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RADIATION PRACTICES

Annual Report 2004

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Abstract

A total of 1791 safety licences for the use of radiation were current at the end of 2004. There were 1924 responsible parties engaged in licence-exempt dental X-ray practices, made notifiable to STUK. Regulatory control of the use of radiation was carried out 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 to support the regulatory control.

In 2004, STUK conducted 438 inspections of licensed practices and 38 inspections of notifiable licence-exempt dental X-ray practices. Restrictions were imposed on the use of five appliances. Repairs were ordered in 150 inspections and recommended in 85 inspections. No remarks were given in 229 inspections.

A total of 11 082 workers engaged in radiation work were subject to individual monitoring in 2004. 135 000 dose entries were made in the register maintained by STUK. In no case did the individual dose of any worker exceed the dose limits stipulated in the Radiation Decree.

Regulatory control of natural radiation concentrated on radon at workplaces and exposure of aircrews to cosmic radiation. At the end of 2004, 55 workplaces including a total of 74 work areas were subject to radon monitoring. A total of 2540 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 focused particularly on mobile phones and sunbeds. Radiation safety assessments were also made for public broadcasting equipment, radars, “artificial sun” aboard a cruise liner, UVC bactericide lamps in a bakery and show laser lights. A recommendation on radiation safety for sunbeds was prepared in association with other Nordic countries. Most research and development work was done in jointly financed research projects and particularly concerned assessments of the health risks of mobile communications and methods of determining radiation exposure caused by mobile phones.

There were 18 abnormal incidents involving the use of radiation in 2004. Six of these incidents concerned the use of radiation in industry, research and education, eleven involved medical uses of radiation and one concerned the use of non-ionizing radiation. None of these incidents resulted in serious consequences.

Contents

1 Background

The expression "use of radiation" refers to the use of radiation appliances and radioactive substances in health care, industry, research and education, and to import, export, production of and trading in radiation appliances and radioactive substances. 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 regulatory body for the safety of the use of radiation and other practices causing exposure to radiation is the Radiation and Nuclear Safety Authority (STUK) pursuant to the Radiation Act (592/1991). The regulatory control also applies to the use of non-ionizing radiation insofar as the said use is not controlled by other public authorities. The regulatory control of the safety of the use of radiation and of other practices causing exposure to radiation is the responsibility of the Department of Radiation Practices Regulation (STO) and the Laboratory of Non-Ionizing Radiation Surveillance (the NIR Laboratory) at STUK.

This annual report covers events involving the use of ionizing and non-ionizing radiation and other practices causing exposure to radiation, and to the regulatory control of these events in 2004. The report also includes statistics for 2004 gathered in the course of the regulatory control by STO and the NIR Laboratory, and details of the metrological and research activities, regulation work, Finnish and international co-operation, and the information activities and services of these units. Abnormal incidents involving the use of radiation are explained in the report as example events, so that similar incidents can be avoided in future. This annual report also includes the results of customer satisfaction surveys conducted in 2004 regarding the work of STO and the NIR Laboratory.

2 Regulatory Control of the Use of Ionizing Radiation

2.1 Background

Under section 16 of the Radiation Act, a safety licence is required for the use of radiation. This licence is granted by STUK on application. An amended licence must be requested in the event of any change in operations that is significant from the point of view of radiation safety. Such changes include, for example, a change in place of use, commissioning of new radiation appliances or a change in the radiation safety officer responsible for the safety of the use of radiation. Granting a safety licence involves applying the principle of justification in respect of new forms of the use of radiation. STO maintains a safety licence register of all licences granted and of the radiation sources referred to in the said licences.

Under section 17 of the Radiation Act, STUK may exempt the use of radiation from the safety licence if it is possible to ascertain with sufficient reliability that use of the radiation will not cause damage or danger to health. On certain conditions the use of dental X-ray appliances in general dental surgeries is exempt from safety licensing. Appliances and practices that are exempt from licensing must be notified to STUK for registration. STUK maintains a dental X-ray appliance register of notified appliances.

Through its on-site inspections at places of the use of radiation STUK supervises compliance with radiation legislation and the terms stipulated in safety licences, and ensures that practices are otherwise carried out in a safe and acceptable manner. Inspections usually cover the entire scope of the practice. Cases in which a separate, more restricted inspection may be made include, inter alia, occasions when a partial change of the practice occurs, for example when commissioning a new place of the use of radiation or radiation appliance. The first inspection of radiation sources and their use generally occurs when the practice begins. Subsequent inspections are conducted at intervals determined according to the nature of the practice concerned. The safety of dental X-ray appliances is controlled using test packages sent by post. This procedure is described in greater detail in report STUK-B-STO 33.

Under the Radiation Act, the party running a radiation practice (hereafter the responsible party) must arrange radiation exposure monitoring of persons engaged in radiation work. This monitoring must be individual for category A workers. For reasons of expediency, individual monitoring is also often arranged for persons engaged in category B. Pursuant to section 34 of the Radiation Act, STUK maintains a Dose Register of the radiation exposure of workers engaged in radiation work.

STUK also maintains a national storage facility for solid low-level radioactive waste pending final disposal. This storage facility forms part of the final disposal facility for intermediate- and low-level power plant waste at the Olkiluoto nuclear power plant of Teollisuuden Voima Oy.

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

2.2 Use of Radiation in Health Care

Safety licences

17 new safety licences for the use of radiation in health care were granted in 2004. 219 applications

for amendments to existing licences were also processed. 96 of these applications concerned a change of the radiation safety officer and 123 concerned a change in the practice, such as commissioning of new equipment or a change in the place of use. 199 decisions were also made, for example, to record a licence or part thereof as having expired due to discontinuation of the practice or decommissioning of a radiation source. This figure also includes decommissioning of e.g. dental X-ray appliances in licence-exempt dental X-ray practices.

698 safety licences for the use of radiation in health care were current at the end of 2004. The number of radiation practices referred to in these licences is shown in Table I.

Licence-exempt dental X-ray practices

The use of dental X-ray appliances has been exempted from safety licensing by decision no. 202/310/99 of STUK. If the use of an appliance fails to comply with the conditions set out in the decision, then a safety licence must be sought for the said use. Compliance with the conditions is investigated at the time of registering appliances that are notified to STUK.

A total of 1924 responsible parties engaged in notifiable licence-exempt dental X-ray practices in 2004.

For the regulatory control of dental X-ray appliances a total of 1504 test packages were sent by post to responsible parties. Acceptable measurement results were received for 1283 appliances.

Radiation appliances

Table II shows details of the radiation appliances and radionuclide laboratories in health care listed in the safety licence register and in the register of dental X-ray appliances at the end of 2004 (the table also includes X-ray appliances used in veterinary X-ray practices). 7123 radiation appliances and 71 radionuclide laboratories were entered in the registers. Most of these appliances were dental X-ray appliances. While the number of radiation appliances remained roughly the same as in the preceding year, there was a fall of about 8 per cent in the number of radionuclide laboratories.

X-ray diagnostics

Inspections of X-ray diagnostics conducted by STUK revealed no serious inadequacies in safety arrangements. Broadly speaking the safety standard of X-ray diagnostics may be considered to be relatively good, even though considerable differences in patient doses of as much as many tenfolds continued to be found between various places of use. It is usually possible to reduce these higher doses without compromising the purpose of the procedure. This will require greater safety awareness in modes of practice and optimization of diagnostic methods.

STUK has imposed reference levels for the skin doses of adult patients subject to conventional X-ray examination. The radiation exposure of patients and any occasions on which the reference levels are exceeded are monitored in inspections of the use of radiation and on the basis of measurements by the responsible party. The reference levels were exceeded in 9 per cent of measured lumbar spine and chest imaging and in 8 per cent of mammography examinations in 2004.

Mammography

Methods were specified for the regulatory control of screening mammography. This control includes tests in accordance with the ST Guides and a statement by a specialist physician concerning test images with which the quality of mammography imaging is controlled.

Radiotherapy

The aim of radiotherapy is to destroy a localized tumour while minimizing damage to healthy tissue. For this to succeed, the radiation must be applied to a specified target volume with the greatest possible accuracy and at the correct dose. According to international recommendations, including those of the International Commission on Radiation Units and Measurements (ICRU), the average uncertainty in therapeutic doses should not exceed 5 per cent. In the regulatory control of the proper implementation of the principles of justification and optimization, the main concern therefore focuses on the factors that govern the accuracy of the radiotherapy dose administered to the patient, i.e. on the correct magnitude of the dose and its correct targeting in the patient. To ensure good accuracy of radiotherapy doses, radiotherapy units are required to prepare quality assurance programmes for the use of therapy appliances.

In radiotherapy, regular comparison measurements are made to make sure that the accuracy of therapeutic doses remains good. Comparison measurements made between STUK and hospitals in 2004 indicate that accuracy is very high: the difference in measurements in photon beams was 0.1 per cent on an average (standard deviation 0.3 per cent) and 0.0 per cent in electron beams (standard deviation 0.7 per cent). No overdoses jeopardizing safety in treatment were detected in the comparison measurements. Inspections and comparison measurements of radiotherapy appliances (therapy appliances and radiotherapy simulators) also indicated that the operations and appliance characteristics governing the accuracy of the therapeutic dose generally comply with the requirements prescribed for them.

40 inspections of radiotherapy units were made, two of which concerned the commissioning of a new accelerator. Orders were issued in five cases to rectify deficiencies in safety systems, radiotherapy appliances or quality control methods.

In 2004 in the course of inspections, comparisons were conducted to investigate the effects on therapy doses of a new dosimetry method based on the absorbed dose to water that was introduced throughout Finland. The results of the comparisons have been collated for the 2003 transition year and for 2004. These results comply with internationally published comparison results, meaning that the change in therapeutic dose was about 1.5 per cent. A report on the comparison will be completed in early 2005.

Nuclear medicine

Inspections were conducted at 15 isotope laboratories. No significant deficiencies or abnormalities were observed. The introduction of reference levels was monitored at periodic inspections.

Report on nuclear medicine procedures in 2003

A customer survey was conducted on the use of radiopharmaceuticals in Finland in 2003. The results of this survey will be published in 2005 (STUK-B-STO 58). A corresponding study was made in 2000 (STUK-B-STO 47).

The aim of the study was to investigate the collective effective dose to patients in nuclear medicine examinations, the number of examinations and therapeutic treatments, and the average activities used in various examinations and treatments.

A questionnaire was posted to all licensees (30 in all) who, according to the terms of their licences, conducted nuclear medicine examinations and/or provided therapeutic treatments in 2003. The survey requested details of the radiopharmaceutical used, average activity and number of examinations for each type of examination and treatment. Separate notification was requested for examinations of adults and of children under 16 years of age. Separate notification was also requested of scientific research involving healthy volunteers and patients.

According to the study, 45 120 nuclear medicine examinations were conducted in Finland in 2003, of which about 3000 were examinations of children. Some 1500 examinations of adults were conducted for scientific purposes. The number of therapeutic treatments was 2304. The number of nuclear medicine examinations was 8.6 and treatments 0.44 per 1000 members of the public. The corresponding figures in 2000 were 8.8 and 0.39.

