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Radiation practices

Annual report 2012

Erkki Rantanen (ed.)

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

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Abstract

1743 safety licences for the use of radiation were current at the end of 2012. 1688 responsible parties (parties running a radiation practice) were engaged in notifiable licence-exempt dental X-ray activities. 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. Radiation safety guides were also published and research was conducted in support of regulatory control.

The Radiation and Nuclear Safety Authority (STUK) conducted 618 inspections of licensed practices in 2012. 748 repair orders and recommendations were issued in the course of inspections.

A total of nearly 11 400 workers were subject to individual monitoring in 2012 and about 148 000 dose entries were made in the Dose Register maintained by STUK.

Regulatory control of natural radiation focused on radon at workplaces and exposure of aircrews to cosmic radiation. 172 workplaces including a total of 306 work areas were subject to radon monitoring during 2012. Just over 3600 cockpit and cabin crew members were monitored for exposure to cosmic radiation.

STUK was involved in three ionizing radiation research projects.

In metrological activities, routine calibrations for radiation therapy dosemeters were initiated with a new ^{60}Co appliance. For the calibration of radiation protection measurement devices with a small dose rate, an arrangement making use of STUK's low background radiation room was introduced. The agreement logo was placed on the calibration certificates forming part of the international metrological equivalence agreement (CIPM-MRA). The number of calibration and testing services that were produced clearly exceeded the amounts of previous years.

Regulatory control of the use of non-ionizing radiation in 2012 focused on sunbeds, lasers and mobile phones. The number of sunbed facilities inspected was 6. The amendment of the Radiation Act obliged the health protection authorities of municipalities to inspect sunbeds in connection with the inspections made in accordance with the Health Protection Act and send the inspection details to STUK for evaluation and decision. The health protection authorities submitted the details of the inspections of 16 sunbed facilities. The number of showlaser on-site inspections was 11. In market surveillance of wireless communication devices, 15 mobile phone types were tested.

In 2012, there were 92 abnormal incidents involving the use of radiation: Of these incidents, 17 concerned the use of radiation in industry, research and education, 66 involved uses of radiation in health care and veterinary practices, 4 arose in transportation of radiation sources and 5 concerned the use of non-ionizing radiation. None of these incidents had serious consequences.

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Management foreword

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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 radiation, conducts research in support of regulation into the medical 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 and monitoring of worker radiation doses. It was decided to rename the department from the beginning of 2013 so that the new name better describes the regulatory entity; the English translation was kept the same as before. At the same time, the Non-ionising Radiation Surveillance Unit was added to the department.

The general state of the radiation practice safety is good in Finland. Nevertheless, it is necessary to constantly keep an eye in signals on which the reaction on safety situation is based to maintain its desired level.

A total of nearly 7700 workers involved in the use of ionising radiation were subject to individual monitoring in 2012. This figure excludes nuclear power plant workers. The number of people subject to dose monitoring has increased in industries and in the field of veterinary practices in recent years. In no case did the effective dose of a worker in 2012 exceed the annual dose limit or the five-year dose limit for workers.

Work to revise the individual dose monitoring registers continued during the year under review. The workload of STUK's experts has been higher than anticipated due to errors and deficiencies turning up in testing. Based on the tests, clarifying definitions have been required, and the project has fallen behind its schedule. The individual dose register will be completed during 2013.

Regulatory control of activities exposing persons to natural radiation is an important part of STUK's operations and will be more pronounced in Finland in future due to renewed mining activities. The leakage of Talvivaara's gypsum waste pond led to significant environmental damage. However, the accident did not cause direct radiation hazard to the workers nor to the inhabitants of the surrounding area. The event has had a significant influence for employment in STUK's regulatory control of natural radiation.

Radon exposure in workplaces is a significant source of occupational radiation exposure in certain areas in Finland. These areas have been defined on the basis of STUK's substantial mapping work and can be viewed on STUK's web pages. Based on radon measurements in workplaces, repair orders were issued to over one hundred workplaces to make them undertake the radon repairs needed for reducing workers' exposure to radiation.

There have been many safety licence applications due to mergers of municipal health care services and combinations of their activities. The necessity for constant processing of urgent safety licence applications in the regulatory control operations of STUK has become apparent. In many cases, the application was submitted to STUK only when it was time to take an appliance into use, and sometimes even after the appliance had already been taken into use. Focused and enhanced control measures have revealed unlicensed appliances in the course of inspections and regulatory control surveys. This may indicate a deteriorating safety culture that should be tackled more effectively at places of use. STUK will continue to conduct various regulatory control surveys in addition to normal inspection work and will bring up the aspect of safety culture at training events.

In the use of ionizing radiation, 87 abnormal incidents were reported during the year under review, nearly doubling the amount of the previous year. STUK has encouraged responsible parties to go ahead and notify all incidents and to make the necessary adjustments to their work with a view to avoiding any further abnormal incidents. The falling notification threshold is one factor to bear in mind when considering the reason for the increase in notifications of abnormal incidents to STUK. Abnormal incidents are discussed at training days and conferences arranged by STUK, and notifying them is important for joint training purposes in the sector. STUK carefully monitors the nature of abnormal incidents and focuses its advisory and regulatory control measures in the manner required to ensure high safety standards.

Approximately 200 experts on industrial radiation use participated in the Conference on Radiation Safety in Industry. The number of participants has steadily increased over the years and shows healthy interest from the part of experts to learn about new safety issues in the field.

The need for radiotherapy and the number of treatment sessions have continued growing in Finland, and the number of radiotherapy appliances will increase in coming years. New radiation therapy applications and techniques, the supervision methods for which have been developed, were introduced during the year. New STUK experts were familiarized with radio therapy supervision during the year under review.

In connection with the use of radiation, STUK examined the amount of X-rays taken in Finland. The results show that there has been a halt in the increase in the number of CT scans in Finland. Experts in the field – radiologists, nurses, physicists and STUK's experts – have paid special attention to the increase in the amounts of use of these imaging techniques. The numbers of radiographies have been successfully limited by emphasizing the importance of justification assessment, improving guidance and distributing information in training and other events in the field.

Under the direction of STUK, a research project funded by the European Commission has examined, country by country in Europe, the radiation doses in health care examinations that have given rise to radiation exposure. Overall, it has been noted that the situation in Finland is good and the situation in the whole of Europe in comparison with the rest of the world is also good as a whole. The average radiation exposure in Europe for each citizen is approximately one-third of the corresponding exposure in the USA. The exposure of Finns is about half of the average European exposure.

As in previous years, to maintain accuracy and reliability of radiation measurements, STUK has participated in international comparisons of metrological standard, and its results have been good. The demand for the calibrations and services of the DOS laboratories has been brisk during the year under review.

A radiation and nuclear safety assessment (IRRS assessment), which targeted mainly STUK's activities, was conducted in Finland by an international expert group. Preparations for the IRRS assessment required greater amount of work than expected, and for this reason other tasks have been postponed to some extent. The assessment states that the matters in Finland have reached a good standard. As a result of the assessment, however, many good recommendations and proposals to improve the activities have been received.

STUK's experts have actively participated in Nordic and international cooperation between their authorities. The aim of the cooperation is to standardize the practices of European regulatory control and to try to secure Finland's national interests in the preparation of new international decrees.

STUK's strategy was reshaped for 2013–2017. Several changes in the operation environment affect STUK's activities, producing new and varying challenges. These include the state's economical situation, changes in the state's administration and consolidated corporate governance, growth in mining activities, increase of radiation sources in the environment, growth in the medical use of radiation, threat of spread of terrorism and that of nuclear weapons, retirement of experienced experts, as well as the increasing emphasis on the importance of relationships in society and on communication.

The Non-Ionizing Radiation Unit (the NIR Unit) serves as a regulatory authority for non-ionizing radiation and provides specialist assistance to other public authorities. During the past years, regulatory control of the use of non-ionising radiation has focused particularly on lasers, sunbeds and mobile phones. Regulatory control of the radiation safety aspects of lasers and sunbeds imposes a major radiation safety challenge in the field of optical radiation, whereas the challenge with respect to electromagnetic fields is to produce and disseminate solid expertise, as new technology that causes concern for many members of the public is introduced.

In 2012, STUK received 5 reports concerning abnormal incidents caused by non-ionizing radiation that required immediate measures. One skin burns case was reported: a skin treatment operation carried out with a light-pulse RF device had caused the burning of face. In a laser artwork, a malfunction of the remote control device created a dangerous situation, as the ray suddenly was directed in a wrong direction. STUK learned, directly or through the media, of several cases of prodding with a laser pointer.

Market control of electromagnetic fields focused on mobile phones and fields generated by new technology. The highest measured mobile phone SAR value of 1.18 W/kg did not exceed the maximum value prescribed in the decree of the Ministry of Social Affairs and Health (294/2002).

As far as optical radiation was concerned, the priorities of the market control were sunbeds, skin treatment devices and laser pointers. In 2012, regulatory control of laser pointers continued in association with the Finnish Customs Authority. The highest power of a laser left in the possession of the customs was about 400 mW, whereas the decree allows only 1 mW laser pointers. The incidence of such a laser beam into the eyes at close range can destroy the fovea centralis area of the retina responsible for maximum acuity of vision.

The amendment of the Radiation Act prohibiting sunbed services from people under 18 years of age became effective on 1 July 2012. The new methods related to the inspection activities were agreed on jointly with Valvira and the Association of Finnish Local and Regional Authorities, and a joint circular about the new ways to operate was sent to the municipalities. The amendment of the Radiation Act obliged the health protection authorities of municipalities to inspect sunbeds in connection with the inspections made in accordance with the Health Protection Act, and the health protection authorities sent the details of 16 inspections to STUK. Only slight deficiencies were found in them.

Considerable effort has been applied in recent years to providing public information on the safety of electromagnetic fields and optical radiation. Laser pointers have become more common in the plays of school children. At its worst, the incidence of a laser beam into the eye can cause a permanent injury. In 2012, STUK and the Finnish National Board of Education reminded schools about the dangers of laser indicators by sending a circular to them; also a poster to be hung on the schools' notice board and telling about the dangers of laser accompanied the circular.

In addition to this, during 2012 the NIR Unit received a great number of questions from members of the public, radiation users, media and other sources interested in non-ionized radiation.

STUK and the Finnish Institute of Occupational Health launched a three-year research project “Actions promoting staff job satisfaction in magnetic resonance imaging work”.

By helping the Occupational Safety and Health department of the Ministry of Social Affairs and Health, STUK participated in the preparation work for the occupational safety directive dealing with electrical and magnetic fields.

1 General

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

The expression "radiation" refers to both ionizing and non-ionizing radiation.

Regulatory control of safety in radiation use and in other practices causing exposure to radiation in Finland is the responsibility of the Department of Radiation Practices Regulation (STO) and the Non-Ionizing Radiation Surveillance Unit (the NIR Unit) at STUK.

1.1 Principal key figures

The principal key figures for uses of radiation and other practices causing exposure to radiation are shown in Figures 1–3.

