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Radiation practices

Annual report 2007

Erkki Rantanen (ed.)

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

STUK

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Abstract

1757 safety licences for the use of radiation were current at the end of 2007. 1850 responsible parties 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 a Dose Register. Radiation safety guides were also published and research was conducted in support of regulatory control.

STUK conducted 458 inspections of licensed practices and 20 inspections of notifiable licence-exempt dental X-ray practices in 2007. 223 repair orders and recommendations were issued.

A total of just under 11 500 workers were subject to individual monitoring in 2007. More than 140 000 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. 97 workplaces including a total of 138 work areas were subject to radon monitoring during 2007. 3706 pilots and cabin crew members were monitored for exposure to cosmic radiation.

Metrological activities continued with calibration and development work as in previous years.

Regulatory control of the use of non-ionizing radiation in 2007 focused particularly on mobile phones, sunbeds and lasers. 15 mobile phone types were tested in market surveillance of mobile phones. 31 sunbed facilities were inspected.

There were 24 abnormal incidents involving the use of radiation in 2007. Fifteen of these incidents concerned the use of radiation in industry, research or transportation, and the other nine concerned the use of radiation in health care. None of these incidents had serious consequences.

Contents

Management foreword

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The Department of Radiation Practices Regulation (STO) of the Radiation and Nuclear Safety Authority (STUK) serves as a regulatory authority for the use of ionizing radiation, conducts research 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. Investigations focus particularly on practices that cause substantial exposure to radiation, such as CT scans and interventional radiology. Metrological activities ensure the accuracy and traceability of radiation measurements to international metrological standards. This work also involves calibrating radiation meters used in Finland to ensure the reliability of radiation measurements made in Finland.

The doses sustained by radiation workers remained within the stipulated dose limits. There were 600 fewer radiation workers subject to individual monitoring than in the preceding year. The main reason for the fall in the number of individuals in the register in 2007 was seasonal variation in nuclear power plant servicing. STUK also gathers information on radiation exposure of aircrews. Due to an increase in flight personnel, the combined dose sustained by aircrews exceeds the combined dose sustained by individuals engaged in radiation work proper. Variations in solar activity and growth in air traffic to the Far East have also increased the doses sustained by aircrews in recent years.

STUK revised its guidelines on high activity sealed sources. This revision was part of the national implementation of the Council Directive on high activity sealed sources based on previous amendments to the Radiation Act and the Radiation Decree. Some other guidelines were revised in accordance with adopted practices. The intention is to review the need for revised guidelines at intervals not exceeding five years and to eliminate guidelines that are more than ten years old.

Organizations involved in the use of radiation have been undergoing major changes in recent years with a view to improving efficiency. Industrial functions have been reorganized into separate companies. Efforts have also been made to separate practices involving the use of radiation. Large operating units have been formed in both public and private sector health services. From the point of view of STUK this has taken the form of changes in licences, licensees and responsible persons. Difficulties have arisen in amending licences, as these amendments have called for a great deal of detailed information. Amendments have also tended to blur the division of duties, and in some cases this has obviously resulted in hazardous situations. STUK sent a communiqué on the grounds for issuing safety licences and on the principles governing approval of radiation safety officers to the officers and to responsible parties in spring 2007. A conference on this subject was also arranged in September. The participants at this event agreed that the details provided in the communiqué were appropriate.

STUK arranges several consultation and training events every year for specialists working in various sectors involving the use of radiation. A meeting of responsible parties involved in the sale of radiation sources was held in 2007. This meeting was considered worthwhile, and it should be repeated every few years. Collaboration with radiation use specialists also continued by inviting such specialists to prepare guidelines on such subjects as quality control in X-ray diagnostics and paediatric X-ray examinations.

More abnormal incidents involving the use of radiation were reported than in previous years. Training and guidelines have stressed the importance of predicting such incidents in order to prevent them and of issuing instructions for minimizing damage. Globalization of the scrap metal recycling sector has also brought new problems, as decommissioned radiation sources may be imported to Finland owing to failures of supervision in the country of origin.

The first round of clinical auditing of radiation use in Finnish health services was successfully completed a couple of years ago. A task force of clinical auditing specialists appointed by the Ministry of Social Affairs and Health has issued recommendations for the next auditing round. The role of STUK as organizer of a clinical auditing development project financed by the European Commission was promoted by the good progress made by Finland in this field. This 18-month project is due for completion during 2008.

X-ray examination data from 2005 were used in determining the radiation exposure caused by such examinations. The per capita dose from X-ray examinations in Finland was estimated at 0.45 mSv. This study indicates that public exposure to radiation has continued to be manageable. About 50% of this exposure arises in CT scans. The number of isotope examinations performed annually in Finland has continued to fall. About 10% fewer isotope examinations and 15 per cent fewer isotope treatments were conducted in 2006 than in 2003. The per capita average effective dose from isotope examinations was 0.03 mSv.

Work to revise the recommendations of the International Commission on Radiological Protection (ICRP) was completed at the end of 2007. In addition to the ICRP revision, the European Commission has initiated work to revise the Community radiation safety Directives. The aim is to combine these statutory instruments into a single Directive. Specialists from STUK have also been involved in preparing this new Directive and its projected impact on Finnish legislation has been monitored. It will take several years to revise the Community statutes and implement them in national legislation.

There has been a clear long-term increase in the use of X-ray equipment in industry and research. Besides product and security scanners and analytical appliances, some entirely new applications for X-radiation have also been devised. One notable innovation is the use of backscatter X-radiation in a passenger surveillance scanner currently being tested at Helsinki-Vantaa International Airport. One of the principal factors to be assessed when licensing this appliance was whether its operation was justified under the principles of radiation protection. STUK consulted the Advisory Board for Radiation Safety on this subject and licensed the appliance for an 18-month trial period on the basis of the opinion of the Advisory Board and of other information received.

The Laboratory for Non-ionizing Radiation Surveillance (the NIR Laboratory) serves as a regulatory authority for non-ionizing radiation and provides specialist assistance to the National Agency for Medicines and the labour protection authorities. Regulatory control of non-ionizing radiation has focused particularly on sunbed facilities, lasers and mobile phones. Some of the main points of research in recent years have included dosimetry of radio and low frequency electromagnetic fields, pulsed magnetic fields and the development of increasingly accurate methods of measuring ultraviolet radiation. Considerable effort has been applied in recent years to provide public information on the safety of electromagnetic fields and optical radiation.

Inspections were conducted at 31 sunbed facilities during the year. The most serious infringement found in these inspections was an appliance emitting four times the maximum value of radiation prescribed by the applicable Decree of the Ministry of Social Affairs and Health (294/2002). A RAPEX hazardous consumer product notification to the European Commission was made in the case of three sunbed appliances. STUK has also been actively involved in joint Nordic and European work to impose safety

requirements on sunbed facilities. A joint opinion of the Nordic radiation safety authorities to CENELEC recommends reductions in the power of sunbed appliances and in the ultraviolet radiation doses that are sustained in their use.

Advances in laser technology have enabled consumer marketing of inexpensive battery-operated diode lasers capable of causing ocular damage (class 3B). These appliances may be used in light shows and other applications. At one public event, for example, an unlicensed 30 mW laser was used for drawing graffiti. The organizer of this event was asked to account for this incident and was formally cautioned that presentations must comply with the requirements issued by STUK (Guide ST 9.4). Negotiations on regulatory control of lasers that are available to consumers have been conducted with the Finnish Consumer Agency and labour protection authorities. STUK will probably be assigned to supervise appliances that do not fall within the purview of the Finnish Consumer Agency (toys) or labour protection authorities (tools). Laser projector appliances installed in mobile phones are one example of a product to be included in this new field of market control.

Market control of mobile phones is an important element in monitoring of electromagnetic fields. Tests were conducted in 2007 on 15 mobile phone models, some of which were UMTS phones. The highest measured SAR value of 1.15 W/kg did not exceed the prescribed maximum of 2 W/kg.

Implementation of the labour protection Directive on electromagnetic fields in Finland is increasing the need to assess worker exposure to such fields and to train personnel who are responsible for ensuring health and safety at work. Under a proposal from the European Commission, however, national implementation of the Directive will probably be deferred until 2012, instead of the originally planned deadline of 2008. The reason for this is a concern raised by the manufacturers and users of magnetic imaging equipment that the Directive will hamper use of such equipment, especially in interventional radiology. The Directive will be amended in the interim according to the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The ICNIRP is currently preparing new guideline values for low frequency electromagnetic fields. A representative of the NIR unit is involved in this work as a specialist advisor to the ICNIRP.

Research into electromagnetic fields has focused particularly on absorption of base station radiation in the bodies of nearby workers and absorption of mobile phone RF radiation in swine brain tissue and the human hand. The swine tests are studying the effects of mobile phone radiation on EEG readings and the human hand tests are investigating protein changes in the skin. A review of literature on environmental RF radiation was completed during the year. Other research topics included RF dosimetry in rats exposed to mobile phone radiation.

1 General

The expression “use of radiation” refers to the use and manufacture of, and trade in radiation equipment and radioactive substances, and to associated activities such as possession, safekeeping, servicing, repair, installation, import, export, storage, transport, and the process of rendering radioactive waste harmless. The expression “radiation practices” refers to the use of radiation 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 uses of radiation and in other practices causing exposure to radiation in Finland is the responsibility of the Department of Radiation Practices Regulation (STO) and the Laboratory for Non-ionizing Radiation Surveillance (the NIR Laboratory) 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.

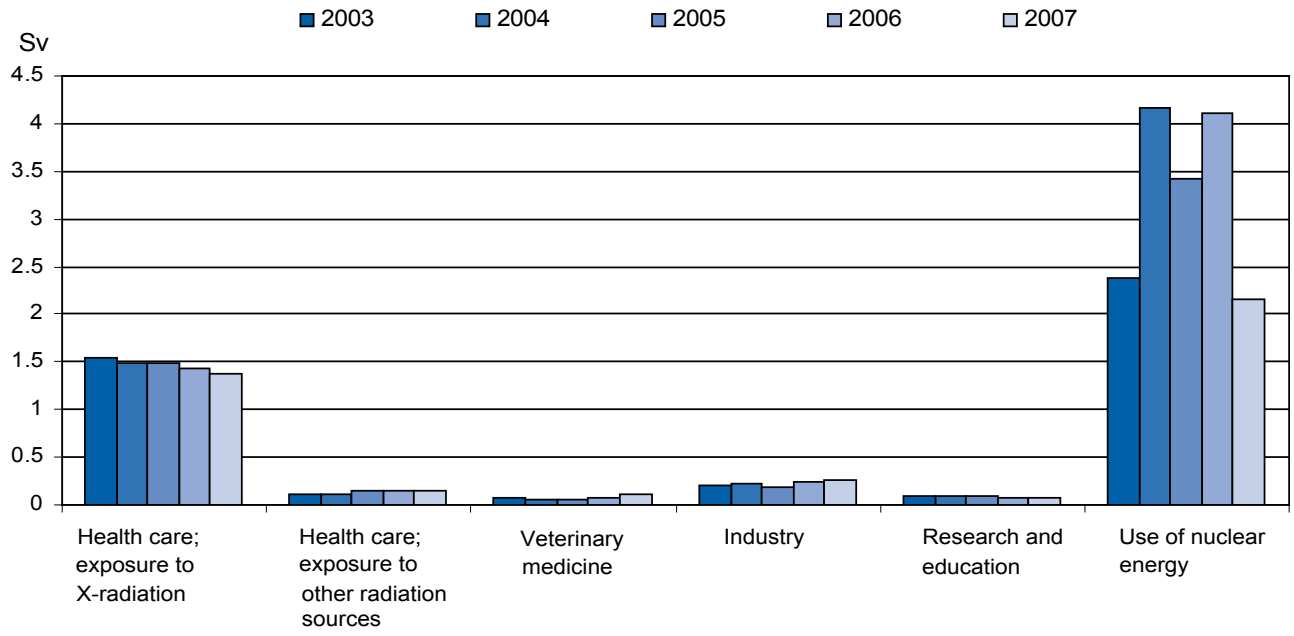

Figure 1. Combined doses ($H_p(10)$) of workers subject to individual monitoring by occupational category, 2003–2007.

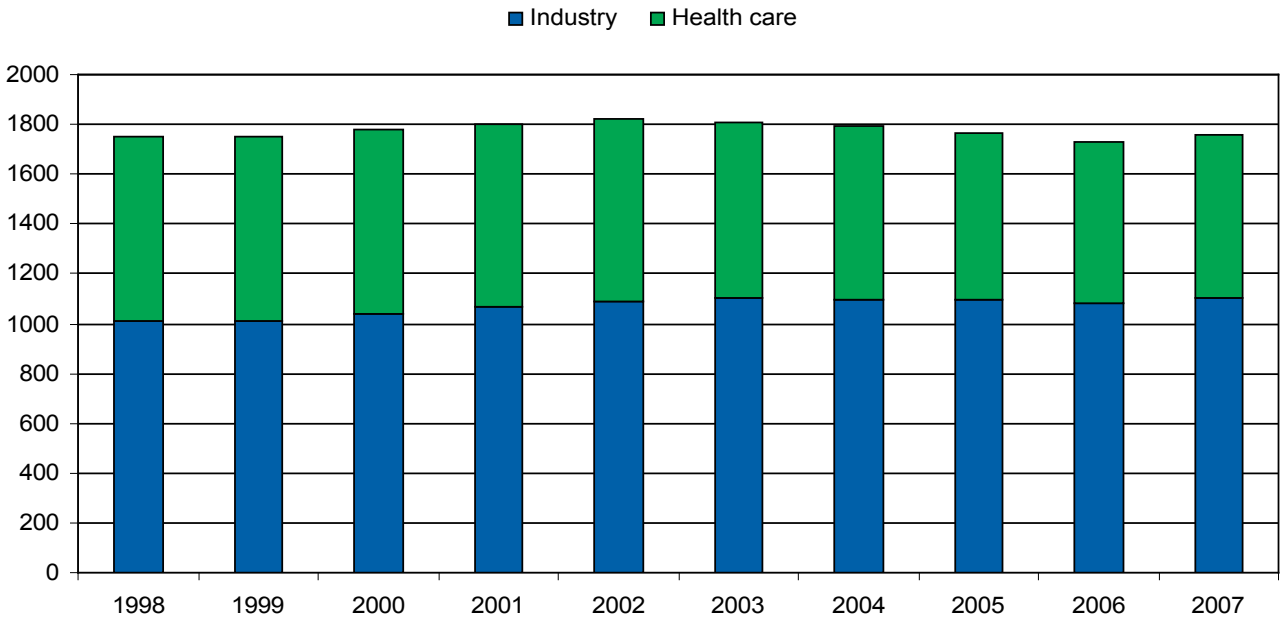

Figure 2. Current safety licences, 1998–2007.

