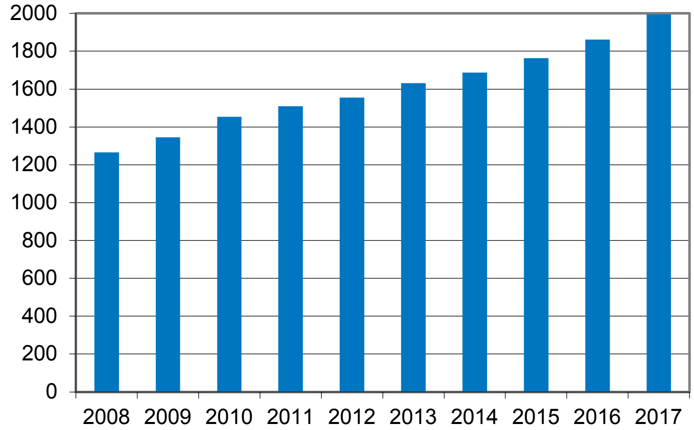

Figure 6. X-ray appliances, 2008–2017.

Table 4 in Appendix 1 shows details of the numbers of radiation appliances and sources as well as radionuclide laboratories in industry, research and education at the end of 2017.

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

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.

In accordance with its plan, STUK inspects licence holders' transportable radiation sources, as well as their use and transport arrangements, every five years. In connection with the inspections, repair orders were issued on any detected shortcomings in transport arrangements, and compliance with the orders was controlled.

No applications concerning transport of radioactive materials were submitted to STUK for processing in 2017.

STUK continued its co-operation with the other regulatory authorities responsible for monitoring the transport of dangerous goods by participating in the meetings of a group coordinated by Finnish Transport Safety Agency (Trafi) and by participating in a joint inspection.

The Safety Investigation Authority's investigation report on the contamination of STUK's premises by radioactive cesium was completed in March 2017. As a result of the incident and the recommendations resulting from the investigation, STUK revised its radiation safety guides (ST Guides) and control practices concerning the use of sealed sources. In addition, STUK commissioned a Master's thesis on the ageing of sealed sources, the results of which were taken into account when preparing regulations pursuant to the new Radiation Act.

STUK published a report on the radiation safety of battery-powered X-ray scanners that transmit pulsed X-radiation.

STUK started preparing a guide on security arrangements, aiming to help responsible parties to fulfil the requirements. The work was a thesis assignment, and it involved interviewing responsible parties and carrying out a more extensive survey.

Sealed source survey

In 2017, a survey was carried out concerning sealed source wipe tests and the storage of sealed sources. The target group consisted of licence holders using 20 or more sealed sources. Since October 2016, Guide ST 5.1 has included more detailed requirements on sealed source wipe tests. The purpose of the survey was to investigate compliance with these requirements. In addition, the survey provided information on the number of stored sources and reasons for their storage.

The questionnaire was sent to 76 licence holders and the response rate was 80 per cent. Most recipients of the questionnaire were industrial companies or energy production companies that use radiometric sealed source devices for process monitoring. In addition, some of the respondents were licence holders who use several types of sealed sources for research purposes.

Of the licence holders that responded to the survey, 64 per cent had instructions and clearly defined procedures in place for wipe tests. STUK will continue to include inspection of instructions related to wipe tests and the performance of the tests in its inspections and other regulatory control.

Altogether 65 per cent of the respondents kept radiation sources in storage. In most cases, a plan existed on the further use or decommissioning of the stored sources. The most common method to dispose of sealed sources no longer in use is to deliver them to a recognized installation. In some cases, they are returned to the supplier or manufacturer.

The storage of redundant sealed sources has clearly become less common in recent years and decades. This is positive with respect to radiation safety and security arrangements alike.

Survey on the use of nuclear medicine devices and X-ray appliances in industrial radiography

HERCA (Heads of the European Radiological Protection Competent Authorities) wanted to survey the use of different imaging methods in industrial radiography in European countries. In May 2017, STUK sent the questionnaire on the use of nuclear medicine devices and X-ray appliances in industrial radiography to all Finnish radiography companies. Among other things, the questions were related to imaging techniques as well as the pros and cons of the use of isotope sources and X-ray equipment. In addition, the respondents were asked to provide reasons for using ionizing instead of non-ionizing methods. In Finland, use of X-ray appliances is by far the most common imaging method.

If isotope sources were replaced with X-ray appliances, respondents found that the most important benefits would be improved radiation safety, improved image quality and not having to exchange and transport the sources (ADR transport). The disadvantages included the high price of X-ray equipment and, in some cases, its unsuitability for very thick materials. The use of non-ionizing methods would improve occupational safety, as radiation exposure would be avoided.

At the beginning of 2018, STUK requested reports from all vendors of X-ray equipment operating in Finland (32 vendors) on appliances delivered in 2017 and their holders. According to the delivery information, six responsible parties did not have a licence for the operation or possession of X-ray appliances. In addition, it was found that 12 licence holders had not reported their new X-ray appliances to STUK. STUK issued the necessary orders to rectify the shortcomings discovered and controlled that safety licence applications for the use of all the aforementioned appliances were submitted or that the appliances were appropriately incorporated into an existing safety licence.

2.3 Inspections of licensed radiation practices

Health care, dental care and veterinary practices

In 2017, a total of 405 inspections were conducted on the use of radiation in health care and veterinary practices. Of these, 55 were inspections on veterinary practices. These inspections resulted in 255 repair orders issued to the responsible parties. Eight appliances were found that did not have the safety licence required for their use. Three doses exceeding the reference level were measured.

Approximately 1300 responsible parties were engaged in dental X-ray practices in 2017. Patient radiation exposure from dental X-ray imaging was measured in 914 intraoral X-ray appliances using testing equipment sent by post (altogether 1000 test packages were sent). The average dose was 1.3 mGy. The dose refers 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 39 appliances.

In 2017, STUK inspected 154 panoramic tomography X-ray appliances used in conventional dental X-ray practices. Most of the deficiencies observed in these inspections were related to quality control, the appliance itself, its auxiliary instruments or accessories, or the accuracy of the registration information. Doses exceeding reference levels were detected in 11 panoramic tomography X-ray appliances.

After the inspections, a feedback survey was sent to the respective radiation safety officers, asking them to provide their opinion on the inspections. Most of the respondents found that the inspections were useful and the repair orders issued were justified. Respondents were satisfied with the content and prompt preparation of the inspection protocols.

Industry, research and education

Inspections in 2017

In 2017, a total of 179 inspections were conducted at locations where radiation is used in industry, research or education. 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 2017, nearly all new licences were inspected within a year of issuance. Some of the licences were not inspected for timetable-related reasons or because the licence holder was not active in 2017. The date of inspection is normally agreed on in advance with the radiation safety officer.

After the inspections, a feedback questionnaire was sent to the respective radiation safety officers, asking for their opinion on the inspections. Most of the respondents found that the inspections were useful and the repair orders issued were justified. Respondents were particularly satisfied with the post-inspection review that focused on the findings and the orders issued on the basis of them. In some cases, radiation safety officers reported that the inspection protocol took too long to arrive after the inspection.In general, respondents found that the inspections improve radiation safety. Feedback on the inspections and the professional expertise of the inspectors was positive.

Unannounced inspections

In 2017, STUK carried out five unannounced inspections to the facilities where radiation is used. Four of these were inspections of radiography facilities and one an inspection of an unsealed source facility. The inspections revealed defects that could have gone undetected if a notification of the inspection had been given in advance.

Below are listed some observations made during the inspections, organized in accordance with the inspection protocol headings:

1. Radiation user's organization and training of the personnel

Training of personnel in the radiation user's organization was mainly in compliance with radiation legislation. Foreign operators were an exception. For example, they did not have the qualification of a safety officer to act as the on-site radiation safety person. In one inspection, the inadequate education of foreign operators resulted in discontinuation of the use of radiation.

2. Instructions related to the use of radiation

Of the five inspected sites, only one had radiation safety instructions available at the place where radiation was used.

3. Use of radiation equipment and its location

At three of the inspected sites, the place where radiation was used was appropriately isolated from outsiders. At one inspection site, radiation practice had to be interrupted, because the place where radiation was used was inadequately isolated and the employees did not know about the work of the other imaging team. In addition, in one place of radiation use, isolation of the area had to be enhanced before continuing the radiation practice.

4. Protection of workers

Only at one inspection site was the protection of workers in compliance with radiation legislation. A suitable radiation meter was not available at two inspection sites. In addition, shortcomings were detected in personal dosemeters and radiation alarms. At one location, health examinations of radiation workers were inadequate.

5. Security arrangements

Security arrangements were mainly in order. However, it must be kept in mind that all storage facilities of radiation equipment were not visited on unannounced inspections.

6. Transport of radioactive materials

Of the five inspected sites, two used radioactive materials. The other inspected sites were purely X-ray equipment facilities. No defects were found at the inspected site, which was engaged in transporting radioactive materials.

2.4 Manufacture, import and export of radioactive materials

Details of deliveries of radioactive materials to and from Finland and the manufacture of such materials in Finland in 2017 are shown in Tables 6 and 7 of Appendix 1. The figures in the tables are based on data gathered from holders of safety licences who are engaged in trade, import, export or manufacture.

The tables do not include the following information:

- Radioactive materials 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 materials delivered to other countries via Finland.
- Sealed sources with equal or lower activity than the exemption value.
- Smoke detectors and fire alarm system ion detectors containing americium (Am-241). Approximately 49 900 of these devices were imported with a combined activity of about 1.6 GBq. Approximately 120 smoke detectors with a combined activity of about 0.4 MBq were exported from Finland.
- Lamps and fuses containing radioactive substances imported to Finland. Some special lamps and fuses contain small quantities of tritium (H-3), krypton (Kr-85) or thorium (Th-232).
- Unsealed radioactive sources imported to Finland and exported from Finland. On the basis of activity, the most common unsealed sources imported were Mo-99, I-131, Lu-177, I-123, Br-82, P-32, Y-90, F-18, Tl-201 and Ge-68.