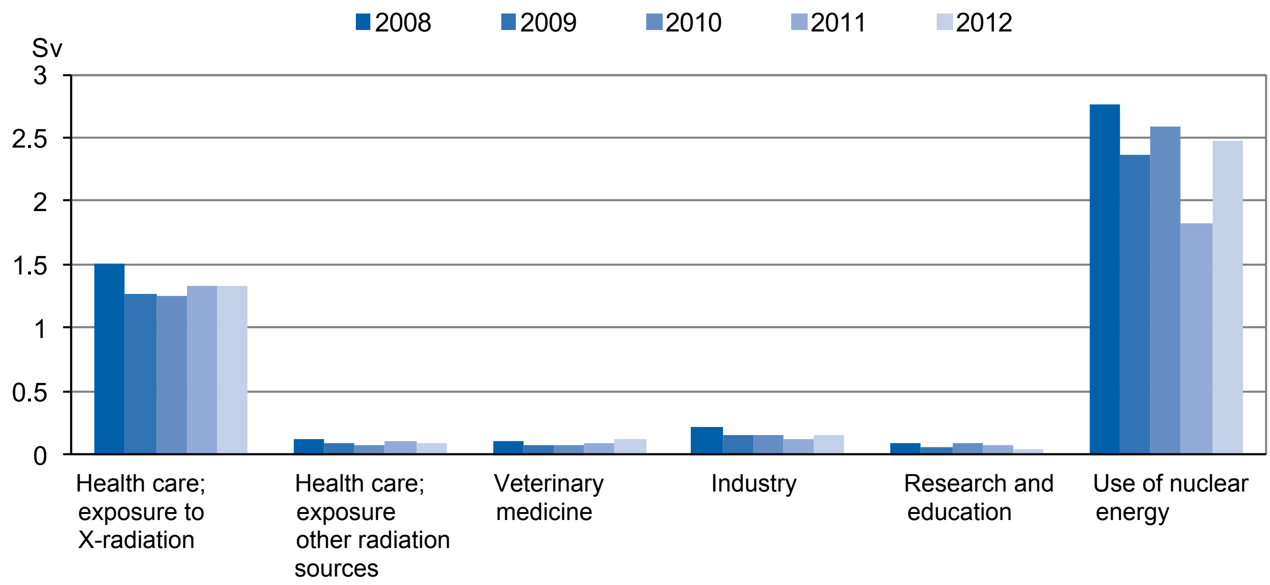

Figure 1. Combined doses ($H_p(10)$) of workers subject to individual monitoring by occupational category, 2008–2012. $H_p(10)$ values are generally (sufficiently accurate) approximations of the effective dose. One exception to this is the use of X-rays in health care and veterinary practices, in which workers use personal protective shields and in which the dose is measured by a dosemeter on the exposed side of the shield. The effective dose is then obtained by dividing the $H_p(10)$ value by a factor between 10 and 60. Besides the workers specified in the graph, a small number of people subject to individual monitoring also work in the following sectors: 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).

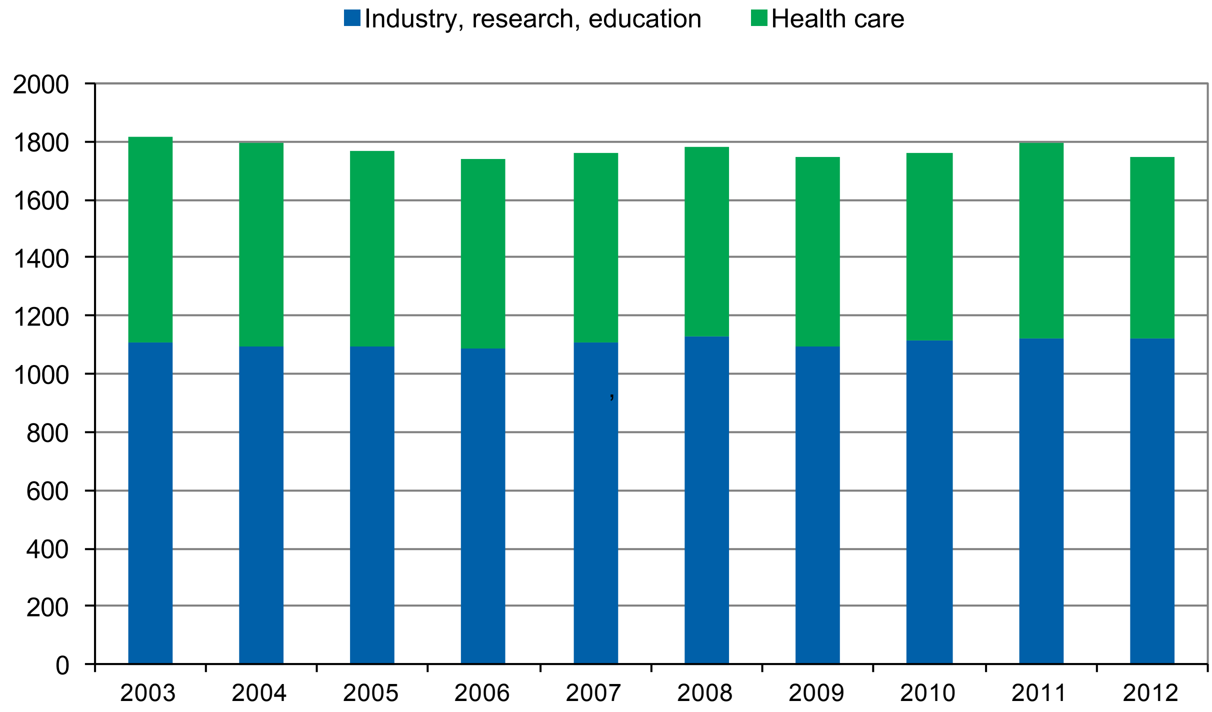

Figure 2. Current safety licences, 2003–2012.

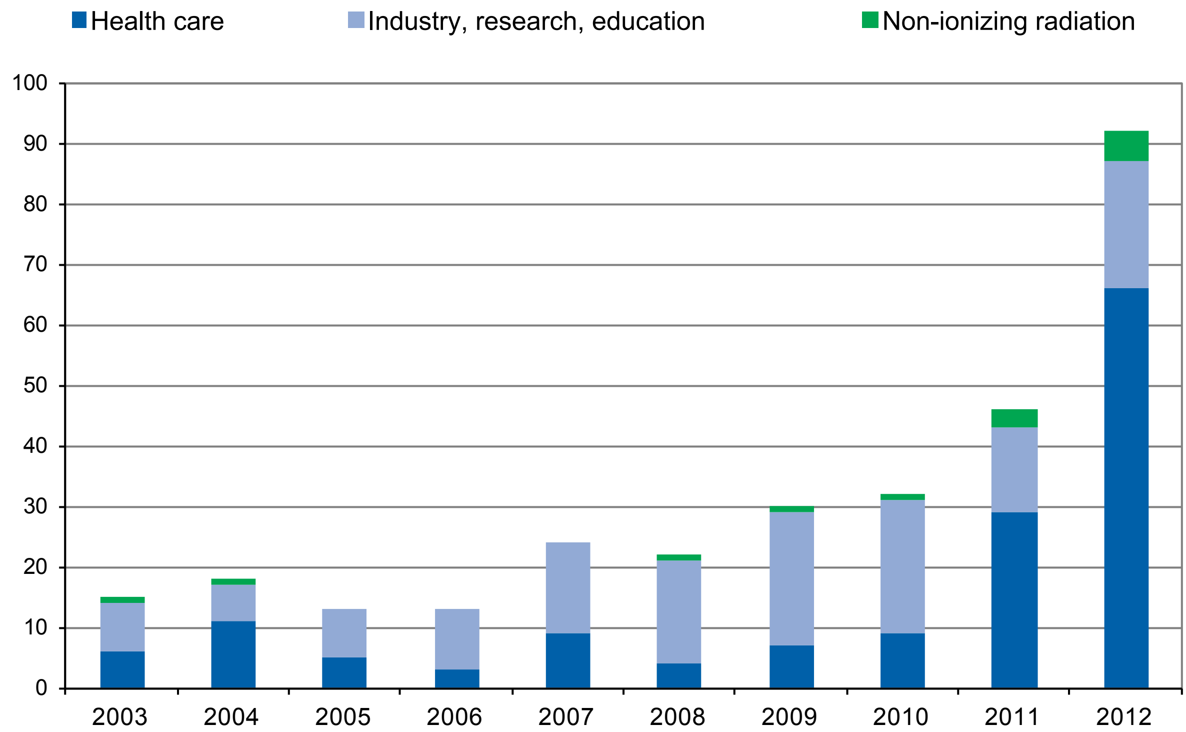

Figure 3. Abnormal incidents, 2003–2012.

2 Regulatory control of the use of ionizing radiation

2.1 Use of radiation in health care and veterinary practices

Safety licences

At the end of 2012 there were 626 current safety licences for the use of radiation in health care (see also Figure 2), of which 247 concerned veterinary practices. A total of 474 licensing decisions (new licences or amendments to previous licenses) were issued during the year. The numerical distribution of radiation practices referred to in these licences is shown in Table 1 of Appendix 1. There was no significant change in the total number of safety licences compared to the previous year.

The average time taken to process safety licence applications for X-ray practices in health care was 12 days. A little less than 30% of all licence applications were processed as urgent applications, meaning that the application was submitted to STUK only when it was time to take an appliance into use, and sometimes even after the appliance had already been taken into use.

Radiation appliances, sources and laboratories

Table 2 in Appendix 1 shows details of radiation appliances and sources, and of radionuclide laboratories used in health care and veterinary practices at the end of 2012.

X-ray practices

In the inspections of X-ray practices in health care, the main emphasis has been on the inspections of demanding X-ray practices, that is, of CT scans and interventional radiology. Some inspections have been postponed on purpose, because replacement by new devices has been ongoing in the sites of these facilities. During the initial inspections for these devices, further deficiencies have been found in the structural radiation protections of some X-ray rooms, for example deficiencies in the lead protections of door frames. Municipal mergers and combining of health care activity have caused more than a normal amount of handling of licence amendments and registration changes for dental X-ray work.

Inspection activities have been further developed, emphasizing the overall content of the inspection event instead of measurements involving device-oriented technologies. The targets of inspections have included functioning of organizations and information flow, responsibilities in quality management systems, further education of radiation users and the real ability of those in positions of responsibility to carry out their tasks. The regulatory control of dental X-ray practices exempted from the licensing requirement was continued as during previous years in a form of remote control with TLD and film measurements. If required, an inspection was carried out at the facility. Inspections without a prior notification were made in some places when suspected that there might be unlicensed devices.

The national survey on the number of radiological examinations was initiated with a questionnaire to responsible parties. By the end of 2012, responses had been received from almost all locations, and the analysis of the results is nearing its end. A report on the amount of research will be completed by the spring of 2013. Also dose information was collected from the responsible parties to update the reference levels for patient doses from CT scans. Determination of reference levels was discussed with national experts in the field.

In early 2012, information related to maintenance activities was collected with a survey from companies involved in these activities. The results will be utilized for example as training material in future. Based on the feedback received, maintenance operations of X-ray devices in Finland are appropriately organized, and the methods followed comply as a rule with STUK's instructions. In some respects, the maintenance carried out by the hospitals themselves is more comprehensive than the maintenance done by the device suppliers. The maintenance of CT scan devices and fluoroscopy appliances is realized partially in accordance with the maintenance instructions of the client. The educational level of the persons carrying out maintenance for dental X-ray devices is below that in other areas of health care. Of the specific areas of dental X-ray device maintenance, the maintenance of devices for cone-beam computed tomography and that for panoramic radiography are still in search of their final mode of practice.

