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RADIATION PRACTICES

Annual Report 2002

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Summary

A total of 1820 safety licences granted for the use of radiation in Finland were current at the end of 2002. There were also 2037 undertakings for dental X-ray diagnostics (licence-free). The Safety Licence Register of the Radiation and Nuclear Safety Authority (STUK) listed 14 120 radiation devices and 262 radionuclide laboratories.

In 2002, STUK performed 401 inspections of licensed practices and 25 inspections of licence-free dental X-ray practices. Restrictions were ordered on the use of one device. Repairs were ordered in 116 cases and recommended in 55 cases. No remarks were given in 254 cases.

Imports of radioactive substances amounted to 110 157 GBq and exports totalled 22 359 GBq. Short-lived radionuclides produced in Finland amounted to 42 487 GBq. The STUK interim storage for radioactive wastes received 65 batches of low-level wastes.

A total of 11 190 workers were individually monitored for radiation exposure at 1176 workplaces. Of these workers, some 32% were category A workers and 67% category B workers. In no case were annual dose limits exceeded. The total dose in the use of radiation and nuclear energy recorded in the STUK Dose Register was 6.35 Sv.

The mean doses in typical diagnostic X-ray procedures based on phantom measurements were below the reference levels issued by the European Community, the IAEA and STUK. Accuracy of the therapeutic doses underlying good therapeutic results in radiotherapy has remained within acceptable limits, and no excessive doses jeopardizing the safety of therapy have occurred.

In the regulatory control of natural radiation, inspection reports requesting performance of radon repairs or measurements of radon concentrations were sent to 145 enterprises. Underground radon inspections were performed in 4 mines and 7 excavation sites. The mean effective dose to aircraft crew caused by cosmic radiation was 1.6 mSv.

Ministry of Social Affairs and Health Decree on the Limitation of Public Exposure to Non-Ionizing Radiation entered into force in 2002. The regulatory control and research activities of non-ionizing radiation were mainly focused on sunbeds, transformer substations, metal seekers, mobile phone base stations, the dosimetry of RF fields and pulsed magnetic fields. A SAR testing equipment was purchased to be used in market surveillance of mobile phones.

A total of 10 abnormal occurrences were studied by STUK in 2002. Three of these involved the use of radiation in industry and research, 5 involved medical uses of radiation, 1 involved transport of radioactive substances and 1 involved the use of non-ionizing radiation.

Contents

1 General

The use of radiation denotes the use of radiation equipment and radioactive substances in health care, industry, research and teaching, and the import, export and production of and trade in radiation equipment and radioactive substances. Radiation practices signify, in addition to the use of radiation, any operations or circumstances in which a person's exposure to natural radiation causes or may cause a health hazard.

Under the provisions of the Radiation Act (592/1991), STUK – the Radiation and Nuclear Safety Authority – is the regulatory body for the use of radiation and other radiation practices in Finland. This also includes the use of non-ionizing radiation unless specifically delegated to other authorities. Regulatory control of radiation practices within STUK is mainly allocated to the Department of Radiation Practices Regulation (STO) and the Laboratory of Non-Ionizing Radiation Surveillance (NIR).

This report presents some events that occurred in 2002 concerning the use of ionizing and non-ionizing radiation and other radiation practices and their regulatory control. The report also presents annual statistics gathered by STO and the NIR Laboratory. The metrological and research activities of these units are also presented. Abnormal occurrences involving radiation are described as separate examples with a view to avoiding such events in future.

In 2002, the Ministry of Social Affairs and Health issued a Decree on the Limitation of Public Exposure to Non-Ionizing Radiation (294/2002). This Decree entered into force in May 2002.

Appendix 1 contains a list of current legislation governing radiation practices in Finland and Appendix 2 provides details of the most important regulations, decisions, directives and recommendations concerning radiation safety in the European Community. Appendix 3 gives a list of ST Guides published by STUK and Appendix 4 lists training organizations that have received STUK authorization to conduct qualification interviews for radiation safety officers and other radiation users pursuant to Section 18 of the Radiation Act.

2 Use of Ionizing Radiation

2.1 Safety Licences and Radiation Sources

Under the provisions of the Radiation Act, the use of radiation is subject to a safety licence. Safety licences are granted by STUK on application. There were 1820 current licences at the end of 2002. STO maintains a Safety Licence Register of licences issued and the radiation sources covered by these licences. Table I shows the number of safety licences and the number of practices in each specific category of use for which licences have been granted.