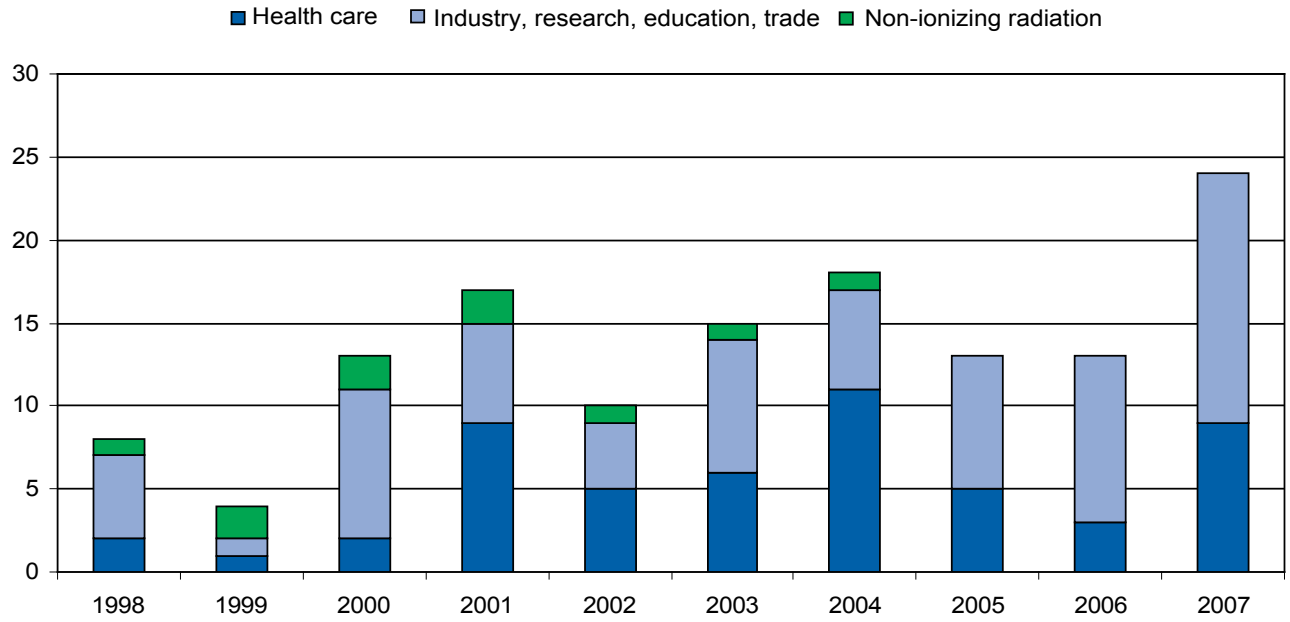

Figure 3. Abnormal incidents, 1998–2007.

2 Regulatory control of the use of ionizing radiation

2.1 Use of radiation in health care

Safety licences

654 safety licences for the use of radiation in health care were current at the end of 2007 (see also Figure 2). The numerical distribution of radiation practices referred to in these licences is shown in Table I of Appendix 1. There was no significant change in the total number of safety licences compared to the previous year.

Radiation appliances and sources, and laboratories

Table II in Appendix 1 shows further details of radiation appliances and sources used in health care and in veterinary X-ray practices, and radionuclide laboratories that were entered in the safety licence register at the end of 2007. The number of linear accelerators used in radiotherapy continues to grow. There were 35 accelerators in use at the end of 2007, compared to 31 in use at the end of 2006.

Radiation exposure in CT scans and interventional radiology

Substantial radiation exposure may arise in X-ray examinations and therapies when conducting CT scans and interventional radiology. STUK called attention to the considerable increase in radiation exposure caused by using the latest CT scanners in Finland at the Finnish Medical Convention arranged in Helsinki in January and at a conference on radiation safety and quality in X-ray diagnostics that took place in March. There are very large differences between the exposure levels sustained at various hospitals. Radiation exposure levels may be moderated by eliminating unnecessary repeated examinations and specifying referrals more carefully. Examination techniques may also be reassessed.

The radiation exposure sustained from examinations and therapies in interventional radiology can be sufficiently large to cause skin damage. Even though only a few sporadic cases are ever reported, the International Atomic Energy Agency (IAEA) regards this as a global problem. Dermatologists do not readily diagnose changes in the skin caused by radiation, nor do the medical practitioners who perform procedures involving exposure to radiation normally come into contact with their patients when the damage becomes apparent some days or weeks later. In January the IAEA began preparations to establish an international reporting and monitoring procedure among specialists in this field. A pilot stage is due to begin in 2008. STUK will be involved in this process in an expert capacity, as the Authority's reporting of abnormal incidents and its good relations with radiation users in the health services are considered exemplary.

New reference levels for adult X-ray examinations

By decision no. 44/310/07 issued on 24 October 2007 STUK established new reference levels for patient radiation exposure in conventional X-ray examinations of adults. These reference levels were issued as both entrance surface doses (ESD) and dose-area products (DAP). The new decision replaces the reference levels issued by STUK in its decision no. 26/310/07 of 27 March 2007. Reference levels are predetermined radiation dose levels in X-ray examinations that are not presumed to be exceeded in any examination of a person of normal size that is performed according to the standards of good practice. None of the reference levels were increased, but some of them were reduced on account of new appliance technology and improved examination techniques.

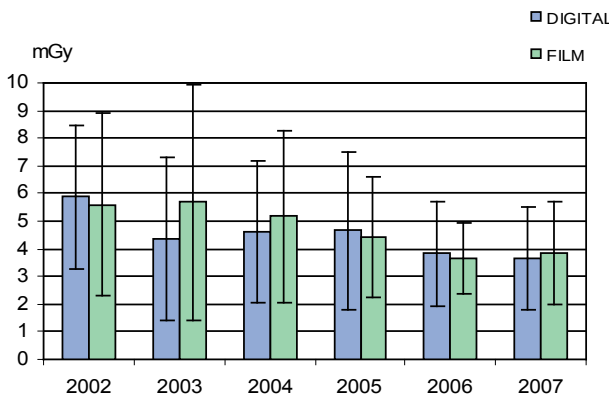

Figure 4. ESD averages of lumbar spine measurements (AP) by image receptor type, 2002–2007.

Measurements taken in the course of inspections revealed that reference levels were exceeded in health service X-ray practices at eleven inspection sites. Remedial recommendations were issued for these sites. Figure 4 shows the results for lumbar spine measurements (AP) in 2002–2007 (reference level 6 mGy as of the beginning of 2008).

Mammography

Breast cancer screening by mammography increasingly depends on digital imaging methods. STUK has required imaging sites that convert to digital methods to submit clinical images in accordance with specified criteria for assessment by a specialist committee. The first round of assessment has been completed and the evaluation of a committee of four radiologists with expertise in digital mammography indicates that all of the images were of at least adequate quality.

The assessment was made using an image monitor adapted to mammography under appropriate viewing conditions. The assessors were unaware of the imaging venue and the images included no details that could identify individuals. The assessment will be continued at half-yearly intervals. Under a Decree of the Council of State (1339/2006) that took effect at the beginning of 2007, mammography screening will be extended from the previous age band of 50–59 years of age to a new age band of 50–69 year-olds.

Study of the use of radiopharmaceuticals in isotope examinations and treatments

Recording of data in medical procedures is governed by section 43 of the Decree of the Ministry of Social Affairs and Health on the medical use of radiation (423/2000). Under the said provision, a summary of the number of examinations and of radiation doses must be prepared according to separately issued instructions, and this summary then forms the basis for preparing national appraisals of the radiation exposure caused by the medical use of radiation and changes in this exposure. The national appraisals are compiled and published by STUK.

The Authority conducted a study of the use of radiopharmaceutical products in Finland in 2006. For this purpose a questionnaire was sent to all hospitals in which isotope examinations and/or treatments were administered in the said year.

A total of 40 824 isotope examinations were performed in Finland in 2006, of which 2737 were paediatric examinations. Just over 1 000 examinations of adults were conducted for scientific purposes. There were 1962 isotope treatments performed in 2006. Figure 5 shows the rate of isotope examinations performed between 1975 and 2006. Figure 6 shows the rate of isotope treatments performed over the same period.

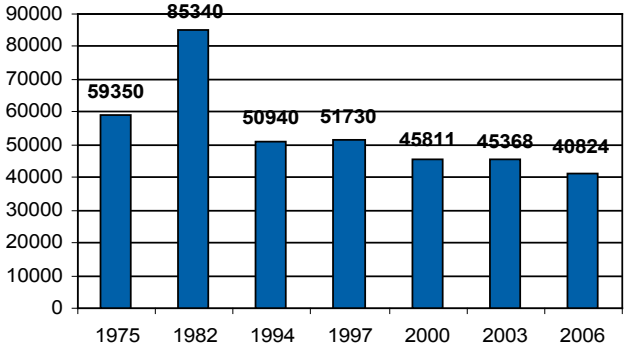

Figure 5. Isotope examinations performed in 1975, 1982, 1994, 1997, 2000, 2003 and 2006.

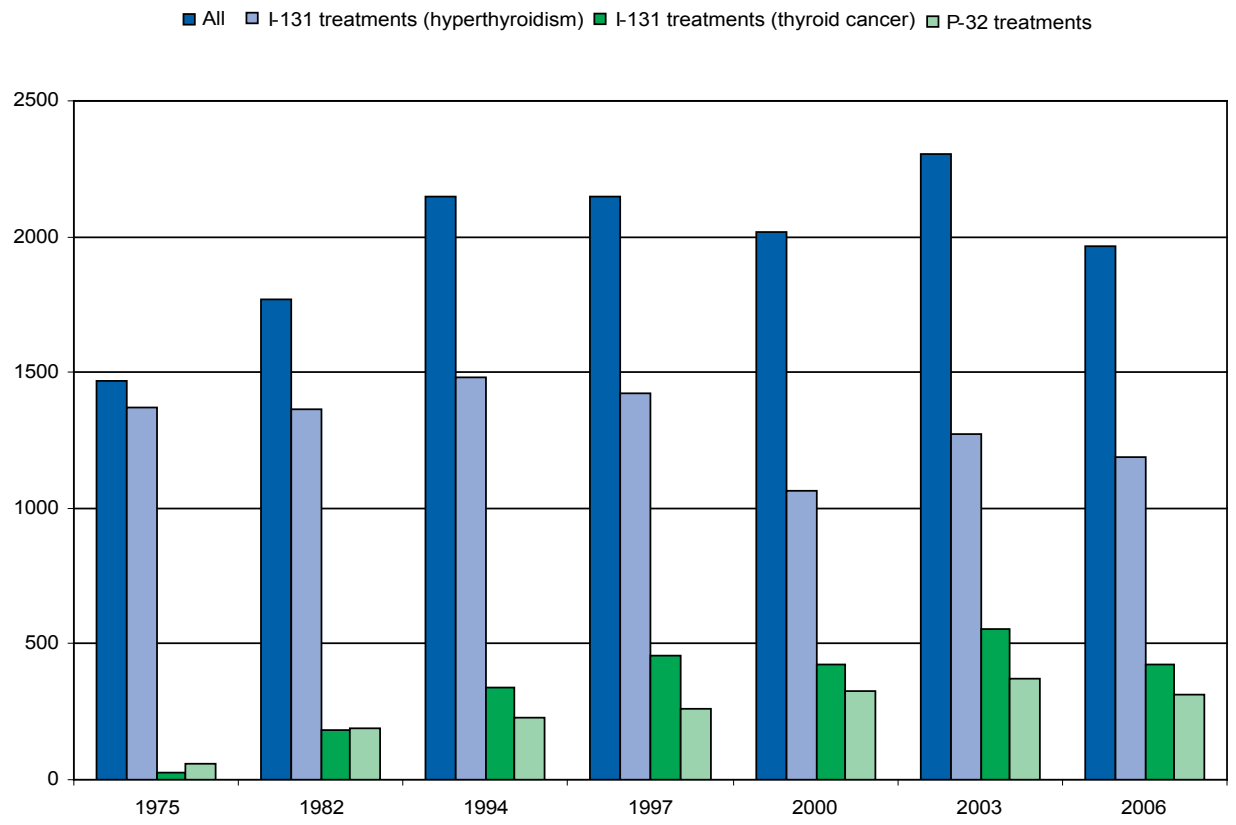

Figure 6. Isotope treatments performed in 1975, 1982, 1994, 1997, 2000, 2003 and 2006.

The number of isotope examinations performed annually in Finland has continued to fall. About 10% fewer isotope examinations and 15% fewer isotope treatments were conducted in 2006 than in 2003. There were 7.7 isotope examinations and 0.37 isotope treatments per 1 000 residents in 2006. Skeletal gamma imaging (39.1%) was the most common such procedure in Finland in 2006, followed by examinations of vascular organs (14.4%) and respiratory organs (12.7%). The greatest proportional increase was in tumour imaging, which nearly doubled between 2003 (6.4%) and 2006 (11.5%).

83% of isotope examinations were conducted using ^{99m}Tc, with 4% using ^{18}F, 3% using ^{123}I, 3% using ^{201}Tl, 2% using ^{51}Cr and 2% using ^{111}In. Examinations using other radionuclides (^{11}C, ^{15}O, ^{57}Co, ^{67}Ga, ^{75}Se and ^{131}I) accounted for 4% of the total. The use of radiopharmaceuticals labelled with ^{99m}Tc fell by about 12% and the use of ^{18}F increased by about 73% compared to 2003.

The collective effective dose administered to patients from isotope examinations in 2006 was 160 manSv, and the consequent average effective dose per member of the public was 0.03 mSv. The average effective dose per isotope examination (clinical examinations of adults) in 2006 was 3.9 mSv. The ten most important isotope examinations from the point of view of collective effective dose are shown in Table III of Appendix 1.