In 2012, a survey regarding the use of C-arms in hospitals' surgical operations was conducted in cooperation with the University of Oulu. Preliminary results of that survey were presented in 2012 at the Radiation Safety Conference in Tampere. Based on the preliminary analysis of the results, the training of the operation personnel varies considerably. In C-arm practice, for approximately 70% of the devices quality assurance has been arranged in accordance with the requirements. The overwhelming majority (80%) of the personnel involved in the use of radiation uses personal protective devices. The personnel generally are classified as belonging to radiation workers in category B. Both personal dosemeters as well as group dosemeters are in use. In C-arm practices, optimization of radiation use is not regarded as important. In addition to a thesis, training material for the use of STUK can be anticipated from the results of the survey.

The Radiation Safety Guides ST 1.4 and 1.8, which had been completed at the end of 2011 and in the beginning of 2012, dealt with the radiation user's organization and the competency of the people in that organization. In connection with these updated guides, the biggest organizations holding safety licences were sent a questionnaire, which examines whether the organizations are up-to-date and whether they satisfy the requirements of the Radiation Safety Guides. The results of the survey will be available for use in the spring of 2013.

The ST 8.1 guide dealing with veterinary X-ray practices came into effect during the summer. Consequent to the appearance of the new guide, in the inspections of veterinary X-ray practices, special attention has been paid to the implementation of quality assurance for the activities and to compliance with the requirements at time of use. The value of device performance measurement in the inspection has been reduced. In connection with the inspections, particular attention has been paid to the doses of people restraining animals, and there have been on-site discussions about proper work practices and use of protective devices.

The number of abnormal incidents reported still kept on growing – during 2012, STUK received 47 reports related to X-ray practices in health care. The incidents were analyzed and the matter was discussed for example in connection with the Radiation Safety Conference and with the responsible parties. More attention was paid to abnormal incidents also in the inspections. The most common abnormal incident in X-ray practices was radiography of a wrong person. A typical reason for this was deficient verification of the identity of the person (the social security number was not asked when the patient was brought to be X-rayed).

Information about the current topics of X-ray practices in the field of health care was communicated through professional magazines and in several training events.

Nuclear medicine

In nuclear medicine, activities have expanded, especially concerning the use of PET-CT. Figure 4 shows that the number of PET and PET-CT appliances has quadrupled in ten years. Combination radiography has become more common due to the more widespread use of SPECT-CT appliances. Two SPECT cameras equipped with cone beam CT were deployed as a new device type. The first PET-MRI (positron emission tomography – magnetic resonance imaging) was introduced to use in Finland as a new combination device.

According to the report by STUK, at nuclear medicine departments the use of CT appliances for X-ray diagnostics other than combination radiography was meagre.

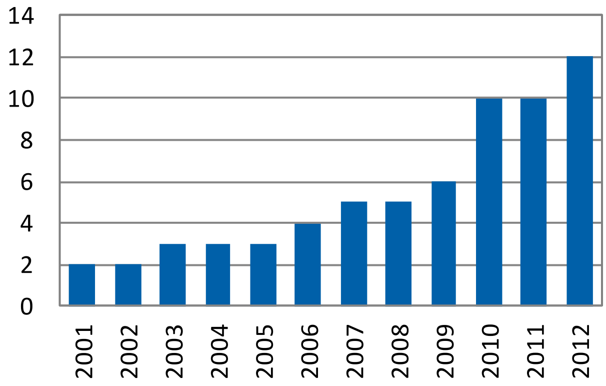

Figure 4. The number of PET and PET-CT appliances in Finland during 2001–2012.

Radiotherapy

Treatment technologies in radiotherapy have been updated during recent years. In 2012, the first Cyberknife treatment appliance was introduced to Finland as the first one in the Nordic countries. Also flattening filter free fields of new linear accelerators were employed. BNCT treatments ceased when the company providing those treatments went bankrupt.

In the regulatory control of radiotherapy, attention was turned to the fulfilment of the requirements that came into effect on 1 June 2011 and concerned the strength of the personnel as specified in Guide ST 2.1. Orders to correct the personnel shortfall in radiotherapy physicians were given to each of the five inspected radiotherapy centres. The requirements concerning hospital physicists and radiographers were satisfied in all the inspected centres.

During the year under review, STUK – in the 3-year EMPR-MetrExtRT research project (see Item 6.1) – started the development of a new control method applicable to electron beams.

The radiotherapy inspections by STUK were evaluated in the IRRS assessment (see Item 2.9) by three foreign evaluators as appropriate and focusing on right issues. Especially the expertise in quality control and the control methods to verify the treatment dose produced by the dose plan chain in radiotherapy received praise.

The annual conference of radiotherapy physicists dealing with current topics was arranged for the 29th time. The conference programme particularly focused on quality control of new appliances and methods, on dosimetry and on instructions of authorities.

The comparison measurements taken between STUK and hospitals indicated that radiotherapy dose precision is very high: the average discrepancy in measurements was 0.25% in photon beams and 0.27% in electron beams. No doses jeopardizing safety in treatment were detected on the basis of comparison measurements.

2.2 Use of radiation in industry, research and education

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

Safety licences

There were 1117 current safety licences for the use of radiation in industry, research and education at the end of 2012 (see also Figure 2). The numerical distribution of radiation practices referred to in these licences is shown in Table 3 of Appendix 1.

Radiation appliances, sources and laboratories

Table 4 in Appendix 1 shows details of radiation appliances and sources, and of radionuclide laboratories operating in industry, research and education at the end of 2012.

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

Inspections

Inspections targeted, in accordance with the annual plan, holders of the safety licences. The aim has been to inspect the functions of new safety licences within a year from the granting of the licence. After the inspections, an electronic feedback questionnaire, where the opinions of the radiation safety officers responsible for the safe use of radiation were solicited, was sent. In the opinion of many of the respondents, inspections helped in improving their operations, and it was felt that the repair orders were justified.

X-ray appliance survey

STUK requested an annual notification from all known vendors of X-ray appliances (50 vendors) concerning appliances sold and their custodians. These notifications disclosed 16 responsible parties who had failed to apply for a licence on taking one or more X-ray appliances into use. It was also discovered that 13 licensees had acquired one or more new X-ray appliances without notifying this to STUK. STUK issued the required orders to rectify the observed shortcomings and supervised appropriate licensing of all of the foregoing appliances.

Regulatory control of transport

In 2012, a licence was granted for one specially arranged transport (the transport took place in 2013). The transport was connected with the shipment of radioactive waste to the national storage facility for low-level waste. Moreover, Finnish shipping companies were sent a questionnaire concerning the numbers of sea shipments of radioactive material in Finland's territorial waters. The results have not yet come out.

Conference on Radiation Safety in Industry

In September, the 9th Conference on Radiation Safety in Industry was organized in Tampere. The emphasis at the conference was on radiation physics and the importance of good safety culture. The conference on radiation safety has established its role as a meeting place for responsible parties, and in 2012 the number of participants was the greatest ever.

2.3 Inspections of licensed radiation practices

408 inspections were made of the use of radiation in health care and veterinary practices. These inspections resulted in 187 repair orders or recommendations issued to the responsible parties. A further 4 appliances were also found that did not have the safety licence required for their use.

210 inspections were made of the use of radiation in industry, research and education. These inspections resulted in 561 repair orders or recommendations.

There has been no real change in the numbers of inspections or recommendations and orders from the previous year.

Table 6 in Appendix 1 shows the number of inspections itemized by type of practice.

2.4 Inspections of notifiable dental X-ray practices

There were 1688 responsible parties engaged in dental X-ray practices. Patient radiation exposure due to dental X-ray imaging was measured, in 916 appliances, with testing equipment sent by mail. The average dose was 1.4 mGy. This dose corresponds to the dose administered at the surface of the cheek (Entrance Surface Dose, ESD) when imaging a tooth. The reference level of 5 mGy was exceeded in 5 imaging appliances (0.5% of the measured appliances).

Of notifiable dental X-ray appliances, 31 were inspected. The number of repair orders issued was 23. No repair recommendations were given. In addition, inspections disclosed 35 dental X-ray appliances that had not been duly notified to STUK for registration. Doses exceeding the reference level were measured in 10 panoramic tomography appliances.

2.5 Importing, manufacture and exporting of radioactive materials

Details of deliveries of radioactive materials to and from Finland and of manufacturing of such materials in Finland in 2012 are shown in Tables 7–8 of Appendix 1. The figures in the tables are based on data gathered from radiation safety licensees engaged in trading, importing, manufacturing and exporting.

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 the said use to other European Union countries.
- Radioactive materials supplied to other countries via Finland.
- Smoke detectors and fire alarm system ion detectors containing americium (^{241}Am). Approximately 142 000 of these were imported with a combined activity of about 4.7 GBq. Around 5200 smoke detectors with a combined activity of 0.17 GBq were exported from Finland.
- Lamps and fuses containing radioactive

materials imported to Finland. Some of these appliances contain small quantities of tritium (^{3}H), krypton (^{85}Kr) or thorium (^{232}Th).
- Unsealed radioactive sources imported to Finland and exported from Finland. The most common sources of this type were ^{131}I, ^{99}Mo, ^{123}I, ^{177}Lu, ^{153}Sm, ^{32}P and ^{18}F.

2.6 Radiation doses of workers

A total of nearly 11 400 workers engaged in radiation work were subject to individual monitoring in 2012. Including doses falling below the recording level, about 148 000 dose records were entered in the Dose Register maintained by STUK (this figure also includes the dose records of workers exposed to natural radiation, see Chapter 3).

In no case did the effective dose of a worker in 2012 exceed the annual dose limit of 50 mSv or the five-year dose limit of 100 mSv. In no case did the dose to a worker's hands exceed the annual limit of 500 mSv.

The combined doses (Hp(10) values) of workers by occupational category sustained in the use of radiation were nearly 1.8 Sv and those sustained in the use of nuclear energy nearly 2.5 Sv. The total dose sustained in the use of radiation was at the level equal to that of the previous year, but in the use of nuclear energy it was nearly 35% greater than during the previous year. The total dose in the use of nuclear energy varies considerably each year depending on the duration of annual nuclear power plant servicing and the duties performed in servicing work at these facilities.

The largest (Hp(10)) value in health care was 44.6 mSv recorded in the case of an interventional radiologist. This corresponds to an effective dose of 0.7–4.5 mSv. The largest effective dose in health care from a source other than X-radiation was 4.7 mSv recorded in the case of a radiographer, whose exposure was caused by many different types of sources. The largest Hp(10) value in veterinary practice was 9.0 mSv recorded in the case of a veterinarian performing X-ray examinations. This corresponds to an effective dose of 0.2–0.9 mSv. The largest effective dose in industry was 6.0 mSv. The largest effective dose in research was 7.0 mSv sustained by a laboratorian using unsealed sources.

The largest dose to the fingers was 259 mSv, recorded in the case of a laboratory worker working in the research field and using unsealed sources.

Table 9 of Appendix 1 shows the number of workers by occupational category subject to individual monitoring over the last five years. The combined doses of workers by occupational category are shown in Figure 1 (Item 1.1) and in Table 10. Table 11 shows the doses in 2012 of persons sustaining high levels of exposure or of numerically large worker groups.

2.7 Approval decisions and verification of competence

Training organizations providing radiation protection training for radiation safety officers

In Guide ST 1.8 STUK has stipulated the minimum qualifications of the radiation safety officers who are responsible for the safe use of radiation. Training organizations that arrange training and competence exams for radiation safety officers must apply to STUK for the right to arrange such exams. Guide ST 1.8 has been subjected to changes, and the revised guide became effective on 1 April 2012. The competence area of the radiation safety officers for the trade of radioactive materials has been removed from this guide, and the matters that earlier were a part of this competence area have been included in other competence areas.