There were also 2037 dental X-ray practices that are licence-free but notifiable to STUK. Under STUK decision No. 202/310/99, dental X-ray practices no longer require safety licences if the following requirements are met:

1) the X-ray equipment must bear a CE marking according to the Medical Devices Act (1505/1994) and the Medical Device Directive (93/42/EEC)
2) on-site radiation shielding complies with the requirements imposed by Guide ST 3.1
3) a dentist or physician is responsible for the X-ray equipment and for its safe use.

A safety licence is required whenever the use of dental X-ray equipment does not comply with the foregoing requirements. Compliance with these provisions is checked when registering the equipment notified to STUK.

Tables II–IV give more detailed information on the radiation equipment, radiation sources and radionuclide laboratories listed in the Safety Licence Register at the end of 2002. The Register included 14 120 radiation devices and 262 radionuclide laboratories. Compared to the previous year, there was an increase of 4% in the number of devices and a decrease of 2% in the number of laboratories. There were 7011 radiation devices for the use of radiation in health care, most of which were dental X-ray devices. Veterinary X-ray devices in use totalled 213. The majority of the 7109 radiation devices in use in industry, research and teaching were industrial devices containing sealed sources. Small sources with activities falling below exemption levels (such as calibration sources employed in laboratories) and radiation sources in the warehouses of importers were not individually registered.

Table I. Number of safety licences and practices by specific category of use at the end of 2002.

Category	Number of safety licences	Number of practices
Use of radiation in health care	**728**	
• X-ray diagnostics		464
• dental X-ray diagnostics		10 *)
• veterinary X-ray diagnostics		186
• use of unsealed sources		59
• use of sealed sources		21
• radiotherapy		13
• others		16
Use of radiation in industry, research and teaching; trade in and installation and maintenance of radiation sources	**1092**	
• use of sealed sources (other than gamma radiography)		651
• use of unsealed sources		138
• import, export and trade		257
• installation, testing and maintenance		138
• use of X-rays (other than radiography)		183
• X-ray radiography		82
• gamma radiography		8
• production of radioactive substances		5
• others		15
Safety licences, total	**1820**	

*) Licences are granted for dental X-ray devices, which, however, are primarily used to other than dental X-ray practices.

Table II. Number of radiation devices and radionuclide laboratories: health care and veterinary use of radiation at the end of 2002.

Equipment/laboratories	Number
X-ray diagnostic equipment (generators)[*)]	**1598**
X-ray tubes, of which	1864
• mammography (screening excluded)	105
• screening mammography	101
• computed tomography (CT)	69
• angiography (DSA excluded)	20
• digital subtraction angiography (DSA)	82
• bone densitometers	51
Dental X-ray equipment	**5055**
• intraoral X-ray units	4388
• panoramic X-ray units	667
Radiotherapy equipment	**85**
• linear accelerators	26
• Co-60 radiotherapy equipment	0
• afterloading equipment	12
• X-ray therapy equipment or radiographic equipment	17
• radiotherapy simulators	9
• BNCT equipment	1
• others	20
Equipment with radioactive sources	**60**
• blood irradiation equipment	7
• calibration sources and other equipment	53
Veterinary X-ray equipment	**213**
Radionuclide laboratories	**87**
• type B laboratories	18
• type C laboratories	63
• others	6

[*)] One unit of X-ray diagnostic equipment consists of a high-voltage generator, one or more X-ray tubes and one or more examination stands.

Table III. Number of radiation devices and radionuclide laboratories: industry, research and teaching at the end of 2002.

Equipment/laboratories	**Number**
Equipment containing radioactive substances	**6277**
• level switches	2432
• continuous level gauges	1017
• density gauges	1013
• basis weight meters	621
• weight scales	534
• moisture and density gauges	133
• fluorescence analyzers	130
• thickness gauges	63
• radiography equipment	22
• others	312
X-ray equipment and accelerators	**832**
• radiography equipment	348
• diffraction and fluorescence analyzers	169
• fluoroscopic equipment	189
• thickness gauges	32
• particle accelerators	16
• ash meters	18
• other X-ray equipment	31
• other analyzers	29
Radionuclide laboratories	**175**
• type A laboratories	2
• type B laboratories	28
• type C laboratories	126
• others	19

Table IV. Radionuclides most commonly used in sealed sources; number and total activities of sources at the end of 2002.