2.5 Radiation doses to workers

A total of 11 381 workers engaged in radiation work were subject to individual monitoring in 2017. Including doses below the recording level, a total of 70 536 dose records were entered in the Dose Register maintained by STUK. This figure includes the dose records of workers exposed to natural radiation – radon and cosmic radiation.

In 2017, there were no cases of the effective dose to a worker exceeding the annual dose limit of 50 mSv or the five-year dose limit of 100 mSv set for workers. The average occupational doses were of the same magnitude as in previous years. The combined doses ($H_p(10)$) to workers were approximately 1.51 Sv in the use of radiation and approximately 1.53 Sv in the use of nuclear energy. The total dose in the use of radiation decreased by 8.8 per cent compared with the previous year. In the use of nuclear energy, the total dose was 15.6 per cent lower than the previous year. The total dose in the use of nuclear energy varies considerably from year to year, depending on the duration of annual nuclear power plant servicing and the type of the servicing tasks at these facilities. The highest individual dose resulting from radiation work at Finnish nuclear power plants was 9.0 mSv. The highest individual dose accumulated over the last five years (2013–2017) was 37.5 mSv, resulting from working at the Olkiluoto plant.

In the health care sector, the highest $H_p(10)$ dose (29.6 mSv) was recorded for an interventional radiologist. The highest $H_p(10)$ dose in veterinary practice (7.0 mSv) was recorded for an animal attendant. These correspond to effective doses of approximately 1.0 and 0.2 mSv, respectively. The highest $H_p(10)$ dose in health care from a source other than X-radiation (3.6 mSv) was recorded for a radiographer who used several radiation sources. In industry, the highest $H_p(10)$ dose (5.9 mSv) was recorded for an individual performing tracer tests. In research, the individual exposed to the highest $H_p(10)$ dose, 2.6 mSv, used several different types of sources. In the production and conditioning of radioisotopes, the highest $H_p(10)$ dose was 11.5 mSv.

In some tasks, such as the handling of unsealed sources, workers are exposed to radiation unevenly. In such cases, the dose to the hands, for example, may be considerably high, even when the effective dose is relatively low. A specific annual dose limit, 500 mSv has been specified for skin, and workers use a so-called finger dosemeter to monitor radiation doses to the hands. In 2017, the dose to the hands did not exceed the annual dose limit for any worker. The highest annual dose was 126.1 mSv, measured for a researcher. In health care, industry and research, the highest doses to the skin of the hands have decreased from the previous year, while the doses have slightly increased in the production of radioisotopes. With the exception of the production of radioisotopes, the number of workers using finger dosemeters has also decreased slightly compared with the previous year. The dose to the skin of the hands was below 100 mSv for nearly all workers handling unsealed sources.

Radon at workplaces

Dose information of workers exposed to natural radiation at work is also recorded in the Dose Register, even though such workers are not yet classified as actual radiation workers.

In 2017, nine responsible parties were under an obligation to organize radon exposure monitoring at the workplace (including subcontractors' workers). Altogether 90 workers were subject to radon exposure monitoring during the year, and their doses were recorded in the Dose Register. However, one employer with five employees did not submit the working hours for 2017 to STUK despite the orders issued by STUK.

At the end of the year, the number of responsible parties subject to radon exposure monitoring had decreased to five, and two of them had nearly completed their radon mitigation measures. At four sites, successful radon mitigation measures were carried out. In 2017, the monitoring of 62 workers ended, because radon exposure decreased below the action level.

The distribution of the estimated effective doses at the workplaces included in the exposure monitoring is presented in Figure 7. The average effective dose to the monitored workers was 1.4 mSv, while the median was 0.9 mSv. The highest effective dose was 14.8 mSv. The data of seven workers are missing.

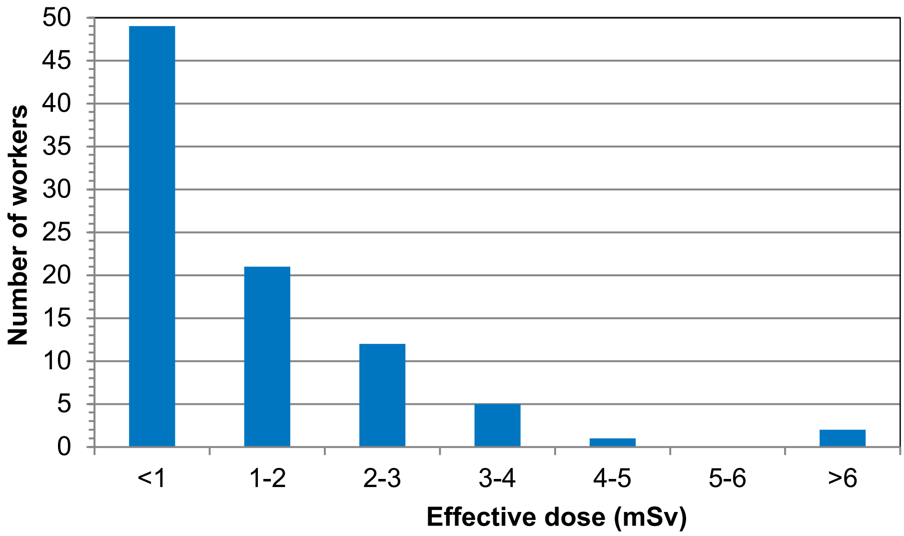

Figure 7. Distribution of the estimated effective doses at the workplaces included in exposure monitoring in 2017.

Cosmic radiation

The doses to the workers of three airlines were entered in STUK's dose register in 2017. The 6 mSv limiting value for the effective dose, stipulated in Guide ST 12.4, was not exceeded for any worker. The highest individual annual doses recorded were 5.4 mSv for cockpit personnel and 5.7 mSv for cabin crew. The average annual doses were 2.6 mSv for cockpit personnel and 3.1 mSv for cabin crew. The average doses from 2013 to 2017 are presented in Figure 8.

Compared with 2016, the number of flight crew workers increased by 8.3 per cent and the collective dose to workers increased by 14.0 per cent. Table 8 of Appendix 1 shows the number of workers subject to individual monitoring of radiation exposure and the total doses to them.

Table 9 of Appendix 1 shows the number of radiation workers subject to individual monitoring over the last five years by field of activity. 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 2017 to workers subject to high levels of exposure and to large worker groups.

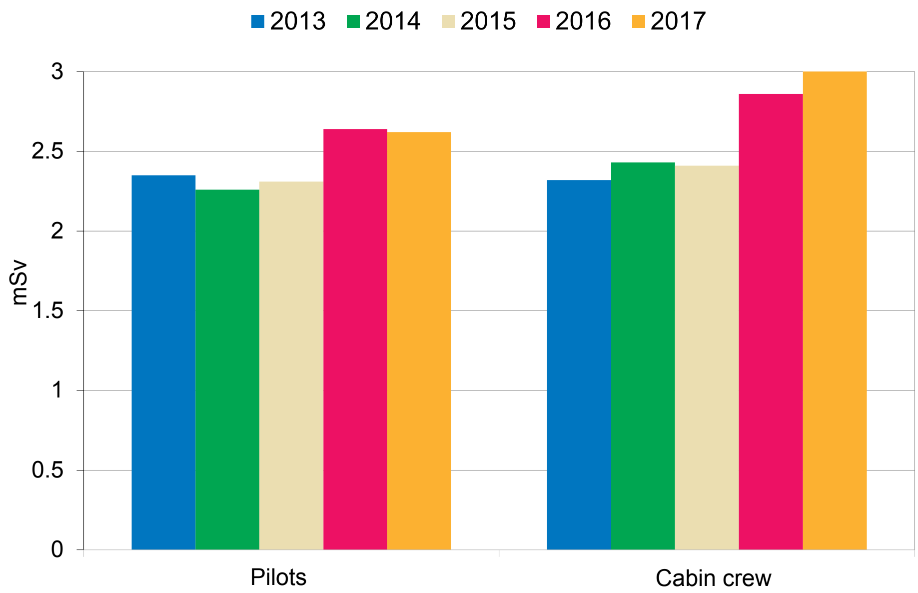

Figure 8. Average doses to flight crews, 2013–2017.

2.6 Approval decisions and verification of competence

Training organizations providing radiation protection training for radiation safety officers

In Guide ST 1.8, STUK stipulates 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 2017, approval decisions to arrange exams and training for radiation safety officers were issued to five training organizations. A total of 20 training organizations held valid approval decisions at the end of 2017. The approved training organizations are listed on STUK's website (www.stuk.fi).

Practitioners responsible for medical surveillance

STUK verified the competence of medical practitioners responsible for medical surveillance of category A radiation workers until the end of May 2017. Since then, National Supervisory Authority for Welfare and Health (Valvira) has been responsible for this task. In January–May 2017, STUK verified the competence of a total of 13 doctors as medical practitioners responsible for medical surveillance. After this, STUK transferred the data on all of its verification of competence to Valvira.

Parties engaged in aviation operations

In 2017, STUK did not inspect any airlines. Airlines are inspected every three years, and the next inspections will be carried out in 2018.

Approval decisions for dosimetric services and measurement methods

In 2017, STUK did not approve any new dosimetric services or measurement methods.

Approval decisions for radon measuring equipment

Five new approval decisions for a radon measurement method were issued in 2017. A list of organizations with measuring methods that have been approved in accordance with the requirements of Guide ST 1.9 is found on the STUK website. It includes the organizations that have consented to their names being published. Radon measuring equipment must also be appropriately calibrated.

2.7 Radioactive waste

STUK maintains a national storage facility for low-level radioactive waste. The amounts of the most significant types of waste kept in the storage facility at the end of 2017 are shown in Table 12 of Appendix 1. Since the beginning of the year 2017 some of the waste has been disposed at the TVO's final disposal repository for nuclear power plant waste.

2.8 Abnormal events

Pursuant to section 17 of the Radiation Decree (1512/1991), any abnormal event pertaining to the use of radiation that is substantially detrimental to safety at the place where the radiation is used or in its environs must be reported to STUK without delay. Similarly, any disappearance, theft or other loss of a radiation source such that it ceases to be in the possession of the holder of the safety licence must be reported. Any other abnormal observation or information of essential significance for the radiation safety of workers, other people or the environment must also be reported.