In 2012, three training organizations were given the approval to arrange exams and organize training for radiation safety officers. Of these decisions, two were made after the new guide had become effective. A total of 23 training organizations held valid approval decisions at the end of 2012.

There is a list of approved training organizations on the STUK website (http://www.stuk.fi/proinfo/koulutus/sateilysuojelu/fi_FI/koulutusorganisaatiot_1/ (in Finnish only).

Responsible medical practitioners

STUK verifies the competence of medical practitioners responsible for medical surveillance of category A workers. There were 358 STUK-accredited responsible medical practitioners in Finland at the end of 2012, of whom 16 were accredited during the year under review.

2.8 Radioactive waste

STUK maintains a national storage facility for low-level radioactive waste. The activities or masses of the most significant waste held in the storage facility at the end of 2012 are shown in Table 12 of Appendix 1. In 2012, there were no shipments to the storage facility.

2.9 International assessment of the regulatory control of the use of ionizing radiation

The international IRRS working group (Integrated Regulatory Review Service) evaluated STUK's regulatory activities in the autumn of 2012. The evaluation also included the assessment of the regulatory control in the use of ionising radiation, and the representatives of the Department of the Radiation Practices Regulation (STO) participated in many of the modules that belonged to the assessment.

The working group gave STUK 8 recommendations and 20 suggestions for the development of operations. Of these, 2 recommendations and 10 suggestions had to do with STO. No major deficiencies were discovered in STO's operations. To implement the recommendations and suggestions, plans, which include the persons in charge and schedules, have been drawn up.

The working group also praised STO's activities (see Item 2.1 Radiotherapy).

2.10 Abnormal incidents

Under section 17 of the Radiation Decree (1512/1991), STUK must be notified of any abnormal incident involving the use of radiation that is substantially detrimental to safety at the place where the radiation is used or in its environs. The disappearance, theft or other loss of a radiation source such that it ceases to be in the possession of the licensee must likewise be reported. Any other abnormal observation or information of essential significance for the radiation safety of workers, other persons or the environment must also be notified.

There were 87 cases in 2012 in which abnormal incidents or situations occurred or were suspected in the use of ionizing radiation, of which 17 concerned the use of radiation in industry, research and education, 66 involved medical uses of radiation and veterinary practices, and 4 arose in transportation of radiation sources (see also Item 4.4 for abnormal incidents in the use of non-ionizing radiation). Figure 3 (in Item 1.1) shows abnormal incident numbers between 2003 and 2012.

Described below are the abnormal incidents in the use of ionizing radiation that occurred in 2012 and the reasons for them. Differing from the style of presentation in the previous reports, the events are grouped in a way that describes similar kinds of events as a single whole.

Incidents 1–21

A wrong patient X-rayed or subjected to a nuclear medicine examination:

A typical reason for radiographing or examining a wrong patient was a deficient verification of the identity of the person (the social security number was not asked when the patient was brought to be radiographed or the verification was erroneous due to communication difficulties). In many cases, there were two patients of the same name on the waiting list. In five cases, the doctor made a referral for a wrong patient. The largest dose due to imaging was estimated to be 15 mSv.

Incidents 22–38

Appliance fault in X-ray imaging or in nuclear medicine examinations:

In several cases, a patient's radiography has had to be redone due to a malfunction in or breaking down of a CT appliance. Also faulty operation instructions and software errors caused aborted or faulty imagings. Additional exposure for a patient due to a device fault was 8 mSv at its highest.

Incidents 39–54

Personnel involvement in X-ray imaging in health care:

Many of the incidents were related to examinations in which contrast medium was used. There were problems either in the timing of radiography or injection of the contrast agent, and these led to the repetition of the radiography. During some incidents, a wrong imaging protocol was used or there were extra people in the exposure room during radiography. The extra dose for the patient due to these incidents was at most 32 mSv. In all cases, the effective dose for the personnel remained clearly below 1 mSv. In one case, a foetus of a pregnant woman being radiographed was subjected to a small extra radiation exposure.

Incidents 55–58

Wrong radiopharmaceutical:

In nuclear medicine, the patient is given radiopharmaceutical for the purpose of examination. For dose administration, the radiopharmaceutical is placed in readiness to the syringe. Mix-ups were caused by that adequate markings had not been made on syringes or that their lead protections or markings had not been checked before administering the radioactive medicine. The largest dose resulting from this to a patient was estimated to be 10 mSv.

Incidents 59–62

The patient was given radiopharmaceutical, but no examination could be done:

For examinations, a radiopharmaceutical was given to a patient several hours before radiography was to take place. The imaging appliance started malfunctioning after the radiopharmaceutical had been administered, and it could not be speedily repaired. Thus, the examination could not be done. The largest dose resulting from this to a patient was estimated to be 4 mSv.

Incident 63

In nuclear medicine, an injection of a radiopharmaceutical bypassed the blood vessel. The examination had to be redone later, and the patient sustained a 5 mSv extra radiation exposure.

Incident 64

In nuclear medicine, the activity of the test source of the imaging appliance was clearly weaker than specified in the order, and it could have weakened the quality of examinations. The examination had to be redone later.

Incident 65

In radiotherapy, a female patient received treatment with 9 MeV electron radiation for a cancerous tumour in front of the ear. The intended dose for the patient was 20 Gy. When 16 Gy of the treatment had been administered, the patient told she was pregnant. The treatment was immediately halted. The exposure for the foetus was determined to be 1.0–1.2 mSv, which does not create an imminent danger. The hospital has changed its practices with which the information about a possible pregnancy of a patient is verified.

Incident 66

In radiotherapy, a patient received a 59 Gy dose in the spinal cord along a distance of about 3 cm within the thoracic vertebrae 7–9. The treatment sequence planned for the patient required radiation of several areas, but, in some of the treatments irradiation alignment were not done, and the treatment focused incorrectly. As a normal limiting value for the spinal cord, the hospital has used the value of 50 Gy.

Incidents 67–74

Exposure of a worker in the industrial use of radiation:

In most of the cases, the worker was exposed to the radiation of a radiometric measuring device in connection with maintenance work when the shutter of the radiation source had not been appropriately closed or when the shutter was faulty. Based on estimates, the biggest extra dose resulting from these incidents was 0.1 mSv.

In one case, the dose of a worker exceeded the annual dose limit of 1 mSv for general population. The worker had been instructed to shut the radiation source used in automated control application for the duration of a maintenance stoppage. The shutter of the radiation source was very tight, and the worker undid the screw in the shutter part of the radiation source to make the shutter move easier. The screw undone was the holder of the radiation source, which the worker pulled out of its protection shield, thus becoming exposed to radiation. The worker quickly understood the situation and returned the radiation source to its shield. The licensee estimated the extra dose received by the worker as being about 3 mSv.

Incidents 75–79

Exposure in industrial radiography:

In four cases, an outsider to the radiography imaging was allowed too close to the imaging situation due to deficient markings, inadequate surveillance of the area or bad operational planning. None of these incidents resulted in significant exposure.

In one case, a pulse X-ray device used in radiography was turned on by itself during imaging. The incident did not expose the radiographers or other persons to significant radiation doses. The importer warned other users of similar devices about the fault. The incident is still being examined.

Incidents 80–83

Non-identifiable sources of radiation and disappearances of radiation source:

In three incidents, articles with radiation hazard markings on them were found. In two of these cases, the markings were unnecessary, and one of the cases concerned a ^{99}Mo/^{99}mTc generator which was left in a wastepaper basket and the radioactive substances of which had decayed. In one incident, a gaseous ^{85}Kr radiation source was noticed to have leaked and become diluted in the air.

Incidents 84–87

Transport of radioactive materials:

In two incidents, a transport package was damaged on an airfield during transfer. In both cases, only the exterior part of the packing was damaged, and the contents were not leaked. The contents were repacked and forwarded. Two incidents were related to the marking of packages: in one of them, the package was left unmarked, and, in the other, the classification of the package was incorrect.

3 Regulatory control of practices causing exposure to natural radiation

3.1 Radon at workplaces

During 2012 STUK received 238 radon measurement notifications concerning either a radon concentration exceeding the action level of 400 Bq/m^3 measured in a work area, or further investigations of previously reported excessive levels. Based on measurement results, 100 reports were sent to enterprises, requiring the performance of radon repairs or an investigation of radon concentration during working hours at 88 work areas, and a measurement at another time of year in order to determine an annual average at 19 work areas. Orders to investigate workplace radon concentrations were also sent to a further 15 enterprises. These enterprises are located in regions where high radon concentrations are known to occur.

Radon concentrations were successfully reduced at 43 workplaces during the year. STUK discontinued regulatory control in 22 work areas on the basis of further investigations (measurement during working hours or determination of annual averages). Regulatory control was terminated at a total of 74 work areas for other reasons (e.g. short working periods or discontinued use of premises). 306 work areas at 172 workplaces were subject to regulatory control by STUK during the year.

A statutory radon inspection was conducted at five subterranean mines. In two of them, the action level was found to have been exceeded, but with corrective measures the radon concentration was brought to an allowed level.

Inspections were conducted at 21 underground quarries, of which 13 were tunnelling projects for the Western Metro Extension in the Helsinki metropolitan area. Six underground sites were ordered to reduce radon concentration, and for two of these an order for radiation exposure monitoring was issued because their radon concentration couldn't be reduced below the action level.

Radon exposure of workers was monitored by regular radon measurements and monitoring of working hours at four conventional workplaces and two underground quarries, in all of which the radon concentration exceeded the action level. In addition, the radon exposure information for seven persons who worked in several different underground tunnels was recorded in the Dose Register. A total of 79 workers, whose doses (effective doses) were recorded in the Dose Register, were subject to radon exposure monitoring during 2012. In conventional workplaces, the largest single annual dose resulting from radon to a worker was 33.4 mSv and, in quarrying sites, 6.9 mSv.

No new approval decisions for radon measuring equipment were issued in 2012. A list of organizations with measuring methods that have been approved in accordance with the requirements of Guide ST 1.9 appears on the STUK website (http://www.stuk.fi/proinfo/valvonta/luonnonsateily/radon_tyopaikoilla/fi_FI/radonin_mittaaminen/ (in Finnish only)). These organizations have given permission for their names to be published on the approval list. It is a condition of such approval that the measuring instrument is properly calibrated.

3.2 Other natural radiation from the ground

STUK monitors radiation exposure caused by radioactive nuclides that occur naturally in water intended for human consumption, construction materials and other materials. 19 inspection reports on the radioactivity of construction materials were prepared during 2012. These reports imposed restrictions on the use of materials where necessary. Inspection reports on the radioactivity of water intended for human consumption were prepared for 2 waterworks or foodstuffs manufacturers. An order was issued to one water abstraction facility to reduce radioactive substances in the water, and the radioactivity of the water of another facility was found to be on a permitted level after corrective measures had been carried out.

The dam failure at the Talvivaara mine showed that the operations of the mine in question may give rise to a situation where it is necessary to limit radiation exposure. For this reason, STUK made a decision that the water management of Talvivaara mines is radiation practice as determined in the Radiation Act.

In 2012, STUK also participated in drafting several statements related to mining and concentration activities.