The average activities of radiopharmaceuticals administered to patients undergoing various isotope examinations, as notified by hospitals, are also used for determining isotope examination reference levels. New reference levels will be issued in 2008.

The survey also requested details of imaging devices, their quality control, and various acceptability criteria used for performance parameters. There were 46 gamma cameras and 5 PET cameras in Finland in 2006. STUK is working with hospital physicists to prepare a quality control guide for nuclear medicine appliances. Imaging device quality control data will be used in this work.

Patient doses and number of examinations in radiology

The collective dose from X-ray examinations was determined from the results of report STUK-B-STO 62 on the number of radiological examinations performed in 2005. The collective dose was used to estimate the dose due to X-ray examinations at 0.45 mSv per person.

The number of conventional examinations fell by about 7% and the number of fluoroscopy examinations fell by about 40% between the year 2000 and 2005, while the number of CT scans and interventional radiology procedures both increased by about 30%.

2.2 Use of radiation in industry, research and education

Safety licences

There were 1103 current safety licences for the use of radiation in industry, research, education, trade and servicing operations at the end of 2007 (see also Figure 2). The numerical distribution of radiation practices referred to in these licences is shown in Table IV of Appendix 1.

One new type of practice was the issuing of a temporary (18-month) safety licence for trials of a passenger security scanner using backscatter X-radiation at Helsinki-Vantaa International Airport. The terms of this licence included a condition that scanned individuals must be over 18 years of age and must submit to the procedure voluntarily. Studies and measurements indicated that the dose from a single examination is very small, amounting to less than 0.1 µSv. The prospects for continuing the practice after the trial is completed will be separately assessed on the basis of experiences gained during the trial.

Radiation appliances and sources, and laboratories

Figure 7 shows the number of X-ray appliances and accelerators used in Finland over the last decade. The number of appliances increased by 59% between 1998 and 2007. New X-ray appliances have been commissioned especially in product and security scanning and in elemental analysis.

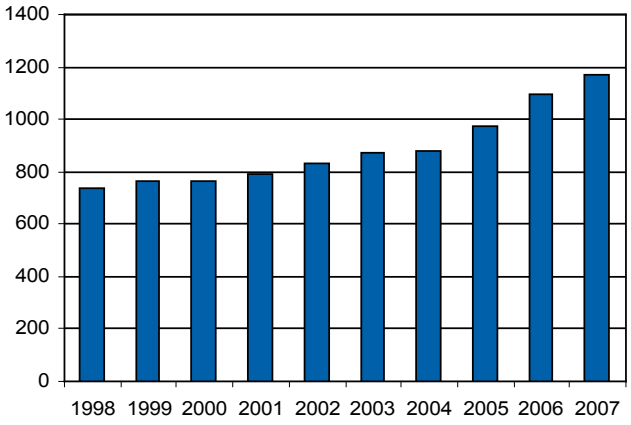

Figure 7. X-ray appliances and accelerators entered in safety licences for the use of radiation in industry, research and education, 1998–2007.

There have been no substantial changes in the number of appliances containing radioactive substances over the last decade, and this number has fairly consistently remained between 6100 and 6300.

There were 155 radionuclide laboratories operating at the end of 2007, which was about 15% fewer than ten years ago.

Table V in Appendix 1 gives further details of radiation appliances and sources and of radionuclide laboratories in industry, research and education that were listed in the safety licence register at the end of 2007.

Table VI in Appendix 1 shows the number and total activities of radionuclides used in sealed sources.

2.3 Inspections of licensed radiation practices

304 inspections were made of the use of radiation in health care. These inspections resulted in 148 repair orders or recommendations issued to the responsible party. Most defects arose in warning lights and signs, and in other corresponding safety systems. One order was also issued to limit use of an appliance in health services due to inadequate radiation shielding of X-ray premises.

154 inspections were made of the use of radiation in industry, research, education and trading. These inspections resulted in 68 repair orders or recommendations.

Table VII in Appendix 1 shows the number of inspections itemized by type of inspection. Table VIII in Appendix 1 shows the number of inspections in health care itemized by type of practise.

2.4 Inspections of notifiable dental X-ray practices

1850 responsible parties were engaged in dental X-ray practices. Patient radiation exposure from dental X-ray imaging was measured in 1275 appliances (see Figure 8). The average dose was 2.2 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 49 imaging appliances.

20 inspections of notifiable dental X-ray practices were made. Repairs were ordered in 5 inspections and recommended in 2 inspections.

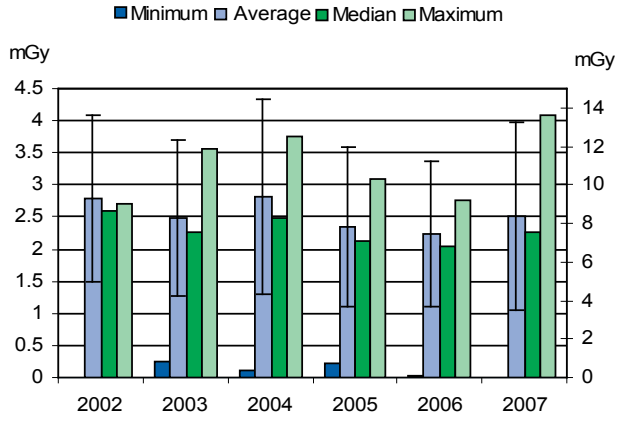

Figure 8. Measurements of dental X-ray practices in 2002–2007: largest and smallest surface dose (ESD) and average and median values. The largest value has its own ESD axis (to the right of the graph), due to the large difference between the largest and smallest value.

Inspections of dental X-ray practices itemized by type of inspection are also shown in Table VII of Appendix 1.

2.5 Import, manufacture and export of radioactive substances

Details of radionuclides imported to, manufactured in and exported from Finland in 2007 are shown in Tables IX–XI of Appendix 1. The figures in the tables are based on data gathered from radiation safety licensees engaged in import, manufacture and export. The import and export statistics exclude radioactive substances imported and exported by responsible parties within the European Union for their own use. The statistics also exclude radioactive substances supplied to other countries via Finland.

Table IX of Appendix 1 excludes smoke detectors and fire alarm system ion detectors containing americium (^{241}Am). A total of 439 876 such devices were imported with a combined activity of about 15 GBq.

2.6 Radiation doses of workers

A total of just under 11 500 workers engaged in radiation work were subject to individual monitoring in 2007. Including doses falling below the registration threshold, about 140 000 dose records were entered in the Dose Register maintained by STUK.

In no case did the effective dose of a worker exceed the 50 mSv annual dose limit or the 20 mSv average annual dose based on the five-year dose limit (100 mSv). In no case did the dose to a worker's hands exceed the annual limit of 500 mSv.

The total dose recorded was 1.98 Sv in the use of radiation and 2.16 Sv in the use of nuclear energy. The total recorded dose was 1 per cent larger in use of radiation and 48% smaller in use of nuclear energy than the corresponding figures for the previous year. Total doses in the use of nuclear energy vary considerably each year depending on the duration of annual servicing and the duties performed in servicing work.

The largest $H_p(10)$ was 27.3 mSv recorded in the case of an interventional radiologist. This corresponds to an effective dose of about 0.5–2.7 mSv. The largest effective dose in industry was 13.8 mSv sustained by a person performing tracer tests, while the largest effective dose in research was 9.5 mSv sustained by a person using unsealed sources.

The largest recorded dose to the fingers was 293 mSv, sustained by a laboratory assistant using unsealed sources.

Table XII 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 (in item 1.1) and in Table XIII. Table XIV shows the doses in 2007 of persons sustaining high levels of exposure or of numerically large worker groups. The measurement results

($H_p(10)$ values) shown in the figures and tables 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 estimated by dividing the measurement result ($H_p(10)$ value) by a factor between 10 and 60.

2.7 Approval decisions and verification of competence

Training organizations providing radiation safety 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 examinations for radiation safety officers must apply to STUK for the right to arrange such examinations. One application was reviewed in 2007 and a decision was issued to the training organization concerned. There is a list of currently approved training organizations on the STUK website.

Responsible practitioners

STUK verifies the qualifications of medical practitioners responsible for medical surveillance of category A workers. At the end of 2007 there were 247 responsible practitioners in Finland, 18 of whom were accredited during 2007.

2.8 Radioactive waste

195 waste packages had been transported to the national storage facility for low-level radioactive waste maintained by STUK by the end of 2007. The activities or masses of the most significant waste held in the storage facility are shown in Table XV of Appendix 1.

Waste is initially held in an interim storage unit at STUK's premises in Helsinki pending transportation to the national storage facility. This interim storage unit received 51 consignments of low-level radioactive waste in 2007, comprising a total of 64 packages. Table XVI of Appendix 1 shows the activities or masses of the waste that was delivered to STUK in 2007.

2.9 Abnormal incidents

Under section 17 of the Radiation Decree (1512/1991), STUK must be notified of any abnormal event 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 24 cases in 2007 in which abnormal incidents or situations occurred or were suspected in the use of ionizing radiation. Fifteen of these cases concerned the use of radiation in industry, research or transportation, and the other nine concerned the use of radiation in health care. Figure 3 (in item 1.1) shows abnormal incident numbers between 1998 and 2007.

The case histories set out below specify the abnormal incidents that occurred in 2007 and the reasons for them, together with the measures taken on account of each incident.

Incident 1

After taking a break a welder returned to his workplace at a metal structure imaging site and inadvertently encroached on the radiation beam of an X-ray appliance. The welder estimated that some ten seconds had been spent in the vicinity of the radiation beam at a range of 2–3 metres from the appliance. The welder sustained a radiation dose of about 10 µSv in this incident. Efforts will be made to ensure that future corresponding X-ray imaging is performed outside of working hours and that the area is more effectively restricted with hazard warning signs and ropes.

Incident 2

An abnormal incident occurred during ^{123}I production in an accelerator laboratory when the window membrane of the target was broken after irradiation for about one hour. As a result of the incident, stable and radioactive gas contained in the target spread along the beam line towards the

accelerator. This triggered a fast-acting safety valve that trapped the gas in the beam line between the target and the valve. Most of the gas escaped to the surroundings within half an hour of the incident. The total emissions were about 8.2 GBq of ^{123}Xe and 2.9 GBq of ^{123}I, and the annual emission limits of the laboratory were exceeded by some margin. No exposure was sustained by any of the accelerator laboratory staff or by any person outside of the laboratory.

Incident 3

Two fitters working in an industrial plant were exposed to radiation when a device containing a radiation source was dismounted from a silo. This level metering device contained a ^{137}Cs source of activity 3.7 GBq, and is designed so that the source moves together with a transfer rod from its housing to the operating position in the silo. The source was not locked during the dismounting work, and was outside or on the outer edge of the housing. Although this incident could have caused substantial radiation doses, the actual doses sustained remained minimal in this case, as the exposure times were very brief. The fitters sustained effective doses of 0.19 mSv and 0.06 mSv. One of them also sustained an equivalent dose of 60 mSv to the hand. The annual limit for equivalent doses to the skin is 500 mSv.

Incident 4

A consignment of scrap metal arriving at a steel mill was found to contain a radiating metal item identified as containing depleted uranium. The consignment had come from abroad and it was not possible to identify the origin of the radiating item. The uranium item was placed in separate storage and subsequently sent to the STUK storage facility for low-level radioactive waste.

Incident 5

When dismantling a conveyor system in an industrial plant a 37 MBq ^{60}Co radiation source contained in the assembly was accidentally consigned to the scrap metal processing area. This procedure was contrary to the plant regulations, but was detected before the scrap metal was processed and the radiation source was consigned to proper storage. The activity of the radiation source was minimal and nobody involved in the dismantling work was near the source during the work. This meant that the incident caused no extraordinary radiation exposure. The radiation source was not handled and decommissioned in accordance with instructions, and retraining of staff involved in handling such sources will be arranged at the plant to avoid similar incidents in future.

Incident 6

A worker using a fluoroscopy appliance crossed the radiation beam for about two seconds and sustained a minimal radiation dose (< 0.1 mSv). This hazardous situation arose because the operator unwittingly initiated two simultaneous functions and the appliance operating system failed to give a warning or to prevent the irradiation. The responsible party was instructed to inspect and rectify the fluoroscopy appliance operating system to discourage accident situations. More precise regulations and guidelines for the operator may also help to prevent corresponding hazards in future.

Incident 7

During servicing and maintenance of a boiler one worker was exposed to the radiation beams of a set of level meters for a period of 10–15 minutes. The worker did not notice that the radiation sources were in the open position when entering a fuel feed appliance to prepare the servicing work. According to measurements taken by the responsible party, the radiation dose sustained by the worker did not exceed 0.4 mSv. Although the plant has clear instructions for boiler work of this kind, these instructions were not followed. The responsible party was instructed to arrange supplementary training on this subject and to install the appropriate warning signs in a more prominent place.

Incident 8

An old ^{60}Co radiation source that had been used in fire extinguisher tank level meters in the 1970s was found in a shipbuilder's scrap store. Five level meters used by the shipbuilder had been decommissioned more than 20 years ago, but by mistake only four of these had been sent to the STUK storage facility as radioactive waste. The activity of the source was originally 18.5 MBq, but had fallen to less than 0.3 MBq at the time when

the source was found. The finders of the radiation source reported that they had handled the source manually for no more than a few minutes. The effective doses sustained by the persons exposed were estimated at a few microsieverts and the equivalent doses to the hands were also a few microsieverts.

Incident 9

A periodic inspection performed by an inspector from STUK found that a radiation source used to detect blockages in a power plant feeder horn (^{137}Cs, of activity 185 MBq) was missing. The feeder horn was demolished in autumn 2005. To find the source and investigate the course of events, the responsible party interviewed all of the workers who had been involved in demolishing the power plant, including employees of the scrap metal business who performed the demolition and took away the scrap metal. Nothing to suggest the presence of a radiation source in the said scrap metal consignment had been detected in the radiation measurements of the scrap metal business. Despite an extensive search and investigation, the radiation source was not found. The responsible party took various steps to prevent any repetition of such incidents, including improving internal guidelines and information flow, and retraining workers.

Incident 10

Four men were servicing the lower section of a shaft furnace in a metal foundry. The upper section of the furnace had two level switches, each containing a ^{137}Cs radiation source of activity 2960 MBq. The radiation source shutters were open during the work even though the working instructions stipulate that irradiators must be closed for the duration of servicing work. The furnace was normally accessed from the upper platform, which was fitted with warning lights and hazard warning signs calling attention to the radiation sources, but on this occasion the lower platform was used to gain access to the furnace.