The collective effective dose on patients from nuclear medicine examinations in 2003 was 168 manSv, and the consequent average effective dose per member of the public was 0.03 mSv. The average effective dose per examination was 3.7 mSv. In 2000 respectively, the collective effective dose was 172 manSv, the consequent average effective dose per member of the public was 0.03 mSv, and the average effective dose per examination was 3.8 mSv. The radiation doses were mainly calculated using the conversion coefficients in publication 80 of the International Commission on Radiological Protection (ICRP).

Reference levels for nuclear medicine examinations

The average activities used in various isotope examinations in 2003 obtained as results of the study by STUK (the averages notified by various hospitals of average activities used in various examinations, weighted by the number of examinations) will be used when updating the reference levels for nuclear medicine examinations. The activity used on average in examinations in 2003 exceeded the reference level in about 20 per cent of the examinations for which STUK issued the reference level in 2000. The reference level was exceeded by 8 per cent in two examinations. The average activity used correspondingly fell below the reference level in about 80 per cent of examinations. These shortfalls from the reference level varied between 2.5 and 39 per cent. It may also be necessary to issue a reference level for some new examinations.

2.3 Use of Radiation in Industry, Research and Education

Safety licences

33 new safety licences for the use of radiation in industry, research and education were granted in 2004. 194 applications for amendments to existing licences were also processed. 79 of these applications concerned a change of the radiation safety officer and 115 concerned a change in the practice, such as commissioning of new equipment or a change in the place of use. 114 decisions were also made, for example, to record a licence or part thereof as having expired due to discontinuation of the practice or decommissioning of a radiation source.

1093 safety licences for the use of radiation in industry, research and education were current at the end of 2004. The number of radiation practices referred to in these licences is shown in Table III.

Radiation appliances and sources

Table IV shows details of radiation appliances and sources and of radionuclide laboratories in industry, research and education listed in the safety licence register at the end of 2004. 7066 radiation appliances and 176 radionuclide laboratories were entered in the register. The numbers of radiation appliances and radionuclide laboratories remained almost unchanged compared to the previous year. Most of the appliances were of a type containing sealed sources for use in industry. Small sources falling below the exemption values (e.g. calibration sources for use in laboratories) and radiation sources held in stock by importers were not registered by type of source.

Table V shows details of sealed sources and the radionuclides used therein.

HASS investigation

European Union Directive no. 2003/122/Euratom on high activity sealed sources (known as the HASS Directive) was approved in December 2003. To provide a foundation for preparing the amendments to radiation legislation that are required for implementing the Directive, STUK performed an investigation in 2004 into the number and nature of radiation sources covered by the Directive in Finland and into the plans of responsible parties when use of the sources comes to an end (the Directive requires a binding plan).

The investigation indicated that there are a total of 117 high activity sealed sources in Finland, held by 62 responsible parties (situation as of April 2004). The most common sources of this kind are ^{137}Cs (62 sources), ^{60}Co (21 sources) and ^{192}Ir (17 sources). The high activity thresholds defined for the said nuclides in the HASS Directive are 20 GBq (^{137}Cs), 4 GBq (^{60}Co) and 10 GBq (^{192}Ir). The most common application of these sources is in industrial radiometric measuring appliances (60 sources), with other uses including industrial radiography (15 sources), gamma irradiation (13 sources) and radiotherapy (13 sources). Sources are also used in radiation meter calibration (6 sources) and research (9 sources).

Source users had the following plans for the sources when their use is no longer required:

- return to the manufacturer (46 sources).
- consignment to the national storage facility for low-level waste (20 sources).
- no plans as yet or plans not known (51 sources). These users will have to present a plan when the statutes implementing the Directive enter into force in Finland (the deadline imposed by the Directive is the end of 2007).

Table I. Number of radiation practices referred to in safety licences for the health care sector at the end of 2004.

Use of radiation	Number of practices
X-ray examination	444
Dental X-ray examination*)	11
Veterinary X-ray examination	192
Use of unsealed sources	44
Use of sealed sources	22
Radiotherapy	13
Other uses of radiation	21

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

Table II. Number of radiation appliances and radionuclide laboratories used in health care and veterinary X-ray practices at the end of 2004.

Appliances/laboratories	Number
X-ray diagnostic appliances (generators)*)	**1566**
X-ray tubes	1765
• mammography (not screening)	97
• screening mammography	100
• computer tomography	74
• angiography (not DSA)	21
• digital subtraction angiography (DSA)	88
• bone mineral density measurement	80
Dental X-ray appliances	**5147**
• conventional dental X-ray appliances	4533
• panoramic X-ray appliances	614
Radiotherapy appliances	**88**
• accelerators	30
• afterloading appliances	12
• X-ray therapy appliances or radiographic appliances	20
• radiotherapy simulators	8
• BNCT equipment	1
• other appliances	17
Appliances containing radioactive substances	**99**
• blood irradiation appliances	7
• calibration sources and other appliances	92
Veterinary X-ray appliances	**223**
Radionuclide laboratories	**71**
• B-type laboratories	18
• C-type laboratories	51
• other laboratories	2

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

Table III. Number of radiation practices referred to in current safety licences for the use of radiation in industry, research and education at the end of 2004

Use of radiation	Number of practices
Use of sealed sources (excluding gamma radiography)	633
Use of unsealed sources	139
Import, export and trade	143
Installation, test operation and servicing	135
Use of X-radiation (excluding radiography)	173
X-ray radiography	75
Gamma radiography	7
Production of radioactive substances	5
Other uses of radiation	45

Table IV. Number of radiation appliances and sources, and radionuclide laboratories in industry, research and education at the end of 2004.

Appliances/laboratories	Number
Appliances containing radioactive substances	**6225**
• level switches	2323
• continuous level gauges	1056
• density gauges	996
• basis weight meters	567
• weight scales	527
• moisture and density gauges	137
• fluorescence analyzers	129
• thickness gauges	76
• radiography appliances	24
• other appliances	390
X-ray appliances and accelerators	**841**
• radiography appliances	316
• fluoroscopic appliances	257
• diffraction and fluorescence analyzers	178
• thickness gauges	36
• ash meters	18
• particle accelerators	15
• other X-ray appliances	2
• other analytical appliances	19
Radionuclide laboratories	**176**
• A-type laboratories	2
• B-type laboratories	33
• C-type laboratories	124
• other laboratories	17

Table V. Radionuclides most commonly used in sealed sources in industry, research and education, and number and activities of sources at the end of 2004.

Radionuclide	Number of radiation sources	Total activity*) (GBq)
Activity < 400 GBq		
Cs-137	3835	10 240
Co-60	1487	1254
Kr-85	403	5048
Am-241 (gamma sources)	348	2469
Pm-147	178	4740
Fe-55	151	420
Am-241 (AmBe neutron sources)	126	1086
Sr-90	65	195
Cd-109	64	38
Cm-244	26	124
Activity > 400 GBq		
Cs-137	29	670 020
Ir-192	12	50 240
Co-60	7	114 430**)
H-3	1	3700

*) 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.
**) Activity on 31 December 2004.

2.4 Inspections of the Use of Radiation

Through its on-site inspections at places of the use of radiation STUK supervises compliance with radiation legislation and the terms stipulated in safety licences, and ensures that radiation practices are otherwise performed in a safe and acceptable manner.

The matters verified in the course of these inspections include the following:

- that the appliances and practice meet the applicable requirements
- that radiation shields, quality assurance and safety arrangements are adequate
- that the maximum and intervention levels imposed are not exceeded
- that monitoring of the radiation exposure of workers and health surveillance have been arranged in accordance with instructions
- that radioactive substances and waste are appropriately managed
- that users are adequately trained and qualified, with adequate instructions for the use of radiation sources and for action in the event of accidents.

A report is prepared of every inspection.

The first inspection of radiation sources and their use generally occurs when the practice begins. Periodic inspections are thereafter conducted at intervals of between 2 and 5 years (±1 year), depending on the nature of the practice. Repeat inspections are noted in the report, where necessary.

In 2004, STUK conducted 438 inspections of licensed practices and 38 inspections of notifiable licence-exempt dental X-ray practices on the premises where radiation is used. Table VI shows the number of inspections itemized by type of inspection. Table VII shows inspections of licensed practices itemized by type of practice.

Exceptions were made to inspection intervals for health care only in the case of X-ray practices, where the inspection interval exceeded the target period in the case of 28 licensees. Eleven of these have orally notified that they will cease the practice within the year. 95 per cent of inspections of demanding X-ray practices, such as computer tomography and angiography, were performed within prescribed time limits. The inspection interval exceeded the target period in 18 cases involving the use of radiation in industry, research and education, and 30 per cent of the pactices have never been inspected. 24 of these are new practices for which safety licences were issued only in 2004. The remainder are mainly small-scale radiation users for which there is no high inspection priority on grounds of safety.

Use restrictions were imposed on five appliances used in licensed practices. Repairs were ordered in 128 inspections and recommended in 80 inspections of licensed practices. Repairs were ordered in 22 inspections and recommended in 5 inspections of notifiable licence-exempt dental X-ray practices. No remarks were given in 218 licensed practices and 11 practices engaged in notifiable licence-exempt dental X-ray practices.

2.5 Import, Production and Export of Radioactive Substances

STUK gathers data for regulatory purposes annually from the importers and manufacturers of radioactive substances on trade in and production of such substances. Data on radioactive substances brought to Finland from within the European Union are also received directly from the consignors, pursuant to Council Regulation (Euratom) No. 1493/93[*)]. The information on radionuclides imported to, produced in and exported from Finland in 2004 is shown in Tables VIII–X. The figures in the tables are based on data gathered from licensees engaged in import, production 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.

6272 sealed sources were imported and 5999 sealed sources were exported (Table VIII). Sealed sources are mainly used in industrial measurement and research appliances. The gadolinium and iodine isotopes ^{153}Gd and ^{125}I are used in health care and tritium (^{3}H) is used in bearing instruments.

The smoke detectors and ionization detectors used in fire alarm systems and containing americium (^{241}Am) are excluded from Table VIII. A total of 328 000 such appliances were imported with a combined activity of about 11 GBq.

The total activity of imported unsealed sources was 59 280 GBq and the total activity of exported unsealed sources was 14 788 GBq (Table IX). Unsealed sources are used in nuclear medicine and in indicator tests for industry and research.

A total of 45 496 GBq in short-lived radioactive substances for use as unsealed sources were produced in Finland in 2004 (Table X). Short-lived isotopes manufactured in particle accelerators are mainly used for labelling pharmaceutical products.

Table VI. Inspections of the use of radiation in 2004.

Type of inscpection	Number of inspections		
	Industry, research, education, trade, installation, maintenance	Health care	
		Licenced practices	Notifiable licence-exempt dental X-ray practices
Initial inspections	19	140	0
Periodic inscpections	110	155	5
Repeat inspections	0	3	0
Other inspections or measurements	6	5	33
Total	**135**	**303**	**38**

*) The expression “shipment of radioactive substances” is used to denote the import, export and transit conveyances of radioactive substances between the Member States of the European Union. This chapter uses the terms “import” and “export” regardless of the country of origin or destination of a radioactive substance.

Table VII. Inspections of licensed practices in 2004.