3.3 Cosmic radiation

The doses sustained by employees of 7 airlines were entered in the Dose Register in 2012. In no case did the annual dose (effective dose) sustained by an employee exceed the limiting value of 6 mSv stipulated in Guide ST 12.4. The largest individual doses of cosmic radiation were 4.4 mSv sustained by a pilot and 5.0 mSv sustained by a cabin crew member. The average annual dose sustained by pilots in 2012 was 2.2 mSv and the average annual dose of cabin crew members was 2.4 mSv. The average doses over the period from 2008 to 2012 are shown in Figure 5.

The total number of workers in flight crews has diminished less than 1% and the total dose has diminished about 7% compared to the preceding year. The number of workers subject to individual monitoring of radiation exposure and their total dose are shown in Table 13 of Appendix 1.

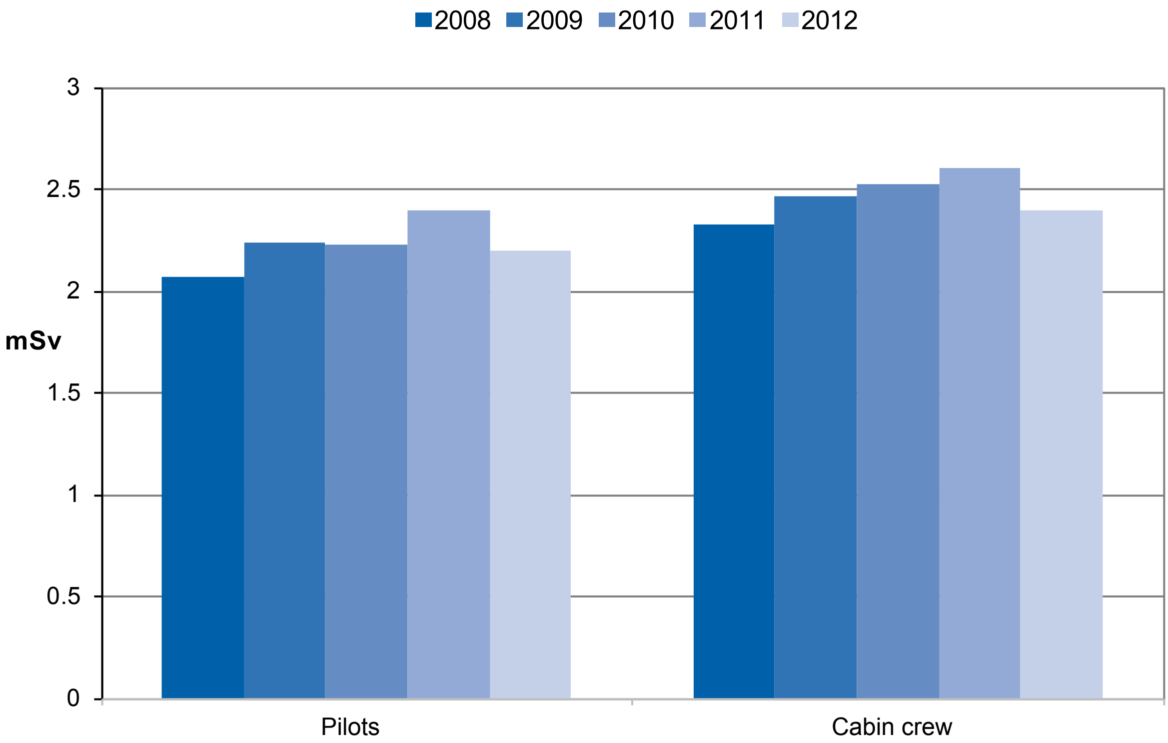

Figure 5. Average doses of air crews, 2008–2012.

4 Regulatory control of the use of non-ionizing radiation

4.1 General

The expression non-ionizing radiation refers to ultraviolet radiation, visible light, infrared radiation, radio frequency radiation, and low frequency and static electric and magnetic fields. STUK controls activities that give rise to non-ionizing radiation (its regulatory control is not directly comparable to the regulatory control of ionising radiation):

- Sunbed equipment and facilities have been monitored since 1995. The amendment of the Radiation Act (326/2012, effective from 1 July 2012) obliged the health protection authorities of municipalities to inspect sunbeds in connection with the inspections made in accordance with the Health Protection Act and send the inspection details to STUK for evaluation and decision.
- Market control of the mobile phones started in 2003.
- Non-compliant laser pointers that are hazardous to the eye have been increasingly used for harassment. During 2009, STUK began regulatory control of laser appliances primarily intended for consumer use in accordance with an agreement concluded with the Ministry of Social Affairs and Health (STM) and the Finnish Customs.
- Regulatory control of high power laser equipment used in public performances began back in the late 1980s. Their use has again increased due to advances in laser technology (semiconductor lasers) and falling prices.
- Annual inspections have been made of a few public broadcasting stations and radar stations.

The work of the NIR Unit in regulatory control of the use of non-ionizing radiation between 2003 and 2012 is shown in Table 14 of Appendix 1. Numerous (about 60) requests for clarification and enquiries concerning importation of laser devices submitted by the Customs and by importers (including private individuals) and comparable to regulatory inspections have increased the need for regulatory control of lasers, as in the preceding year.

4.2 Optical radiation

Regulatory control of sunbed equipment

The number of sunbed facilities inspected was 6 (Table 15 of Appendix 1). These included 13 solarium appliances overall. Of these establishments, 3 were self-service units and 3 were attached to gyms. Based on the amendment of the Radiation Act (see Item 4.1), health protection authorities of municipalities also sent the details of the inspections of 16 sunbed establishments to be assessed and decided on by STUK.

The new methods related to the inspection activities were agreed on jointly with Valvira (National Supervisory Authority of Welfare and Health) and the Association of Finnish Local and Regional Authorities, and a joint circular about the new ways to operate was sent to the municipalities. For the inspection of sunbed facilities, a form was drafted for the health protection authorities. The form can be used in reporting their observations in the field to STUK. In line with the amendment to the act, STUK began revising the guide for the regulatory control of sunbed establishments (Guide ST 9.1). STUK also revised the sunbed poster, display of which STUK has required in the vicinity of sunbed appliances.

The amendment of the Radiation Act mentioned above also prohibits the offering of sunbed services to those under 18 years of age.

Regulatory control of laser devices

On-site inspections were conducted at 11 laser show installations, and further 19 notifications of shows were received from responsible parties that had received STUK's approval for the use of transferable laser equipment. Inspections indicated that safety precautions and the orientation of laser beams largely complied with requirements, except in one case. In Helsinki, in a demonstration of a laser beam designed as a work of art, an abnormal incident took place (see Item 4.4).

There were 43 requests sent to the huuto.net online sales forum and other internet sales sites, requesting the removal of sales advertisements because of excessively powerful laser pointers. Moreover, 2 enquiries were submitted concerning online sales of laser pointers and light fittings. Some laser equipment was shown to be compliant by the importer/vendor, while some were withdrawn from sale due to non-compliance.

The Finnish Customs solicited advice from STUK in 21 cases involving importation of battery-powered lasers from outside of the European Union. In 11 of these cases, the laser appliances or components thereof could be released for free circulation, because they fell outside the scope of type inspection under the relevant government decree concerning laser equipment and their inspection (291/2008). Most of the equipment within the scope of type inspection was meant for work use, and they were released from the customs for free circulation by virtue of type inspection certificate alone or after a follow-up inspection carried out in Finland. The import permits of only two laser pointers were refused either due to a lack of type inspection certificate or to excessive power. The largest power found was 400 mW, whereas the decree allows only 1 mW laser pointers.

4.3 Electromagnetic fields

Market control of wireless communication devices

STUK began market surveillance of mobile phones in 2003 and extended this to UMTS phones in 2007. A total of 15 GSM and UMTS type mobile phones were tested in 2012 (Table 16 of Appendix 1). The highest measured SAR value was 1.18 W/kg. This did not exceed the maximum value of 2 W/kg prescribed in the decree of the Ministry of Social Affairs and Health (294/2002) concerning limitation of exposure caused by non-ionized radiation to general population.

Other regulatory control

The compliance of a magnetic therapy appliance employing low frequency magnetic fields and that of a skin treatment device utilizing light pulses and radio frequency (RF) radiation were examined. Magnetic fields created by magnetic therapy applications do not create health problems for their users, even though it is possible, according to the information received, to exceed the exposure limits locally. The decree (294/2002) of the Ministry of Social Affairs and Health construes the exposure limits as recommendations. Thus, follow-up measures such as sales limitations for the appliance or a more detailed explanation about the exposure caused by the appliance are not justified on the basis of radiation safety issues. It was found that the maximum exposure values of RF radiation were exceeded with the skin treatment device, and for this reason a request for clarification was sent to the responsible party. On the other hand, in the current legislation there are no exposure limits for visible light, and therefore the use of the device cannot be interfered with for reasons involving visible light.

4.4 Abnormal incidents

The abnormal incident reporting required under section 17 of the Radiation Decree also applies to incidents arising in the use of non-ionizing radiation (see Item 2.10). STUK received 5 reports in 2012 concerning incidents caused by non-ionizing radiation that required immediate measures.

Figure 3 (in Item 1.1) shows abnormal incident numbers between 2003 and 2012.

Incident 1

In a procedure carried out by a cosmetologist, a patient's face was burnt. There were also pigment changes on the face. The appliance used in the process was a device utilizing visible light and radio frequency (RF) radiation. The radiation from the appliance exceeded the values of skin exposure to visible light recommended by ICNIRP (International Commission on Non-Ionizing Radiation Protection) and the maximum values for population exposure to RF radiation. If RF radiation of an appliance exceeds the maximum values for general population exposure, it can be used only by the operation units of health care. Having learnt about the requirements related to the use of the appliance, the beautician gave up the use of the appliance. In Finland, there are no maximum values limiting population exposure to visible light. Therefore, based on the breaching of the recommended values, it wouldn't have been possible to restrict the use of the appliance.

Incident 2
A laser beam designed to be a work of art was demonstrated in Helsinki in April by directing the beam from Tähtitorninmäki (Observatory Hill) to the Kallio church tower. Due to cold weather, the remote keyboard for the laser malfunctioned, and the laser beam was suddenly directed from the church tower to the street level. The laser operator immediately stopped the beam with the use of an emergency switch. STUK demanded an explanation for the hazardous situation. The incident could have been avoided by restricting the path of the laser beam with a mechanical barrier and by testing the operation of the remote control in cold conditions beforehand. Even in temporary installation, all safety measures must be paid attention to. According to the assessment by STUK, the laser beam wouldn't have caused eye injuries in a possible exposure situation.

Incidents 3–5
Harassment with laser pointers:

In all of these incidents, small laser pointers were used in schools or in traffic to target other persons or vehicles. The efficiencies of these laser pointers were 30–200 times higher than the efficiency limit (1 mW) allowed for laser pointers. In one incident, a laser beam hit the eye of a schoolgirl, and the eye has felt sore since. The girl visited an ophthalmologist, but no damage was found in the eye.

5 Regulation work

Radiation safety guides

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

The following radiation safety guides were published in 2012:

- ST 1.7 Radiation protection training in health care
- ST 1.8 Qualifications of persons working in radiation user's organization and radiation protection training
- ST 5.6 Radiation safety in industrial radiography
- ST 8.1 Radiation safety in veterinary X-ray examinations.