Radionuclide	Number of radiation sources	Total activity[*)] (GBq)
Activity < 400 GBq		
Cs-137	3806	10 864
Co-60	1458	1451
Kr-85	414	5134
Am-241 (gamma sources)	342	2561
Pm-147	172	4489
Fe-55	164	473
Am-241 (Am/Be neutron sources)	122	1272
Sr-90	67	212
Cd-109	65	40
Cm-244	30	131
Activity 400–400 000 GBq		
Cs-137	24	660 800
Ir-192	15	55 800
Co-60	8	168 700[**)]
H-3	1	3700
Pu-238 (Pu/Be neutron source)	1	888
Activity > 400 000 GBq		
Co-60	1	32 900 000[**)]

[*)] Sum of the nominal activities reported upon being taken into use. For short-lived radionuclides (e.g. Ir-192), the extant total activities can be significantly less than the nominal activities.
[**)] Activity on 31 December 2002.

1 GBq = 1 gigabecquerel = 10^9 Bq

2.2 Inspections of the Use of Radiation

By performing inspections at places where radiation is used, STUK supervises compliance with statutes and with the conditions imposed by safety licences, and ensures that radiation practices are performed in a manner that is safe and acceptable in all respects.

These inspections ensure, among other things, that

- radiation equipment and operations in which radiation is used meet the requirements placed upon them
- arrangements for radiation shielding, quality assurance and safety are adequate
- stipulated maximum values or action levels are not exceeded
- monitoring of radiation exposure and health surveillance of exposed workers are performed according to the relevant guidelines
- radioactive materials and wastes are properly handled
- the users of radiation have been given adequate instructions in the use of radiation sources and in how to deal with accidents.

The results of every inspection are presented in a written report.

Radiation sources and their use are usually inspected for the first time when radiation practice begins. After the initial inspection, periodic inspections are performed at intervals of 1–5 years, depending on the practice. The need for re-inspections is recorded in the report, where necessary.

STUK performed 401 inspections of licensed practices and 25 inspections of licence-free dental X-ray practices in 2002. The numbers of inspections performed, classified according to the type of inspection, is shown in Table V. The number of inspections of licensed practices, classified according to the type of practice, is shown in Table VI.

The use of one device in a licensed practice was limited. Repairs were ordered in 103 inspections and recommended in 52 inspections in licensed practices. Respectively, repairs were ordered and recommended in 13 and 3 inspections in licence-free dental X-ray practices. No remarks were given in 245 inspections in licensed practices and 9 inspections in licence-free dental X-ray practices.

Table V. Inspections of the use of radiation in 2002.

Type of inspection	**Number of inspections**	
	Licensed practices	**Licence-free dental X-ray practices**
Initial inspection	136	0
Periodic inspection	240	6
Re-inspection	17	0
Other inspection or measurement	8	19
Total	**401**	**25**

Table VI. Inspections of licensed practices in 2002.

Type of practice	Number of inspections
Use of radiation in health care	
• X-ray diagnostics	164
• dental X-ray diagnostics	1
• veterinary X-ray diagnostics	43
• use of unsealed sources	14
• use of sealed sources	1
• radiotherapy	37
• other	1
Use of radiation in industry, research and teaching; trade in and installation and maintenance of radiation sources	
• use of sealed sources (other than radiography)	95
• use of unsealed sources	13
• trade and maintenance	0
• use of X-rays (other than radiography)	21
• X-ray and gamma radiography	11
• other	0
Total	**401**

2.3 Import, Production, and Export of Radioactive Substances

For regulatory purposes, STUK annually requires information on the trade in radioactive substances from the manufacturers and importers involved. Based on Council Regulation (Euratom) No. 1493/93, STUK receives information on radioactive substances imported into Finland from within the European Community directly from the consignors[*)]. Tables VII–IX give information on the quantities of radionuclides imported, produced and exported in 2002. The Tables are based on information received from licence holders. Radioactive substances supplied to other countries through Finland are not included in the import and export statistics.

The total activity of imported radioactive substances in 2002 was 110 157 GBq (Tables VII and VIII). Sealed sources are used in industrial measurement and research equipment and unsealed sources in nuclear medicine. The data in Table VII does not contain smoke detectors and ionization detectors used in fire detection systems containing ^{241}Am. The number of such appliances imported in 2002 was 260 516 and the total activity contained in these appliances was about 8 GBq.