A total of 112 abnormal events of the use of ionizing radiation were reported to STUK in 2017. Some of the abnormal events that occurred in 2017 were not reported to STUK until early 2018.

Of these reports, 84 concerned the use of radiation in health care and 25 the use of radiation in industry. No abnormal events were reported in veterinary practices. The numbers of abnormal events that occurred in Finland in 2008–2017 are shown in Figure 3 (item 1.1), including abnormal events in the use of non-ionizing radiation, which are described in more detail in item 4.7.

Abnormal events in X-ray practices in health care that are of minor significance for safety and do not require immediate reporting may be compiled and reported together annually. An annual notification differs from immediate reports in that annual notifications only list the number of abnormal events under each respective event category. Notifications on the year 2017 were received from 52 parties, reporting a total of 1085 abnormal events.

The numbers of abnormal events reported in annual notifications are shown by category in Table 1 below.

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

Abnormal events in health care

Abnormal events in X-ray practices

In health care X-ray practices, 48 abnormal events were reported immediately following the event, compared with 55 events in 2016. The most common reasons for an abnormal event in 2017 were a human error during an examination (11 cases) and imaging of a wrong patient (11 cases). Both of them accounted for 24 per cent of immediately reported abnormal events. Many of the abnormal events were related to failed use of contrast medium during imaging. The highest individual exposure, 34 mSv, was caused to a foetus when a 14-year-old female trauma patient was examined several times by CT and other imaging methods immediately following the accident and during the treatment period of approximately one month. The imaging examinations causing the highest doses to the foetus were performed in weeks 4 and 5 of pregnancy. Because of her young age, the patient had not been routinely asked about the possibility of pregnancy, and the pregnancy was detected later in an ultrasound control.

Example event 1:

An extensive CT scan of the body was performed on the patient. During the injection of contrast medium, some of it entered the vein, but in the middle of the procedure the injection tube got broken as a result of high pressure. Enough contrast medium had entered the vein to be visible in the aorta, and the scan was started. Afterwards, when viewing the images, it was noted that hardly any contrast medium was visible in the images. After checking the images, the radiologist decided that the CT scan had to be repeated. The extra CT scan caused an effective dose of approximately 23 mSv to the patient. It was decided that a pressure-resistant injection tube will be used in the future if the patient's arm is in a difficult position or the pressure may rise high for some other reason.

Example event 2:

A CT scan of the abdomen was performed on a patient. A radiographer student working as a substitute was assigned to operate the device during the scan (except for the dosing of the contrast medium), because the examination was a simple abdominal scan. Preparing the patient for the examination turned out to be a laborious and time-consuming task. When the examination was underway, the student at one stage pressed the imaging button too early by mistake. For this reason, the preliminary image had to be retaken. In addition, the delay time set for the examination unexpectedly switched to zero, which led to incorrect timing of the scan and, consequently, failure of the examination. The scan was immediately repeated. The employees supervising the student could not anticipate the unexpected change in the imaging parameters in the abnormal situation, and the change remained unnoticed. The patient received a double dose of radiation in the abdominal area, that is, an extra effective exposure of approximately 4 mSv.

Table 1. Abnormal events in health care reported through annual notification.

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	49
		Human error, the high likelihood of errors in the referral system*) a contributing factor	3
Patient	Incorrect examination or anatomical object in the referral	Human error	89
		Human error, the high likelihood of errors in the referral system*) a contributing factor	22
	Another type of error in the referral		125
Abnormal events related to the performance of the examination			
Wrong patient	Wrong patient examined	The patient's identity was not verified before the examination	26
Patient	An incorrect examination was performed or an incorrect anatomical object was imaged	Human error during the performance of the examination	89
	Failed examination or an excess exposure related to the examination	Erroneous or deficient instructions	10
		Human error during the performance of the examination	97
Extraordinary exposure, other events			
Patient	Failed examination or an excess exposure related to the examination	Isolated case of equipment failure	205
		The high likelihood of errors in equipment, an auxiliary appliance or system*) as a contributing factor	83
	Examination repeated unnecessarily	No information available on earlier similar examination, or results from earlier examination not available	29
Patient and worker	Worker also exposed due to the abnormal event mentioned above (when the worker's exposure is not significant)		7
Worker	Worker exposure (when the exposure is not significant)		39
	Other event:		20
Unintended exposure of the foetus			
Foetus	Pregnant person exposed	The pregnancy is at such an early stage that it cannot be verified	4
		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		181

*) 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 3:
The imaging unit was waiting for two patients to arrive from the ward; one of them was coming for a chest X-ray and the other for an abdominal CT scan. A CT scan was by mistake performed on the patient coming for the chest X-ray, because the patient's identity was not established. The patient was unable to communicate but was accompanied by a nurse from the ward.

In addition to the 16 categories specified in advance (see Guide ST 3.3), the events reported in annual notifications (1085 in total) were divided into other events with minor significance in terms of radiation safety and into undefined near-misses. Additional information was reported for some events. One third of the reported events concerned errors in a referral. It is estimated that this category also included some near-misses, that is, incorrect referrals that were caught before they led to imaging errors. Individual equipment failures were reported in 205 cases. Imaging of wrong patient was reported 75 times, and a foetus was inadvertently exposed to radiation in six cases. This was the third year when annual notifications were collected. Their number did not significantly increase from the previous year even though reporting activity increased slightly.

Abnormal events in nuclear medicine units

Nuclear medicine units in the health care sector reported 34 abnormal events. The number of reported abnormal events increased considerably compared with 2015 and 2016 (27 and 13 reported abnormal events, respectively). In 2017, the number of abnormal events was the same as in 2014. No particular reason has been identified for the increase in reported abnormal events.

In eight cases, the abnormal event was related to a failed injection of a radiopharmaceutical. Four notifications were received in the following event categories: the user's mistake in carrying out an imaging examination; the imaging of a patient had to be repeated because of imaging equipment failure; and a worker or work area was contaminated by a radiopharmaceutical. In 27 cases, the exposed party was a patient, in five cases a worker and in one case a foetus (member of the public).

The highest individual extra exposure of a patient caused by an abnormal event was 14 mSv. It occurred when the injection of a radiopharmaceutical failed in a PET-CT scan and the patient had to be scanned a second time. The highest local skin exposure of a worker was caused by contamination. When injecting a beta-active radiopharmaceutical, the syringe joint broke and a splashing radiopharmaceutical contaminated the environment. An exposure of approximately 430 mSv resulted from the contamination to a small area of the forearm of the physician administering the injection. The effective dose caused to the doctor by the incident was under 0.1 mSv.

Example event 1:
After performing a PET-CT scan it was noticed that the radiopharmaceutical injection had failed and most of the FDG tracer had ended up in the patient's hand and wrist. Evidently the tracer had been injected into an artery by mistake. The quality of the scanned images was inadequate and the examination had to be repeated. The failed examination caused an extra exposure of 14 mSv to the patient.

Example event 2:
In a sentinel lymph node examination performed on a patient, a lymph node was localized in the pelvic area. It was scanned with SPECT and CT. Later it was found out that the patient had been in the fourth week of gestation at the time of the examination. The low-dose CT scan caused an exposure of approximately 2 mGy to the foetus.

Example event 3:
A nurse was transferring a 14 GBq bottle of F-18 FDG from one lead jacket to another when the bottle fell on the floor and was broken. The nurse immediately left the room. A physicist removed most of the leaked radioactivity with spill pads. The cleaning caused an exposure of approximately 0.4 mSv to the physicist.

Example event 4:
A physician was administering P-32 radionuclide therapy to a patient. When injecting the substance, the syringe joint broke and splashes of beta-active radiopharmaceutical contaminated the environment. An exposure of approximately 430 mSv resulted from the contamination to a small area of the forearm of the physician administering the injection. The effective dose caused to the doctor by the incident was under 0.1 mSv.

Abnormal events in radiotherapy
Two abnormal events were reported in radiotherapy. In the first case, a radiographer was exposed to radiation when checking the functioning of contrast medium injection in the CT simulator scanning room. The nurse was exposed because of an incorrectly chosen imaging protocol; it did not include the delay time before the initiation of irradiation that is applied in contrast medium examinations. In the second case, the radiotherapy accelerator's 6 MV treatment field profile and dose level deviated by nine per cent from the target, but the therapeutic device did not detect the error. The error was detected in normal quality control. The dosimetric deviation caused by the incorrect dose level and profile of the 6 MV treatment field was less than five per cent for patients at the target of treatment.

Abnormal events in industry, research, education and transport
In 2017, STUK received reports of 25 abnormal events concerning the use of radiation in industry, research, education and transport. The reports were related, for instance, to industrial radiography, the use of unsealed sources, transport of radioactive materials, and detection of radiation sources in a metal recycling process or elsewhere.

Use of radiation in industry
Ten abnormal events related to the use of radiation in industry were reported to STUK in 2017. In three cases, shutters of sealed source devices had not been closed after maintenance work, and also in three cases, people or their body parts had ended up in a radiation beam or close by. In two cases, the sealed source was found to be damaged. One case was related to a major industrial fire, and one case involved slight contamination of transport packaging.

Example event 1:
A fire broke out in the production facilities of an industrial plant. Dozens of radiometric measuring devices containing sealed sources were in use on the premises. Because of the duration and size of the fire, there was the possibility that the lead linings in the shields of the sealed sources could melt or the sealed sources be damaged. As a result of the damage, radioactive material could easily spread across a wide area in firefighting water, for example. Particular attention was also paid to finding all the sealed sources and ensuring radiation safety during the clearing of the site of fire. All the sealed source devices were found, and no elevated dose rates or signs of leaks from sealed sources were detected.

Example event 2:
A food industry worker manually removed products that were jammed inside a fluoroscopy appliance without switching the X-ray scanner off first. However, it was not possible to stick one's hand all the way into the radiation beam in the device located on the production line. Therefore, the dose to the hand from the scattered radiation was insignificant. The correct practices in using the appliance were discussed with all users.