Other regulation work

The NIR Unit assisted in work led by the Ministry of Social Affairs and Health to prepare an amendment to the Radiation Act. The amendment took effect on 1 July 2012 (see Items 4.1 and 4.2)

When clarifying the regulatory control process for cosmetic appliances producing non-ionized radiation, the NIR Unit compiled a summary on the legislation on the basis of which these kinds of appliances are kept under regulatory control. While examining the conformance of the appliances to the requirements, also the effectiveness of the current legislation was evaluated. Maximum values for visible light should be included in the decree of Ministry of Social Affairs and Health (294/2002) concerning the limitation of general population's exposure, because without them it is not possible to intervene to prevent harmful effects to health, such as incidents of skin burns, caused by visible light.

The NIR Unit assisted the occupational health department of the ministry of Social Affairs and Health in preparation of the new directive on health and safety at work in relation to electric and magnetic fields. Finland's negotiation objectives were achieved. In addition to exposure limits, the main negotiation objectives included getting an exception in the application of limits related to magnetic imaging. The NIR Unit actively participated in the activities of the working group drafting the directive, and Denmark and Ireland were assisted in technical and scientific questions during their presidency of the Council of the EU. The directive is being processed by the European Parliament and could be completed by 2013.

A staff member of STO who was authorized by the Ministry of Social Affairs and Health to represent Finland participated in the handling of the Basic Safety Standards Directive in the European Council's Atomic Questions Group. The new directive takes into account ICRP's latest recommendations published in 2007. At the same time, all current directives related to radiation protection and supplementing the Basic Safety Standards Directive are directly added to it.

6 Research

The aim of research work conducted by STUK is to provide information on the occurrence of radiation, on its detrimental effects and how to combat them, and on the safe and optimal use of radiation sources and methods of using radiation. Research supports the regulatory activities of STUK and the maintenance of the preparedness to respond to radiological and nuclear emergencies.

Research into uses of radiation also seeks to improve knowledge and expertise in this field and to ensure reliable radiation measurements.

6.1 Ionizing radiation

Most research into ionizing radiation concerns medical uses of radiation and focuses on the radiation safety of patients. There is a growing need for research owing to rapid progress in examination and treatment methodologies. Research and development work was done in the following projects.

Extension of IAEA dosimetry guidelines (X-ray diagnostics)

The project launched in 2010 is developing extensions to existing IAEA dosimetry guidelines for such areas as paediatric imaging, skin dose determination in interventional radiology and the latest imaging technologies. STUK was in charge of the sub-project related to determination of organ doses. Supplementary responses to a survey conducted in 2011 were received in 2012 from those whose original responses were lacking in some respects or who had not responded earlier. Based on the results and individual explanations, the first draft of the text for the project's final report was made. Results of the project were presented in the IRPA 2012 conference. STUK also participated in a project meeting that took place in October. The project continues until 2013.

European Metrology Research Programme (EMRP)

A new co-financed metrology research programme project (MetrExtRT) was launched in 2012 seeking to develop measurement methods for small and complex radiation fields in novel types of radiotherapy. Under development in the project are new measurement quantities, new parameters describing the radiation spectrum and treatment verification methods. STUK's aim in the project is to develop a measurement method for the verification of electron radiation therapies, especially in the photon-electron combination treatments (breast cancer radiation therapy) and electron radiotherapy for the head and neck. Also calibration of dosemeters for electronic radiation is under investigation. The project will continue until 2015.

A co-financed metrology project launched in 2011 continued with its aim to develop radiation measurement methods for smelting works that process recycled metal. During 2012, measurement methods used by the smelting works were being charted and preparations were made for the creation of reference sources and comparison measurements, both to be implemented in 2013. The project seeks to improve radiation safety at smelting works processing recycled metal and to establish a uniform method of determining the radioactive contamination level of steel.

Academic thesis work

The results of academic thesis work may be used in the activities of STUK or will help to improve radiation safety in Finland.

The state of quality management for digital dental X-ray imaging in Finland

This university-based applied science investigation led by a STO expert mapped the use of and quality assurance of panoramic radiography and cone-beam computed tomography appliance in Finland. The work is part of the Nordic EQD (Evidence based quality assurance in digital dental imaging) project to develop curricula, teaching programs and training material for web-based instruction.

6.2 Non-ionizing radiation

Personnel wellbeing in magnetic resonance imaging work

STUK and the Finnish Institute of Occupational Health participated in a research project entitled “Actions promoting staff wellbeing in magnetic resonance imaging work”. This project determines the exposure of workers to magnetic fields, and prepares safety guidelines for magnetic resonance imaging work. The project began in March 2012 and will end during 2015.

7 International co-operation

Participation in the work of international organizations and commissions

Representatives of STO and the NIR Unit are involved in several international organizations, commissions and expert groups dealing with the regulatory control and with the development of safety regulations and measuring methods in the use ionizing and non-ionizing radiations, as well as with standardizing activities in the field of radiation (e.g., IAEA, NACP, EURADOS, EURAMET, ESTRO, ESOREX, AAPM, IEC, ISO, CEN, CENELEC, ICNIRP, EAN, EUTERP, HERCA, EURATOM/Article 31 – Group of Experts). Representatives of STO and the NIR Unit participate annually in several international conferences, congresses and working groups and give presentations and lectures at these events.

Participation in meetings of international working groups

During 2012, representatives of STUK took part in meetings of the following international organizations and working groups:

- EURAMET's (European Association of National Metrology Institutes) annual meeting of contact persons
- Meeting of the Nordic dosimetry group
- HERCA (Heads of the European Radiological Protection Competent Authorities) and its working groups
- Annual meeting of EURADOS' (European Radiation Dosimetry Group) and its working groups
- NORGIR meeting (Nordic Working Group on Industrial Radiation)
- Meeting of EACA (European Association of Competent Authorities on the transport of radioactive material)
- Meeting (twice) of the main committee of ICNIRP (International Commission on Non-Ionizing Radiation Protection).

8 Co-operation in Finland

Participation in work of Finnish organizations and commissions

Representatives of STO and the NIR Unit are involved in several Finnish organizations and commissions dealing with regulatory control of and research into the use of ionizing and non-ionizing radiation and with standardizing activities in the field of radiation (such as the Advisory Committee on Metrology, the Radiation Safety Conference committee, Eurolab-Finland, SESKO and the Finnish Advisory Committee for Clinical Audit appointed by the Ministry of Social Affairs and Health).

Finnish conferences arranged by STUK

STUK arranged the following conferences in 2012:

- Radiation Safety Conference, 1–2 November 2012, Tampere, in association with the Radiological Society of Finland
- Conference of radiotherapy physicists 14–15 June 2012.

Participation in meetings of Finnish working groups

Representatives of STUK took part in the following meetings of Finnish organizations and working groups:

- Screening committee of the Ministry of Social Affairs and Health
- SESKO SK 61 committee (Safety of domestic electrical appliances)
- SESKO SK 106 committee (Exposure to electromagnetic fields)
- National RAPEX network (Rapid alert system for non-food consumer products; European Union notification system for consumer products causing serious danger)
- Deployment of a national ICSMS information and communication system (Internet-supported information and communication system for pan-European, cross-border market surveillance of products) in Finland.
- MATIVA network (National co-operation related to the national RAPEX network and ICSMS system)

Other co-operation in Finland

STO's inspectors of radiation therapy and nuclear medicine met in these activities auditors carrying out clinical audits. In these meetings, it was found that there is no unnecessary overlap between the inspections and clinical audits. In official meetings with Valvira's unit exercising oversight over medical equipment, abnormal incidents and notifications of hazardous situations in radiotherapy and nuclear medicine were scrutinized. In a meeting with the teachers of radiographers at universities of applied sciences, no special viewpoints related to radiation therapy or nuclear medicine were brought up.

STO's representative acts as a STUK's representative and secretary in the Finnish Advisory Committee for Clinical Audit (KLIARY) set up by the National Institute for Health and Welfare (THL) and funded by the Ministry of Social Affairs and Health (STM). In 2012, the group was preparing two recommendations for clinical audits of radiation use by health care. These recommendations dealt with the development of criteria for good practices and with the priorities of the third audit. The former of these recommendations was completed at the end of the year. In addition, the group carried out a survey related to the compliance of clinical audits with the recommendations and to their effectiveness. The survey was directed to the users of radiation in health care, and its results were reported at the Radiation Safety Conference.

9 Communication

During the year STUK received, through its web site and by phone, several questions from members of the public, radiation users, the media, and other parties interested in radiation. Most of the questions were related to non-ionizing radiation. Several interviews about current radiation topics were given to the media.

For the last ten consecutive years STUK has organized a UV press event in association with the Finnish Meteorological Institute and the Cancer Society of Finland. STUK's topic dealt with general protection against UV radiation during summer.

The amendment of the Radiation Act (see Items 4.1 and 4.2) prohibits sunbed services from people under 18 years of age. This was the reason for creating the K-18 campaign web site (www.solariumK18.fi), in which the main target group are young people (mainly females) and sunbed entrepreneurs, on whom the impact of the legislative amendment is the greatest.

STUK and the Finnish National Board of Education jointly organized a laser campaign for schools. Laser pointers have become more common in the plays of school children, and they can be used for pointing oneself and others without heeding the consequences. At its worst, the incidence of a laser beam into the eye can cause a permanent injury. Yearly, STUK learns about some laser harassment incidents at schools, but their real number is certainly much larger. For this reason, STUK and the Finnish National Board of Education advised the schools to intervene in cases of harassment and reminded the schools of the dangers of laser pointers. The schools were approached with a circular and an accompanying poster, which described the dangers of laser and which was to be hung on schools' notice boards.

Press releases were written on the following topics:

- Increased use of CT causes concern among radiation protection officials in the Nordic countries
- Occurrence of malignant brain tumours has not significantly increased with more widespread use of mobile phones
- Workers were exposed to radioactive substance in Tornio
- It is advisable to use moderation when enjoying the sunshine
- Each CT scan of a child patient must be carefully considered
- The SolariumK18.fi site disseminates sunbed information
- New knowledge about the possible effects of mobile phones on the brain's metabolism and blood circulation
- International assessment of the regulatory control of the use of nuclear energy and radiation in October
- An international group began the evaluation of STUK's work in regulatory control
- An international assessment emphasizes the importance of STUK's neutrality
- Schools are warned about the dangers of laser pointers
- The IRRS assessment report was completed.

10 Metrological activities

10.1 General

STUK serves as the national standard laboratory for radiation quantities and maintains standards to ensure the accuracy and traceability of radiation measurements taken 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 of the European Association of National Metrology Institutes (EURAMET). STUK also participates in the international equivalence agreement (CIPM–MRA), the implementation of which is coordinated in Europe by EURAMET, and in the network of secondary standard dosimetry laboratories (SSDL), which is jointly coordinated by IAEA and WHO.

Metrological activities are the responsibility of the Radiation Metrology Laboratory (the DOS Laboratory) at STO for ionizing radiation and the NIR Unit for non-ionizing radiation. Metrology of ionizing radiation activity quantities is the responsibility of the Department of Research and Environmental Surveillance (TKO) at STUK.

10.2 Ionizing radiation

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

Irradiation equipment and metrological standards were maintained to the calibrations of the radiation meters for radiotherapy, radiation protection and X-ray imaging. Routine calibrations for radiation therapy dosemeters were initiated with a new ^{60}Co device. For the calibration of radiation protection measurement devices with a small gamma-radiation dose rate, an arrangement making use of STUK's low background radiation room was adopted. The calibration certificates forming part of the international metrological equivalence agreement (CIPM-MRA) will now display the agreement logo.