The total activity of exported substances was 22 359 GBq (Tables VII and VIII). The exported items comprised bearing appliances containing tritium, analyzers with sealed sources, radiopharmaceuticals and decommissioned radiation sources (for return to manufacturers).

Short-lived radioactive substances (unsealed sources) produced in Finland in 2002 had a total activity of 42 487 GBq (Table IX). Short-lived isotopes produced by particle accelerators are mainly used for labelling pharmaceuticals.

In 2002, STUK participated in the work of a subgroup of an expert group referred to in Article 31 of the European Treaty. The item of this group was the radioactivity in consumer goods.

*) The term "shipment of radioactive substances" is used in the European Community to denote import, export and transit conveyances of radioactive substances between the Member States. In this chapter the terms "import" and "export" are used irrespective of the country of departure or destination.

Table VII. Import and export of sealed sources in 2002.

Radionuclide	Import		Export	
	Activity (GBq)	Number	Activity (GBq)	Number
Ir-192	45 567	29	8451	30
H-3	9033	3690	2240	1718
Kr-85	1105	84	907	64
Pm-147	531	37	133	28
Cs-137	175	119	13	19
Fe-55	119	81	169	85
Am-241	64	69	10	522
I-125	39	2341	- *)	-
Po-210	30	50	-	-
Co-60	27	61	-	-
Cd-109	14	94	44	95
Gd-153	14	36	-	-
Cr-51	4	116	-	-
Cm-244	-	-	3	2
Others, total **)	10	99	1	472
Total	**56 732**	**6906**	**11 971**	**3035**

*) "-" means that there was no import or export.
**) Import, nuclides: Co-57, Cm-244, Ni-63, Ge-68, Sr-90, I-131, Cf-252, Ra-226, Ba-133, Na-22, Eu-152, Ce-139, Mn-54 and Sn-113.
Export, nuclides: Co-60, Gd-153, Sr-90, C-14 and Eu-152.

Table VIII. Import and export of unsealed sources in 2002.

Radionuclide	Activity (GBq)	
	Import	Export
Mo-99	41 883	8091
I-131	7921	1828
Sm-153	2000	193
Ho-166	426	46
I-125	260	7
W-188	256	178
P-32	190	- *)
I-123	161	30
Tl-201	98	-
Kr-85	67	-
S-35	54	-
H-3	37	2
In-111	22	-
Cr-51	16	7
F-18	-	5
Others, total **)	34	1
Total	**53 425**	**10 388**

*) "-" means that there was no import or export.
**) Import, nuclides: Y-90, C-14, Ga-67, P-33, Xe-133, Ir-192, Ge-68, Ca-45, Cu-64, Sr-89, Fe-55, Co-57, Se-75, Po-210, Sr-85, Eu-152, Na-22, Sr-90 and Ni-63.
Export, nuclides: C-14, Y-90, Cu-64, P-32, Eu-152 and Pu-236.

Table IX. Production of radioactive substances (unsealed sources) in 2002.

Radionuclide	Activity (GBq)
O-15	23 700
C-11	8718
F-18	6024
I-123	2098
Br-82	1832
La-140	74
Na-24	30
Cu-64	7
Ar-41	3
Others, total*)	2
Total	**42 487**

*) Nuclides: Sm-153, Au-198, Cs-129, Cs-132 and Cs-136.

2.4 X-ray Diagnostics

No serious shortcomings in safety arrangements were found in the course of inspections of X-ray diagnostics performed by STUK in 2002, and no emergency situations were notified. In general, the level of safety in X-ray diagnostics can be considered to be rather good, although patient doses still exhibit considerable variation (as much as 10-fold and more) in level from place to place. This variation can usually be reduced without jeopardizing the purpose of the medical procedure involved. Such reduction calls for procedures to be implemented with increased awareness of safety and optimization of diagnostic methods.

As a result of the recommendations issued, the highest patient doses have been substantially reduced in nearly all cases studied. For technical reasons, it is not possible to diminish patient doses in some cases of CT tomography without noticeable deterioration in image quality.

STUK found no cases of unjustified use in X-ray diagnostics in 2002 except for a few cases in screening mammography.