An inspection ascertained by measurement that the workers had not been exposed to radiation, as servicing was only performed in the lower part of the furnace, the radiation sources were installed at a height of about 5 metres, and the radiation beam was very narrow. To prevent any repetition of the incident, it was decided that the responsible party would add a warning sign and warning light to the lower platform as well.

Incident 11

A private individual notified STUK that unwarranted radiation hazard indicator signs and notices had been attached to lampposts and terrain along a road in the Simo district. The police removed the unwarranted signs at the request of STUK.

Incident 12

An earthfill densitometer containing two radiation sources (300 MBq ^{137}Cs and 1480 MBq ^{241}Am-Be) belonging to the principal contractor went missing from a subcontractorís construction site hut in a road building project. The meter was found a week later in the subcontractorís city office to which it had been consigned, but notice of the said consignment had not been forwarded. The principal contractor will no longer allow subcontractors to use radiation sources.

Incident 13

A radiation safety officer suspected that a person working in a laboratory had been exposed to radiation. The worker in question had dried a sample labelled with a ^{32}P isotope in a vacuum dessicator and had watched the apparatus for several minutes over a plexiguard. A few days after this the worker reported a burning sensation in the cheeks and fingers. The radiation safety officer initially assessed that the symptoms were the result of receiving a ^{32}P source of excessively high activity from the source supplier. On further investigation it was found that the source activity was not excessive and that no significant exposure could have been caused by the incident, even after looking over the shielding. The responsible party was instructed to ensure that workers were adequately informed about radiation and its effects, and about safe working practices.

Incident 14

A power plant worker suspected personal radiation exposure when X-ray imaging was performed at the plant. The worker contacted the occupational health service to determine the importance of the matter. An investigation of the case indicated that no radiation exposure could have occurred

even though the worker had only been about 5 metres away from the imaging appliance, thanks to the substantial attenuating effect of intervening metal and concrete structures on the radiation in question.

Incident 15

An ^{241}Am radiation source was melted down with scrap metal in a steel foundry. Most of the americium was captured in the slag from the smelting process and a minimal quantity was released in exhaust gas dust. No radioactivity was detected in the steel manufactured from the smelting batch. Measurements taken and studies conducted at the foundry indicated that worker exposure was negligible at the time of the incident and immediately thereafter. No americium was released to the surroundings of the steel foundry. The americium-contaminated slag and dust were stored in separate vessels within the plant area.

Incident 16

Six patients were given the wrong radiopharmaceutical and their examinations had to be repeated. The isotope laboratory had ordered an ^{123}I-β-CIT radiopharmaceutical of activity 185 MBq for the purpose of imaging dopamine transporters with gamma radiation. The radiopharmaceutical package received was labelled in accordance with the order, but the patient imaging exhibited unusually poor image quality. An investigation revealed that, owing to an error at the factory, the radiopharmaceutical was actually ^{123}I-nor-β-CIT, which is used for imaging serotonin transporters. The radiation dose administered to the patients from the incorrect radiopharmaceutical was estimated at 4–5 mSv.

Incident 17

The field weighting required by a radiotherapy plan was omitted, whereupon the dose distribution of the patient's treatment did not match the plan. This resulted in a 7% deviation from the average target dose for the patient. The basis for the dose plan in this case was data from a previous patient, for which the data in the dose plan were correctly assigned apart from the weighting. Following this incident the patient received a new systematic course of radiotherapy. The dose plan checking procedure was amended so that primary dose planners always inspect the final dose plan for therapies for which they are responsible and values used in previous therapies may not be used as a basis for planning.

Incident 18

A single whole brain irradiation dose of 4 Gy was administered to the wrong patient. The identity of the patient had not been adequately ensured. A nurse brought the patient into the radiotherapy unit in a wheelchair, even though the patient was supposed to report for chemotherapy. Another wheelchair-bound patient of similar age and sex should have been brought to the radiotherapy unit. The patient who received radiotherapy was in palliative care and had received radiotherapy during the previous week to alleviate bone pain. The radiotherapy had no effect on the condition of the patient. The radiotherapy clinic will pay more attention in future to identifying the patient and consideration will be given to including a portrait photograph in the therapy verification system.

Incident 19

A malfunction in a gamma emitter used for irradiating blood products was reported to STUK. Quality monitoring had revealed that the blood product irradiation was uneven. The appliance functioned correctly again after the control card was replaced. The malfunction was also reported to the appliance manufacturer and the National Agency for Medicines.

Incident 20

STUK was notified that ten lead containers bearing radiation hazard warning labels had been delivered to a waste collection point in Mäntsälä. The containers had been scattered along a roadside in Mäntsälä, from which they had been brought to the collection point. An inspector from STUK went to retrieve the lead containers. Although nine of the containers were labelled ^{125}I, they did not contain ^{125}I or any other radioactive substances. One of the containers was contaminated with ^{90}Sr.

The uses of ^{125}I and ^{90}Sr include radiotherapy. It was subsequently determined that the containers were transportation packages for radiation sources used in ophthalmic radiotherapy. The radiation sources had been removed from the containers, but the radiation hazard warning signs had not been

removed when the lead shields were discarded as scrap metal. Contamination measurements had also not been performed in an appropriate manner, as the interior surface of the lid of one of the lead containers was contaminated. Empty lead shields may be discarded as scrap metal when the radiation hazard warning signs have been removed and measurements have shown them to be uncontaminated.

STUK inspected the clinic from which the containers had originated. The inspection determined that the incident was due to human error. The arrangements and written instructions for handling radiation sources were in order. The individuals who handled the lead shields were not exposed to radiation, nor did the incident occasion any other hazard to the environment.

Incident 21

Bile duct gamma imaging was performed on a two month-old baby boy using ^{99m}Tc mebrofenin. According to a notification submitted to STUK, an excess of the radiopharmaceutical was mistakenly administered to the child. The activity of the administered dose of ^{99m}Tc mebrofenin was 86 MBq, when it should have been 25 MBq.

The radiation dose caused to the patient by the examination substantially depends on whether the patient's hepatic functions are normal. An examination determined that the child's hepatic functions were normal, and estimated that the excessive radiation dose administered to the child was approximately 9 mSv. The incident was also reported to the referring medical practitioner and to the National Agency for Medicines.

Incident 22

STUK was notified of an error in radiotherapy dose planning for a breast cancer patient. The dose calculation was performed by an assistant physicist who had been working in this capacity for 5 months. The patient's 25-fraction radiotherapy course began normally, but after four weeks and 21 fractions the patient developed a strong reddening of the skin in the area of the photon field. This led the medical practitioner to ask the physicists to check the dosage. It was at this stage that the error in dose calculation was discovered. The consequence was that the patient sustained a therapeutic dose that was 31 per cent higher than planned within the area of the photon field and 80% lower than planned with respect to the electron field. The nurses attending the therapy sessions had not noticed that the electron field therapy time was only 6–7 seconds instead of the normal 30 seconds. The therapy was terminated for the photon field area and the electron therapy was continued in order to achieve the planned therapeutic dose.

To prevent any repetition of the incident, a decision was taken at the clinic that a second physicist would check the dose calculations made by assistant physicists during the first year of training. Radiographers would receive further training to give them a better understanding of the doses to be administered and of the duration of therapies.

This incident could have endangered the health of the patient in question. The radiation overdose administered to the patient may lead to post-therapeutic responses to radiotherapy which are larger than normal. This was explained to the patient at the clinic.

Incident 23

A university hospital reported that a CT scanner at the hospital had malfunctioned on 18 occasions. The system had "crashed" during imaging and had to be restarted. After such restarts it was necessary to repeat the CT scanning, which had meant administering an excess effective dose of 2–3 mSv to the patient concerned. There had also been other malfunctions in the scanner. STUK issued an order for the scanner to be properly repaired or decommissioned. The scanner was properly repaired.

Incident 24

Some university researchers secured the permission of the radiation safety officer to perform research-related ^{90}Y labelling in the nuclear medicine unit of a hospital. The labelling was unusually performed with the permission of the unit manager in a heating appliance next to a shielded cupboard used for radiopharmaceutical dosage in the dosage room of the unit. Due to an oversight, the nurse working in the dosage room on the day of labelling was not informed of this abnormal procedure. The nurse entered the room and after working for some time noticed a glass ampoule in the heating appliance.

The nurse used a dose rate meter to measure "high dose rates" on top of the heating appliance and immediately vacated the room. The nurse was also concerned for the safety of persons performing the labelling, as they had neither protective clothing nor protective gloves. The nurse also could not say whether they were wearing personal dosemeters.
The radiation safety officer immediately prohibited further labelling in the nuclear medicine unit. The incident was discussed at a meeting of the unit quality group and at an abnormal incident analysis meeting. A feedback session on the abnormal incident was also arranged for the staff of the hospital nuclear medicine unit and for the university research team.

The radiation safety officer submitted a written report of the abnormal incident to STUK. According to this report, the persons performing the labelling had been instructed in how to do so. Their radiation exposure was monitored using electronic dosemeters and they had not sustained any radiation dose from labelling. The dose to the fingers was not monitored. The results from the personal dosemeter of the nurse working in the dosage room at the time of the labelling in December 2007 indicates that the nurse sustained no radiation dose arising from the abnormal incident.

The cause of the abnormal incident was found to be poor communications.

3 Regulatory control of practices causing exposure to natural radiaton

3.1 Radon at workplaces

During 2007 STUK received 155 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. 86 inspection reports were sent to enterprises on the basis of radon measurements. These reports required reductions in radon concentrations or an investigation of radon concentration during working hours in 49 work areas, and a measurement at another time of year in order to determine an annual average in 16 work areas. Radon concentrations were successfully reduced in 13 work areas during the year. STUK discontinued regulatory control in 18 work areas on the basis of further investigations (measurement during working hours or determination of annual averages). Regulatory control was discontinued at a total of 34 work areas for other reasons (e.g. short working periods or discontinued use of premises). 138 work areas at 97 workplaces were subject to regulatory control by STUK during the year.

Statutory radon inspections were conducted in six mines, at all of which the average radon concentration fell below the action level. Thirteen underground excavation sites were inspected, and the radon concentration was found to exceed the action level at four of these. Repair orders were issued for these work sites in order to reduce the radon concentration.

Radon exposure of workers was monitored by regular radon measurements and monitoring of working hours at two conventional workplaces and three excavation sites where the radon concentration exceeded the action level. A total of 89 workers were subject to radon exposure monitoring during 2007.

The measuring instruments or methods used for establishing radon concentrations when determining worker exposure to radiation must be approved by STUK. Instruments provided by the organizations listed in Table XVII of Appendix 1 have been approved in this way. It is a condition of such approval that the instrument is properly calibrated.

3.2 Other natural radiation from the ground

STUK monitors radiation exposure caused by radioactive substances that occur naturally in household water, construction materials and other materials. Seventeen inspection reports on the radioactivity of construction materials were prepared during 2007. These reports imposed restrictions on the use of materials where necessary. Inspection reports were also prepared on activity measurements taken at three supply points of household water. The concentrations of radioactive substances at all of these points fell below the action level in treated water supplied to consumers. An official opinion was also issued on the processing of ore containing naturally occurring radioactive substances.

3.3 Cosmic radiation

The employees of six Finnish airlines were sufficiently exposed to cosmic radiation to require radiation exposure monitoring for employees. The doses sustained by the 3706 employees in question were recorded in the Dose Register.

The largest individual dose of cosmic radiation sustained by a pilot was 4.5 mSv. The largest individual dose of cosmic radiation sustained by a cabin crew member was 5.1 mSv. The average doses sustained were 2.0 mSv for pilots and 2.2 mSv for cabin crews. The number of workers subject to individual monitoring and their combined effective doses are shown in Table XVIII of Appendix 1.

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, even though this control is not directly comparable to regulatory control of the use of ionizing radiation.

The principal focus of regulatory control measures since 1995 has been sunbed appliances and their places of use. Another important focus is mobile phones, which have been subject to market surveillance since 2003. The use of high power laser equipment at public performances fell considerably in the recession years of the early 1990s. In recent years, however, there has been renewed interest in "show lasers" with the development of advanced laser technology (semiconductor lasers).

Annual inspections have been made of a few public broadcasting stations and radar stations.

The work of the NIR Laboratory in regulatory control of the use of non-ionizing radiation between 2000 and 2007 is shown in Table XIX of Appendix 1. Most regulatory inspection work takes place at sunbed facilities and in market surveillance of mobile phones.

4.2 Optical radiation

Regulatory control of sunbed equipment

31 sunbed establishments were inspected (see Table XX in Appendix 1) with a total of 52 clam shell type and 2 upright sunbed appliances.

Deficiencies affecting the safety of sunbed users were found at almost all establishments. About one fifth of the sunbed appliances inspected did not belong to the appliance class approved in Finland (UV type 3), which is slightly less than in the preceding year. However, the inspections did reveal four appliances in which the erythema-effective irradiance exceeded the maximum value of 0.3 W/m^2 prescribed in the Decree of the Ministry of Social Affairs and Health on the Limitation of Public Exposure to Non-ionizing Radiation (294/2002) to such an extent that use of these appliances was immediately prohibited. The largest measured irradiance exceeded 1 W/m^2 and all four appliances exceeded the prohibition limit of 0.5 W/m^2 prescribed in guide SKV 8.2. The appliances may be used again only after their lamps have been changed to comply with the requirements of the Decree. RAPEX dangerous consumer product notifications to the European Commission were made for three appliances. Measurements taken by STUK indicated that the appliance classification (UV type 3) notified by the manufacturer was incorrect. The spectra of tubes fitted in one appliance with the same type designation also differed significantly from one another. The differing spectrum distributions previously verified were measured in two other appliances with tubes bearing the said type designation.

While about 90% of appliances included radiation safety instructions, three out of every four sets of instructions included information that was generally contrary to requirements on such matters as the health impact of sunbeds, or inadequate technical operating instructions. Only about half of the operating instructions referred to the regulation limiting annual use of sunbed appliances (5 kJ/m^2, corresponding to about 20 tanning sessions) and to the 18-year age limit recommendation included in the Decree of the Ministry of Social Affairs and Health (294/2002). One third of the sunbed appliances inspected also lacked the required timer that enables the user to select recommended exposure times and switches the appliance off after the set period has elapsed. The durations of the first tanning sessions recommended for the appliances were also too long

in two appliances out of three.