Type of practice	Number of inspections
Use of radiation in health care	
• X-ray diagnostics	214
• dental X-ray diagnostics	5
• veterinary X-ray diagnostics	24
• nuclear medicine	15
• radiotherapy	40
• other users of radiation	5
Use of radiation in industry, research and education, and in trade, installation and maintenance of radiation sources	
• use of sealed sources (excluding radiography)	82
• use of unsealed sources	13
• trade and maintenance	3
• use of X-radiation (excluding radiography)	22
• gamma and X-ray radiography	13
• other users of radiation	2
Total	**438**

Table VIII. Imports and exports of sealed sources in 2004.

Radionuclide	Imports		Exports	
	Activity (GBq)	Number	Activity (GBq)	Number
Ir-192	58 565	20	5848	23
H-3	9257	4200	7099	4900
Pm-147	615	76	115	28
Kr-85	977	94	858	60
Fe-55	159	58	116	53
Cs-137	115	89	37	48
Gd-153	29	36	2	26
Cd-109	27	55	29	58
Am-241	23	32	4	763
Ni-63	8	18	1	2
Am-241 *)	7	5	- **)	-
Co-60	6	7	-	-
Po-210	6	23	-	-
others total ***)	24	1559	2	38
Total	**69 818**	**6272**	**14 111**	**5999**

*) AmBe neutron sources.

**) The "-" symbol indicates no imports/exports.

***) Imports, nuclides: Cm-244, Co-57, Ge-68, I-125, Na-22, Pb-210, Sr-90 and Y-88.
Exports, nuclides: Eu-152 and Ge-68.

Table IX. Imports and exports of unsealed sources in 2004.

Radionuclide	Activity (GBq)	
	Imports	Exports
Mo-99	51 350	13 131
I-131	6728	1532
Sm-153	270	44
Br-82	236	-*)
P-32	137	-
Tl-201	115	-
I-125	77	4
I-123	74	53
H-3	72	< 1
Ho-166	60	3
Y-90	54	-
S-35	51	-
In-111	27	-
F-18	-	20
others total **)	29	1
Total	**59 280**	**14 788**

*) The "-" symbol indicates no imports/exports.
**) Imports, nuclides: C-14, Ca-45, Co-57, Cr-51, Eu-152, Fe-55, Fe-59, Ga-67, Ge-68, I-125, I-129, Na-22, P-33, Po-208, Pb-86, Re-186, Sb-125, Se-75, Sr-85 and Sr-89.
Exports, nuclides: C-14 and I-129.

Table X. Manufacturing of radioactive substances (unsealed sources) in 2004.

Radionuclide	Activity (GBq)
O-15	22 400
C-11	9658
F-18	8468
I-123	3350
Br-182	1554
La-140	55
Na-24	11
others total*)	< 1
Total	**45 496**

*) Nuclides: Au-198, Cd-109, Cu-64 and Sm-153.

2.6 Individual Monitoring

Background

The Dose Register maintained by STUK records the radiation exposure data of workers subject to individual monitoring. The individual doses of workers are determined by approved dosimetric services. Data were supplied to the Register in 2004 by nuclear power plants and by Doseco Oy (which also maintains the dosimetric service for the Olkiluoto nuclear power plant), by the measurement services of STUK with respect to internal radiation and chromosome analyses, and by the airlines Finnair Oyj and Oy Air Finland Ltd. Data are also recorded in the Register from Radiological Monitoring Documents for persons who have worked abroad and from reports received from the Swedish Dose Register.

The doses arising for workers from external radiation are measured using personal dosemeters. The measurement results are reported in terms of the quantity personal dose equivalent, either $H_p(10)$ or $H_p(0.07)$, which are (usually) sufficiently accurate approximations of the effective dose and the equivalent dose to the skin. If the personal dose equivalent is large, then the exposure circumstances are investigated and an assessment is made of the effective dose or the equivalent dose to the skin of the person concerned. The measurement results of $H_p(10)$ fail to correspond to the effective dose when using individual protective appliances (use of X-radiation in health care and veterinary medicine), in which case the effective dose is reckoned from $H_p(10)$ by dividing the latter by a figure between 10 and 60. The dosemeter is placed on the lead apron so that the result of dose measurement will also describe the exposure of unshielded parts of the body.

The doses arising for the worker from internal radiation are determined from secretion samples or from body activity measurements performed using whole body counting appliances. The worker's effective dose is reckoned from the measured activity and recorded in the Dose Register.

The recording level (value below which doses are recorded as zero) for $H_p(10)$ 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 persons, depending on the duration of the measurement period. The recording level for $H_p(0.07)$ is either 2 mSv per month or 6 mSv per quarter.

Category A workers departing for radiation work within the territory of the European Union require a Radiation Passbook. This comprises a Radiological Monitoring Document procured from STUK (an extract from the Dose Register) and a certificate issued by the medical practitioner responsible for medical surveillance of the worker. The Monitoring Document must be submitted to the responsible party abroad, who records details of the duration of radiation work, of radiation exposure and of any medical inspections on the said document. The document is returned to STUK after the overseas assignment ends, so that the details can be recorded in the Dose Register.

Individual monitoring in 2004

11 082 workers were subject to individual monitoring at 1153 workplaces. A total of approximately 135 000 dose entries were made. 35 per cent of employment relationships of exposed workers were classified in category A and 65 per cent were classified in category B. A small number of persons not classified as exposed workers were also subject to individual monitoring.

In no case did the effective dose of a worker exceed the annual dose limit of 50 mSv. However, the annual average value of 20 mSv reckoned from the five-year dose limit (100 mSv) was exceeded in the case of one person due to an abnormal incident (see incident 1 at item 2.8). In no case did the dose to a worker's hands exceed the annual dose limit of 500 mSv. The total dose was 2 per cent lower in the use of radiation and 75 per cent larger in the use of nuclear energy than the corresponding figures for the previous year. The 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 effective dose in industry was a dose of 25.9 mSv sustained by an industrial radiographer (see previous paragraph). The largest radiation doses in industry are generally caused by unsealed sources and the use of industrial X-ray appliances. Some industrial radiographers working in industry also work at nuclear power plants. The radiation doses that they sustain at nuclear power plants are reckoned together with the dose for persons working in material testing (see Table XIII).

The largest $H_p(10)$ arising from X-radiation in health care was 31.7 mSv recorded for an interventional radiologist. This corresponds to an effective dose of about 0.5–3.2 mSv. Besides X-ray appliances, other radiation sources are used in health care, and the $H_p(10)$ values measured for the users of such sources are approximations of the effective dose. The largest dose in health care (excluding doses due to X-radiation) was 2.8 mSv.

The largest $H_p(10)$ in veterinary diagnostics was 7.0 mSv, recorded in the case of a veterinary surgeon. This corresponds to an effective dose of about 0.1–0.7 mSv. Besides X-ray appliances, only a few (2–6) people in veterinary diagnostics use other radiation sources (unsealed sources) each year. The largest effective dose for users of such unsealed sources in 2004 was 0.1 mSv.

The largest $H_p(10)$ sustained in research and education was 18.8 mSv recorded for a person who had used unsealed sources. Most of the total dose arising in research work is shared between only a few people. The doses arising for other persons were minor or fell below the recording level. The largest dose to the fingers was 337.1 mSv, recorded in the case of a researcher using unsealed sources.

The total dose sustained by workers at Finnish nuclear power plants was 4.0 Sv (sum of effective doses). 3.3 Sv of this total dose was recorded for outside workers and the remaining 0.7 Sv was sustained by the permanent staff of the power plants. 940 persons subject to individual monitoring worked permanently at Finnish nuclear power plants, of whom 462 sustained doses exceeding the recording level. There were 2125 outside workers, of whom 1298 sustained doses exceeding the recording level. The largest $H_p(10)$ was 16.9 mSv, sustained by a person working in electrical and instrument duties.

Effective doses exceeding the recording level of 0.1 mSv and arising from exposure to internal radiation occurred in the case of 12 nuclear power plant workers, one person working in industry and four persons working in research. The combined dose sustained by these workers from internal radiation was 3.7 mSv. One industrial worker also sustained a thyroid dose of 5.2 mSv, which exceeded the recording level of 2 mSv. Chromosome analyses were made for two industrial workers due to an abnormal incident. No doses exceeding the analysis observation threshold of approximately 100 mSv were found in these measurements.

32 Radiological Monitoring Documents were supplied from the Dose Register during 2004. 44 worker doses were investigated more thoroughly than normally in routine work.

Trends observed in individual monitoring

The overall number of persons subject to individual monitoring on account of the use of radiation has steadily fallen in recent years. This is particularly noticeable in research, but can also be observed in industry. On the other hand, the opposite trend has occurred in the use of X-radiation in health care and veterinary medicine.

No corresponding trend has been visible in overall doses. Discounting minor deviations, overall doses have remained broadly constant. The overall dose has fallen only in the use of X-radiation in health care. The reason for this is a clear fall in the largest doses obtained.

Statistical information

The number of workers subject to individual monitoring in 2004 is shown in Table XI and the combined doses of workers in various occupational categories are shown in Table XII. For comparison, the tables also show the corresponding details for the years 2000 to 2003. Table XIII shows the doses in 2004 of persons sustaining high levels of exposure or of numerically large worker groups.

2.7 Radioactive Waste

184 waste packages had been transported to the national storage facility for low-level radioactive waste maintained by STUK by the end of 2004. The activities or masses of the most significant waste held in the storage facility are shown in Table XIV.

Before the waste is sent to the storage facility, it is transported to an interim storage unit at the STUK's premises at Roihupelto in Helsinki. This interim storage unit received 59 batches of low-level waste in 2004, comprising a total of 160 packages. Table XV shows the activities or masses of the waste consigned to STUK in 2004.

Table XI. Number of workers subject to individual monitoring in 2000–2004.

Year	Number of workers in various occupational category						
	Health care		Veterinary medicine	Industry	Research and education	Use of nuclear energy*)	Total**)
	Exposed to X-radiation	Exposed to other radiation sources					
2000	4530	954	292	1032	1255	2826	10 757
2001	4576	919	288	1128	1362	2753	10 899
2002	4697	891	296	1180	1209	3055	11 190
2003	4741	906	305	1114	1109	2862	10 901
2004	4759	915	328	1070	1025	3124	11 082

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

**) The figure shown in certain rows 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 XII. Total doses in various occupational categories (sums of $H_p(10)$ values) in 2000–2004.

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					
2000	1.63	0.11	0.07	0.22	0.10	4.40	6.53
2001	1.68	0.11	0.06	0.22	0.10	2.58	4.75
2002	1.69	0.13	0.07	0.24	0.09	4.12	6.36
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

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

Table XIII. Data on certain occupational groups in 2004.

Group	Number of workers	Total dose (Sv)	Average dose (mSv)		Largest dose (mSv)
			Workers*) whose dose ecxeeds recording level*)	All workers subject to individual monitoring	
Cardiologists**)	167	0.56	4.3	3.4	28.2
Radiologists**)	574	0.41	2.3	0.7	26.4
Interventional radiologists**)	21	0.18	9.2	8.7	31.7
Surgeons**)	229	0.09	2.4	0.4	16.6
X-ray assistants**)	2580	0.11	0.5	0.0	3.1
Industrial radiographers	349	0.13	1.5	0.4	25.9
Researchers	769	0.04	1.2	0.0	3.7
Nuclear power plant workers					
• mechanical duties	852	1.41	2.3	1.7	15.0
• cleaning	188	0.50	4.1	2.7	14.9
• material testing	266	0.52	2.4	1.9	15.8
• insulation work	146	0.56	4.4	3.9	15.3
• radiation protection	83	0.28	4.2	3.3	15.2
• operating staff	238	0.11	0.9	0.5	6.6

*) 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.