STUK participates in the working group formed by the Nordic radiation protection institutes dealing with X-ray diagnostics. National implementations of the Directive concerning the medical use of radiation was discussed in the ordinary meeting of the Nordic Society for Radiation Protection in Turku at the end of summer 2002.

Inspections of fluoroscopic units

A total of 17 fluoroscopic units (3% of all units) were inspected in 2002. The air kerma rate and the quality of the fluoroscopic image of all the units were satisfactory according to the grading scale established in Guide ST 3.3. The results for 1996–2002 are shown in Table X.

Patient dose and image quality studies

In its inspections during recent years, STUK has studied patient doses and image qualities in common X-ray examinations. These studies used a phantom and the technique adopted by the particular user to measure the ESDs (Entrance Surface Doses) and some parameters of image quality. Measurements were taken for lumbar spine AP and chest PA projections in 10% of X-ray wards in 2002.

Table XI gives the ESDs measured in inspections performed over the period 1996–2002. The Table also shows the reference levels provided by the European Community expert group and STUK (for the reference levels see the Radiation Practices Annual Report 2000, STUK-B-STO 44). The mean doses are lower than the STUK reference levels for these examinations. Figures 1 and 2 give the dose distributions of the measurements taken in 2002.

Table X. Air kerma rate and image quality of fluoroscopic units, 1996–2002.

Year	Number of inspected units	Air kerma rate*) ($\mu Gy \cdot s^{-1}$) Mean (range)	Image quality	
			Contrast sensitivity, (mm Al) Mean (range)	Spatial resolution, (line pairs·mm^{-1}) Mean (range)
1996	22	0.43 (0.16–0.76)	**)	**)
1997	18	0.39 (0.15–0.66)	0.24 (0.20–0.40)	1.25 (0.70–1.80)
1998	28	0.34 (0.08–0.70)	0.30 (0.20–0.60)	1.23 (< 0.60–2.20)
1999	14	0.44 (0.11–1.60)	0.27 (0.20–0.40)	1.16 (< 0.70–1.60)
2000	18	0.31 (0.13–0.63)	0.23 (0.20–0.30)	1.30 (0.90–1.80)
2001	21	0.37 (0.18–0.87)	0.22 (0.20–0.30)	1.49 (0.90–2.20)
2002	17	0.37 (0.17–0.65)	0.26 (0.20–0.70)	1.30 (0.60–1.80)
Requirement in Guide ST 3.3		< 0.8	≤ 0.6	≥ 0.7

*) Air kerma rate is measured on the front surface of the image intensifier.
**) 1996 results for image quality have not been gathered.

Table XI. Radiation doses on the surface of the phantom in lumbar spine and chest X-ray, 1996–2002.

Year	Dose*) (mGy) Mean (range)	
	Lumbar spine AP	Chest PA
1996	6.0 (2.3–16)	0.14 (0.06–0.36)
1997	4.7 (1.1–12)	0.12 (0.03–0.30)
1998	6.0 (0.4–26)	0.12 (0.03–0.47)
1999	5.4 (1.1–11)	0.13 (0.03–0.33)
2000	5.9 (0.7–23)	0.13 (0.04–0.44)
2001	5.8 (1.1–21)	0.13 (0.04–0.37)
2002	5.6 (1.5–19)	0.13 (0.04–0.40)
EC reference level**)	10	0.3
STUK reference level	8	0.2

*) Dose on the surface of the phantom (Entrance Surface Dose).
**) Normal-sized, 70-kg patient.