Meter and measurement comparisons

The DOS Laboratory took part in the annual TLD comparison measurement of the absorbed dose of ^{60}Co radiation (radiotherapy dose accuracy) between calibration laboratories belonging to the network of SSDL laboratories maintained by the IAEA/WHO. The deviation of the laboratory result from the IAEA reference value was 0.6%. This result is well within the IAEA acceptable variation of results. Figure 6 shows the deviations, in the measurement results of STUK, from the reference value in these comparisons over the period from 2003 to 2012.

In addition, the laboratory took part in the annual TLD comparison measurement of the absorbed dose of ^{137}Cs radiation (protection level dose accuracy) among the IAEA/WHO laboratory network and in the CT chambers' calibration comparison related to an IAEA project. The results of these comparisons have not yet been made available.

Preliminary details were received from the EURAMET comparison (calibration of patient dosemeters in X-ray diagnostics). According to them, the results of STUK were very good. More accurate results will be made available during 2013.

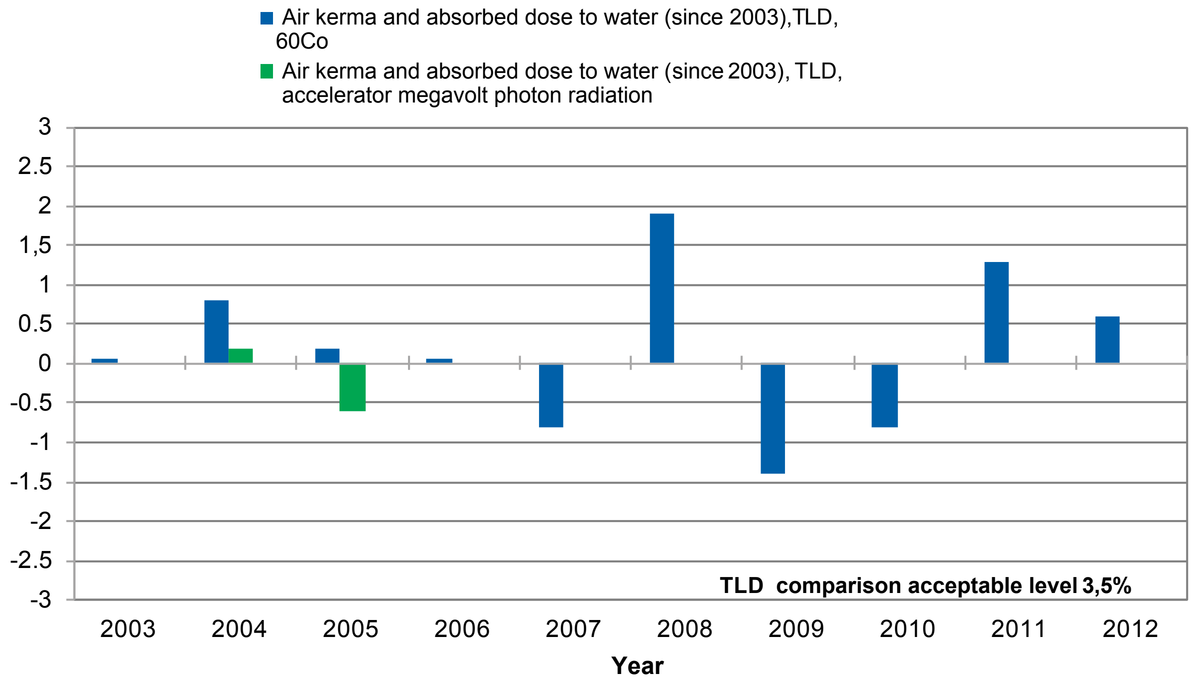

Figure 6. Deviations (%) in measurement results of STUK from the reference value in IAEA/WHO measurement comparisons (radiotherapy dose accuracy), 2003–2012.

11 Services

11.1 Ionizing radiation

Calibration, testing and irradiation

The DOS Laboratory performed radiation meter calibrations and testing on request. 164 radiation meter calibration, inspection and testing certificates and 72 irradiation certificates were issued. About 13% of the calibrations and about 26% of the irradiations were performed for STUK´s own instruments and samples.

Other services

In the Dose Datamed 2 project (DDM2), STUK coordinated the definition of European population exposure arising from radiological examinations (i.e., nuclear medicine and X-ray examinations). This was the first time the issue was tackled. The two-year project was funded by the European Commission. The main result was that in Europe the collective effective dose due to radiological examinations was 1.1 mSv per person. The corresponding figure is 1.7 mSv in Australia and 3 mSv in the USA. In Finland, the corresponding figure, less than 0.5 mSv, is one of the lowest in Europe. The results will be published in the European Commission's Radiation Protection publication series on radiation protection at the end of 2013 at earliest.

STUK is involved as a work package leader in a two-year (2012–2013) European Commission project entitled "Guidelines on a Risk Analysis of Accidental and Unintended Exposures in Radiotherapy" (ACCIRAD). With the help of an Internet-based survey, the project examined European countries' legislation and arrangements concerning classification and reporting of abnormal incidents in radiotherapy as well as methods of risk analysis. Aided by the results of the survey and by other reports, the first draft to serve as an EU recommendation dealing with the topic was prepared.

A PCXMC computer application designed for calculating patient doses in X-ray diagnostics was maintained, and 89 copies of it were sold. One test and report were prepared on compliance of X-ray equipment with standards.

STUK arranged the following event as a training service in 2012:

- The 9th Conference on Radiation Safety in Industry in Tampere 26–27 September 2012.

11.2 Non-ionizing radiation

Calibration, testing and irradiation

The NIR Unit performed a total of 8 radiation meter calibrations and tests and 16 safety assessments and radiation measurements. The service work of the NIR Unit between 2003 and 2012 is shown in table 14 of Appendix 1.

APPENDIX 1

Table 1. Radiation practices in the use of radiation in health care and veterinary medicine at the end of 2012.

Use of radiation	Number of practices
X-ray practices	288
Veterinary X-ray practices	271
Extensive X-ray practices	91
C-arm practices	85
Minor X-ray practices	89
X-ray practices outside X-ray departments	57
Screenings with X-rays	52
Use of unsealed sources	29
Use of sealed sources	25
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 2012.

Appliances/Sources/Laboratories	Number
X-ray diagnostic appliances (generators)*)	**1452**
fixed conventional X-ray appliances	480
portable fluoroscopy appliances	224
portable conventional X-ray appliances	212
mammography appliances, of which	158
• screening mammography	72
• tomosynthesis	1
fixed fluoroscopy appliances	108
• angiography	51
• fluoroscopy	29
• cardioangiography	28
CT-appliances, of which	103
• SPECT-CT	24
• PET-CT	9
dental X-ray appliances (licensed)	92
• CBCT appliances	42
• panoramic scanners	34
• conventional dental X-ray appliances	15
• cephalostats	1
bone mineral density measurement appliances	71
other appliances	4
Dental X-ray appliances (notifiable)	**5744**
conventional dental X-ray appliances	5090
panoramic scanners	654
Radiotherapy appliances	**135**
accelerators	41
X-ray imaging appliances	34
afterloading appliances	7
manual afterloading appliances	3
X-ray therapy appliances	1
radiotherapy simulators	16
sealed sources (check sources)	32
BNCT therapy unit	1

Sealed sources	**247**
calibration and testing equipment	229
attenuation correction units	14
gamma irradiators	3
other sealed sources in health care	1
X-ray appliances in veterinary practices	**276**
conventional X-ray appliances	230
bone mineral density measurement appliances	3
fluoroscopy appliances	4
dental X-ray appliances	30
CT scanners, of which	7
• SPECT-CT	3
• PET-CT	2
other appliances	2
Radionuclide laboratories	**41**
B-type laboratories	23
C-type laboratories	18

*) 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 2012.

Use of radiation	Number of practices
Use of sealed sources	592
Use of X-ray appliances	492
Installation, test operations and services	150
Importing and exporting of radioactive materials or trading in them	118
Use of unsealed sources	113
Use of particle accelerators	15

Table 4. Radiation sources and appliances and radionuclide laboratories in the use of radiation in industry, research and education at the end of 2012.

Appliances/Sources/Laboratories	Number
Appliances containing radioactive materials	**5981**
level switches	2015
continuous level gauges	1090
density gauges	995
weight scales	568
basis weight meters	538
appliances or sources used for calibration, testing or education	244
moisture and density gauges	123
fluorescense analyzers	75
radiography appliances	23
other appliances	310
X-ray appliances and accelerators	**1555**
X-ray screening appliances	589
diffraction and fluorescense analyzers	441
radiography appliances	366
basis weight meters	42
particle accelerators	23
other X-ray appliances	94

Radionuclide laboratories	**152**
A-type laboratories	6
B-type laboratories	27
C-type laboratories	116
activities outside laboratories (tracer element tests in industrial plants)	3

Table 5. Radionuclides most commonly used in sealed sources in industry, research and education at the end of 2012.

Radionuclide	Number of sources
Other than high-activity sealed sources	
Cs-137	3976
Co-60	1071
Kr-85	353
Am-241 (gamma sources)	348
Fe-55	121
Pm-147	118
Am-241 (AmBe neutron sources)	117
Ni-63	63
Sr-90	63
High-activity sealed sources	
Cs-137	51
Co-60	44
Ir-192	11
Am-241 (gamma sources)	8
Sr-90	5

Table 6 Inspections of licensed practices in 2012 (itemized by type of inspection).

Type of inspection	Number of inspections	
	Industry, research and education	**Health care and veterinary practices**
Initial inspection	0	129
Periodic inspection	208	269
Repeat inspection	2	8
Other inspection or measurement	0	2
Total	**210**	**408**

Table 7. Deliveries of sealed sources to and from Finland in 2012.

Radionuclide	Deliveries to Finland		Deliveries from Finland	
	Activity (GBq)	Number	Activity (GBq)	Number
Ir-192	70 010	22	9186	22
Se-75	6660	3	846	3
Kr-85	1388	99	1478	111
Pm-147	301	33	39	12
Fe-55	139	30	119	26
Cs-137	99	79	26	16
I-125	78	*)	- **)	-
Gd-153	31	21	1	1
Co-60	10	37	-	-
Am-241 (gamma and alpha sources)				
H-3	7	10	1	119
Co-57	6	2082	6	1958
Sr-90	5	35	-	-
Ni-63	4	10	9	8
others total ***)	2	3	21	58
	7	50	< 1	11
Total	**78 747**	**2514**	**11 732**	**2345**

*) The exact number of small sources of I-125 used in radiotherapy is not known.
**) The symbol "-" indicates no deliveries from Finland.
***) Deliveries to Finland, nuclides: Co-57, Cd-109, Am-241 (AmBe neutron sources), Ge-68, Po-210, Co-58, Ba-133, Eu-152, C-14, I-129 and Pb-210.
Deliveries from Finland, nuclides: Eu-152.

Table 8. Manufacturing of radioactive materials (unsealed sources) in Finland in 2012.

Radionuclide	Activity (GBq)
F-18	108 746
C-11	14 619
O-15	4150
Br-82	2994
others total*)	148
Total	**130 657**

*) Nuclides, such as: Cu-64, Zn-63 and Au-198.

Table 9. Number of workers subject to individual monitoring in 2008–2012.

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							
2008	4872	984	392	1293	884			3444	11 550
2009	4440	992	458	1232	810	15	49	3704	11 571
2010	4467	989	491	1192	817	21	73	4151	12 062
2011	4320	1050	550	1209	742	22	79	3830	11 659
2012	3989	1083	582	1286	720	22	107	3676	11 341

*) 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 2008–2012.