**) Doses given in this table are measured $H_p(10)$ values. These values have to be divided by a figure of 10–60 to get the effective dose in cases where a worker is exposed to X-radiation and is wearing individual protective appliances. Workers in other worker groups in this table do not usually wear protective appliances. Thus, their $H_p(10)$ values are good estimates to effective doses.

Table XIV. The principal low-level radioactive waste in the Olkiluoto facility (December 2004).

Radionuclide	Activity (GBq) or mass
H-3	17 502
Co-60	227
Kr-85	1312
Sr-90	268
Cs-137	2273
Ra-226	231
U-238	687 kg
Pu-238	1634
Am-241	1196
Cm-244	80

Table XV. Low-level radioactive waste received by STUK in 2004.

Radionuclide	Activity (GBq) or mass
H-3	17,9
Co-60	9,6
Ni-63	0,7
Kr-85	181
Sr-90	129
Cs-137	164
Pm-147	63
Ra-226	1,0
U-238	240 kg
Am-241	211

2.8 Abnormal Incidents

There were 17 cases in 2004 in which abnormal incidents or situations occurred or were suspected in the use of ionizing radiation. 6 of these cases concerned the use of radiation in industry and research and 11 involved the use of radiation in health care.

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

Incident 1

Two industrial radiographers were exposed to radiation because the radiation source used in radiography did not return to its container after the work. This was due to a fault in the container locking mechanism. While the radiographers were using alarming dosemeters to detect hazardous situations, they did not hear the alarm immediately as the workplace was noisy and they were wearing earmuffs. The radiographers sustained radiation doses of 11 and 18 mSv. Although this means that the annual dose limit of 50 mSv for a worker was not exceeded, the dose received at work in addition to this abnormal incident was enough for the annual dose of one of the radiographers to exceed the average dose of 20 mSv reckoned from the five-year dose limit of 100 mSv (see item 2.6).

STUK classified this incident at level 1 on the 7-level International Nuclear Event Scale (INES). STUK also notified the International Atomic Energy Agency of the incident, as any fault in the radiographic appliance could also be repeated in other corresponding apparatus.

The faulty appliance was taken out of use.

Incident 2

An industrial radiographer was exposed to X-radiation passing through an object to be imaged when installing the film on the said object. The radiographer's alarming dosemeter sounded an alarm and the radiographer immediately withdrew from the area. Another radiographer had mistakenly activated the X-ray appliance too soon without noticing the whereabouts of the exposed radiographer. The dose sustained by the radiographer was 6 µSv.

The responsible party reminded the worker to pay attention to the movements and whereabouts of the worker's partner.

Incident 3

An X-ray tube used for imaging welded joints was warming up in preparation for imaging at an industrial plant. Although the radiation aperture of the X-ray appliance was shielded with a lead bulb, the radiographers did not allow for the leakage radiation emerging backwards from the X-ray tube. An alarm came from the alarming dosemeter of the plant's own radiation supervisor, who was nearby. The leakage radiation dose rate was measured to be 10–15 $mSv{\cdot}h^{-1}$. Both radiographers sustained a dose of about 80 µSv.

STUK instructed the responsible party in charge of radiography to ensure that supervision was also adequate during pre-heating of the X-ray tube.

Incident 4
The ^{137}Cs radiation source of a flow meter, of activity 74 MBq, was lost in the course of renovating a papermaking machine. None of the workers who dismantled the machine had noticed the warning sign on the radiation source. The radiation source had been taken together with other scrap to the paper mill scrap yard for interim storage, from which it had been further consigned to the storage area of a scrap processing facility. A search for the radiation source was conducted at the facility, but this was unsuccessful. The facility was advised of the matter and given a precise description of the lost item. The facility is now continually monitoring all outgoing material.

Incident 5
A responsible party lost the ^{244}Cm radiation source of a fluorescence analyzer with an activity of 2220 MBq. The responsible party suspects that the apparatus has been sent for scrap together with other decommissioned electronic equipment.

STUK asked the responsible party to investigate the scrapping route. The responsible party distributed a brochure on industrial safety in the disposal of radiation sources to the persons in charge.

Incident 6
A faulty industrial radiography appliance was sent from Finland for inspection and repair in the United Kingdom. The recipient observed that the appliance had not been serviced regularly and that repairs had been made thereto that differed from the appliance certificate issued by the manufacturer, meaning that the appliance no longer satisfied the terms of the certificate. As the said terms were not satisfied, the approval for use of the appliance as a transportation package for radioactive substance was likewise no longer in force. This means that the appliance should not have been consigned for transportation.

An investigation of the case revealed that the transportation did not occasion any direct safety risk, as the source had been locked in the "safe" position during transportation. The reason for inadequate servicing proved to be a lack of clarity over division of duties between the user of the appliance and the enterprise responsible for changing the source of the appliance.

STUK ordered the enterprise using the appliance to maintain a record of all inspections, servicing and repairs of the apparatus and instructed the enterprises in question to agree on their mutual division of duties. Instructions were also issued to ensure that the requirements of the manufacturer's appliance certificate were met in the case of other corresponding appliances.

Incident 7
Cancerous metastases on the cervical spine of a radiotherapy patient were treated using a single dose that was nearly twice the planned dosage. Two therapy fields were planned for the patient instead of the normal single field therapy, but the monitor units of the therapy appliance were calculated in accordance with single field therapy. The monitor unit calculation was made at the time of arranging the therapy simulation. The intention was for the patient to receive 10 therapy sessions, but the therapy was terminated after seven sessions after the error had become apparent.

The incident was explained to the patient. The therapeutic practices were changed so that corresponding two-field therapies would in future be performed only through dose planning based on computer tomography imaging. The incident will also be discussed at the radiotherapy physicists' conference in 2005.

Incident 8
A radiotherapy overdose was administered as symptomatic therapy because of an incorrect single dose. Therapy comprising a single dose of 2 Gy for five therapy sessions was erroneously entered into the computation program as two therapy sessions with a single dose of 5 Gy. The therapy was therefore administered at settings corresponding to a dose of 5 Gy, but the single dose was entered on the therapy chart as 2 Gy. One further therapy session was subsequently added to the therapy order. The patient thereby received a dose of 30 Gy instead of 12 Gy.

The practice of dose planning inspection was changed so that even the calculations for small single doses are checked against the dose plan in addition to the present inspection. The incident will be discussed at the radiotherapy physicists' conference in 2005.

Incident 9
Metastases on the cervical spine of a radiotherapy patient were to be treated by administering five single doses of 4 Gy. Due to an error in calculation, however, the single dose was 8 Gy. The error was noticed in a routine inspection of therapy cards after the fourth therapy session. The patient therefore received a dose of 32 Gy instead of 20 Gy. The error was due to an operating error in the computation program in which the calculation of two opposing fields was performed using a computation method for an individual field.

The incident was discussed with the persons involved in administering the therapy and also with the patient. It was also discussed at the radiotherapy physicists' conference in 2004. The inspection procedure was amended so that a physicist now inspects the therapy card for the first time before the therapy begins.

Incident 10
A radiotherapy patient received pain therapies at several points in the spinal area. Due to a misinterpretation of old and new entries, the therapy field and about 10 per cent of the therapeutic dose was partially applied to the wrong area. The error was detected from the machine image and the matter was rectified before the next therapy session.

Procedures have been amended so that the technician now has access to a printout of the therapy when beginning radiotherapy.

Incident 11
An outdated table of readings was restored to the planning software when updating a radiotherapy program version. As a result, 63 patients received therapy at a dose that was approximately 4 per cent too low. The error in readings was detected when the machine broke down and a patient was treated using another machine. The therapy of 31 of the incorrectly treated patients was not yet complete, and so it was possible to revise and supplement their doses. However, 32 patients had completed their therapies, and so no dose supplement was made. An entry regarding the abnormal therapy was made on the therapy cards of these patients for further follow-up.

Quality control practises in therapy have been amended so that the correspondence between the dose planning equipment and the doses from the therapy appliance is verified by measurement after any program version update.

Incident 12
Internal radiotherapy using an ^{192}Ir source was incorrectly planned and in the first therapy session a patient sustained a dose that was approximately five times the correct dose. The error was detected before the second therapy session and the therapy was terminated, as it was considered that the single large dose had biological effects corresponding to the tolerance dose for the entire course of therapy. The reason for the incident was a miscalculation made when translating the source activity times that were programmed into the dose planning system into the source activity of the therapy appliance. The source activity of the therapy appliance at the time was not programmed into the dose planning system.

Following the incident the activity of the therapy appliance radiation source was programmed into the dose planning system. Attention was also paid to independent inspection of dose plans.

Incident 13
An X-ray technician remained in a computer tomography imaging room for a period of about one minute while the appliance was warming up. The technician was about 2 metres from the tunnel of the imaging appliance. Although the technician was exposed to scatter radiation from the appliance, the amount of scattered radiation was very small because there was no patient in the appliance.

The incident will be discussed at the radiotherapy physicists' conference in 2005.

Incident 14

A patient due for skeletal gamma imaging was administered 150 MBq ^{99m}Tc-MAA instead of ^{99m}Tc-HDP. The reason for the incident was the failure of a technician to check the contents of the syringe again before the injection.

The patient sustained an effective dose of 1.8 mSv. The matter was discussed between the persons involved in the incident.

Incident 15

A patient who arrived for iodine therapy was unable to swallow the therapy capsule (518 MBq). The capsule remained in the patient's mouth for a few minutes before it was removed. The capsule remained intact and no iodine escaped. The capsule was replaced in its transport container.

Incident 16

The movable lead cover protecting a technetium generator in a radiopharmaceutical processing cupboard failed to close in a normal manner. A technician attempted to replace the cover by hand, but the technician's hand became jammed between the heavy lead cover and the front wall of the cupboard. The cover was opened after receiving instructions from the cupboard manufacturer by telephone. The dose to the fingers was less than 500 µSv and the dose to other parts of the hand was less than 10 µSv. The skin of the hand was mildly abraded but no fractures were found.

The incident was discussed with the manufacturer and supplier of the cupboard. The device mechanism was improved and warnings were added to the operating instructions.

Incident 17

A patient requiring therapy for a hyperactive thyroid was mistakenly given an ^{131}I capsule intended for another patient. The patient sustained an amount of 370 MBq ^{131}I instead of the prescribed amount of 185 MBq. The error was quite soon detected and the patient was recalled within a couple of hours of administering treatment. Within about three hours of the treatment, a 130 mg Jodix tablet was administered to the patient.

Inactive iodine administered within some 5–6 hours of sustaining radioactive iodine reduces thyroid uptake of radioactive iodine by about 50 per cent when the thyroid is functioning normally. Uptake of ^{131}I may be more rapid in a patient with a hyperactive thyroid, however. At best, the effect of the treatment was close to the intended effect.

The attending physician was notified of the incident immediately. The radiation safety officer only learned of the incident some two months later, and STUK was not advised until three months after the incident. A feedback session arranged by the radiation safety officer after the incident reviewed operating procedures to avoid any corresponding incidents and stressed the importance of faster notification procedures.