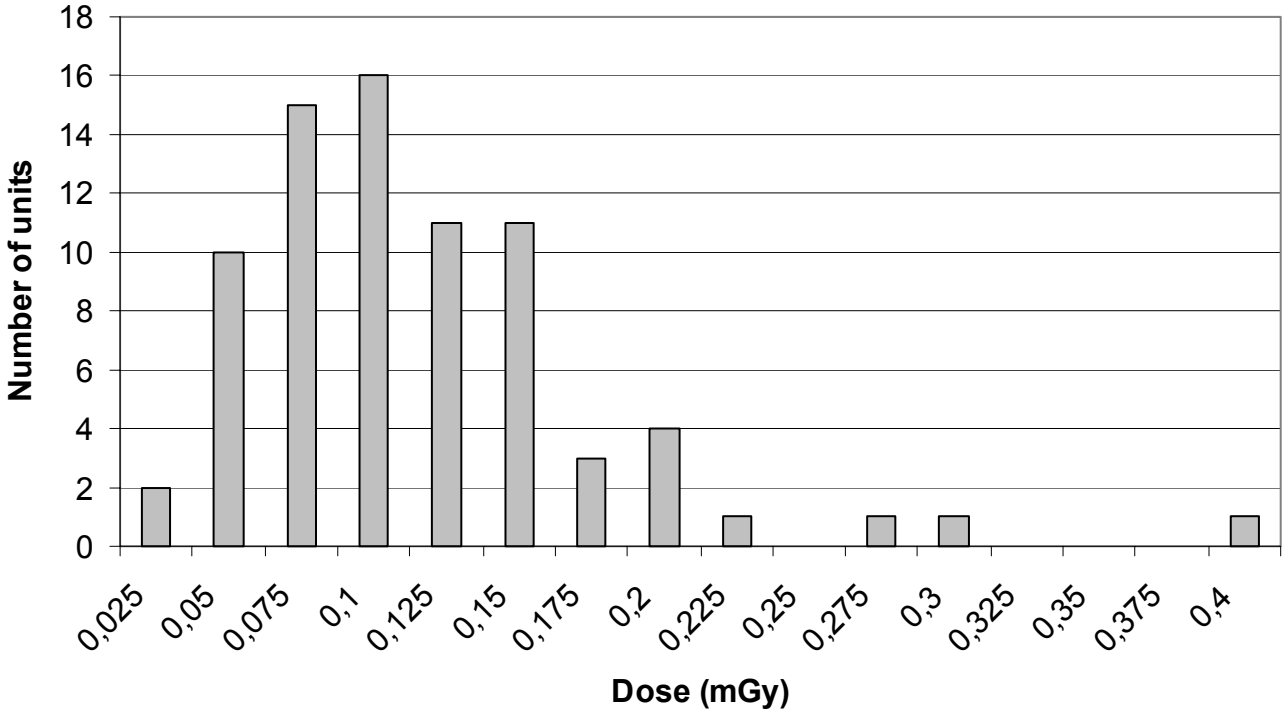

Figure 1. Dose distribution of chest X-ray measurements, 2002.