Example event 3:
A car with two people inside was X-ray scanned at a border crossing station. The scanning was immediately interrupted when the people inside were noticed. The passengers in the car had been asked to come out of the car for the X-ray scanning. The driver and the person sitting next to the driver stepped out. The driver had not understood the oral instructions and did not inform about the other passengers. On the basis of the measurements performed, the dose caused by the scan was estimated to be approximately 5 µSv. Following the incident, the instructions related to X-ray scanning were specified in more detail.

Industrial radiography
In 2017, STUK received one report of an abnormal event in industrial radiography. The case concerned suspected defects in the definition of the scan range and possible exposure of workers to radiation. In case the exposure had occured at the distance described, computationally estimated exposure to workers would have been 253 µSv (at the worst). The computationally estimated exposure does not exceed the dose constraint 300 µSv per year and it would have not posed any hazard to health.

Use of unsealed sources
In 2017, four abnormal events related to the use of unsealed sources were reported to STUK. Three cases concerned slight contamination of working areas or workers. One case concerned the malfunction of the transfer equipment of radioactive gas; as a result, gas leaked out of the equipment.

Example event 1:
Radioactive iodine (I-123) leaked into the air of the production premises of a radiopharmaceutical manufacturing company and, consequently, into outdoor air. The production cabinet waste tube had been disconnected so that iodine leaked into the waste container of the cabinet and from there to the floor. The worker who detected the leak carried out cleaning measures with a coworker immediately after detecting the leak, and the room was put in quarantine. Thyroid gland contamination was detected in both workers (committed effective doses 3.7 µSv and 0.6 µSv). The release into outdoor air amounted to 92 MBq. The release had no effect on the environment. The mechanism for connecting the waste tube to the waste container was changed as a corrective action.

Transport of radioactive materials
Of the abnormal events reported to STUK in 2017, one was related to the transport of radioactive materials. The case involved a damaged outer packaging of a transport package, while the inner packaging was undamaged.

Found radiation sources

Of the abnormal events reported to STUK in 2017, nine were related to found radiation sources or radiating loads detected in a metal recycling process or elsewhere. In one of these cases, an object containing depleted uranium was found among recycled metal. The batch of metal came from Poland. The object's origin and purpose of use were not known, and it was taken to STUK's radioactive nuclear waste storage. In one case, an Am-241 sealed source was melted in a steel manufacturing process, and in one case, an old sealed source was found on the premises of a responsible party with activity decreased below the exemption value.

3 Regulatory control of practices causing exposure to natural radiation

This chapter describes the regulatory control of natural radiation from the ground and related operations.

3.1 Radon at conventional workplaces

Radon measurements are carried out by STUK and other parties, and radon concentrations are recorded in STUK's national radon database. Only a few workplace radon concentrations measured by other parties that are below 400 Bq/m^3 were reported to STUK. The radon measurement season covers the end and beginning of the year, and there is a two- to four-month delay between the ordering of an alpha track radon measurement and the sending of the results. Therefore, the numbers of alpha track radon measurement-related orders and results are different.

Workplace radon control covered nearly 2100 inspection sites (= a workplace or a separate building). Over 7800 radon concentration measurements from over 7600 measurement sites were recorded in the radon database for them. Nearly 1800 protocols were prepared relating to radon at the workplace.

Workplace radon concentrations reported to the radon database were lower compared with the previous years (Figure 9). At conventional workplaces, the 400 Bq/m^3 radon concentration was exceeded at approximately 13 per cent and 300 Bq/m^3 at approximately 17 per cent of the measured workplaces. At least one radon concentration of over 400 Bq/m^3 was measured at approximately 260 workplaces. According to employers' reports, at the end of 2017, over 1000 employees worked in a space where the radon concentration of 400 Bq/m^3 was exceeded. In addition, nearly 1400 employees worked in a space with a radon concentration of over 300 Bq/m^3 .

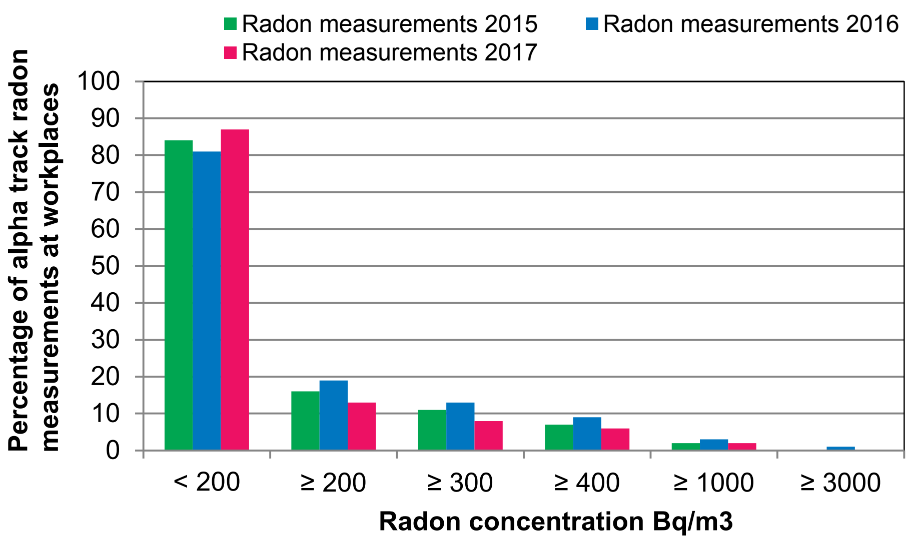

Figure 9. Distribution of the radon concentrations measured by alpha track detectors across concentration categories in 2015–2017.

3.2 Radon in underground mines and at excavation sites

Radon exposure in underground mines was inspected in accordance with the specified goals. The basic inspection interval is two years. In addition, all long-term underground excavation sites reported to STUK pursuant to section 29 of the Radiation Decree were inspected. Altogether 24 radon inspections at 19 sites were carried out in mines and at underground excavation sites.

Radon concentration was higher than 400 Bq/m^3 at two excavation and construction sites. STUK issued orders to reduce the radon concentration at these sites. All of the sites succeeded in reducing the radon concentration to below 400 Bq/m^3. In all mines, radon concentrations were found to be below 400 Bq/m^3.

3.3 Radioactivity of construction materials

STUK monitors exposure caused by natural radioactive substances contained in construction materials and other materials. The action level for radiation exposure to the population caused by construction materials used for buildings is 1 mSv a year. A total of 87 measurements were carried out concerning the radioactivity of construction materials intended for building production. These resulted in the preparation of seven inspection protocols that required further reporting. According to the reports submitted to STUK, there were no cases in which the action level was exceeded.

3.4 Radioactivity of household water

The rules for the regulatory control of household water radioactivity were amended in 2017, and the radioactivity of household water was monitored more extensively and systematically. The dose caused by long-lived radioactive substances in household water must not exceed 0.1 mSv a year (dose ingested in food and drink). The radioactivity of household water was controlled at approximately 360 locations, which included waterworks and public premises. In five locations, radioactivity exceeded the action level, and the responsible party has taken measures to reduce the radioactivity of drinking water. In 2016–2017, radioactivity was controlled at nearly a thousand locations.

3.5 Regulatory control of other natural radiation

In 2017, STUK carried out two inspections at Terrafame Oy's Sotkamo mine that involved sampling. In addition, Terrafame Oy's own monitoring results and water condition reports are actively followed, and STUK engages in close co-operation with the Kainuu Centre for Economic Development, Transport and the Environment.

In 2017, Terrafame Oy's operations did not cause any uncontrolled releases of uranium into the environment. From the radiation protection perspective, the situation is stable and no particular risk of natural radiation exposure exists at the moment. Some water management problems have occurred, but they have not resulted in significant releases of uranium into the environment. The central water treatment plant and discharge pipe have been working as planned. In 2017, the average uranium concentration of the water discharged from the pipe was 1 µg/l and the highest individual uranium concentration was 4 µg/l, while the limit specified in the environmental permit is 10 µg/l. The efforts to reduce the old uranium-containing water supplies in the open pit have been successful and the supplies have decreased considerably. Lake Salminen still contains stratified water with elevated uranium concentrations, even though the uranium concentration has gradually decreased over the years.

In addition to environmental surveillance, STUK has been involved in the preparation of various statements related to mining operations and provided radiation protection guidelines related to natural radiation.

4 Regulatory control of the use of non-ionizing radiation

4.1 General

"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 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 of devices and practices that expose the public to non-ionizing radiation. Market surveillance is targeted at the following functions:

- 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, to uses such as 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 in 2008–2017 is shown in Tables 13–16 of Appendix 1. Some dangerous laser devices were found, but devices such as laser pointers have been available in the market less frequently than before. In 2017, STUK intervened 22 times in the sale of a dangerous device and three times in the unlicensed use of an effect laser. Similar to previous years, STUK received a number of requests for official statements and information requests related to electromagnetic fields from the authorities. In particular, STUK received requests for statements on power line projects.

Enhanced regulatory control of the use of non-ionizing radiation was targeted at providers of beauty treatments and sunbed services that apply radiation. Many shortcomings were detected that affect safety. As a result of the enhanced regulatory control of beauty treatment companies initiated in 2016, powerful laser devices were removed from many treatment parlours. On the other hand, some companies in the beauty care industry seem to be concealing their activities that involve the use of non-ionizing radiation. The number of importers of treatment devices has increased.

The increased online trade with consumers ordering products directly from outside the EU poses a challenge to the regulatory control of consumer products. In addition, the prices of products such as high-powered laser equipment have decreased considerably as a result of the advancement of technology. In many product categories, traditional branded products are accompanied by cheap non-branded models. STUK monitored the situation actively and noticed a positive development: dangerous laser pointers were found less frequently than in the peak years. Regarding laser products, a laser effect product purchased from an online store outside the EU in autumn 2017 was sent to STUK for inspection. On the surface, the package, product and product name were nearly identical to a product sold in Finnish stores. On the basis of the measurements, the product purchased from the Finnish store is eye-safe, while the product purchased through the internet is not. The product purchased on the internet was sent to STUK by a citizen who was concerned about its safety. The character of online trade is well depicted by the fact that the store in question no longer existed in April 2018.