3 Regulatory Control of Practices Causing Exposure to Natural Radiation

3.1 Background

Under section 45 of the Radiation Act, whoever uses earth, rock or other raw materials existing in nature for industrial purposes is required to investigate the radiation exposure caused by this practice if it is found, or if there is reason to suspect, that the practice constitutes a radiation practice. The same applies to an employer if it is discovered, or if there is reason to suspect that the radiation exposure originating from natural radiation and occurring in the employer's working facilities or other workplace causes or is liable to cause a health hazard.

3.2 Radon

Radon at workplaces

The principal factor causing exposure to natural radiation at workplaces is indoor radon. STUK monitors radon in mines, excavation works and other underground workplaces and in other workplaces where there is a high concentration of radon. The action level for radon concentration in regular work is 400 Bq·m^{-3}.

The responsible party is required to notify STUK of the results of radon measurements made at workplaces whenever the concentration exceeds the level of 400 Bq·m^{-3}. During 2004, STUK was notified of a total of 166 track detector measurements and 46 measurements made during working hours using a continuously monitoring instrument. 85 of the measurements notified concerned a radon concentration measured at a work area that exceeded the action level, and the rest concerned further investigations of previously measured excessive levels. 117 workplaces including a total of 246 work areas were monitored by STUK during the year.

A total of 90 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 at 45 work areas, and a measurement at another time of year in order to determine an annual average at 3 work areas. Even though the radon concentration exceeded 400 Bq·m^{-3} at 45 work areas, no requirements were imposed, as annual working hours at these work areas were shorter than normal. A total of 54 orders were issued to workplaces on account of failure to take remedial measures or to perform investigations. One workplace was also ordered to keep records of working hours and perform regular radon measurements in order to monitor worker exposure.

Monitoring was discontinued at 55 work areas during the year due to successful radon reductions. Monitoring was discontinued for a total of 35 work areas on the basis of further investigations (measurement during working hours or determination of annual averages). Monitoring was discontinued at 37 work areas for other reasons (e.g. closure of the premises). A total of 55 workplaces and 74 work areas were under control at the end of the year.

A periodic radon inspection was conducted at five underground mines, at all of which the average radon concentration fell below the action level of 400 Bq·m^{-3}. 12 underground excavation sites were inspected, and the radon concentration action level was exceeded at one of these. Worker exposure will be monitored through regular radon measurements and recording working hours at this workplace until the radon concentrations will be reduced to less than the action level.

Approval of radon measuring instruments

The measuring instruments or methods used for establishing radon concentrations when determining worker exposure to radiation must be approved by STUK. It is a condition of such approval that the measuring instrument is properly calibrated. Table XVI shows a list of organizations (enterprises, corporations, institutions etc.) having instruments that are approved for determining worker exposure to radon and possess a current calibration. The table includes the dates by which the instrument must be recalibrated in order for the approval to remain in force.

3.3 Other Natural Radiation from the Ground

STUK monitors the radioactivity of water intended for human consumption pursuant to Guide ST 12.3. The Guide applies to water distributed by water utilities for consumption by more than 50 people or 10 households. No water utility or water co-operative was ordered to take action during 2004. Monitoring was discontinued for two utilities, of which one had completed repairs to eliminate radioactive substances from the water and the other had been connected to the local authority water network.

An inspection report was also prepared on radioactivity measurements on the water used in manufacturing bakery products. The amounts of radioactive substances remaining in the final products were so small that no further measures were necessary.

3.4 Cosmic Radiation

Section 28 a of the Radiation Decree (Amendment 1143/1998) requires monitoring of radiation exposure to be arranged for aircraft crews on the same principles as for those engaged in radiation work where the effective dose of crew members may exceed 1 mSv per year.

The exposure of aircraft crews to cosmic radiation has been monitored in Finland since 1992. The doses are estimated using special computation programs. The calculations allow for the flight paths and flying times of workers. The individual doses sustained by aircrews from cosmic radiation have been recorded in the Dose Register since 2001.

Individual radiation doses in 2004

The staff doses notified by Finnair Oyj and Oy Air Finland Ltd were recorded in the Dose Register. The largest individual doses of cosmic radiation were 4.4 mSv sustained by a pilot and 4.9 mSv sustained by a cabin crew member. In no case did the individual dose sustained by a worker exceed the annual action level of 6 mSv. The average doses sustained were 1.6 mSv for pilots and 1.9 mSv for cabin crew. The number of workers subject to individual monitoring and their combined effective doses are shown in Table XVII, which also shows the corresponding figures for 2001–2003 to facilitate comparison. The figures for pilots and cabin crew are shown separately.

Table XVI. 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 2006	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 • Turku Polytechnic • Tampere Polytechnic	• Pylon AB-5 • Pylon AB-5 • Pylon AB-5 and AlphaGuard	• 11 Jun 2006 • 11 Jun 2006 • 22 Sep 2006 23 Sep 2006	Continuously monitoring instruments that can record variations in radon concentration over time. These instruments are suitable for measuring radon concentration during working hours.

Table XVII. Number of air craft crew members subject to individual monitoring and total effective dose of cosmic radiation in 2001–2004.

Year	Number of workers		Total dose (Sv)	
	Pilots	Cabin crew	Pilots	Cabin crew
2001	677	1751	1.14	3.03
2002	692	1799	1.07	2.93
2003	739	1746	1.09	3.02
2004	739	1801	1.19	3.45

4 Regulatory Control of the Use of Non-Ionizing Radiation

4.1 Background

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 practices giving rise to non-ionizing radiation, even though this control is not directly comparable to regulatory control of the use of ionizing radiation. Regulatory control by STUK focuses particularly on areas involving safety risks that are not controlled by other public authorities.

Regulatory control of non-ionizing radiation by STUK is based on the Radiation Act and subordinate statutes.

4.2 Optical Radiation

Regulatory control of sunbed equipment

Regulatory control of sunbeds was continued as before by inspecting 30 sunbed facilities. The inspections paid particular attention to ensuring that exposure schedules comply with the Decree of the Ministry of Social Affairs and Health on the Limitation of Public Exposure to Non-Ionizing Radiation (294/2002), and that sunbed keepers are familiar with the requirements of the said Decree restricting the use of sunbeds by persons under 18 years of age. The situation remained broadly the same compared to previous years. Appliance timers failed to comply with requirements in about one-third of all places of use. A few appliances were fitted with lamps that were too powerful. Written instructions for users were found at nearly all facilities, even though these instructions did not comply with requirements in all cases.

The radiation safety of "artificial sun" installed aboard a cruise liner was assessed by radiometric measurements and instructions were issued on limiting the dose of UV radiation to the skin and eyes of customers.

A sunbed inspection conducted at the end of 2003 discovered a sunbed appliance that had been incorrectly classified as a UV type 3 appliance, even though the radiation emitted by the appliance clearly exceeded the radiation limits for a type 3 appliance. A RAPEX notification regarding a hazardous consumer product was submitted to the European Commission regarding this appliance during the year under review.

A new, improved CCD spectroradiometer proved a serviceable measuring instrument for regulatory control of sunbed facilities.

Other regulatory control

STUK prohibited the organizer of a techno music event at the Old Students' House in Helsinki from distributing laser pointers to the audience at the time of purchasing tickets to the event.

Three items of high power laser equipment for use in public performances were inspected.

The occupational safety risks involved in using a UVC sterilizer in a bakery were reviewed by taking measurements and the bakery staff were given the necessary precautionary instructions.

4.3 Electromagnetic Fields

Market surveillance of mobile phones

SAR-measurements in accordance with European standard EN 50361 were performed for 18 GSM mobile phones of varying type on the market and the results were published on the website of STUK. The highest SAR value measured was 1.07 $W \cdot kg^{-1}$, and so no mobile phone exceed the maximum prescribed value of 2 $W \cdot kg^{-1}$. The measurement results matched those notified by the manufacturers within the measurement uncertainty. Two mobile phones were also tested in comparison measurements arranged with the South African Bureau of Standards (SABS), and SAR measurements were taken as a service assignment for one mobile phone antenna under development.

Other regulatory control

The radiation safety of one GSM base station was assessed.

The radiation safety of mast work at one public broadcasting station was assessed with measurements and instructions were issued for diminishing radiation levels during the said work.

The radiation level generated by four air surveillance radar installations was measured at a military base. The objectives of these measurements included checking whether the permitted radiation levels were exceeded at a training centre constructed in a manner contrary to previous instructions of STUK. While no excessive radiation levels were detected, it was agreed for the sake of caution that the main beam would be restricted to exclude the training centre. A further objective of the measurements was to guide the Finnish Air Force in revising its current precautionary instructions.

4.4 Abnormal Incidents

The abnormal incident notification required by section 17 of the Radiation Decree also applies to incidents arising in the use of non-ionizing radiation (see item 2.1). One abnormal incident concerning exposure of a worker to UV radiation occurred in 2004.

Incident 1

A person working in a pharmacy was exposed to powerful UVC radiation. A UV lamp (30 W) was mistakenly left on in a laminating cupboard when preparing a medicine, and a worker was then exposed to UVC radiation for approximately 40 minutes. The worker sustained skin burns on the forehead, neck and cheekbones. The worker also suffered from eye inflammation despite wearing spectacles providing partial protection from UV radiation. The symptoms were reddening of the conjunctiva and mild photophobia. STUK advised the worker of the dangers of UVC radiation. The worker had not sought medical advice, as the pain was not acute. There were no warnings at the pharmacy regarding the hazardous character of the UV lamp.

Greater attention will be paid in future to protecting and warning employees.

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 2004:
ST 1.4 Radiation User´s Organization
ST 1.8 Qualifications of Persons Working in Radiation User´s Organization and Radiation Protection Training Required for Competence.

5.2 Other Regulation Work

Proposals for amendments to legislation were prepared for the Ministry of Social Affairs and Health in respect of implementation of the HASS Directive (see also item 2.3) and of dosimetric services and methods. This preparatory work will continue in 2005. The Ministry of Social Affairs and Health was also assisted in preparing a Directive on optical radiation.

Together with the Natural Radiation Laboratory (LSL) of the Department of Research and Environmental Surveillance (TKO) of STUK, STO began preparing an application guide for the European Commission on arranging radioactivity monitoring in accordance with the Directive on water intended for human consumption. This work will continue in 2005.

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

Improved optimization in the use of CT appliances

The number of computerized tomography (CT) examinations has risen continually and new areas of use have been discovered for this technique as the appliance technology has developed. Even though CT scans constitute only 5 per cent of all X-ray examinations, they give rise to about 40 per cent of the total X-ray dose administered to patients for diagnostic purposes. The quality criteria and reference levels issued by the European Union are partially out of date, and optimization of the use of new multi-slice appliances in respect of image quality and dose has often laid too much emphasis on good image quality. The aims of the research project of STUK are:

- to prepare recommendations for improving optimization
- to update the reference levels for CT scans and to issue such levels also for paediatric examinations
- to develop a suitable routine method for inspections
- to update the quality assurance guide for CT scans.

All new CT appliances were measured on commissioning in 2004 and old appliances were measured in accordance with a separate schedule. Quality assurance practices were investigated at each place of imaging. The project plan was revised and expanded to include an assessment of optimization, which will be performed by radiologists from the Hospital District of Helsinki and Uusimaa (HUS) in spring 2005. A final project report will be prepared at the end of 2005.