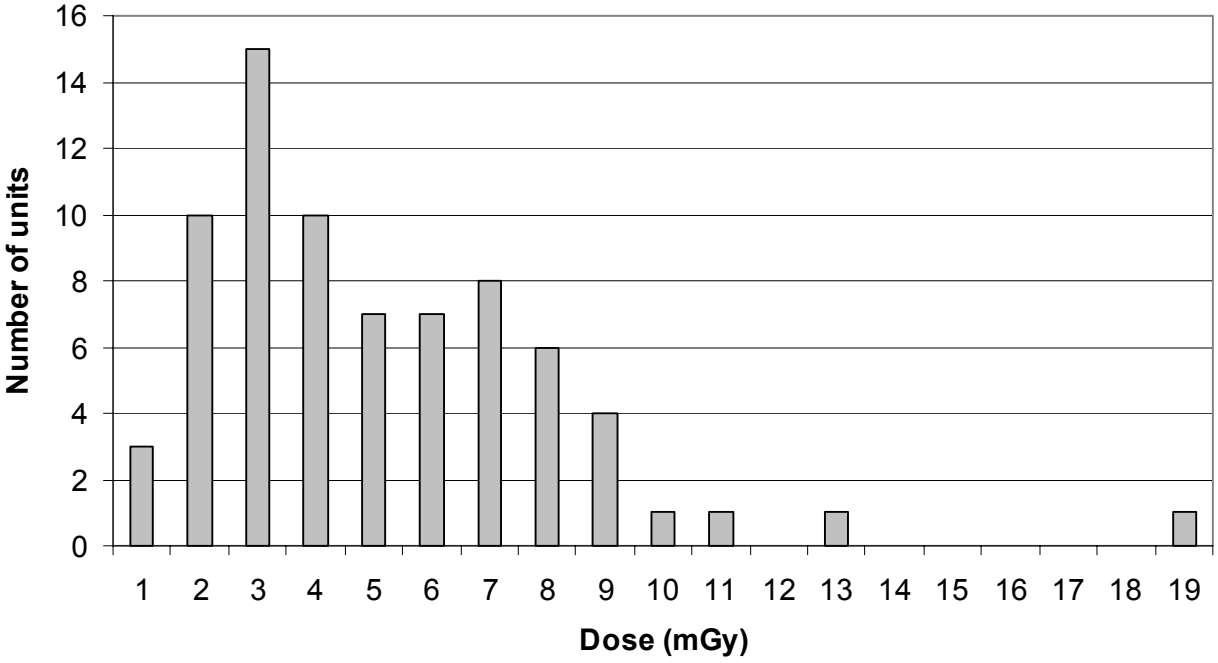

Figure 2. Dose distribution of lumbar spine X-ray measurements, 2002.

The European Community expert group has also issued recommendations for X-ray image quality. These recommendations, however, are for clinical X-ray images. There are no international reference values for technical image quality. The national status of technical image quality may be estimated by comparing the results of image quality measurements conducted in various years.

Table XII gives the results of image quality measurements for 1996–2002. The measurements were performed using the phantoms and measuring methods specified in Guide ST 3.5. No essential differences can be seen on the basis of these results.

Regulatory control of dental X-ray units

The regulatory control of dental X-ray units involves mailing test packages to dental X-ray users every 3–5 years. Measurement of returned packages yields various information, including radiation doses in practice. For further details of measurements see the Radiation Practices Annual Report 1995 (STUK-B-STO 33).

Measurements of molar X-ray doses were taken for 844 dental X-ray units in 2002. These doses correspond to the entrance dose at the surface of the cheek when a molar tooth is X-rayed. Figure 3 shows the distribution of the measured doses: the mean dose was 2.9 mGy and the range of doses 0.7–12.9 mGy. The reference level recommended by the IAEA (International Atomic Energy Agency)[*)] for dental X-rays is 7 mGy (Entrance Surface Dose). The corresponding reference level issued by STUK is 5 mGy. A total of 7% of the X-ray units measured in 2002 exceeded the value of 5 mGy. A dose of 5 mGy in dental X-rays is equivalent to an effective dose of about 7 μSv.

The dose-area-products of 214 dental panoramic X-ray units were measured over the period 1995–2002. Figure 4 shows the distribution of the measured dose-area-products: the mean dose was 93.3 mGy·cm^2 and the range of doses 34–254 mGy·cm^2. The reference level issued by STUK for the dose-area-product is 120 mGy·cm^2.

Mammography

In 2002, STUK completed the inspections of screening mammography programmes. A total of 127 decisions were given based on the inspections.

Mammography appliances have been studied by STUK in a project carried out in 2000–2002. The distribution of the doses of mammography appliances measured on a plexiglass phantom (4.5 cm thick) is shown in Figure 5. The mean dose was 7.2 mGy. The reference level issued by STUK is 10 mGy.

*) International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. Safety Series No. 115, Schedule III, p. 279, International Atomic Energy Agency (IAEA), Vienna 1996.

Table XII. Image quality in lumbar spine and chest X-ray, 1996–2002.

Year	Optical density (OD) Mean (range)		Contrast (OD) Mean (range)		Spatial resolution (line pairs·mm^{-1}) Mean (range)	
	Lumbar spine AP	Chest PA	Lumbar spine AP	Chest PA	Lumbar spine AP	Chest PA
1996	1.24 (0.67–2.16)	1.53 (0.72–2.35)	0.21 (0.11–0.29)	0.33 (0.24–0.49)	2.0 (1.2–2.8)	3.9 (2.6–5.0)
1997	1.23 (0.67–1.83)	1.43 (0.63–2.21)	0.24 (0.12–0.40)	0.32 (0.20–0.47)	2.2 (1.2–4.0)	3.8 (2.0–5.0)
1998	1.31 (0.52–2.27)	1.60 (0.43–2.39)	0.22 (0.06–0.50)	0.31 (0.10–0.52)	2.2 (1.0–4.3)	3.9 (2.2–5.0)
1999	1.26 (0.66–1.97)	1.64 (1.06–2.33)	0.25 (0.06–0.47)	0.30 (0.13–0.54)	2.0 (0.8–3.1)	3.7 (1.4–5.0)
2000	1.22 (0.58–1.88)	1.67 (0.60–2.26)	0.22 (0.08–0.39)	0.30 (0.08–0.52)	2.2 (0.9–4.3)	3.9 (1.8–5.0)
2001	1.24 (0.71–2.37)	1.76 (0.75–2.69)	0.22 (0.07–0.51)	0.30 (0.15–0.62)	2.0 (1.0–3.4)	3.7 (1.6–5.0)
2002	1.34 (0.82–2.13)	1.76 (0.77–2.40)	0.23 (0.08–0.45)	0.30 (0.10–0.78)	2.1 (1.0–5.0)	4.0 (1.8–5.0)