Premises of use were inspected in seven districts, with local health inspectors also involved in four districts. These inspectors were trained in inspecting radiation safety aspects. Other collaboration with health inspectors consisted of consultancy regarding inspections, for example when determining the radiation characteristics of ultraviolet lamps in use and the compliance of equipment with safety requirements.

Other regulatory control

An unauthorized public event was arranged in February 2007 at which laser radiation was directed at the audience in a manner contrary to Guide ST 9.4. STUK cautioned the organizer of this event and stressed in its letter that a licence is required for the use of high power lasers at public events. The general public was also warned about online sales of lasers that can damage the eyes.

A 30 mW diode laser hazardous to eyesight was used without authorization for drawing graffiti at a public event. This performance would not have been authorized, as the appliance in question does not meet the safety requirements of Guide ST 9.4. The organizer of this event was asked to account for the incident and a formal caution was issued briefly specifying the requirements of STUK for safety in laser displays.

4.3 Electromagnetic fields

Market surveillance of mobile phones

Market surveillance of mobile phones began in 2003. Market surveillance of UMTS mobile phones began in 2007. Radiation tests have been conducted on a total of 75 mobile phones to date (see Table XXI of Appendix 1). Tests were conducted in 2007 on 15 mobile phone models, four of which were UMTS phones. No phone exceeded the maximum value of 2 W/kg specified in the Decree of the Ministry of Social Affairs and Health (294/2002). The highest measured value was 1.15 W/kg.

Six GSM phones were also tested in collaboration with Russian partners using a simplified testing method. This testing was one aspect of a meeting held at STUK on the initiative of the European Commission to discuss radiation testing of mobile phones and harmonization in this field. The Russian participants represented the Russian ministries of communications and health, together with their subordinate research institutes. Other participants included representatives of the Mobile Manufacturing Forum (MMF) and Nokia Plc.

Other regulatory control

STUK issued an opinion on a project to extend the IKEA showroom in the vicinity of 400 kV power lines at Porttisuo in Vantaa. In the authority's view the electric and magnetic fields generated by the power lines are no obstacle to the extension.

4.4 Abnormal incidents

The abnormal incident reporting required by section 17 of the Radiation Decree also applies to incidents arising in the use of non-ionizing radiation (see item 2.9 above). There were no reports of abnormal incidents in the use of non-ionizing radiation in 2007.

5 Regulation work

5.1 ST Guides

To achieve a standard of safety that complies with the Radiation Act, STUK publishes Radiation Safety Guides (ST Guides) for responsible parties that use radiation or that engage in practices causing exposure to natural radiation.

The following guides were published in 2007:

- ST 5.1 Radiation Safety of Sealed Sources and Devices Containing Them
- ST 5.3 Use of Ionising Radiation in the Teaching of Physics and Chemistry
- ST 5.8 Installation, Repair and Servicing of Radiation Appliances
- ST 7.1 Monitoring of Radiation Exposure
- ST 7.2 Application of Maximum Values for Radiation Exposure and Principles for the Calculation of Radiation Dose
- ST 7.3 Calculation of the Dose Caused by Internal Radiation
- ST 7.5 Medical Surveillance of Occupationally Exposed Workers
- ST 9.4 Radiation Safety of High Power Display Lasers.

These Finnish language guides are also translated into Swedish and English.

5.2 Other regulation work

The requirements for high activity sealed sources prescribed in amendments to the Radiation Act (1179/2005) and the Radiation Decree (1264/2005) had to be wholly implemented by the end of 2007. The duties of a responsible party were more closely specified in Guide ST 5.1 with respect to such matters as record keeping and regular monitoring of such radiation sources, and safeguarding them from unlawful activity, loss and damage.

The department for occupational safety and health of the Ministry of Social Affairs and Health has collaborated with STUK to prepare a new proposal for a decree of the Council of State on regulatory control and inspection of laser appliances. It is proposed that, according to the present decision of the Council of State, the labour protection authorities would continue to serve as the regulatory authority for lasers used at work, and the Finnish Institute of Occupational Health would inspect any battery-operated laser devices that are not governed by the Low Voltage Directive. The proposal also recommends discontinuing type approval, however. An official statement from the European Commission on this matter points out that Finland should ensure that public authorities have adequate statutory powers to remove from the market any laser products that are hazardous to consumers. It is the view of the Finnish Consumer Authority that regulatory control of lasers sold as consumer goods must be based on radiation protection legislation, with STUK serving as the regulatory authority, and that these arrangements should also govern mains-operated consumer products. The Consumer Authority controls the use of laser appliances in toys on the basis of the Toy Safety Directive. Finland's radiation protection legislation affords adequate powers for regulatory control of consumer laser products (Decree 1306/1993 and Decree of the Ministry of Social Affairs and Health 294/2002). A decision on such regulatory control has not yet been issued, however.

6 Research

The aim of research work conducted by STUK is to provide information that will improve expertise, support regulatory activities and enhance preparedness to respond to radiological and nuclear emergencies.

6.1 Ionizing radiation

Research and development work on ionizing radiation formed part of the following projects:

Examination-specific radiation doses of staff in interventional radiology

The aim of the study is:

- to investigate examination-specific staff radiation doses and the dependency between staff doses and the doses sustained by patients in corresponding examinations
- to investigate doses to various parts of the body (hands, legs, eyes and whole body) of interventional radiologists/cardiologists.

Measurements were taken at three hospitals for the cardiology studies. The properties of radiation meters will further be tested under laboratory conditions and a summary of findings will be prepared during 2008.

The SENTINEL project

Safety and efficacy for new techniques and imaging using new equipment to support European legislation (SENTINEL) is a project related to the diagnostic use of radiation, which was launched in 2005 and is co-ordinated by the European Union. The project comprises eight work modules covering nearly the entire field of diagnostic use of radiation with the exception of computed tomography. STUK is primarily involved in the following subject areas:

- performance standards/mathematical assessment of fluoroscopic image quality
- cardiology/collation of patient doses in heart examinations
- interventional radiology/collation of patient doses in interventional radiology
- staff doses in interventional radiology
- mammography examinations.

In 2007 the project compiled a summary of interventional radiology patient doses. A review of the doses of interventional radiologists and cardiologists was also performed. The project came to an end in spring 2007.

IAEA code of dosimetry practice in X-ray diagnostics

An IAEA research project to test a code of diagnostic dosimetry practice began in 2006 (Coordinated Research project 2006–2007: Testing of the Implementation of the Code of Practice on Dosimetry in X-ray Diagnostic Radiology). STUK is particularly involved in this project in testing work on dose-area product meters (DAP meters), in testing calibration and measurement methods for the meters used in CT dosimetry, and in mammography dosimetry. Test calibrations of DAP meters were performed in 2007 in accordance with guidelines and STUK took part in measurement comparisons between laboratories. The results of these comparisons are not yet available. This project will continue in 2008.

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.

A patient dose measuring method for postal monitoring of the use of radiation

This Master's thesis work prepared a method of measuring patient doses (ESD) in conventional X-ray examinations by means of thermoluminescence dosimetry (TLD). A water-filled dosimetry phantom

developed in the course of the work was calibrated for air kerma using International Electrotechnical Commission (IEC) RQR-X-radiation qualities at tube voltages of 50–150 kV. The air kerma values measured in lumbar spine and chest X-ray examinations were converted to patient doses using backscatter coefficients tabulated by the International Commission on Radiation Units and Measurements (ICRU). The results were consistent with patient doses measured using ionization chambers within the 5% measuring uncertainty of the TLD method. The method studied is suitable for monitoring the use of radiation by post.

6.2 Non-ionizing radiation

Most of the research and development work on non-ionizing radiation was done in the course of the jointly financed research projects set out below.

Health risk evaluation of mobile communications (HERMO)

The NIR Laboratory has been involved in four areas of the national HERMO study into the effects of mobile phone system radio frequency radiation on electrical activity in the brain:

1. The first area is a joint study together with Tampere University of Technology and the Technical Research Centre of Finland (VTT) into EEG changes in the brains of anaesthetized swine caused by 900 MHz mobile phone radiation. The role of the NIR Laboratory was to develop the exposure equipment and to determine SAR in swine brains. During the year a manuscript on this subject was prepared for an article in the journal Bioelectromagnetics. Judging by the observations of peer reviewers, this article will probably be approved for publication.
2. The second research area was a joint study by the NIR Laboratory and the Radiation Biology Laboratory (SBL) in the Department of Research and Environmental Surveillance of STUK of the effects of 900 MHz mobile phone radiation on cutaneous proteins in volunteer test subjects. The role of the NIR Laboratory was to develop the exposure equipment and to determine SAR in the skin. A manuscript submitted to Bioelectromagnetics was edited and published in the journal.
3. The third research area investigated the impact on cell SAR distribution of the meniscus effect arising in a cell exposure chamber previously designed and constructed for the University of Kuopio. The meniscus effect is due to bending and sharpening of the liquid surface at the edges of the vessel owing to surface tension, resulting in a substantial increase in SAR at these edges. The main conclusion of the investigation, however, was that the impact of the meniscus effect is minimal in this case, as the cells are fixed in a single layer at the bottom of the vessel.
4. The fourth research area was collaboration with VTT to improve the dosimetry of a rat exposure device previously designed for the University of Kuopio. During the year a text on the dosimetry was included in the manuscript submitted by the university to the journal Radiation Research discussing the effects of mobile phone radiation on the brains of juvenile rats. The article was subsequently published in the said journal. A manuscript on the rat exposure device and its associated dosimetry that had been previously submitted to Bioelectromagnetics was also updated using SAR data computed by VTT using numerical rat models. The corrected manuscript was resubmitted to the same publication.

Software development for simulating electromagnetic fields (EMSOFT)

The EMSOFT project measured the electric fields in the immediate vicinity of six mobile phone base stations in air, and the SAR values in a standardized (EN 50383) liquid phantom. These measurements were performed at the frequency bands used in Finland (GSM 900, GSM 1 800 and UMTS 2 100). The results from one antenna were compared to results computed using the FDTD simulation program developed by the Electromagnetics Laboratory at Helsinki University of Technology. A good correspondence was found between the measurements and simulation results. With a disparity of less than 10%, the programme yielded reliable results.

Local field exposure was studied numerically using the FDTD method by calculating the power density and SAR generated by two base station antennae operating at frequencies of 900 MHz and 1800 MHz. An average for the power density was determined in accordance with draft standard

IEC 62232 in the mid-section of the body. The calculation also compared SAR values obtained using three numeric phantoms of varying character and size. The principal finding was that, at least at distances of more than 30 cm, it was safe to compare the average value determined from the power density in accordance with the standard with the reference value, without the average SAR of the body or the 10-g local peak value exceeding the basic limits.

It is technically very difficult to measure the fields around a base station precisely, as the signal strength varies with the number of communications transmitted and the modulation is complex, especially in the case of a UMTS transmission. Even though the power densities are small in relation to the exposure limits (not exceeding one hundredth and typically one ten-thousandth), measurements must be made with reasonable precision for the public to have confidence in the measurement results and in the measurer. The comparison measurements were taken in the vicinity of two base stations at ranges where the general public could be exposed to base station radiation. Three measurement devices of varying type were used: a conventional antenna-spectrum analyzer combination, a frequency-selective Rohde&Schwarz TS-EMF measuring system, and a frequency-selective Narda SRM-3000 radiation meter. The measurement results indicate that the findings of a conventional spectrum analyzer can differ from the true value by an order of magnitude either way, and that this device can therefore not be used, at least for UMTS base station measurements. The frequency-selective measuring instruments are reliable. Thanks to its compact design, the hand-held Narda SRM-3000 meter used by STUK for environmental measurements was better suited to fieldwork than the Rohde&Schwarz TS-EMF measuring instrument, which has three separate parts.

Other research activities

Besides jointly financed research projects into non-ionizing radiation, research and technical development work also continued as part of the basic activities of the NIR Laboratory.

Exposure of the general public in the vicinity of defence forces radar stations

A more general investigation did not prove to be necessary. Problems can only arise with a radar station if the radiation beam from the antenna is directed into an area to which the general public has unimpeded access at a range of less than one kilometre. Such extremely rare exposure occurrences will be assessed in each individual case.

Background radio frequency (RF) radiation

This investigation gathered information on environmental radiation caused by radio transmitters operating in the 80–3000 MHz frequency band for the purpose of risk communication. Studies focused particularly on radio frequency fields generated by new wireless communication devices (GSM, UMTS, WLAN, mobile-TV), the exposure from which was compared with exposure due to public broadcasting, VHF and TV stations. A manuscript was completed during the year for release in the STUK publications series together with a more generally accessible STUK bulletin in the early months of 2008.

7 International co-operation

Representatives of STO and the NIR Laboratory are involved in several international organizations, commissions and expert groups dealing with regulatory control of and with the development of safety regulations and measuring methods in the use of ionizing and non-ionizing radiation, as well as with standardizing activities in the field of radiation (IAEA, NACP, EURADOS, EURAMET, ESTRO, ESOREX, ICRU, NEA, AAPM, NOG, IEC, ISO, CEN, CENELEC, ICNIRP, EAN, EUTERP).

Participation in meetings of international working groups

During 2007 representatives of STUK took part in meetings of the following international organizations and working groups:

- EU Euratom Article 31 group of experts
- IAEA radiation safety standards committee (RASSC)
- Nordic sealed source working group (NORGUSS)
- Nordic dosimetry working group
- European Collaboration in Measurement Standards (EURAMET) ionizing radiation working group
- European Metrology Research Programme (EMRP) project working group planning meetings
- European Alara Network (EAN): two meetings
- European Training and Education in Radiation Protection Platform (EUTERP)
- European Radiation Dosimetry Group (EURADOS)
- European Committee for Electrotechnical Standardization (CENELEC) Ad-Hoc UV working group
- CENELEC TC 106X/WG9 working group
- IEC: 62232 project working group of the TC 106 committee
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) TG-ELF working group.

Participation in other international conferences

Representatives of STO and the NIR Laboratory took part in several international conferences and congresses in the field of radiation safety and gave presentations and lectures at these events (organizers included IAEA, EANM, ESTRO, EURAMET, CIPM and the European Commission).