Optimization of radiotherapy quality control based on risk analysis

This project seeks to develop a method based on risk analysis enabling assessment of the effectiveness of radiotherapy quality control methods and optimization of quality control programmes. The study will be conducted in association with the radiotherapy unit of HUS. During 2004 an analysis was made of how quality control measures and the intensity of quality control (the frequency of testing) in determining doses in various ways affect the risk to the patient (tumour control). An article will be prepared for publication on the basis of the findings in 2005. The study will continue until autumn 2005, when a second publication will be prepared.

Radiation doses of staff in interventional radiology examinations

The aim of the study is:

- to investigate the radiation doses of staff in each examination separately and to relate these to patient doses in corresponding examinations
- to investigate the proportion of the dose to staff sustained at various stages of work (fluoroscopy/imaging).

While measures taken to initiate the project included agreeing with Rados Technology Oy on the loan of dosemeters, the project did not otherwise proceed according to the planned schedule. The aim of the project is to obtain preliminary results during 2005.

Irradiation equipment for biological research

The aim of the project is to design and manufacture an irradiation appliance based on an alpha source for the purpose of biological research. The project will be implemented in association with the Radiation Biology Laboratory (SBL) of the Department of Research and Environmental Surveillance (TKO) of STUK and will form part of research conducted by SBL into the bystander effect.

The irradiation appliance was designed in 2004 and the necessary radiation source was obtained. The appliance is currently being constructed and will be commissioned on a trial basis in early 2005.

Measurement and calibration methods for radiotherapy

This project began in 2003 with the following aims:

- to prepare instructions for calibrating radiotherapy dosemeters and the measurements made using them (calibrations of radiotherapy radiation beams)
- to prepare technical instructions and model calibration certificates for the Radiation Metrology Laboratory of STO (the DOS Laboratory).

The project was completed and its findings were published in report STUK-STO-TR-1. The instructions were mainly based on the TRS 398 and TRS 381 guidelines of the IAEA and will be used by STUK and by hospital radiotherapy units.

Masters's thesis work

The masters's thesis work of STO with university students continued from the previous year and three new theses were started in 2004. The results of this work may be utilized in the operations of STUK or will help to improve radiation safety in Finland.

Reference levels for paediatric X-ray examinations

The aim of the work was to study the basis for establishing patient dose reference levels for paediatric X-ray examinations.

The work was completed in 2004. It was not possible to establish reference levels based on the work, as the available background data were insufficient. Work to gather the missing data was begun immediately on completion of the thesis and the reference levels will be established in 2005.

Calibration and measurement methods for DAP meters

The aims of this work were:

- to produce a guide for STUK and radiation users on a calibration procedure for DAP meters (instruments measuring the product of dose and surface area) used in X-ray diagnostics
- to produce a methodology and operating format for arranging calibration of DAP meters as a service function of the DOS Laboratory.

The work was completed in 2004 and the calibration procedure that was developed in the work has been adopted by the DOS Laboratory. A draft was prepared of field meter calibration instructions for radiation users. Draft internal guidelines also exist for the DOS Laboratory.

The role, responsibilities and duties of a radiation safety officer

The aims of this work were to investigate:

- the duties and work of radiation safety officers engaged in medical uses of radiation
- the safety culture prevailing among radiation safety officers.

The work was begun and completed in 2004. The findings of the work indicate that improving the safety culture of radiation safety officers will require clarification of their terms of reference, reinforcement of their status within the organization and an increase in their capacity to influence their workplaces. The work also found that training of radiation safety officers and co-operation with various parties should be increased and improved in order to ensure that their ability to act is consistent with their responsibilities to enable them to influence radiation safety attitudes and practices at work.

Quality assurance in digital imaging

The aims of the work are:

- to prepare a summary of the principles that may be applied to quality control for various types of digital imaging appliances
- to investigate any recommendations that may

be issued for quality control of digital X-ray imaging systems.

This work has not progressed according to schedule and is continuing. The findings of the work will be used in a guide to quality assurance to be prepared for radiation users in 2005 and published in the bulletin series of STUK.

Patient radiation exposure in X-ray examinations

This work is investigating the radiation exposure sustained by patients in the most common X-ray examinations and the reliability of exposure determinations. The work is proceeding on a trial basis ("as a pilot study") with the assistance of selected X-ray examination units. The findings of the work will form the basis for conclusions and proposals on a procedure for national monitoring of patient radiation exposure. The work is due to be completed in spring 2005.

Patient radiation exposure in bone mineral density measurements

This work is developing methods to measure the radiation exposure sustained by the patient in bone mineral density measurements based on X-ray imaging. The measured data are used to calculate the effective doses caused by typical examinations. The work will also provide information for national monitoring of patient exposure. The work is due to be completed in spring 2005.

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.

Development of irradiation systems for research (CEMFEC)

The effects of mobile phone radiation on rats was studied at the University of Kuopio using exposure equipment developed by STUK. The project came to an end in 2004. A final meeting and concluding seminar for the project was held in Brussels at the end of April. The main findings were summarized in a published scientific article.

Health risk evaluation of mobile communications (HERMO)

The HERMO project is developing the equipment and methods required for exposing cells and animals to 900 MHz mobile phone radiation. The aims of the project are:

- to specify the dosimetry of a horizontal cell exposure chamber developed in earlier projects
- to develop the technology and dosimetry required in animal testing by other research teams.

The radial exposure chambers used for exposing young rats were serviced and installed in working condition at the University of Kuopio. A dipole irradiation system required for swine tests at Tampere University of Technology was designed, constructed and installed.

Research into methods of determining exposure arising from mobile phones and base stations (AMEST)

This project is developing testing and measuring methods to determine the exposure caused by electromagnetic fields emanating from mobile phones and base stations.

The pulsed currents from mobile phone batteries induce low frequency currents in the body. A program developed to calculate these was extended into a computation model covering the entire body. The findings were used to prepare two articles for publication in scientific journals partly in collaboration with the Electromagnetics Laboratory of Helsinki University of Technology.

A system was developed for calibrating antennae and near-field meters intended for measuring the radiation emanating from 3G base stations, comprising a waveguide and an antenna radiating in a radio anechoic chamber. A small electric field measurement probe is calibrated in the waveguide and the calibration is transferred by the measurement probe to the radio anechoic chamber. A similar system was also completed in a project financed by STUK for the 900 MHz GSM mobile phone frequency.

A rough method was developed for measuring scattered radiation emanating from 3G base stations using a spectral analyzer, and an investigation was made into how 3G modulation affects near-field meters and SAR measurement probes. It was observed that due to modulation a measurement probe fitted with a diode detector gives a reading that is much higher than it should be.

Development of practical methods of quality assurance for UV phototherapy appliances (UV therapy)

The final report of this project was prepared for the National Agency for Medicines. An article on the CCD spectroradiometer referred to in item 4.2 was prepared for publication in a scientific journal.

Other research activities

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

A meter for broadband magnetic fields

A version of a meter for measuring weighted peak values of magnetic fields fit for field service was constructed for in-house use. Small-series construction by STUK is no longer necessary, as a meter suitable for the purpose came onto the market at the end of last year. Negotiations on commercialization of the meter were begun with Environmentor of Sweden. These negotiations were assisted by Sirius Consulting Oy under the TULI ("from research to business") programme of the National Technology Agency of Finland (TEKES).

Other activities

An article on the transfer standard of SAR measurement probes was prepared for publication in a scientific journal.

An article on the temperature sensitivity of Bentham spectroradiometer diffusers was prepared for publication in a scientific journal. It was observed that there is a sudden and unexpected change of 3 per cent in diffuser attenuation at 19 °C, which is due to a phase change in the Teflon material. This kind of previously unknown shift significantly impairs measuring accuracy in the most precise measurements of solar UV radiation.

7 International Co-operation

Participation in meetings of international working groups

During 2004, representatives of STUK took part in meetings of the following international organizations and working groups:

- Radiation Safety Standards Committee (RASSC) of the IAEA. The committee held two meetings at which radiation protection regulations and instructions under preparation were discussed.
- Physics committee of the European Society for Therapeutic Radiology and Oncology (ESTRO), Amsterdam 24–28 October 2004.
- ESTRO EQUAL group, Villejuif, France 10 February 2004.
- Nordic working groups on dosimetry, X-ray diagnostics and sealed sources.
- Seminar for Nordic regulatory authorities. This seminar was arranged for the first time in Stockholm on 25–26 March 2004.
- European Collaboration on Measurement Standards (EUROMET) ionizing radiation working group.
- European Radiation Dosimetry Group (EURADOS) working group on harmonizing worker individual dose measurement methods.
- Nordic sealed source working group (NORGUS). This working group held its second meeting in Helsinki on 11–12 March 2004.

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 e.g. IAEA, EANM, ESTRO, EUROMET, CIPM and the European Commission).

Other international co-operation

In 2004, STUK became a voting member of the EURADOS organization.

A representative of STO participated in a collaboration project on X-ray diagnostics in the Russian Republic of Karelia co-ordinated by the Expert Services (ASP) unit of STUK. This collaboration seeks to provide guidance to local public authorities and X-ray specialists and to inform them of good practises.

Representatives of STO took part in projects to harmonize radiation legislation in Armenia, Romania and Slovenia, which were co-ordinated by ASP and financed by the European Union.

STO implemented a comparison of individual dosemeters as part of a European Union Twinning project (radiation protection development project for Lithuania). The findings of the comparison were analyzed and a report was prepared.

The NIR Laboratory assisted in preparing a Nordic radiation protection opinion on mobile phones and base stations led by the Swedish Radiation Protection Authority (SSI).

STUK led the preparation of the Nordic opinion on sunbed use and radiation safety.

A representative of STUK served as a thesis work director at the University of Tartu in Estonia. The aim of the thesis was to develop a method of measuring patient doses in X-ray examinations, measurement of average patient doses and comparison with European Union recommendations, and presentation of recommendations for implementing the patient dose determination requirements of Directive no. 97/43/Euratom in Estonia.

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

8 Co-operation in Finland

Finnish conferences arranged by STUK

An annual conference for radiotherapy physicists was arranged as a jointly financed event in Laukaa on 10–11 June 2004.

The annual Radiation Safety Conference was arranged jointly with the Radiological Society of Finland on 21–22 October 2004 in Tampere. Several lectures were given at this conference.

Together with the Ministry of Education, STUK arranged a seminar on 21 September 2004 for representatives of organizations providing radiation protection training in health care, the aim of which was to promote implementation of new guidelines for radiation protection training and co-ordination, implementation and documentation of such training.

Participation in meetings of Finnish working groups

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

- The National Board for Metrology and its measurement services and calibration subcommittees. Each subcommittee held one meeting.
- The SK 106 and SK 61 standardization committees for radiation safety of electromagnetic fields and domestic electrical appliances. Each committee held two meetings at which the corresponding standards proposals of the IEC and CENELEC were discussed. Comments and opinions were issued on 16 standards drafts in the final vote. Particularly noteworthy was the negative opinion in the final vote regarding the draft sunbed standard of the IEC (61/2688/FDIS). This standard permits uncontrolled use of appliances that are too powerful, the annual UV radiation dose from sunbeds is too high, and vagueness in the classification of appliances will hamper regulatory control at places of use.
- National group of experts on clinical auditing. The committee met three times.
- The national inter-university advisory board co-ordinating specialization of hospital physicists, which held its initial organization meeting.
- A working group appointed by the National Research and Development Centre for Welfare and Health (Stakes). This working group prepared a Stakes guide on recording the data gathered from mammography screenings and notifying the said data to public registers. This guide replaces the instruction of the National Board of Health (7/1990) on registration of mass examinations with respect to mammography screening. The findings of the work formed the basis for a Stakes report: "Guidelines and classifications 2004:6. Notice of mass screenings for breast cancer and cervical cancer".