In addition to carrying out regulatory control, STUK promotes the reduction of the harmful effects of UV radiation through active communication. Last year, the dangers of UV radiation were communicated to children and their parents, among others, through the ”Oppi & ilo, Iloisen turvallisia seikkailuja (Fun Adventure With Safety)” booklet. The booklet also includes information about the dangers of radon. Furthermore, STUK participates as an expert in the debate concerning the health effects of electromagnetic fields. Concerns related to mobile phone base stations and wireless networks have been particularly apparent in citizens’ inquiries and information requests to STUK.

4.2 Regulatory control of UV radiation devices

Regulatory control of sunbed devices and facilities is carried out in co-operation with the municipal health protection authorities under the amendment to the Radiation Act that entered into force on 1 July 2012, prohibiting the use of sunbeds from under 18-year-olds. Health inspectors inspect 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, STUK carries out its own inspections where necessary.

The transition period for the amendment (section 44 of the Radiation Act) that prohibited self-service sunbed facilities ended on 1 July 2015. In 2017, non-compliance with the requirement was still frequently detected and enhanced regulatory control was continued. Altogether 31 inspections of sunbed facilities were carried out by municipal health protection authorities. In addition to this, six sunbed facilities were surveyed on the basis of STUK’s own monitoring (Appendix 1, Table 15). Altogether 44 on-site inspections of sunbeds were carried out, including the inspections performed by municipal health protection authorities. In 34 per cent of the supervised facilities, the responsible person required by law was not present during all hours of use of the sunbed. Major technical deficiencies affecting safety were detected in 12 per cent of the facilities, and minor deficiencies were found in 44 per cent. The most common shortcomings were associated with instruction manuals and timers.

4.3 Regulatory control of laser devices

The regulatory control of consumer lasers is divided into market surveillance of traditional and online trade. In addition, the use of high-powered laser equipment in public performances is subject to regulatory control.

In connection with market and on-site surveillance, STUK intervened in the sale or use of 22 laser devices. These cases were related to the selling of a laser device on a website for trade between consumers.

STUK received 68 notifications on the use of laser equipment in public shows. STUK inspected 15 of these performances on site. In the inspections, the safety arrangements and the pointing of the laser beams were mainly found to comply with the requirements. In two shows, the operator gave up the idea of using effects pointed towards the audience because of the safety issues detected in the inspection. In 2017, more laser shows were arranged in Finland than ever before.

4.4 Regulatory control of devices producing electromagnetic fields

In 2017, the market surveillance carried out by STUK did not include testing of any wireless communications devices. The testing equipment was modernized to comply with the latest product standard testing requirements. The modernized equipment was used for the development of a testing system for beauty care devices.

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

4.5 Regulatory control of cosmetic NIR applications

The extensive campaign for the regulatory control of companies providing cosmetic treatments, initiated in 2016, continued in 2017. STUK investigated the compliance of operations with 29 responsible parties. In addition, STUK developed measurement methods for the safety assessment of equipment. In most of the inspected cases, operations were not compliant with the requirements of the Radiation Act, and knowledge of the requirements among companies in the industry was still found to be low. However, a detected positive trend is that responsible parties in the beauty care industry and importers of devices are increasingly contacting STUK. For instance, STUK has been asked about the safety requirements related to the use of devices before purchasing or selling a device.

STUK actively informed operators in the industry about the proposed amendments to legislation, as these will have a significant effect on the industry. Stricter provisions are expected in law, such as the obligation to inform customers and the inclusion of new radiation techniques in legislation. On the other hand, some regulations are to be made less strict, taking into account the needs of the responsible parties without endangering customer safety.

4.6 Other tasks

STUK received a number of requests for statements on power line projects and land use plans near power lines. Altogether seven statements were issued on projects. Four statements were issued on other matters related to non-ionizing radiation.

In addition to regulatory control, STUK's NIR unit replied to 491 citizen inquiries in 2017. Of these inquiries, 209 were made by telephone and 282 via email. In particular, these inquiries concerned radiation related to mobile phones, base stations and power lines as well as household electrical equipment and electrical power network. Many inquiries also concerned lasers and UV radiation.

4.7 Abnormal events

In 2017, STUK received three notifications of events caused by non-ionizing radiation that required immediate action. In one case, a customer got a skin burn at a sunbed facility and also other symptoms, such as stinging of the skin. STUK performed measurements and the sunbed was found to meet the requirements set for the strength of UV radiation in Finland. The customer of the sunbed facility was advised to see a dermatologist. Two cases of show laser use were reported to STUK. They concerned parties arranged in a night club and a school. In both cases, laser beams had been pointed at people. The high-power laser device used in the night club had technical defects, and it had been used without STUK's permission. The circumstances of exposure were demonstrated at STUK with the device used at the night club. The maximum values for eye exposure were not exceeded when the beams were pointed at people. STUK ordered the defects in the night club's laser device to be corrected before it can be used again, and its use must be reported to STUK. As regards the school party, evidently no eye damage was caused, but according to STUK's assessment, the installation and orientation of the laser beams was not compliant with the requirements. The investigation of the case is still underway.

The numbers of abnormal events in 2008–2017 are shown in Figure 3 (item 1.1; see also item 2.9 on abnormal events in the use of ionizing radiation).

5 Regulation work

Radiation safety guides

For the achievement of 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. The guides are published in Finnish and translated into Swedish and English.

The following guides were updated and published in 2017:

- ST 6.2 Radioactive waste and discharges from unsealed sources
- ST 1.11 Security arrangements of radiation sources.

Because of the ongoing overall revision of radiation legislature, only the absolutely necessary updates were made to ST Guides.

Other regulation work

The EU's new radiation safety directive (2013/59/Euratom, BSS Directive) was approved on 5 December 2013. It must be implemented in national legislation by 6 February 2018. The Finnish radiation legislation will be comprehensively revised 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 2015. In March 2015, the Ministry set up subordinate working groups for the processing of specific areas of the directive. The steering group and subordinate working groups completed their work at the end of 2017.

Government proposal for the new Radiation Act was submitted to the European Commission for an advance statement at the beginning of September 2017. After this, the proposal was finalized by public officials at STUK and the Ministry of Social Affairs and Health. The Ministry of Social Affairs and Health will submit the government proposal to the committee stage in March 2018. Pursuant to the proposed Act, one government decree and two decrees of the Ministry of Social Affairs and Health were prepared. The finalization of the decrees will be complete in March 2018. In addition, three STUK Regulations were prepared pursuant to the proposed Act that were sent out for external comments in 2017. These regulations concerned the protection of workers, security arrangements and the exemption values of radioactive substances. The other STUK Regulations, approximately seven, are expected to be completed in 2018.

The new Radiation Act and the lower level statutes issued under it implement the requirements of the EU's radiation safety directive concerning ionizing radiation and revise the provisions concerning non-ionizing radiation. The government proposal also involves amendments to a number of associative laws. The key principle of the revision is to concentrate regulatory control more accurately on areas with the highest radiation risks. The new Act will provide a new framework for the safe use of radiation. Those requirements that are significant for society and restrict the rights of individuals will be transferred to the new Act in the manner required by the Constitution. Provisions on less significant matters will be laid down in decrees, and provisions on the authorities' rights to issue regulations will be exactly and clearly defined.

The comprehensive revision of radiation legislation is an extensive project and requires co-operation between different ministries and the fields they represent. The participants of the revision work include experts from ministries, national boards, labour market organizations, training organizations and responsible parties, more than 100 people altogether.

6 Research

The objective of STUK's research activities is to produce new information on the occurrence and measuring of radiation, the harmful effects of radiation and their prevention, and the safe and optimal use of radiation. Research supports the regulatory and metrological activities of STUK and the maintenance of emergency preparedness.

A further purpose of research related to the uses of radiation is to increase knowledge and expertise in this field and to ensure reliable measurement of radiation. Research on ionizing radiation is mainly related to medical uses of radiation and focuses on the radiation safety of patients. There is a continuous need for research because of the rapid progress of examination and treatment methods. Research on non-ionizing radiation focuses on the exposure determination methods necessary for regulatory control and the development of regulations.

STUK has been active in its efforts to expand the pool of competence in Finnish radiation safety research.

In October 2015, STUK and nine Finnish universities established a consortium for radiation safety research coordinated by STUK. The consortium aims to secure the continuation of high-quality radiation safety research in Finland through closer co-operation. A national programme, which describes the key research needs, was prepared and published in June to serve as the foundation for the consortium. The national programme will be updated in 2018.

STUK joined the agreement on the Helsinki Institute of Physics. The agreement will enable closer co-operation in radiation safety research and more flexible use of research resources. As part of the co-operation, a detector development project was launched by STUK, University of Helsinki, Aalto University and Lappeenranta University of Technology. The project is funded by the Academy of Finland. STUK is a member of the Knowledge Transfer for Medical Applications group of the European Organization for Nuclear Research (CERN).

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

Research and development work was carried out through the following projects:

STUK participated in the work of the EURADOS working groups 2 (Harmonization of individual monitoring), 7 (Internal dosimetry), 9 (Radiation dosimetry in radiotherapy) and 12 (Dosimetry in medical imaging). The work of the EURADOS working groups focused on the assessment and development of personal dosimetry methods, the development of patient dosimetry methods in interventional radiology and cardiology and the computational dosimetry of imaging. In patient dosimetry, particular attention was paid to the possibility of setting alarm thresholds for the monitoring of a patient's skin dose, so that the dose will not exceed the risk limit for skin damage. A proposal concerning the alarm thresholds was prepared and published. The EURADOS co-operation also involved preparations for a project that investigates patient doses caused by imaging in radiotherapy. STUK participates in the computational determination of patient doses. STUK coordinated a project covering 13 countries that investigates the possibility to propose joint European reference levels for patient exposure in interventional cardiology. The results will be submitted for publication in 2018.