Other international co-operation

The European Union approved an offer from Finland to prepare European guidelines on clinical auditing, and an 18-month project for this purpose was launched in June 2007. STUK is leading this project. The consortium also includes Tampere University Hospital from Finland and four other organizations from Europe, including the European Society for Therapeutic Radiology and Oncology (ESTRO).

A joint opinion of the Nordic radiation safety authorities to CENELEC suggests reductions in the intensity of sunbed appliances and in the ultraviolet radiation doses that are sustained in their use. The authorities stress that sunbed use increases the risk of contracting various skin cancers.

A representative of the NIR Laboratory took part in the EUROSKIN UV conference in Hamburg to deliver a requested presentation of three opinions formulated by the Nordic radiation safety directors on sunbed use and the safety of sunbed appliances. These opinions stress that the irradiance of sunbeds should be limited, that sunbeds should not be used by persons under 18 years of age or by those with sensitive skin,

and that customers must be provided with clear operating instructions and guidance in adequately limiting the annual radiation dose sustained from sunbed use.

As part of the EMF-NET co-ordination project under the sixth European Union framework programme, representatives of the NIR Laboratory took part in a workshop arranged at the University of Umeå, Sweden, on worker exposure to magnetic fields generated by magnetic imaging appliances. The workshop also provided an opportunity to make highly successful measurements of gradient fields and kinetic potentials using an isotropic magnetic field probe constructed at STUK. A similar EMF-NET-workshop on magnetic fields generated by welding equipment was jointly organized by STUK and the Finnish Institute of Occupational Health. A research team from the University of Umeå also took part in this workshop.

8 Co-operation in Finland

Representatives of STO and the NIR Laboratory are involved in several Finnish commissions and expert groups 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 National Board for Metrology, the Radiation Safety Conference committee, Eurolab-Finland, and SESKO).

Finnish conferences arranged by STUK

STUK organized the following conferences in 2007:

- Conference of radiotherapy physicists. The subject of the 2007 conference was the rapidly increasing use of radiotherapy. New appliances are being commissioned more rapidly than anticipated, with three new linacs taken into use in 2007. The new therapeutic techniques call for new kinds of quality control tests, which are being developed both by operators and to meet the needs of regulatory control by STUK. The most significant recent abnormal incidents in radiotherapy internationally have involved computerized dose planning, and the conference paid particular attention to quality control in this area.
- Conference of X-ray physicists. This event was arranged in August 2007 on the premises of Turku University Central Hospital at Luonnonmaa near Naantali in southwest Finland. There were 35 participants in all. Conference topics included digital image receptors and associated quality control, optimization of digital imaging systems, patient doses in conventional imaging, quality control of image monitors and CT scanners, and measurement of patent doses in interventional radiology.
- Training conference on radiation safety and quality in nuclear medicine. This conference was arranged in Helsinki in November 2007 for a total of 64 participants. The conference themes were radiation protection during pregnancy, patient discharge following isotope treatment, quality control and image quality, clinical auditing and new radiation protection instructions. An IAEA specialist lectured on the international radiation protection system and on ICRP foetal protection guidelines.
- Information and discussion session with enterprises engaged in trade in radioactive substances. This event was targeted particularly at sealed source vendors. It provided an opportunity to present new statutes and regulatory control procedures applied by STUK. Introductory presentations served as the basis for discussing the role and function of stakeholders in radiation source trading, and the procedures that are involved in decommissioning radiation sources.
- A seminar on the scope of safety licences and approval of radiation safety officers was held at STUK in September. The seminar examined the grounds for issuing safety licences and the principles governing the approval of radiation safety officers. This event was considered important because of recent and ongoing changes in the field of the use of radiation. It was attended by 69 representatives of responsible parties and radiation safety officers.

Participation in meetings of Finnish working groups

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

- SESKO SK 61
- SESKO SK 106.

Participation in other Finnish conferences

Representatives of STO and the NIR Laboratory took part in several Finnish conferences in the

field of radiation safety and gave presentations and lectures at these events.

Other co-operation in Finland

The Ministry of Social Affairs and Health has reappointed the specialist group on clinical auditing for a term of office running from 1 January 2007 to 31 December 2009. STUK will provide the secretary to the group. The planned activities of the group in 2007 included investigating clinical auditing practices and recommendations issued in audits (continuing a previous investigation by ensuring that all of the first audits are considered) and reviewing the expediency of auditing criteria with a view to eliminating needless duplication with respect to other quality assessments and regulatory control by public authorities.

9 Information activities

Books, bulletins, reviews

STUK publishes the Radiation and Nuclear Safety book series comprising a total of seven books (in Finnish). The following parts of the book series were published between 2002 and 2006:

- Part 1: Radiation and its detection
- Part 2: Radiation in the environment
- Part 3: Use of radiation
- Part 4: Health impacts of radiation
- Part 5: Nuclear safety
- Part 6: Electromagnetic fields

The last part of the book series will concern ultraviolet and laser radiation. 85% of this volume had been completed by the end of 2007.

In 2007 STUK prepared a guidebook on quality control of digital X-ray imaging appliances in association with professionals working in X-ray units, consulting foreign partners where necessary. The guidebook also covers quality control of image monitors. The medical practitioners who issue opinions on images and are ultimately responsible for adequate image quality also play an essential role in quality control. The guidebook was published in spring 2008.

STUK has also prepared a guidebook on criteria for paediatric X-ray examinations. This presents X-ray examinations that are justified from the point of view of paediatric diagnosis or therapy, and specifies the criteria for good paediatric X-ray examinations. The guidebook reviews the most typical paediatric X-ray examinations, including dental imaging. It describes what should be visible in images of various types and how images should be delimited. The guidebook also refers to examinations that should generally not be done on children. For example imaging of nasal sinuses or tonsils is seldom necessary on children under the age of seven years.

The guidebook is mainly intended for medical practitioners who refer child patients for X-ray examination. It supplements a previous publication – Guidelines for X-ray examinations of children (STUK bulletin no. 1/2005) – that was mainly addressed to radiographers. The guidebook includes instructions for using protective devices and practical examples of imaging value selections for child patients of various ages. The guidebook will be published in early 2008.

Public information on current affairs

STUK continued the practice, started in the year 2000, of publishing the UV radiation index on its website between April and June.

During the year the NIR Laboratory received several questions from members of the public, radiation users, the media, and other parties interested in non-ionizing radiation. Several interviews were given to the media. Queries came from members of the public through the website every day and telephone calls were received on a very wide range of radiation concerns. The traditional ultraviolet information session was arranged in the spring in association with Finnish Cancer Organisations and the Finnish Meteorological Institute. An information session was arranged in association with the Finnish Institute of Occupational Health at the end of the Finnish national mobile phone radiation research programme (HERMO).

Press releases were prepared on the following subjects:

- No clear link found between mobile phone use and brain cancer
- STUK publishes new ProInfo website for radiation users
- Nordic radiation safety authorities seek to reduce sunbed use
- Worker radiation doses remain clearly within maximum limits
- Laser radiation must not be directed at people attending public events

- UV forecast advises the public when to avoid sunshine
- Principles for issuing safety licences and approving radiation safety officers
- Radiation levels of new mobile phone models tested by STUK remain within recommended limits
- Alara magazine: Enjoy the sunshine in moderation
- Radiotherapy administered to the wrong patient – more attention to be paid to patient identification
- No evidence found for mobile phone health risks
- Radioactive strontium found in Mäntsälä
- Origin of Mäntsälä radioactive strontium determined
- Alara magazine: The healing power of radiation
- Seminar held at STUK: Scope of safety licences and approval of radiation safety officers
- Americium source winds up in steel foundry in Tornio
- Americium source in Tornio foundry: No radiation hazard to workers
- STUK prohibits use of excessively powerful sunbeds.

Educational lectures

The Director of the NIR Laboratory gave a course of lectures at Helsinki University of Technology on the subject “Biological effects and measurements of electromagnetic fields and optical radiation” (course equivalent to two study credits).

10 Metrology

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. It 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 EURAMET organization.

Standard laboratory activities are the responsibility of the Dosimetry Laboratory (the DOS Laboratory) at STO for ionizing radiation and the NIR Laboratory for non-ionizing radiation.

10.1 Ionizing radiation

Maintenance of metrological standards, and development work on irradiation equipment and methods of measurement

In 2007 the DOS Laboratory introduced two new reference standards (ionization chambers) for measurements on the calibration track of protection level radiation meters. The standards were calibrated at the PTB Laboratory (Physikalisch-Technische Bundesanstalt) in Germany.

The standard dosimetry activities of the DOS Laboratory in 2007 were the subject of one internal audit covering calibrations and measurements made outside of the laboratory. Technical Research Centre of Finland (VTT) also audited the DOS Laboratory with particular reference to diagnostic X-ray appliance radiation safety tests produced by the laboratory. Remedial measures arising from observations made during the audits have already been taken or will be taken during 2008.

Chapter 6 gives details of research projects on standard laboratory activities and dosimetry.

Meter and measurement comparisons

The DOS Laboratory took part in the annual TLD comparison measurement of the absorbed dose of ^{60}Co gamma radiation between calibration laboratories belonging to the laboratory network maintained by the IAEA/WHO. The STUK result differed from the reference value by -0.8%. This result was well within the acceptable range of ±3.5%.

Figure 9 shows the deviations in the measurement results of STUK from the reference value in IAEA/WHO measurement comparisons over the period from 1997 to 2007.

10.2 Non-ionizing radiation

Development work on measurement and irradiation equipment and methods

An isotropic measurement probe was developed for measuring static fields and gradient fields generated by magnetic imaging equipment.

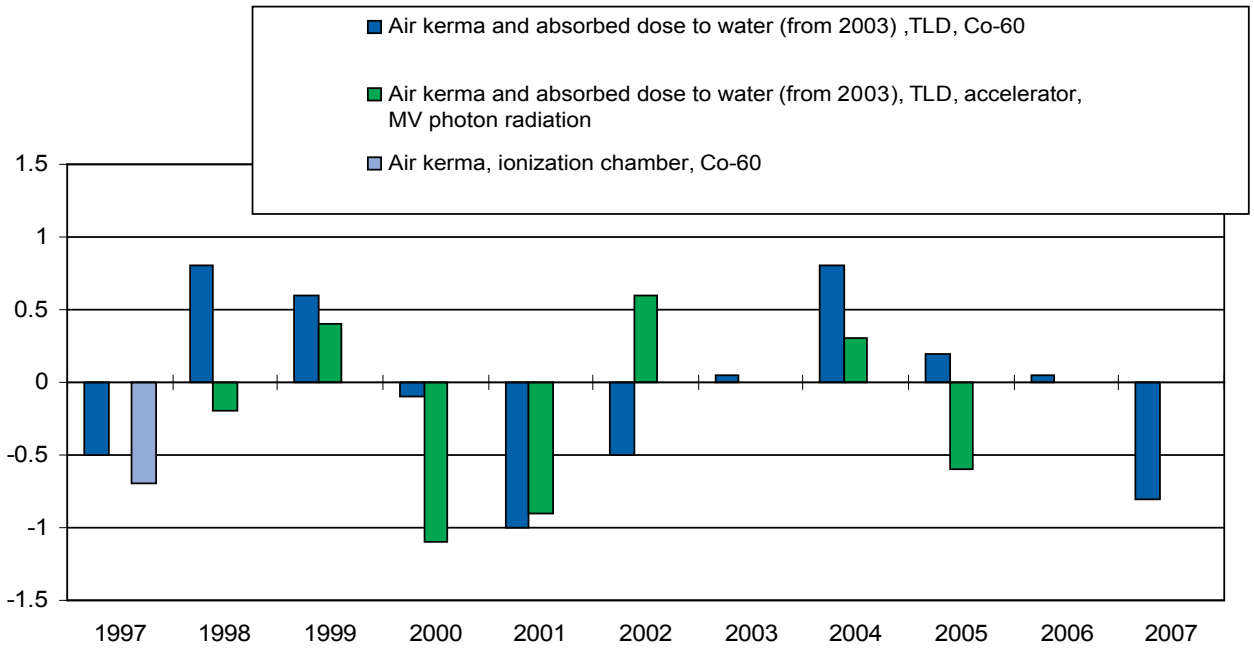

Figure 9. Deviations (%) in measurement results of STUK from the reference value in IAEA/WHO measurement comparisons, 1997–2007.

11 Services

11.1 Ionizing radiation

Calibration, testing and irradiation

The DOS Laboratory performed radiation meter calibrations on request. 86 radiation meter calibration certificates and 34 irradiation certificates were issued. About one quarter of the calibrations and about half of the irradiations were performed for STUK's own measuring instruments and samples.

Other services

58 copies of the PCXMC measurement program developed at STUK were sold for dose computation in X-ray diagnostics. Tests were also provided as a service to confirm the compliance of X-ray appliances with standards.

11.2 Non-ionizing radiation

Calibration, testing and irradiation

The NIR Laboratory performed a total of 33 radiation meter calibrations and tests and 17 safety assessments and radiation measurements. The service work of the NIR Laboratory between 2000 and 2007 is shown in Table XIX of Appendix 1.

APPENDIX 1 TABLES

Table I. Radiation practices referred to in safety licences for the use of radiation in health care at the end of 2007.

Use of radiation	Number of practices
X-ray examination	397
Dental X-ray examination*)	10
Veterinary X-ray examination	206
Use of unsealed sources	41
Use of sealed sources	23
Radiotherapy	13
Other uses of radiation	18

*) Licence granted for dental X-ray appliances that are nevertheless mainly used for purposes other than dental X-ray practices.

Table II. Radiation sources and appliances used in health care and in veterinary X-ray practices, and radionuclide laboratories at the end of 2007.

Appliances/laboratories	Number
X-ray diagnostic appliances (generators) *)	**1561**
X-ray tubes	**1671**
• image intensifier television chain	348
• mammography (not screening)	108
• screening mammography	95
• computer tomography	84
• angiography (not DSA)	30
• digital subtraction angiography (DSA)	77
• bone mineral density measurement	81
• dental X-ray imaging	49
Dental X-ray appliances	**5294**
• conventional dental X-ray appliances	4638
• panoramic X-ray appliances	656
Radiotherapy appliances	**95**
• accelerators	35
• afterloading appliances	10
• X-ray therapy appliances or radiographic appliances	15
• radiotherapy simulators	17
• BNCT therapy unit	1
• other appliances	18
Appliances containing radioactive substances	**123**
• attenuation correction units	22
• flood sources	28
• calibration sources	21
• gamma irradiators	6
• other appliances	46
Veterinary X-ray appliances	**250**
Radionuclide laboratories	**60**
• B-type laboratories	18
• C-type laboratories	41
• other laboratories	1

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

Table III. The ten most important isotope examinations from the point of view of collective effective dose in 2006.