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

STO continued its guidance of university student theses that began in 2003 and also began guiding three new student theses (see item 6.1). A representative of STO also served as a director of the following student theses prepared outside of STUK:

- Radiation dose and radiation risk to foetuses and newborns in X-ray examinations. This work sought to investigate the radiation dose and radiation risks in X-ray examinations of newborn children and foetuses, and to review radiation protection practices in X-ray examinations of women in fertile age. The work was completed at the University of Oulu in 2004.

- Standard of quality assurance regulations for the image quality of imaging workstation displays in radiological imaging units. This work sought to investigate the state of quality control for the image quality of imaging workstation displays in university and central hospital imaging units, the display hardware and the training of staff performing quality assurance. The work was completed at the University of Oulu in 2004.

Representatives of STO and the NIR Laboratory are involved in several Finnish commissions and expert groups dealing with regulatory control and research in the use of ionizing and non-ionizing radiation and with standardizing activities in the field of radiation (including the National Board for Metrology, the Radiation Safety Conference committee, Eurolab-Finland , SESKO).

9 Information Activities

Books, bulletins and reviews

STUK publishes the Radiation and Nuclear Safety book series including a total of seven books. The situation with respect to books edited at STO and the NIR Laboratory in 2004 was as follows:

- The "Use of Radiation" book (no. 3 in the book series) was completed.
- The manuscript was broadly completed for the "Non-ionizing Radiation – Electromagnetic Fields" book (no. 6 in the book series). The layout work for this book will begin in 2005.
- Just under half of the planned manuscript was completed for the "Non-ionizing Radiation – Ultraviolet and Laser Radiation" book (no. 7 in the book series).

A highly popular review of mobile phones and base stations was published in Swedish in the radiation and nuclear safety leaflet series of STUK.

The following bulletin was published in the bulletin series of STUK:

- Determining the radiation exposure of patients in X-ray examinations (1/2004).

The "Safety in the use of radiation" brochure was published as a printed version and the "Regulatory Authorities" and "Radiation Appliance Product Requirements" bulletins were released on the website of STUK (www.stuk.fi).

Public information on current affairs

The radiation arising from mobile phones and base stations continued to be a topic of considerable public interest.

The website of STUK was revised in respect of non-ionizing radiation in both the Finnish and Swedish languages. Adaptation of these pages in English was begun.

STUK continued to maintain the UV radiation index measuring service on its website, and has done so since the year 2000. The required measurement data are continuously gathered between April and September by a UV radiation meter installed on the roof of STUK building at Roihupelto in Helsinki.

Press releases were prepared on the following subjects:

- use of medical physics expertise in X-ray examinations
- regulatory control of dental X-ray practises
- stricter control of sealed sources
- reduction of the individual radiation doses of workers
- radiation protection training of physicians
- clinical auditing
- a hazardous situation in Porvoo caused by an unshielded radiation source and classification of the incident on the international INES scale
- employers and the duty to measure radon
- mammography appliance testing
- radiation testing of mobile phones
- prohibition of distribution of laser pointers to club guests
- the benefits and hazards of sunshine
- revision of the STUK website
- the Nordic opinion on the health effects of mobile phones.

Other information activities:

- Information on radiation protection, on new regulations, and on the background thereto was disseminated to responsible parties and radiation users at conferences, seminars and training events.
- Media interviews were given on questions of exposure to ionizing and non-ionizing radiation.

- Guidance on radiation protection problems was provided in the form of both telephone and Internet-based services to private individuals, enterprises and the public sector.
- Press articles and other written contributions were prepared.
- Articles were written for the ALARA magazine published by STUK.

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 2 study credits).

10 Metrology

The aim of metrological activities is to ensure adequate accuracy and international comparability in radiation measurement.

STUK has a duty under section 23 of the Radiation Act (Amendment 1334/1994) to maintain the metrological standards necessary to ensure reliable radiation measurements.

Development work on DOS Laboratory measurement and irradiation equipment and methods

The development work that was begun in 2003 by the Radiation Metrology Laboratory of STO (the DOS Laboratory) on calibration and measuring methods for dose-area-product meters (DAP meters) in X-ray diagnostics was completed and the methods were taken into use (see item 6.1). A draft of in-house instructions for using the new methods was prepared for the Laboratory.

The calibration and measurement accuracy of scintillation detectors were investigated for beta measurements of radiotherapy eye applicators. A calibration procedure was developed for scintillation detectors using the Laboratory's own beta source. The investigation showed that the measurement uncertainty in beta measurements made using a scintillation detector is about 6 per cent.

Renovation work was completed on the source transfer mechanism and electrical systems of the irradiation appliance used for producing ^{137}Cs and ^{60}Co gamma ray beams in radiation protection calibrations.

Specification of radiation quality parameters of the X-ray beams used in calibration continued. The radiation quality parameters used in radiation protection calibrations were specified in accordance with radiation quality standards.

Meter and measurement comparisons at the DOS Laboratory

The findings of the comparison of mammography radiation quality measurements (EUROMET 526) conducted in 2001 were received in 2004. The result of STUK differed from the reference value by +1.5 per cent. Although this deviation was slightly larger than expected, it was well within the measurement uncertainty of ± 2.5 per cent notified by the party that arranged the comparison.

In 2004, the DOS Laboratory took part in the following comparisons:

- the annual TLD comparison of the IAEA for ^{60}Co gamma radiation and 6 MV photon radiation.
- The TLD comparison of the IAEA for ^{137}Cs gamma radiation.
- The EUROMET 739 comparison of beta radiation measurements.

The findings of the EUROMET comparison and of the IAEA comparisons for ^{60}Co radiation and 6 MV photon radiation are not yet available. STUK result for comparison of ^{137}Cs gamma radiation differed from the reference value by 1 per cent, which is well within the comparison approval limit of ±5 per cent.

Development work on NIR Laboratory measurement and irradiation equipment and methods

The optical laboratory of the NIR Laboratory took part in a comparison of numerical calibrations of broadband UVA meters led by the Measurement

Technology Laboratory of Helsinki University of Technology. The Dutch and Turkish metrological standard laboratories and a UV phototherapy unit from Scotland were also involved in the comparison.

On assignment from the Swiss Federal Office of Metrology and Accreditation (METAS), the radiolaboratory of the NIR Laboratory calibrated two SAR measurement probes manufactured by SPEAG of Switzerland for frequencies of 900 and 1800 MHz. The purpose of these measurements was to compare the compatibility of SPEAG and STUK calibrations. The results of the comparison will be obtained during 2005.

11 Services

Calibration, testing and irradiation

The DOS Laboratory performed radiation meter calibrations on request. 61 radiation meter calibration certificates and 34 irradiation certificates were issued. About one third of these calibrations and irradiations were performed for measuring instruments and samples of STUK itself.

The NIR Laboratory performed a total of 30 radiation meter calibrations and tests and 12 safety assessments and radiation measurements.

Training services

STO arranged its annual training conference on radiation safety and quality in X-ray examinations on 18–19 March 2004 in Kajaani.

The DOS Laboratory took part in radiation protection training for Baltic customs officials hosted by STUK on 18 November 2004 by organizing and directing the practical radiation measurement exercices that formed part of the training.

In association with Tampere University Hospital, STO organized a course on radiation safety and quality control of CT appliances in Tampere on 2 December 2004.

STO arranged a training event on radiation protection for the staff of Mehiläinen Hospital on 31 January 2004 in Tuohilampi.

12 Other

12.1 Investigation of Radiation Protection Training

In 2003–2004, STUK investigated the state of radiation protection training in Finland and the need for training.

This investigation showed that the amount of radiation protection training of professional groups using radiation in health care corresponded on average to the objectives of Guide ST 1.7, with the exception of training of practical nurses and hospital nurses. There appeared to be large differences in the amount of training in certain professional groups depending on the educational institution. These differences may also be explained by the fact that radiation protection training is often provided with other academic subjects, making it difficult to assess the total amount of training. The respondents may also have different interpretations of the topics and subject areas included in radiation protection training. The most common need for further training was among nurses and certain specialist physicians. Some professional groups considered their radiation protection knowledge to be minimal, but were nevertheless unwilling to take further training. On the other hand, there were also professional groups who were keen to receive further training, even though they assessed their own radiation protection knowledge as good.

There appear to be no major shortcomings in radiation protection training among workers involved in the use of radiation in industry. Most industrial workers regarded their radiation protection training as suitable for their duties, and the need for radiation protection training was fairly minimal. The situation probably also reflects the fact that regular training has been arranged for radiation safety officers involved in the use of radiation in industry over the last 25 years.

The results of the survey were published in 2004 in publication STUK-B-STO 53. The findings were also presented at the 11th conference of the International Radiation Protection Association (IRPA) in Madrid and at a seminar arranged by STUK and the Ministry of Education for universities and other training organizations providing radiation protection training to health care staff (see chapter 8). A corresponding seminar for parties providing training in industry, research and education will be arranged in 2005.

12.2 Customer Satisfaction Surveys

STO customer satisfaction survey

In 2004, STUK conducted a customer satisfaction survey in the operating area of STO. This involved sending a questionnaire to 300 licensed responsible parties selected at random from the safety licence register.

114 questionnaires were completed and returned, so the response rate was 38 per cent. 50 responses concerned the use of radiation in industry, education, research and trade, and 52 concerned the use of radiation in health care. The field of work was not specified in 12 responses.

The overall assessment of the work of STUK was 8.8 on a scale from 4 to 10.

Customers were asked to give their opinions on various items on a scale from 1 to 5 (1=very unsatisfied, 2=unsatisfied, 3=neutral, 4=satisfied, 5=highly satisfied). Based on the responses obtained, the respondents were largely either satisfied or highly satisfied with the matters assessed. The averages reckoned from the responses to most questions were 4 or more.

The expertise and businesslike manner of STUK inspectors were very highly appreciated, as were STUK´s expertise, customer friendly manner, co-operative nature and impartiality. The lowest assessments (3.7–3.9) concerned the clarity of

STUK's website, the clarity of its press releases and the adequacy of the training that it arranges. The unstructured comments of respondents also called for STUK to arrange more training.

There were no significant differences between the responses provided from various sectors. The clearest distinction was in the responses that failed to specify the sector. These responses included most of the averages falling below a value of 4.

NIR Laboratory customer satisfaction survey

STUK also performed a customer satisfaction survey in 2004 regarding regulatory inspections and calibration and testing services provided by the NIR Laboratory.

The overall assessment by customers of STUK was 8.7 on a scale from 4 to 10.