STUK implemented a project partially funded by the Ministry of Social Affairs and Health on limiting exposure to ultrasound. The project surveyed the applications of ultrasound and the related safety issues as part of the preparation of the revision of the Radiation Act. On the basis of the results of the survey, a proposal was prepared for limiting non-medical exposure to ultrasound. The final report of the project was submitted to the Ministry of Social Affairs and Health in January 2017. STUK participated in a project led by the Ministry of Economic Affairs and Employment. The project particularly focused on health issues related to infrasound produced by wind power plants. The National Institute for Health and Welfare was the organization in charge of the survey, and the other participants in addition to STUK were VTT Technical Research Centre of Finland Ltd, University of Helsinki and Helsinki Ear Institute.

STUK surveyed citizens' exposure to electric and magnetic fields in railroad environments. The survey was related to the comprehensive revision of radiation legislation. The results of the survey will be included on the STUK website.

STUK surveyed citizens' exposure to electromagnetic fields from amateur radio stations. In summer 2017, STUK measured the electric fields caused by stations located on the roof of an apartment house and in the yard of a single-family house. The results for the apartment house were published in the Radioamatööri newspaper (a newspaper for radio amateurs) in 2017. Further measurements on radio amateur stations are planned for summer 2018. The results will be published as a STUK TR report in 2018.

STUK participated in the ERAMUS+-funded EBreast project. Its main objective is to survey and develop the training of personnel participating in the treatment chain of breast cancer, from early diagnosis to follow-up. STUK is responsible for the improvement of radiation safety and quality assurance skills in screening mammography and clinical mammography. The project will be completed in 2018.

STUK assessed doses to the eye in a group of employees exposed to radiation in nuclear medicine. The assessments were carried out using thermoluminescence detectors. The results will be used in practical radiation surveillance and the radiation protection of personnel. The measurements were completed in 2017, and the results will be published in 2018.

The TIEKKU 2 project on the exposure to and effects of diagnostic radiation in computer imaging made significant observations of imaging practices. These observations help to develop imaging practices in Finland and to reduce radiation exposure, particularly for small children and young adults.

European Metrology Programme for Innovation and Research EMPIR

A three-year project on perfusion imaging dosimetry was launched in summer 2016. STUK participates in the development of patient-specific CT dosimetry in co-operation with PTB from Germany and the University of Helsinki. The objective is to develop measurement and computational methods to be used in daily work with patients.

On the RTNORM project, STUK develops dosimetry for ionization chambers used for dose determination in radiotherapy. The project is related to the update of the IAEA protocol for dose determination in radiotherapy (IAEA TRS 398).

The MetroRADON project was launched in 2017. The objective is to improve the accuracy of radon calibrations across Europe.

Patient skin dose and staff doses in interventional radiology and cardiology

Together with Finnish university hospitals and central hospitals, STUK continued to survey patients' radiation exposure, including measurement of skin doses to patients and personnel's exposure to radiation in cardiological examinations and procedures. New method types are of particular interest, such as transcatheter aortic valve implantation (TAVI procedures). The survey was expanded to cover 13 European countries (EURADOS collaboration). The results of the international project will be published in 2018.

STUK also participated in EURADOS co-operation, which has involved developing a method for measuring patient skin doses in interventional radiology and cardiology. One of the objectives was to set a joint European alarm threshold for skin doses to prevent skin damage to patients. The results of the project were published at the beginning of 2018. The project will continue with dose determination and setting of reference levels for other than cardiological procedures.

A guide for the use of radiation in cardiology was prepared together with Finnish specialists.

Other research activities

A detector development project funded by the Academy of Finland was launched. The work is carried out in co-operation with the Helsinki Institute of Physics. The project develops position-sensitive detectors that identify the type of radiation. They are developed to respond to the needs of diagnostic radiation practices and radiotherapy dosimetry.

STUK and Helsinki University Hospital have collaborated to survey the exposure of workers in medical use of radiation and the probability of potential exposure. The results have been submitted for publication.

7 International co-operation

Participation in the work of international organizations and commissions

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

Participation in meetings of international working groups

In 2017, representatives from STUK participated in the meetings of the following international organizations and working groups:

- EURAMET (European Association of National Metrology Institutes) annual meeting of contact persons
- Meeting of the Nordic Dosimetry Group
- Meeting of the group on the use of radiation in Nordic health care sector (Nordic group for medical applications)
- HERCA (Heads of the European Radiological Protection Competent Authorities) and its working groups
- The annual meeting of EURADOS (European Radiation Dosimetry Group) and its working groups
- 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 (incl. UV matters)
- NIR seminar of the Nordic radiation protection authorities in Oslo
- WHO EMF project and InterSun Programme; international advisory group
- IEC TC 61 MT 16 meeting (including sunbed standards)
- IEC PT 60335-2-115 online meetings (standardization of beauty care devices)
- IAEA: Transport Safety Standards Committee
- IAEA: Radiation Safety Standards Committee
- CERN: Knowledge Transfer for Medical Applications.

8 Co-operation in Finland

Participation in the work of Finnish organizations and commissions

Representatives of STUK are involved in many Finnish organizations and commissions that deal with the regulatory control and research of the use of ionizing and non-ionizing radiation, and with standardization activities in the field of radiation. These include 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 (KLIARY) funded by the Ministry of Social Affairs and Health and appointed by the National Institute for Health and Welfare, the Screening Committee, SOTERKO and the Environmental Intolerance Network. STUK experts take part in several meetings in the field of radiation safety in Finland every year, giving presentations and lectures.

Participation in meetings of Finnish working groups

In 2017, representatives from STUK participated in the meetings of the following Finnish organizations and working groups:

- Subordinate working groups of the Ministry of Social Affairs and Health for the comprehensive revision of radiation legislation
- The Screening Committee of the Ministry of Social Affairs and Health and its subordinate working group preparing the decree amendment.
- Environmental Intolerance Network of the Ministry of Social Affairs and Health
- SESKO SK 34 committee (luminaires)
- SESKO SK 61 committee (safety of domestic electrical appliances)
- SESKO SK 106 committee (electromagnetic 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

In 2017, STUK arranged the following conferences:

- Radiotherapy physicists' conference at STUK 8–9 June 2017
- The 12th radiation safety conference for industry and research at m/s Mariella 5–7 April 2017.

Other co-operation in Finland

A STUK representative served as a member and secretary on the Finnish Advisory Committee for Clinical Audit (KLIARY), appointed by the National Institute for Health and Welfare (THL) and funded by the Ministry of Social Affairs and Health (STM). The STUK representative is also responsible for the maintenance of the group's website. The activities of the group included preparing a recommendation concerning advanced clinical audits of small units performing X-ray examinations. The recommendation was published in January 2018. Some previously published recommendations were updated. Recommendations and more information on the group's activities can be found on the group's website (www.kliininenauditointi.fi).

9 Communication

In 2017, STUK received a number of radiation-related questions through its website and by phone from citizens, radiation users, the media and other parties interested in radiation. Most of the questions were related to non-ionizing radiation. Several interviews on current radiation topics were given to the media.

The harmful effects of UV radiation were actively communicated. STUK participated in the UV press event, which was the 15th 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, protection against UV radiation in summer jobs, the popularity of sun tanning among the young and the UV index. The press release published of the event received wide media coverage, and many reporters were present at the event. Communication related to non-ionizing radiation was enhanced through the improvement of the materials published on the STUK website.

Press releases and online news articles were prepared by the staff of the Radiation Practices Regulation Department on the following topics:

- Research on the connection between the location of a brain tumour and the use of mobile phone
- National action plan for preventing radon risks – a healthier life without radon
- Is the mobile phone an everyman's radiation meter?
- Activities for children! oppijailo.fi
- Radiation doses to flight crews have increased
- Suomen Nukliditekniikka (a company processing small quantities of radioactive waste) will continue its operations
- Abnormal event in Tikkakoski when handling radioactive iodine
- Shade is the best shield against solar UV radiation for the skin of small children
- Verification of occupational physicians with expertise in radiation to be transferred from STUK to Valvira
- STUK participated in a survey of the health and environmental effects of wind power
- STUK granted a safety licence to the VTT Centre for Nuclear Safety
- Ultrasonic fat removal ina cosmetic procedure presents a risk for pregnancy
- Methods developed in a doctoral study have been extensively applied to the measurement of electromagnetic fields
- An americium source melted down in Tornio – no radiation hazard was caused to the workers
- STUK survey: The radon situation in Finnish schools is relatively good
- Enhanced radon monitoring at workplaces in Kotka
- Workplace radon concentrations in Finland
- Enhanced radon monitoring at workplaces in Taipalsaari and Loviisa.

In 2017, STUK published newsletters aimed at health care professionals and industry professionals engaged in radiation practices. The objective is to make the newsletter an integral part of communication.

10 Metrological activities

10.1 General

STUK acts 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). Furthermore, STUK participates in the international Mutual Recognition Arrangement (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 activity quantities of ionizing radiation is the responsibility of the Department of Environmental Radiation Surveillance and Emergency Preparedness (VALO) at STUK.

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

Irradiation equipment and national metrological standards were maintained for calibrations of radiation meters for radiotherapy, radiation protection and X-ray imaging. A new standards laboratory of radon was built for VALO.

Meter and measurement comparisons

STUK received the results of four EURAMET calibration comparisons in which it had participated in previous years. These comparisons were performed using photon radiation and different X-ray qualities. STUK's results were excellent in all comparisons, efficiently supporting STUK's calibration activities.

STUK took part in the bilateral radiotherapy chamber comparison of Co-60 gamma radiation, organized by the IAEA/WHO calibration laboratory network. STUK's result did not deviate from the IAEA's result. Therefore, the result of the comparative measurement efficiently supports STUK's calibration activities.