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							
2008	1.51	0.12	0.11	0.22	0.09			2.76	4.69
2009	1.27	0.09	0.08	0.15	0.06	0.01	0	2.37	4.04
2010	1.25	0.08	0.08	0.15	0.09	0.004	0	2.59	4.25
2011	1.33	0.11	0.09	0.13	0.07	0.007	0.001	1.83	3.56
2012	1.33	0.10	0.12	0.16	0.05	0.007	0.001	2.47	4.23

*) $H_p(10)$ 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 2012.

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**)	201	0.62	3.7	3.1	18.7
Interventional radiologists**)	36	0.30	10.0	8.3	44.7
Radiologists**)	364	0.21	2.3	0.6	20.5
Consultant physicians**) ***)	272	0.07	1.5	0.3	10.6
Nurses**)	1152	0.05	0.5	0.1	2.4
Radiographists (X-rays)**)	1481	0.05	0.5	0.0	2.8
Radiographers (other than X-rays)	486	0.06	0.9	0.1	4.7
Veterinary nurses and assistants**)	352	0.07	1.3	0.2	5.6
Veterinary surgeons**)	236	0.04	1.4	0.2	9.0
Industrial material inspection technicians****)	512	0.10	0.6	0.2	6.0
Industrial tracer testing technicians	24	0.04	2.5	1.6	5.5
Researchers	553	0.03	1.1	0.1	3.5
Nuclear power plant workers					
• mechanical duties and machine maintenance	737	0.69	1.9	0.9	11.8
• insulation work	68	0.34	7.7	5.0	14.3
• cleaning	216	0.33	2.6	1.6	12.0
• material inspection	226	0.28	1.7	1.3	11.0
• radiation protection staff	83	0.19	2.9	2.3	11.0
• electrical and automation work	676	0.15	0.8	0.2	7.3
• stand building and hauling	162	0.13	1.8	0.8	6.1
• operation staff	256	0.09	0.8	0.4	5.4

*) 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 (December 2012).

Radionuclide	Activity (GBq) or mass
H-3	12 769
Cs-137	2568
Am-241	2364
Kr-85	1648
Pu-238	1549
Ra-226	236
Sr-90	233
Co-60	122
Cm-244	94
U-238	1270 kg

Table 13. Number of air crew members subject to individual monitoring of radiation exposure and total dose of crew members (sum of effective doses) in 2008–2012.

Year	Number of workers		Total dose (Sv)	
	Pilots	Cabin crew	Pilots	Cabin crew
2008	1206	2562	2.45	5.93
2009	1195	2460	2.68	6.07
2010	1147	2281	2.56	5.75
2011	1208	2423	2.85	6.23
2012	1182	2419	2.60	5.80

Table 14. Work of the NIR Unit in 2003–2012.

Year	Regulatory inspections	Decisions	Statements	Calibrations and tests	Safety assessments and radiation measurements	Total
2003	49	0	3	23	11	86
2004	55	3	1	30	12	101
2005	66	1	1	25	31	124
2006	48	1	7	17	7	80
2007	64	3	3	33	17	120
2008	67	5	6	46	24	148
2009	47 (108*))	2	9	31	12	101 (162*))
2010	55 (182**))	3	9	36	13	116 (243**))
2011	56 (142***))	6	3	4	10	79 (165***))
2012	53 (117****))	0	15	8	16	92 (156****))

*) The number includes requests for advice by the Finnish Customs concerning the admission to Finland of lasers (46) and requests by the NIR Unit to remove laser pointer advertisements from the huuto.net online sales forum (15).

**) The number includes requests for advice by the Finnish Customs concerning the admission to Finland of lasers (96) and requests by the NIR Unit to remove laser pointer advertisements from the huuto.net online sales forum (31).

***) The number includes requests for advice by the Finnish Customs concerning the admission to Finland of lasers (44) and requests by the NIR Unit to remove laser pointer advertisements from the huuto.net online sales forum (42).

****) The number includes requests for advice by the Finnish Customs concerning the admission to Finland of lasers (21) and requests by the NIR Unit to remove laser pointer advertisements from the huuto.net online sales forum (43).

Table 15. Inspections of sunbed facilities in 2003–2012.

Year	Number of inspections
2003	31
2004	30
2005	36
2006	25
2007	31
2008	26
2009	19
2010	16
2011	7
2012	6

Table 16. Mobile phone SAR tests in 2004–2012.

Year	Number of tests
2004	18
2005	15
2006	15
2007	15
2008	10
2009	15
2010	10
2011	5
2012	15

APPENDIX 2 Publications in 2012

The following publications completed in 2012 were authored by one or more employees of STO or the NIR Unit.

International publications

Ala-Houhala MJ, Vähävihu K, Hasan T, Kautiainen H, Ylianttila L, Viljakainen HT, Snellman E, Reunala T. Comparison of narrowband ultraviolet B exposure and oral vitamin D substitution on serum 25-hydroxyvitamin D concentration. British Journal of Dermatology 2012; 167 (1): 160–164.

Hakanen A. Simulated and measured dose response characteristics of detectors used for CT dosimetry. Physics in Medicine and Biology 2012; 57: N319–N328. doi: 10.1088/0031-9155/57/16/N319.

Holm P, Peräjärvi K, Sihvonen A-P, Siiskonen T, Toivonen H. Neutron detection with a NaI spectrometer using high-energy photons. Epub 2012 Sep 12. Nuclear Instruments and Methods in Physics Research A 2013; 697: 59–63. doi:10.1016/j.nima.2012.09.010.

Koivisto J, Kiljunen T, Tapiovaara M, Wolff J, Kortesniemi M. Assessment of radiation exposure in dental cone-beam computerized tomography with the use of metal-oxide semiconductor field-effect transistor (MOSFET) dosimeters and Monte Carlo simulations. Oral Surgery Oral Medicine Oral Pathology Oral Radiology 2012; 114: 393–400.

Koivunoro H, Siiskonen T, Kotiluoto I, Auterinen I, Hippeläinen E, Savolainen S. Accuracy of the electron transport in MCNP5 and its suitability for ionization chamber response simulations: A comparison with the EGSNRC and PENELOPE codes. Medical Physics 2012; 39 (3): 1335–1344. doi: 10.1118/1.3685446.

Kwon MS, Vorobyev V, Kännälä S, Laine M, Rinne JO, Toivonen T, Johansson J, Teräs M, Joutsa J, Tuominen L, Lindholm H, Alanko T, Hämäläinen H. No effects of short-term GSM mobile phone radiation on cerebral blood flow as measured by positron emission tomography. Bioelectromagnetics 2012; 33 (3): 247–256. doi:10.1002/bem.20702.

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Pöllänen R, Peräjärvi K, Siiskonen T, Turunen J. High-resolution alpha spectrometry at ambient air pressure – Towards new applications. Nuclear Instruments and Methods in Physics Research A 2012; 694: 173–178.

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Toroi P, Könönen N, Timonen M, Kortesniemi M. Aspects of forward scattering from the compression paddle in the dosimetry of mammography. Radiation Protection Dosimetry 2012: 1–7. doi:10.1093/rpd/ncs257.

Conference proceedings, abstracts, posters

Bly R, Czarwinski R. Towards safer and more effective use of radiation in healthcare – Results from European IRPA 2010. In: IRPA13 Abstracts. 13th International Congress of the International Radiation Protection Association. 13–18 May 2012; Glasgow, Scotland, UK. Glasgow: IRPA13 Glasgow Ltd; 2012. P07.142. [PDF publication, p. 1209].

Bly R, Järvinen H, Jahnen A, Olerud H, Vassileva J, Vogiatzi S. European population dose from radiodiagnostic procedures – Results of DOSE DATAMED 2. In: IRPA13 Abstracts. 13th International Congress of the International

Radiation Protection Association. 13–18 May 2012; Glasgow, Scotland, UK. Glasgow: IRPA13 Glasgow Ltd; 2012. P02.09. [PDF publication, p. 427].

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Li C, Pastila R, Lin C. Imaging immune response of skin mast cells in vivo with twophoton microscopy. In: Conference proceeding: Progress in Biomedical Optics and Imaging – Proceedings of SPIE. Photonic Therapeutics and Diagnostics VIII. 21–24 Jan 2012; San Francisco, CA, USA.

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Toroi P, Kelaranta A, Vock P, Siiskonen T, Tapiovaara M, Kosunen A. Interpretation of measured dose data in X-ray imaging. In: IRPA13 Full Papers. 13th International Congress of the International Radiation Protection Association. 13–18 May 2012, Glasgow, Scotland, UK. Glasgow: IRPA13 Glasgow Ltd; 2012. TS2a.9*. [PDF publication].

Regulatory control reports

Rantanen E (toim.). Säteilyn käyttö ja muu säteilylle altistava toiminta. Vuosiraportti 2011. (Radiation practices. Annual report 2011.) STUK-B 146. Helsinki: Säteilyturvakeskus; 2012.

Rantanen E (ed.). Radiation practices. Annual report 2011. STUK-B 151. Helsinki: STUK; 2012.

Regulatory guides

Finnish language

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Strålsäkerheten vid industriell radiografi. Direktiv ST 5.6. (Radiation safety in industrial radiography. Guide ST 5.6.) STUK (9 March 2012).

Transport av radioaktivt avfall och använt kärnbränsle. Direktiv ST 5.7. (Shipments of radioactive waste and spent fuel. Guide ST 5.7.) STUK (6 June 2011).

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APPENDIX 3

ST Guides published by STUK. Situation as of 7 May 2013.

General guides

ST 1.1 Safety fundamentals in radiation practices, 23 May 2005
ST 1.3 Warning signs for radiation sources, 16 May 2006
ST 1.4 Radiation user's organization, 2 November 2011 (in Finnish)
ST 1.5 Exemption of the use of radiation from the safety licence and reporting obligation, 1 July 1999
ST 1.6 Operational radiation safety, 10 December 2009
ST 1.7 Radiation protection training in health care, 10 December 2012 (in Finnish)
ST 1.8 Qualifications and radiation protection training of persons working in a radiation user's organization, 17 February 2012
ST 1.9 Radiation practices and radiation measurements, 17 March 2008
ST 1.10 Design of rooms for radiation sources, 14 July 2011

Radiation therapy

ST 2.1 Safety in radiotherapy,18 April 2011

Diagnostic radiology

ST 3.1 Dental X-ray examinations in health care, 20 August 2011
ST 3.3 X-ray examinations in health care, 20 March 2006
ST 3.8 Radiation safety in mammography examinations, 25 January 2013 (in Finnish)

Industry, research, education and commerce

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

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ST 6.1 Radiation safety when using unsealed sources, 17 March 2008
ST 6.2 Radioactive wastes and discharges, 1 July 1999
ST 6.3 Radiation safety in nuclear medicine, 14 January 2013 (in Finnish)

Radiation doses and health surveillance

ST 7.1 Monitoring of radiation exposure, 2 August 2007
ST 7.2 Application of maximum values for radiation exposure and principles for the calculation of radiation doses, 9 August 2007
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ST 7.4 The dose register and data reporting, 9 September 2008.
ST 7.5 Medical surveillance of occupationally exposed workers, 4 May 2007

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ST 9.1 Radiation safety requirements and regulatory control of tanning appliances, 1 December 2003 (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 high power display lasers, 28 February 2007 (in Finnish)

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 12.3 Radioactivity of household water, 9 August 1993
ST 12.4 Radiation safety in aviation, 20 June 2005

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