Various items were asked on a scale from 1 to 5 (see STO survey above). On the whole, the respondents were largely either satisfied or highly satisfied with the matters assessed. The lowest assessment concerned service pricing. The expertise and businesslike manner of inspectors were very highly appreciated, as were the expertise and customer friendly manner of STUK. The lowest assessments (although these were also high) concerned information and advisory services.

Measures taken on the basis of the survey findings

The measures that STUK has already taken or is taking on account of the shortcomings exposed by the surveys include the following:

- When new ST Guides are distributed the responsible parties will be asked to advise STUK of any deficiencies observed in the Guides and in their application, and of any necessary new guidelines.
- Responsible parties will be advised of ST Guides that are under preparation when the annual report "Radiation Practices" is distributed.
- More efficient radiation protection training operations are being planned in association with various parties. STUK is also preparing a training strategy.
- The website of STUK has been made more user-friendly and a new website was opened in July 2004. The website pages for radiation users will be improved in 2005–2006.

APPENDIX 1 PUBLICATIONS IN 2004

The following publications completed in 2004 were authored by one or more employees of STO or the NIR Laboratory:

International publications

Auterinen I, Serén T, Anttila K, Kosunen A, Savolainen S. Measurements of free beam neutron spectra at eight BNCT facilities worldwide. Applied Radiation and Isotopes 2004; 61: 1021–1026.

Auterinen I, Serén T, Uusi-Simola J, Kosunen A, Savolainen S. A toolkit for epithermal neutron beam characterisation in BNCT. Ninth Symposium on Neutron Dosimetry, 28 September – 3 October 2003, Delft, The Netherlands. Radiation Protection Dosimetry 2004; 110 (1–4): 587–593.

Fantuzzi E, Alves JG, Ambrosi P, Janzekovic H, Vartiainen E. Implementation of Standards for Individual Monitoring in Europe. Radiation Protection Dosimetry 2004; 112 (1): 3–44.

Hakanen AT, Sipilä PM, Kosunen A. Calibration of a scintillation dosemeter for beta rays using an extrapolation ionization chamber. Med. Phys. 2004; 31 (5): 1123–1127.

Tapiovaara MJ, Sandborg M. How should low-contrast detail detectability be measured in fluoroscopy? Med. Phys. 2004; 31 (9): 2564–2576.

Tsapaki V, Kottou S, Vano E, Komppa T, Padovani R, Dowling A, Molfetas M, Neofotistou V. Occupational dose constraints in interventional cardiology procedures: the DIMOND approach. Phys. Med. Biol. 2004; 49: 997–1005.

Uusi-Simola J, Serén T, Seppälä T, Kosunen A, Auterinen I, Savolainen S. Dosimetric comparison at FiR 1 using microdosimetry, ionisation chambers and computer simulation. Applied Radiation and Isotopes 2004; 61: 845–848.

Witzani J, Bjerke H, Bochud F, Csete I, Denoziere M, de Vries W, Ennow K, Grindborg JE, Hourdakis C, Kosunen A, Kramer HM, Pernicka F, Sander T. Calibration of dosemeters used in mammography with different X ray qualities: Euromet Project No. 526. Radiation Protection Dosimetry 2004; 108: 33–45.

Jokela K, Puranen L, Sihvonen A-P. Assessment of the magnetic field exposure due to the battery current of digital mobile phones. Health Physics 2004; 86(1): 56–66.

Conference papers and lectures at conferences

International

Kosunen A, Sipilä P, Järvinen H, Parkkinen R, Jokelainen I. Finnish national code of practice for the reference dosimetry of radiation therapy. In book: Standards and Codes of Practice in Medical Radiation Dosimetry. Proceedings of an International Symposium 25–28 November 2002, Vienna, Austria. Vol 1. Vienna: International Atomic Energy Agency; 2003. p. 263–270.

Parkkinen R, Kosunen A, Sipilä P, Järvinen H. Development of calibration procedures for the electron beam calibration of plane-parallel ionization chambers. In book: Standards and Codes of Practice in Medical Radiation Dosimetry. Proceedings of an International Symposium 25–28 November 2002, Vienna, Austria. Vol 1. Vienna: International Atomic Energy Agency; 2003. p. 361–366.

Zoetelief J, Pernicka F, Alm Carlsson G, Dance DR, DeWerd LA, Drexler G, Järvinen H, Kramer H-M, Ng K-H. Dosimetry in diagnostic and interventional radiology: International Commission on Radiation Units and Measurements and IAEA activities. In book: Standards and Codes of Practice in Medical Radiation Dosimetry. Proceedings of an International Symposium 25–28 November 2002, Vienna, Austria. Vol 1. Vienna: International Atomic Energy Agency; 2003. p. 387–404.

Karppinen J, Tapiovaara M, Järvinen H. The dose length product is the basic dosimetric quantity in computed tomography. In book: Standards and Codes of Practice in Medical Radiation Dosimetry.

Proceedings of an International Symposium 25–28 November 2002, Vienna, Austria. Vol 1. Vienna: International Atomic Energy Agency; 2003. p. 405–410.

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APPENDIX 2

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General Guides

ST 1.1 Radiation Practices and Regulatory Control, 20 June 1996
ST 1.3 Warning Signs for Radiation Sources, 10 November 1999
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
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 Diagnostic X-ray Equipment and Its Use, 27 August 1992
ST 3.4 Quality Control of Image Intensifier - Television Chains, 24 October 1991
ST 3.5 Quality Control of Diagnostic X-ray Equipment and Film Processing, 3 December 1991
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 Equipment Containing Them, 17 February 1999
ST 5.3 Use of Ionising Radiation in the Teaching of Physics and Chemistry, 17 February 1999
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, 17 February 1999

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, 25 February 2000
ST 7.2 Application of Maximum Values for Radiation Exposure and Principles for the Calculation of Radiation Dose, 1 July 1999
ST 7.3 Calculation of the Dose Caused by Internal Radiation, 1 July 1999
ST 7.4 Registration of Radiation Doses, 25 February 2000
ST 7.5 Medical Surveillance of Occupationally Exposed Workers, 29 December 1999 (in Finnish)

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, 8 October 1993 (in Finnish)

Natural Radiation

ST 12.1 Radiation Safety in Practices Causing Exposure to Natural Radiation, 6 April 2000 (in Finnish)
ST 12.2 The Radioactivity of Construction Materials and Ash, 8 October 2003 (in Finnish)
ST 12.3 Radioactivity of Household Water, 9 August 1993

APPENDIX 3

TRAINING ORGANIZATIONS

A. Training organizations approved for organizing radiation safety officer competence exams in accordance with Guide ST 1.8. Situation as of 31 December 2004.

Date of approval	Validity of approval	Organization	Field of competence
Use of radiation in industry, research and education, and trade in and servicing of radiation sources			
27 Aug 2004	1 Jan 2005–31 Dec 2009	University of Jyväskylä, Department of Physics	Use of unsealed sources and of sealed sources and X-ray appliances

B. Training organizations approved for organizing radiation safety officer competence exams before the entry into force of Guide ST 1.8. Situation as of 31 December 2004. An organization to which STUK granted the right to arrange radiation safety officer exams before the entry into force of Guide ST 1.8, and which wishes to continue arranging such exams in accordance with the said ST Guide, must submit the details specified in the said ST Guide to STUK for inspection by no later than 31 May 2005.

Date of approval	Organization	Field of competence
Use of radiation in health care		
5 May 1997	University of Helsinki Faculty of Veterinary Medicine	Veterinary X-ray activities
29 Feb 1996	University of Helsinki, Physics Department	General use of radiation
15 Apr 1993	University of Helsinki, Department of Diagnostic Radiology	X-ray examinations and use of radioactive substances (exam of specialist in radiology)
10 May 1993	University of Kuopio, Department of Clinical Radiology	X-ray examinations and use of radioactive substances (exam of specialist in radiology)
6 Oct 1992	University of Kuopio, Training and Development Centre	Use of radiation (not general use)
20 Dec 1991	University of Oulu, Faculty of Medicine	X-ray examinations and use of radioactive substances
27 May 1993	University of Oulu, Faculty of Medicine	X-ray examinations and use of radioactive substances (exam of specialist in radiology)
20 Dec 1991	Educational and Training Board in Medical Physics	General use of radiation.
3 Mar 1992	Board of Qualification for Hospital Chemists	Use of radioactive substances
29 Feb 1996	Tampere Technical University, Ragnar Granit Institute	General use of radiation.
17 Aug 1993	University of Tampere, Faculty of Medicine	X-ray examinations and use of radioactive substances (exam of specialist in radiology)
26 Jan 1994	University of Turku, Faculty of Medicine	X-ray examinations and use of radioactive substances
8 Jun 1993	University of Turku, Faculty of Medicine	X-ray examinations and use of radioactive substances (exam of specialist in radiology)

Date of approval	Organization	Field of competence
Use of radiation in industry, research and education, and trade in and servicing of radiation sources		
20 Dec 1991	AEL, NDT Technology	Industrial radiography (including operator in charge)
6 Apr 1993	Stadia, Helsinki Polytechnic, Technology and Transport	Trade in and servicing of radiation sources
29 May 2002	Stadia, Helsinki Polytechnic, Technology and Transport	Use of X-rays and sealed sources in industry and research (not industrial radiography)
3 Apr 1992	University of Helsinki, Department of Physics	General use of radiation, use of unsealed sources, use of X-radiation, (not industrial radiography), use of radiation in educational demonstrations and trade in radiation sources
26 Jan 1994	University of Helsinki, Palmenia Centre for Continuing Education, Lahti	General use of radiation and trade in radiation sources
8 Apr 1992	University of Helsinki, Faculty of Agriculture and Forestry, Instrument Centre	Use of sealed and unsealed sources
3 Apr 1992	University of Helsinki, Department of Radiochemistry	Use of sealed and unsealed sources
26 Aug 1992	Jyväskylä Polytechnic Technology and Transport	Industrial radiography, use of sealed and unsealed sources, and trade in and servicing of radiation sources
31 Jan 1995	University of Jyväskylä, Department of Physics	Trade in radiation sources, use of radiation sources in industry, research and education
6 Oct 1992	University of Kuopio, Training and Development Centre	Use of radiation (not general use) and trade in and servicing of radiation sources
12 Mar 1992	Lappeenranta University of Technology	General use of radiation, use of X-rays, use of sealed and unsealed sources
4 Aug 1994	University of Oulu, Department of Physical Sciences	Trade in radiation sources, use of radiation sources in industry, research and education
4 May 1992	University of Oulu, Department of Biochemistry	Use of sealed and unsealed sources
15 May 1992	Hospital District of North Savo	Trade in and servicing of radiation sources
21 Jan 1992	POHTO	Use of X-rays and sealed sources (not industrial radiography)
18 May 1992	Satakunta Polytechnic	Use of X-rays, industrial radiography, use of sealed sources and trade in radiation sources
21 Jan 1992	SPEK, Finnish National Rescue Association	Installation and servicing of fire detection appliances
14 Feb 1992	Tampere Polytechnic, Technology and Transport	Use of X-rays and sealed sources (not industrial radiography)
3 Aug 1992	Turku Polytechnic, Technology and Transport	General use of radiation, industrial radiography, use of X-rays, use of sealed sources, and trade in and servicing of radiation sources
3 Aug 1992	University of Turku, Department of Physics	General use of radiation, industrial radiography, use of X-rays, use of sealed sources, and trade in radiation sources.