11 Services

Calibration, testing and irradiation

Radiation meter calibrations and testing were performed on request. Altogether 178 radiation meter calibration, inspection and testing certificates and 56 irradiation certificates were issued. Altogether 983 samples were irradiated. In 2017, calibration services increased by 45 per cent compared with 2016. Approximately 15 per cent of the calibrations were performed on STUK's own instruments and samples. Figure 10 shows the development of the number of irradiations and radiation meter calibrations and tests carried out at STUK from 2003 to 2017 on the basis of the number of certificates issued.

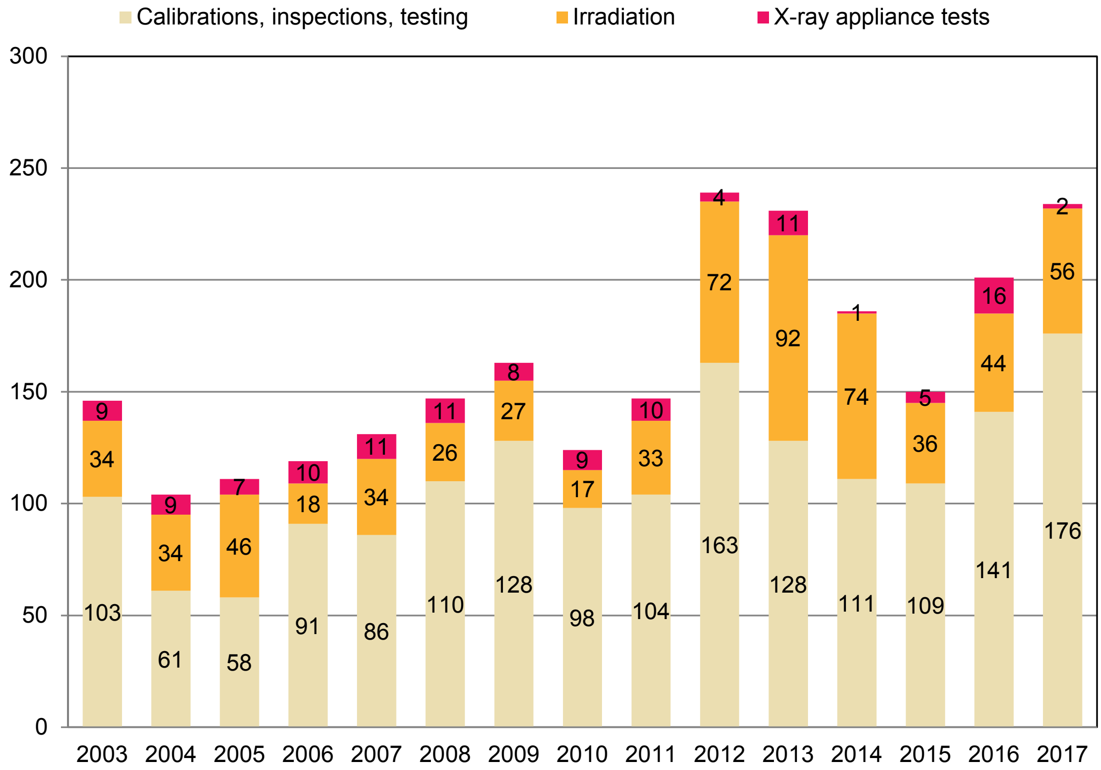

Figure 10. Numbers of irradiation certificates and radiation meter calibration, inspection and testing certificates issued as a service from 2003 to 2017.

The Non-Ionizing Radiation Surveillance Unit performed a total of six radiation meter calibrations and tests, along with three safety assessments and radiation measurements. The service output of the NIR Unit from 2008 to 2017 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 52 copies were sold.

APPENDIX 1

TABLES

Table 1. Radiation practices in the use of radiation in health care and veterinary practices at the end of 2017.

Use of radiation	Number of practices
X-ray practices	301
Veterinary X-ray practices	237
Challenging X-ray practices	96
C-arm practices	82
Small-scale X-ray practices	1439
X-ray practices outside X-ray departments	53
Screening with X-rays	54
Use of unsealed sources	25
Use of unsealed sources (veterinary)	2
Use of sealed sources	25
Use of sealed sources (veterinary)	1
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 2017.

Appliances/Sources/Laboratories	Number
X-ray diagnostic appliances (generators)[*)]	**1604**
fixed conventional X-ray appliances	485
portable fluoroscopy appliances	284
portable conventional X-ray appliances	171
mammography appliances, of which	168
• screening mammography	87
• tomosynthesis	12
fixed fluoroscopy appliances, of which	106
• angiography	43
• fluoroscopy	27
• cardioangiography	44
CT-appliances, of which	135
• SPECT-CT	35
• PET-CT	16
CBCT appliances (other than dental imaging)	18
O-arm appliances	9
dental X-ray appliances (other than conventional dental imaging), of which	167
• CBCT appliances	100
• panoramic tomography X-ray appliances	100
• intraoral X-ray appliances	32
bone mineral density measurement appliances	57
other appliances	4
Dental X-ray appliances (conventional dental X-ray practices)	**6007**
intraoral X-ray appliances	5364
panoramic tomography X-ray appliances	642

Radiotherapy appliances	**117**
accelerators	46
X-ray imaging appliances	47
automatic afterloading appliances	7
manual afterloading appliances	1
X-ray therapy appliances	1
radiotherapy simulators	15
sealed sources (check sources)	37
Sealed sources	**337**
calibration and testing equipment	327
attenuation correction units	6
gamma irradiators	0
other sealed sources in health care	4
X-ray appliances in veterinary practices	**439**
conventional X-ray appliances	316
bone mineral density measurement appliances	0
fluoroscopy appliances	2
intraoral X-ray appliances	110
CBCT appliances	2
CT scanners, of which	9
• SPECT-CT	1
• PET-CT	0
other appliances	0
Radionuclide laboratories	**39**
B-type laboratories	31
C-type laboratories	8

*) 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 2017.

Use of radiation	Number
Use of sealed sources	555
Use of X-ray appliances	645
Installation, test operations and services	195
Importing and exporting of radioactive materials or trading in them	107
Trade in X-ray appliances	32
Use of unsealed sources	83
Use of particle accelerators	17

Table 4. Radiation sources and appliances and radionuclide laboratories in the use of radiation in industry, research and education at the end of 2017.

Appliances/Sources/Laboratories	Number
Appliances containing radioactive materials	**5897**
level switches	1843
continuous level gauges	1117
density gauges	971
weight scales	617
basis weight meters	463
appliances or sources used for calibration, testing or education	377
moisture and density gauges	106
particle analyzers	71
fluorescense analyzers	49
radiography appliances	18
other appliances	265
X-ray appliances	**1995**
fluoroscopy appliances	824
diffraction and fluorescense analyzers	584
radiography appliances	395
basis weight meters	47
other X-ray appliances	145
Accelerators	**27**
research	15
fluoroscopy	7
manufacturing of radioactive materials	5
Radionuclide laboratories	**108**
A-type laboratories	8
B-type laboratories	28
C-type laboratories	70
activities outside laboratories (tracer element tests in industrial plants)	2

Table 5. Radionuclides most commonly used in sealed sources in industry, research and education at the end of 2017.

Radionuclide	Number of sources
Other than high-activity sealed sources	
Cs-137	4126
Co-60	951
Am-241 (gamma sources)	319
Kr-85	313
Fe-55	108
Sr-90	107
Am-241 (AmBe neutron sources)	101
Pm-147	90
Ni-63	76
High-activity sealed sources	
Cs-137	57
Co-60	29
Ir-192	11
Am-241 (gamma sources)	9
Am-241 (AmBe neutron sources)	6
Sr-90	5

Table 6. Deliveries of sealed sources to and from Finland in 2017.

Radionuclide	Deliveries to Finland		Deliveries from Finland	
	Activity (GBq)	Number	Activity (GBq)	Number
Ir-192	57 486	17	5141	17
Kr-85	1693	114	1434	98
Fe-55	162	32	134	24
Cs-137	100	83	-*)	-
Pm-147	40	17	57	11
Ni-63	37	100	51	137
Am-241	11	13	2	317
Gd-153	7	5	-	-
Sr-90	5	12	2	3
Co-57	5	37	-	-
Co-60	3	31	-	-
others total ***)	< 1	27	< 1	25
Total	**59 553**	**488**	**6820**	**632**

*) The symbol ”-” indicates no deliveries from Finland.
**) Deliveries to Finland: Gd-133, Ge-68, Po-210, Ba-133, Na-22, C-14, Eu-152, Cd-109 and Ra-226.
Deliveries from Finland: Po-210.

Table 7. Manufacturing of radioactive substances (unsealed sources) in Finland in 2017.

Radionuclide	Activity (GBq)
F-18	234 617
C-11	16 348
O-15	8570
Cu-64	9
Total	**259 544**

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 2013–2017.

Year	Number of workers		Total dose (Sv)	
	Pilots	Cabin crew	Pilots	Gabin crew
2013	1184	2596	2.79	6.02
2014	1213	2441	2.74	5.93
2015	1153	2527	2.66	6.09
2016	1118	2534	2.95	7.24
2017	1239	2717	3.25	8.36

Table 9. Number of workers subject to individual monitoring in 2013–2017.

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							
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
2016	3548	1218	703	1322	644	27	163	3511	10 951
2017	3222	1184	726	1420	685	34	159	4144	11 381

*) 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 2013–2017.

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							
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
2016	1.22	0.08	0.13	0.16	0.04	0.016	0.007	1.81	3.46
2017	1.04	0.09	0.14	0.18	0.03	0.024	0.003	1.53	3.04

*) $H_p(10)$ 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 2017.