Examination/radiopharmaceutical	**Number of examinations*)**	**Average effective dose per examination (mSv)**	**Collective effective dose (manSv)**)**	**Proportion of collective total dose (%)**
Skeletal gamma imaging/^{99m}Tc phosphates and phosphonates	12 688	3.7	46.64	29.2
Cardiac muscle perfusion SPET/^{201}Tl chloride	1017	24.2	24.56	15.4
Cardiac muscle perfusion SPET/^{99m}Tc tetrophosmin	2820	7.6	20.90	13.1
Whole-body metabolism PET/^{18}F FDG	761	7.0	5.35	3.3
Brain dopamine transporters SPET/^{123}I β-CIT	580	8.8	5.10	3.2
Thyroid metastasis gamma imaging (after ablation)/ ^{131}I iodide	440	11.1	4.88	3.0
Cardiac muscle perfusion SPET/^{99m}Tc MIBI (exertion and rest)	546	8.6	4.64	2.9
Lung perfusion gamma imaging/^{99m}Tc MAA	2646	1.4	3.73	2.3
Inflammation site gamma imaging/^{99m}Tc-labelled leukocytes	1023	2.7	2.79	1.7
Parathyroid gland gamma imaging/^{99m}Tc MIBI	379	6.8	2.59	1.6

*) Clinical examinations for adults
**) The total collective effective dose in 2006 was 160 manSv.

Table IV. Radiation practices referred to in safety licences for the use of radiation in industry, research and education and in trade of radioactive substances at the end of 2007.

Use of radiation	**Number of practices**
Use of sealed sources ((excluding gamma radiography)	624
Use of X-radiation (excluding radiography)	266
Import, export and trade	124
Use of unsealed sources	122
Installation, test operation and servicing	117
X-ray radiography	82
Gamma radiography	7
Use of particle accelerators	7
Production of radioactive substances	5
Other uses of radiation	28

Table V. Radiation appliances and sources used in industry, research and education, and radionuclide laboratories at the end of 2007.

Appliances/laboratories	**Number**
Appliances containing radioactive substances	**6311**
• level switches	2296
• continuous level gauges	1138
• density gauges	1027
• weight scales	566
• basis weight meters	552
• moisture and density gauges	125
• fluorescence analyzers	109
• thickness gauges	73
• radiography appliances	19
• other appliances	406
X-ray appliances and accerators	**1170**
• X-ray screening appliances	394
• radiography appliances	340
• diffraction and fluorescence analyzers	260
• thickness gauges	48
• ash meters	17
• particle accelerators	17
• other analytical appliances	94
Radionuclide laboratories	**155**
• A-type laboratories	2
• B-type laboratories	25
• C-type laboratories	115
• other laboratories	13

Table VI. Radionuclides most commonly used in sealed sources in industry, research and education, and number and activities of sources at the end of 2007.

Radionuclide	**Number of radiation sources**	**Total activity*) (GBq)**
Other than high-activity sealed sources		
Cs-137	3991	9095
Co-60	1401	1002
Kr-85	416	5345
Am-241 (gamma sources)	350	1643
Pm-147	166	4626
Fe-55	124	356
Am-241 (AmBe neutron sources)	119	482
Co-57	90	23
Sr-90	60	31
Gd-153	60	182
Cd-109	59	25
High-activity sealed sources		
Cs-137	64	668 074
Co-60	16	98 111
Ir-192	12	48 575
Am-241 (gamma sources)	8	1036
Sr-90	5	167
Am-241 (AmBe neutron sources)	4	591

*) Sum of the nominal activities notified on commissioning. The activity of short-lived radionuclides (e.g. Ir-192) is much lower than the nominal activity.

Table VII. Inspections of the use of radiation in 2007.

Type of inspection	Number of inspections		
	Industry, research, education, trade, installation, maintenance	Heatlh care	
		Licensed practices	Notifiable licence-exempt dental X-ray practices
Initial inspections	24	179	2
Periodic inspections	128	110	6
Repeat inspections	2	10	0
Other inspections or measurements	0	5	12
Total	**154**	**304**	**20**

Table VIII. Inspections of licensed practices in health care in 2007.

Type of practice	Number of inspections
• X-ray diagnostics	219
• dental X-ray diagnostics	4
• veterinary X-ray diagnostics	31
• nuclear medicine	8
• radiotherapy	35
• other uses of radiation	7
Total	**304**

Table IX. Imports and exports of sealed sources in 2007.

Radionuclide	Imports		Exports	
	Activity (GBq)	Number	Activity (GBq)	Number
Ir-192	52 026	13	5580	12
Kr-85	992	69	930	63
Pm-147	288	36	42	29
Fe-55	178	45	111	32
Am-241	152	52	2	304
I-125	110	*)	< 1	231
Cs-137	83	121	161	22
Gd-153	24	8	< 1	32
Co-60	20	43	- **)	-
H-3	13	75	2872	1406
Ni-63	7	14	6	12
Am-241***)	6	4	-	-
Cd-109	5	11	10	18
Po-210	4	43	-	-
Co-57	3	15	-	-
Sr-90	2	15	2	7
others total ****)	15	85	3	638
Total	**53 928**	**649**	**9719**	**2806**

*) The exact number of small I-125 sources is not known.
**) The "-" symbol indicates no import/exports.
***) AmBe neutron sources.
****) Imports, nuclidies Ba-133, C-14, Cl-36, Co-57, Eu-152, Ge-68, Na-22, Po-210, Ra-226, Sr-90.
Exports, nuclides: C-14, Eu-152, Ge-68, Sr-90.

Table X. Imports and exports of unsealed sources in 2007.

Radionuclide	**Activity (GBq)**	
	Imports	**Exports**
Mo-99	35 342	3416
I-131	5441	1126
Tc-99m	3640	- *)
I-123	492	37
P-32	185	55
Tl-201	110	-
Sm-153	68	-
I-125	60	3
Y-90	51	-
In-111	39	-
S-35	31	-
H-3	18	21
Se-75	8	-
C-14	4	< 1
F-18	-	363
others total **)	9	1
Total	**45 498**	**5022**

*) The "-" symbol indicates no imports/exports.
**) Imports, nuclidies: Ca-45, Co-57, Co-60, Cr-51, Cs-134, Cs-137, Er-169, Fe-55, Ga-67, Gd-153, Ge-68, H-3, I-129, P-33, Po-208, Rb-86, Re-186, Sr-89, Xe-133.
Expors, nuclides: Eu-152, F-18, H-3, Y-90.

Table XI. Manufacturing of radioactive substances (unsealed sources) in 2007.

Radionuclide	**Activity (GBq)**
F-18	26 661
O-15	16 200
C-11	12 193
Br-82	4532
I-123	1554
others total *)	34
Total	**61 174**

*) Nuclides: Au-198, Cu-64, Ho-166.

Table XII. Number of workers subject to individual monitoring in 2003–2007.

Year	Number of workers in various sectors in the use of radiation and nuclear energy						
	Health care		Veterinary medicine	Industry	Research and education	Use of nuclear energy *)	Total **)
	Exposed to X-radiation	Exposed to other radiation sources					
2003	4741	906	305	1114	1109	2862	10 901
2004	4759	915	328	1070	1025	3124	11 082
2005	4837	896	355	1172	995	3584	11 698
2006	4779	936	363	1281	948	3862	12 039
2007	4767	961	368	1275	927	3257	11 441

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

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

Table XIII. Total doses (sums of $H_p(10)$ values) in various sectors in the use of radiation and nuclear energy in 2003–2007.

Year	Total dose (Sv)						
	Health care		Veterinary medicine*)	Industry	Research and education	Use of nuclear energy**)	Total
	Exposed to X-radiation*)	Exposed to other radiation sources					
2003	1.55	0.12	0.07	0.20	0.09	2.38	4.41
2004	1.48	0.12	0.06	0.23	0.09	4.16	6.15
2005	1.48	0.14	0.06	0.19	0.09	3.42	5.38
2006	1.43	0.14	0.08	0.24	0.08	4.11	6.08
2007	1.37	0.15	0.11	0.26	0.08	2.16	4.13

*) $H_p(10)$ 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 medicine 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.

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

Table XIV. Data ($H_p(10)$ values) on certain occupational groups in 2007.

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**)	173	0.56	3.9	3.2	19.3
Radiologists**)	543	0.32	2.1	0.6	18.5
Interventional radiologists**)	25	0.20	9.4	7.9	27.3
Surgeons**)	287	0.08	2.3	0.3	20.1
Radiographers**)	2583	0.11	0.6	0.0	5.4
Industrial radiographers	417	0.10	0.7	0.3	4.3
Researchers	722	0.06	2.1	0.1	9.5
Nuclear power plant workers					
• mechanical duties	709	0.71	1.4	1.0	11.0
• cleaning	245	0.28	1.9	1.1	9.3
• material testing	181	0.14	1.0	0.8	6.8
• insulation work	67	0.19	3.6	2.8	11.2
• radiation protection	78	0.10	1.4	1.2	5.0
• operating staff	267	0.09	0.7	0.3	3.7

*) The recording level is 0.1 mSv per month for persons working in nuclear power plants and 0.1 mSv per month or 0.3 mSv per quarter for other workers depending on the duration of the measurement period.

**) $H_p(10)$ values are generally (sufficiently accurate) approximations of the effective dose. One exception to this is the dose sustained by these worker groups. Workers engaged in the use of radiation (X-rays) in health care and veterinary medicine 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.

Table XV. The principal low-level radioactive waste in the national storage facility (December 2007).

Radionuclide	Activity (GBq) or mass
H-3	14 990
Cs-137	2270
Pu-238	1595
Kr-85	1172
Am-241	1598
Sr-90	251
Ra-226	231
Co-60	158
Cm-244	105
U-238	1055 kg

Table XVI. Low-level radioactive waste received by STUK in 2007.

Radionuclide	Activity (GBq) or mass
Am-241	25
Kr-85	366
Pm-147	37
Cs-137	50
Fe-55	7.6
Co-60	3.5
Pu-Am	4.2
Sr-90	1.1
Ni-63	2.1
U-238	34 kg

Table XVII. Organizations having instruments approved for determining worker exposure to radon.

Organization	Instrument	Calibration valid until	Notes
Gammadata Mätteknik i Uppsala AB/ Gammadata Finland Oy, Helsinki	Alpha track detector	1 Jan 2009	Alpha track detector can determine the average radon concentration over an extended period. The method is not suitable for determining variations in radon concentration over time. The method is also approved for radon measurements in homes.
• City of Lahti • Tampere Polytechnic • Fortum Power and Heat Oy, Loviisa Power Plant	• Pylon AB-5 • Pylon AB-5 and AlphaGuard • AlphaGuard	• 3 Aug 2008 • 25 Sep 2008 25 Sep 2008 • 19 Jun 2009	Continuously monitoring instruments that can record variations in radon concentration over time. These instruments are suitable for measuring radon concentration during working hours.

Table XVIII. Number of air crew members subject to individual monitoring of radiation exposure and total dose of crew members (sum of effective doses) in 2003–2007.

Year	Number of workers		Total dose (Sv)	
	Pilots	Cabin crew	Pilots	Cabin crew
2003	739	1746	1.09	3.02
2004	739	1801	1.19	3.45
2005	739	1861	1.31	3.80
2006	1072	2412	1.73	4.35
2007	1125	2583	2.30	5.61

Table XIX. Work of the NIR Laboratory.

Year	Regulatory control inspections	Decisions	Statements	Calibrations and tests	Safety assessments and radiation measurements	Total
2000	17	0	7	31	1	56
2001	23	2	16	27	9	77
2002	36	1	4	31	13	85
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

Table XX. Inspections of sunbed facilities.

Year	Number
2000	14
2001	17
2002	36
2003	31
2004	30
2005	36
2006	25
2007	31

Table XXI. Mobile phone SAR tests.

Year	Number
2003	12
2004	18
2005	15
2006	15
2007	15

APPENDIX 2 PUBLICATIONS IN 2007

The following publications completed in 2007 were authored by one or more employees of STO or the NIR Laboratory.

International publications

Bravin A, Keyriläinen J, Fernández M, Fiedler S, Nemoz C, Karjalainen-Lindsberg M-L, Tenhunen M, Virkkunen P, Leidenius M, von Smitten K, Sipilä P, Suortti P. High-resolution CT by diffraction-enhanced x-ray imaging: mapping of breast tissue samples and comparison with their histopathology. Physics in Medicine and Biology 2007; 52: 2197–2211.

Hakanen A, Sipilä P, Sahla T. Characteristics of a ^{85}Kr beta-particle source applied in series 1 reference irradiations of TMDIS-1 Direct Ion Storage dosemeters. Radiation Protection Dosimetry 2007; 124:103–106.

Jokela K. Assessment of complex EMF exposure situations including inhomogeneous field distribution. Health Physics 2007; 92: 531–540.

Kiljunen T, Järvinen H, Savolainen S. Diagnostic reference levels for thorax X-ray examinations of paediatric patients. The British Journal of Radiology 2007; 80: 452–459.

Kumlin T, Iivonen H, Miettinen P, Juvonen A, van Groen T, Puranen L, Pitkäaho R, Juutilainen J, Tanila H. Mobile phone radiation and the developing brain: Behavioral and morphological effects in juvenile rats. Radiation Research 2007; 168: 471–479.

Pastila R, Leszczynski D. Ultraviolet-A radiation induces changes in cyclin G gene expression \r\nin mouse melanoma B16-F1 cells. Cancer Cell International 2007; 7 (7). Epub 2007 May 2.

Peräjärvi K, Turunen J, Hakala J, Jokinen A, Moore ID, Penttilä H, Saastamoinen A, Siiskonen T, Toivonen H, Äystö J. The decay of ^{133m}Xe. Applied Radiation and Isotopes 2007.