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**)	217	0.50	3.1	2.3	16.3
Interventional radiologists**)	35	0.19	7.3	5.4	29.6
Radiologists**)	285	0.19	2.8	0.7	16.7
Consultant specialists**) ***)	303	0.05	1.0	0.2	4.0
Nurses**)	1062	0.04	0.4	0.0	1.9
Radiographers (X-rays)**)	980	0.03	0.5	0.0	3.4
Radiographers (other than X-rays)	557	0.07	0.6	0.1	3.6
Veterinary nurses and assistants**)	443	0.09	1.3	0.2	7.1
Veterinary surgeons**)	280	0.05	1.4	0.2	5.7
Industrial material inspection technicians****)	585	0.14	0.7	0.2	3.6
Industrial tracer testing technicians	29	0.04	2.5	1.5	5.9
Nuclear power plant workers					
• mechanical duties and machine maintenance	973	0.51	1.0	0.5	5.9
• cleaning	268	0.14	1.2	0.5	4.8
• material inspection	213	0.12	0.9	0.6	5.2
• electrical and automation work	677	0.15	0.8	0.2	6.3
• radiation protection	94	0.11	1.4	1.2	6.4

*) 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 2017).

Radionuclide	Activity (GBq) or mass
H-3	2969
Am-241	2199
Cs-137	1779
Pu-238	1493
Kr-85	962
Am-241 (Am-Be)	602
Ra-226	235
Sr-90	139
Cm-244	137
Co-60	35
Fe-55	25
Ni-63	32
C-14	18
Pu-238 (Pu-Be)	7
U-238 *)	916 kg
Th-323	2.5 kg
*) Depleted uranium	

Table 13. The work of the NIR Unit in regulatory control of the use of non-ionizing radiation in 2008–2017.

Year	Regularoty inspections	Decisions	Statements	Prohibitions of dangerous laser devices sold on the internet	Total
2008	67	5	6	0	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
2016	72	2	10	18	102
2017	81	3	11	22	117

Table 14. The service work of the NIR Unit in 2008–2017.

Year	Calibrations and tests	Safety assessments and radiation measurements	Total
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
2016	8	4	12
2017	6	3	9

Table 15. Inspections of sunbed facilities in 2008–2017. In addition to STUK's own inspections in 2012–2017, also health inspectors of municipalities inspected the sunbed facilities in 2013–2017 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
2008	26
2009	19
2010	16
2011	7
2012	6 (16)
2013	3 (40)
2014	1 (20)
2015	4 (17)
2016	4 (55)
2017	6 (31)

Table 16. SAR tests of mobile phones and other wireless devices in 2008–2017.

Year	Number of tests
2008	10
2009	15
2010	10
2011	5
2012	15
2013	11
2014	10
2015	14
2016	11
2017	0

APPENDIX 2 Publications in 2017

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 2017:

Scientific articles by STUK employees

Järvinen Hannu, Vassileva Jenia, Samei Ehsan, Wallace Anthony, Vano Eliseo, Rehani Madan. Patient dose monitoring and the use of diagnostic reference levels for the optimization of protection in medical imaging: current status and challenges worldwide. Journal of Medical Imaging 4(3), 031214 (Jul-Sep 2017). https://doi.org/10.1117/1.JMI.4.3.031214

Karvala K. Pekkanen J. Salminen E, Tuisku K, Hublin C, Sainio M. Miten tunnistan ympäristöherkkyyden? (How to recognize environmental intolerance?) Duodecim 2017; 133: 1362–9.

Karvala K. Pekkanen J. Salminen E, Tuisku K, Hublin C, Sainio M. Oireiluherkkyys ei selity ympäristötekijöiden altistevaikutuksilla (Sensitivity to symptoms is not explained by the exposure factor effects of environmental factors). Duodecim 2017; 133: 1959.

Kurttio P. Kansallista toimintaa radonriskien ehkäisemiseksi (National activities to prevent radon risks). Ympäristö ja Terveys 2017; 1: 28–30.

Madekivi V, Boström P, Aaltonen R, Vahlberg T, Salminen E. The sentinel node with isolated breast tumor cells or micrometastases. Benefits and risks of axillary dissection. Anticancer Research 2017; 37(7): 3757–3762.

Niemelä Jarkko, Partanen Mari, Ojala Jarkko, Sipilä Petri, Björkqvist Mikko, Kapanen Mika, Keyriläinen Jari. Measurement and properties of the dose-area product ratio in external small-beam radiotherapy. Physics in Medicine and Biology 2017: 62 (12): 4870–4883. https://doi.org/10.1088/1361-6560/aa6861.

Niiniviita Hannele, Kulmala Jarmo, Pölönen Tuukka, Määttänen Heli, Järvinen Hannu, Salminen Eeva. Excess of radiation burden for young testicular cancer patients using automatic exposure control and contrast agent on whole body computed tomography imaging. Radiology and Oncology 2017; 51 (2): 235–240. doi:10.1515/raon-2017-0012.

Puranen Lauri. Development of measurement techniques for assessment of exposure to electro-magnetic fields. Mittaustekniikoiden kehittäminen altistumisen määrittämiseksi sähkömagneettisille kentille. Aalto University publication series DOCTORAL DISSERTATIONS, 2/2017.

Salminen Eeva, Niiniviita Hannele, Järvinen Hannu, Heinävaara Sirpa. Cancer death risk related to radiation exposure from computed tomography scanning among testicular cancer patients. Anticancer Research 2017; 37 (2): 831-834. DOI: 10.21873/anticanres.11385.

Talibov M, Salmelin R, Lehtinen-Jacks S, Auvinen A. Estimation of occupational cosmic radiation exposure among airline personnel: Agreement between a job-exposure matrix, aggregate, and individual dose estimates. American Journal of Industrial Medicine 2017: 60: 386–393.

Toledano MB, Auvinen A, Tettamanti G, Cao Y, Feychting M, Ahlbom A, Fremling K, Heinävaara S, Kojo K, Knowles G, Smith RB, Schüz J, Johansen C, Harbo Poulsen A, Deltour I, Vermeulen R, Kromhout H, Elliott P, Hillert L. An international prospective cohort study of mobile phone users and health (COSMOS): factors affecting validity of self-reported mobile phone use. International Journal of Hygiene and Environmental Health 2017. Online 20 Sept 2017. https://doi.org/10.1016/j.ijheh.2017.09.008.

STUK's own serial publications

Kojo K, Rantala A, Kurttio P, Perälä M. Työpaikan sisäilman radonkartoitus Suomen kouluissa: Ympäristön säteilyvalvonnan toimintaohjelma 2017 (Workplace indoor air radon survey in Finnish schools: Action programme for monitoring of environmental radiation in 2017). 26 s.

Lehto Jyri. Säteilyturvallisuus hiukkaskiihdyttimien käytössä (Radiation safety for the operation of particle accelerators - Review of the international safety aspects and a proposal for the requirements in Finland). STUK-B 208. Helsinki; Radiation and Nuclear Safety Authority: 2017.

Nylund Reetta. Pulssiröntgenlaitteet teollisuus- ja tutkimuskäytössä (Pulsed X-ray devices in the industrial and research use). STUK-B 219. Helsinki; Radiation and Nuclear Safety Authority: 2017.

Pastila Riikka (toim.). Säteilyn käyttö ja muu säteilylle altistava toiminta. Vuosiraportti 2016. (Radiation practices. Annual report 2016.) STUK-B 213. Helsinki; Radiation and Nuclear Safety Authority: 2017.

Pastila Riikka (ed.). Radiation practices. Annual report 2016. STUK-B 217. Helsinki; Radiation and Nuclear Safety Authority; 2017.

Puranen Lauri. Voimajohtojen sähkökentät (Electric fields of power lines). STUK-TR 25. Helsinki: Radiation and Nuclear Safety Authority: 2017.

Toivo Tim, Orreveteläinen Pasi, Kännälä Sami, Toivonen Tommi. Selvitys ultraäänialtistumisen rajoittamisesta (Survey on limiting exposure to ultrasound). STUK-TR 24. Helsinki; Radiation and Nuclear Safety Authority; 2017.

Toivo Tim, Orreveteläinen Pasi, Kännälä Sami, Toivonen Tommi. Survey on limiting exposure to ultrasound. STUK-TR 26. Helsinki: Radiation and Nuclear Safety Authority; 2017.

STUK brochures / Other publications

Alén Riina. Säteilyä töissä? (Radiation at work?) TTT – Työ Terveys Turvallisuus 2017; 2: 44–46.

Lanki T, Turunen A, Maijala P, Heinonen-Guzejev M, Kännälä S, Toivo T, Toivonen T, Ylikoski J, Yli-Tuomi T. Tuulivoimaloiden tuottaman äänen vaikutukset terveyteen. Työ- ja elinkeinoministeriön julkaisuja 28/2017 (Health effects of the sound produced by wind power plants. Publications of the Ministry of Economic Affairs and Employment 28/2017).

Radiation safety guides

Finnish language

Säteilylähteiden turvajärjestelyt. Ohje ST 1.11. (Security arrangements of radiation sources. Guide ST 1.11) STUK (21 March.2017)

Avolähteiden käytöstä syntyvät radioaktiiviset jätteet ja päästöt. Ohje ST 6.2. (Radioactive waste and discharges from unsealed sources. Guide ST 6.2 STUK (9 January 2017).

Swedish language

Skyddsarrangemang för strålkällor. Direktiv 1.11. (Security arrangements of radiation sources. Guide ST 1.11) STUK (21 March.2017)

Radioaktivt avfall och radioaktiva utsläpp vid användning av öppna strålkällor. Direktiv ST 6.2. (Radioactive waste and discharges from unsealed sources. Guide ST 6.2) STUK (9 January 2017).

English language (translations)

Security arrangements of radiation sources. Guide ST 1.11 (21 March 2017)

Radiation practices and radiation measurements. Guide ST 1.9 (23 November 2016)

Radiation safety of sealed sources and devices containing them. Guide ST 5.1 (13 September 2016)

Trade in radiation sources. Guide ST 5.4 (14 June 2016)

Radioactive waste and discharges from unsealed sources. Guide ST 6.2 (9 January 2017).

APPENDIX 3

ST GUIDES PUBLISHED BY STUK. SITUATION AS OF 31 MARCH 2018.

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, 23 November 2016
ST 1.10 Design of rooms for radiation sources, 14 July 2011
ST 1.11 Security arrangements of radiation sources, 21 March 2017

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 equipment containing them, 13 September 2016
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, 14 June 2016
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 waste and discharges from unsealed sources, 9 January 2017
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

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