Pöllänen R, Siiskonen T, Moring M, Juhanoja J. Direct alpha spectrometry for characterising hot particle properties. Radiation Measurements 2007; 42: 1666–1673.

Siiskonen T. Dose from slow negative muons. Radiation Protection Dosimetry 2007; doi:10.1093/rpd/ncm314.

Siiskonen T, Tapiovaara M, Kosunen A, Lehtinen M, Vartiainen E. Monte Carlo simulations of occupational radiation doses in interventional radiology. The British Journal of Radiology 2007; 80: 460–468.

Toivonen T, Toivo T, Puranen L, Jokela K. Setup and dosimetry for exposure of human skin invivo to RF-EMF at 900 MHz. Bioelectromagnetics 2007. Epub 2007 Nov 28.

Toroi P, Zanca F, Young KC, van Ongeval C, Marchal G, Bosmans H. Experimental investigation on the choice of the tungsten/rhodium anode/filter combination for an amorphous selenium based digital mammography system. European Radiology 2007; 17 (9): 2368–2375.

Ungar K, Zhang W, Aarnio P, Ala-Heikkila J, Toivonen H, Siiskonen T, Isolankila A, Kuusi A, Moring M, Nikkinen M. Automation of analysis of airborne radionuclides observed in Canadian CTBT radiological monitoring networks using LINSSI. Journal of Radioanalytical and Nuclear Chemistry 2007; 272 (2): 285–291.

Zanca F, Van Ongeval C, Jacobs J, Pöyry P, Marchal G, Bosmans H. Evaluation of the global effect of anatomical background on microcalcifications detection. In book: Jiang Y, Sahiner B (eds.). Medical Imaging 2007: Image perception, observer performance and technology assessment. Proceedings of SPIE, Volume 6515, 5 March 2007.

Proceedings publications

Kortesniemi M, Kiljunen T, Kangasmäki A. Radiation exposure in body computed tomography examinations of trauma patients. In book: Vainio J, Pomoell J, Louhivuori M (eds.). Proceedings of

the XLI Annual Conference of the Finnish Physical Society, 15–17 March 2007, Tallinn, Estonia. Report series in physics. Helsinki: University of Helsinki; 2007. p. 8.16.

Pöllänen R, Siiskonen T. Direct alpha spectrometry from swipe samples. In: Proceedings of the 29th ESARDA Annual Meeting. 2007 May 22–24; Aix en Provence, France.

Research publications

Puranen L, Toivo T, Toivonen T, Jokela K. Development of radiofrequency dosimetry. In: HERMO – A Finnish research programme. Health risk assessment of mobile communications. Final Report. Kuopio: University of Kuopio; 2007. p. 31–43.

Regulatory reports

Koskelainen M. Tuote- ja turvatarkastuksissa sekä tutkimuksessa käytettävät röntgenlaitteet (X-ray appliances for use in product and security scanning and research). STUK-B 85. Helsinki: Radiation and Nuclear Safety Authority; 2007.

Rantanen E (ed.). Säteilyn käyttö ja muu säteilylle altistava toiminta (Use of radiation and other activities involving exposure to radiation). Vuosiraportti 2006 (Annual report 2006). STUK-B 76. Helsinki: Radiation and Nuclear Safety Authority; 2007.

Rantanen E (ed.) Radiation Practices. Annual Report 2006. STUK-B 82. Helsinki: Radiation and Nuclear Safety Authority; 2007.

Venelampi E. Radioaktiivisten aineiden käyttö teollisuuden merkkiainekokeissa (Use of radioactive substances in industrial indicator tests). STUK-B 83. Helsinki: Radiation and Nuclear Safety Authority; 2007.

Regulatory guides

Finnish language

Umpilähteiden ja niitä sisältävien laitteiden säteilyturvallisuus (Radiation Safety of Sealed Sources and Devices Containing Them). Ohje ST 5.1 (Guide ST 5.1). Radiation and Nuclear Safety Authority (7 Nov. 2007).

Ionisoivan säteilyn käyttö fysiikan ja kemian opetuksessa (Use of Ionising Radiation in the Teaching of Physics and Chemistry). Ohje ST 5.3 (Guide ST 5.3). Radiation and Nuclear Safety Authority (4 May 2007).

Säteilylaitteiden asennus-, korjaus- ja huoltotyö (Installation, Repair and Servicing Radiation Appliances). Ohje ST 5.8 (Guide ST 5.8). Radiation and Nuclear Safety Authority (4 Oct. 2007).

Säteilyaltistuksen seuranta (Monitoring of Radiation Exposure). Ohje ST 7.1 (Guide ST 7.1). Radiation and Nuclear Safety Authority (2 Aug. 2007).

Säteilyaltistuksen enimmäisarvojen soveltaminen ja säteilyannoksen laskemisperusteet (Application of Maximum Values for Radiation Exposure and Principles for the Calculation of Radiation Dose). Ohje ST 7.2 (Guide ST 7.2). Radiation and Nuclear Safety Authority (9 Aug. 2007).

Sisäisestä säteilystä aiheutuvan annoksen laskeminen (Calculation of the Dose Caused by Internal Radiation). Ohje ST 7.3 (Guide ST 7.3). Radiation and Nuclear Safety Authority (23 Sep. 2007).

Säteilytyötä tekevien työntekijöiden terveystarkkailu (Medical Surveillance of Occupationally Exposed Workers). Ohje ST 7.5 (Guide ST 7.5). Radiation and Nuclear Safety Authority (4 May 2007).

Yleisöesityksissä käytettävien suuritehoisten laserlaitteistojen säteilyturvallisuus (Radiation Safety of High Power Display Lasers). Ohje ST 9.4 (Guide ST 9.4). Radiation and Nuclear Safety Authority (28 Feb. 2007).

Swedish language

Användning av joniserande strålning vid undervisningen i fysik och kemi (Use of Ionising Radiation in the Teaching of Physics and Chemistry). Direktiv ST 5.3 (Guide ST 5.3). Radiation and Nuclear Safety Authority (4 May 2007).

Installation, reparation och underhåll av strålningsalstrande apparater (Installation, Repair and Servicing Radiation Appliances). Direktiv ST 5.8 (Guide ST 5.8). Radiation and Nuclear Safety Authority (4 Oct. 2007).

Övervakning av strålningsexponering (Monitoring of Radiation Exposure). Direktiv ST 7.1 (Guide ST 7.1). Radiation and Nuclear Safety Authority (2 Aug. 2007).

Tillämpning av maximivärdena för strålningsexponering och beräkningsgrunder för stråldosen (Application of Maximum Values for Radiation Exposure and Principles for the Calculation of Radiation Dose). Direktiv ST 7.2 (Guide ST 7.2). Radiation and Nuclear Safety Authority (9 Aug. 2007).

Beräkning av stråldos från intern strålning (Calculation of the Dose Caused by Internal Radiation). Direktiv ST 7.3 (Guide ST 7.3). Radiation and Nuclear Safety Authority (23 Sep. 2007).

Hälsokontroll av arbetstagare i strålningsarbete (Medical Surveillance of Occupationally Exposed Workers). Direktiv ST 7.5 (Guide ST 7.5). Radiation and Nuclear Safety Authority (4 May 2007).

English language (translations)

Radiation Safety of Sealed Sources and Devices Containing Them. Guide ST 5.1. Radiation and Nuclear Safety Authority (7 Nov. 2007).

Use of Ionizing Radiation in the Teaching of Physics and Chemistry. Guide ST 5.3. Radiation and Nuclear Safety Authority (4 May 2007).

Installation, Repair and Servicing of Radiation Appliances. Guide ST 5.8. Radiation and Nuclear Safety Authority (4 Oct. 2007).

Monitoring of Radiation Exposure. Guide ST 7.1. Radiation and Nuclear Safety Authority (2 Aug. 2007).

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Other publications

Järvinen H. (ed.). Säteilyturvallisuus ja laatu röntgendiagnostiikassa 2007 (Radiation safety and quality in X-ray diagnostics 2007). STUK-C6. Helsinki: Radiation and Nuclear Safety Authority; 2007.

Tapiovaara M. Efektiivisen annoksen laskenta PCXMC-ohjelmalla (Effective dose computation using the PCXMC application). In the book: Järvinen H. (ed.). Säteilyturvallisuus ja laatu röntgendiagnostiikassa 2007 (Radiation safety and quality in X-ray diagnostics 2007). STUK-C6. Helsinki: Radiation and Nuclear Safety Authority; 2007. p. 18–22.

Nieminen K. TT-tutkimusten efektiivinen annos (Effective dose in CT scanning). In the book: Järvinen H. (ed.). Säteilyturvallisuus ja laatu röntgendiagnostiikassa 2007 (Radiation safety and quality in X-ray diagnostics 2007). STUK-C6. Helsinki: Radiation and Nuclear Safety Authority; 2007. p. 27–30.

Siiskonen T. Henkilökunnan efektiiviset annokset toimenpideradiologiassa: kuinka dosimetrin lukema tulisi tulkita? (Effective doses of staff in interventional radiology: how should dosimetry readings be understood?). In the book: Järvinen H. (ed.). Säteilyturvallisuus ja laatu röntgendiagnostiikassa 2007 (Radiation safety and quality in X-ray diagnostics 2007). STUK-C6. Helsinki: Radiation and Nuclear Safety Authority; 2007. p. 48–50.

Pöllänen R, Karhunen T, Siiskonen T, Toivonen H, Pelikan A. Deconvolution of alpha spectra from hot particles [abstract]. NATO Advanced Research Workshop. 2007 May 7–11; Yalta, Ukraine.

Pöllänen R, Siiskonen T. Direct alpha spectrometry from swipe samples [abstract]. 29th ESARDA Annual Meeting. 2007 May 22–24; Aix en Provence, France.

Ansaranta T. Uutta STUKin ohjeista (New guides from the Radiation and Nuclear Safety Authority). In the book: Luennot. XXXI Sädeturvapäivät Tampere-talossa. Tampere 25.–26.10.2007 (Lectures. XXXI Radiation Safety Conference at Tampere Hall, Tampere 25–26 October 2007). Tampere: Lege Artis Oy; 2007. p. 81–84.

Pirinen M. Annostarkkailu ja työolojen tarkkailu (Individual monitoring and monitoring of working conditions). In the book: Luennot. XXXI Sädeturvapäivät Tampere-talossa. Tampere 25.–26.10.2007 (Lectures. XXXI Radiation Safety Conference at Tampere Hall, Tampere 25–26 October 2007). Tampere: Lege Artis Oy; 2007. p. 85–87.

Siiskonen T. Suojaesiliinan käyttö ja efektiivinen annos (Use of protective aprons and effective dose). In the book: Luennot. XXXI Sädeturvapäivät Tampere-talossa. Tampere 25.–26.10.2007 (Lectures. XXXI Radiation Safety Conference at Tampere Hall, Tampere 25–26 October 2007). Tampere: Lege Artis Oy; 2007. p. 88–90.

Nieminen K. Röntgentutkimusten efektiiviset annokset (Effective doses in X-ray examinations). In the book: Luennot. XXXI Sädeturvapäivät Tampere-talossa. Tampere 25.–26.10.2007 (Lectures. XXXI Radiation Safety Conference at Tampere Hall, Tampere 25–26 October 2007). Tampere: Lege Artis Oy; 2007. p. 91–93.

Alara magazine

Markkanen M. Säteilylähde suli terässulatossa (A radiation source melts in a steel foundry). Alara 2007; 1:9.

Academic thesis work

Niittymäki Henri. Potilasannoksen mittausmenetelmä postitse tapahtuvaan säteilyn käytön valvontaan (A patient dose measuring method for postal monitoring of the use of radiation). Master's thesis. University of Helsinki, Department of physical sciences, 2007.

Leaflets

Tavanomaisten röntgentutkimusten vertailutasot aikuisille (Reference levels for adults in conventional X-ray examinations). October 2007.

APPENDIX 3

ST GUIDES PUBLISHED BY STUK. SITUATION AS OF 31 DECEMBER 2007.

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, 16 April 2004
ST 1.5 Exemption of the Use of Radiation from the Safety Licence and Reporting Obligation, 1 July 1999
ST 1.6 Operational Radiation Protection, 29 December 1999 (in Finnish)
ST 1.7 Radiation Protection Training in Health Care, 17 February 2003
ST 1.8 Qualifications of Persons Working in Radiation User's Organization and Radiation Protection Training Required for Competence, 16 April 2004

Radiation Therapy

ST 2.1 Quality Assurance in Radiotherapy, 22 May 2003
ST 2.2 Radiation Safety of Radiotherapy Equipment and Treatment Rooms, 2 February 2001

Diagnostic Radiology

ST 3.1 Use and Regulatory Control of Dental X-ray Installations, 27 May 1999
ST 3.2 Mammography Equipment and Their Use, 13 August 2001
ST 3.3 X-ray Examinations in Health Care, 20 March 2006
ST 3.6 Radiation Safety in X-ray Facilities, 24 September 2001
ST 3.7 Breast Cancer Screening Based on Mammography, 28 March 2001

Industry, Research, Education and Commerce

ST 5.1 Radiation Safety of Sealed Sources and Devices Containing Them, 7 November 2007
ST 5.3 Use of Ionising Radiation in the Teaching of Physics and Chemistry, 4 May 2007
ST 5.4 Trade in Radiation Sources, 2 October 2000
ST 5.6 Radiation Safety in Industrial Radiography, 17 February 1999
ST 5.8 Installation, Repair and Servicing of Radiation Appliances, 4 October 2007

Unsealed Sources and Radioactive Wastes

ST 6.1 Radiation Safety Requirements for Radionuclide Laboratories, 1 July 1999
ST 6.2 Radioactive Wastes and Discharges, 1 July 1999
ST 6.3 Use of Radiation in Nuclear Medicine, 18 March 2003

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 Dose, 9 August 2007
ST 7.3 Calculation of the Dose Caused by Internal Radiation, 23 September 2007
ST 7.4 Registration of Radiation Doses, 25 February 2000
ST 7.5 Medical Surveillance of Occupationally Exposed Workers, 4 May 2007

Non-Ionizing Radiation

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, 6 April 2000
ST 12.2 The Radioactivity of Building Materials and Ash, 8 October 2003
ST 12.3 Radioactivity of Household Water, 9 August 1993
ST 12.4 Radiation safety in aviation, 20 June 2005