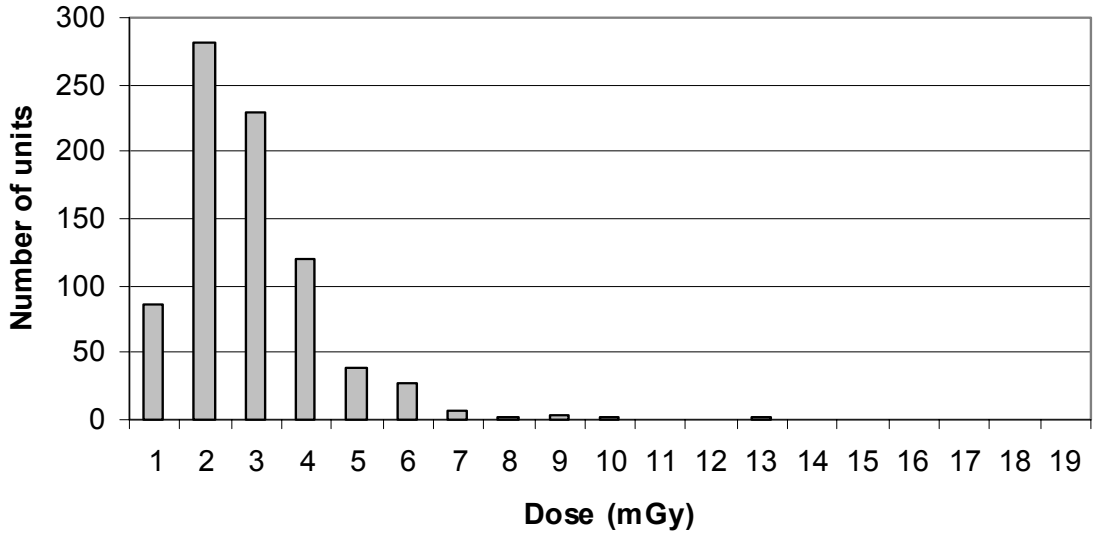

Figure 3. Dose distribution of dental X-ray measurements in 2002.

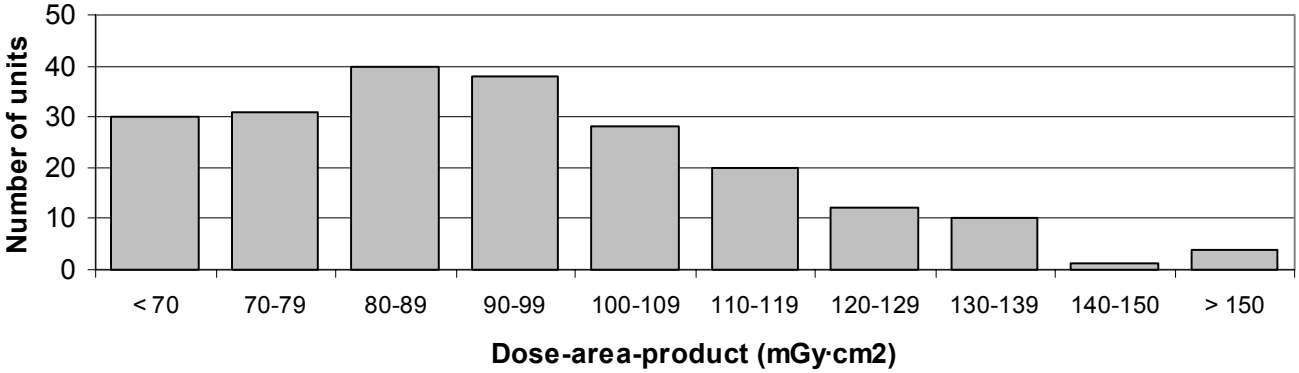

Figure 4. Dose-area-product distribution of dental panoramic X-ray measurements, 1995–2002.

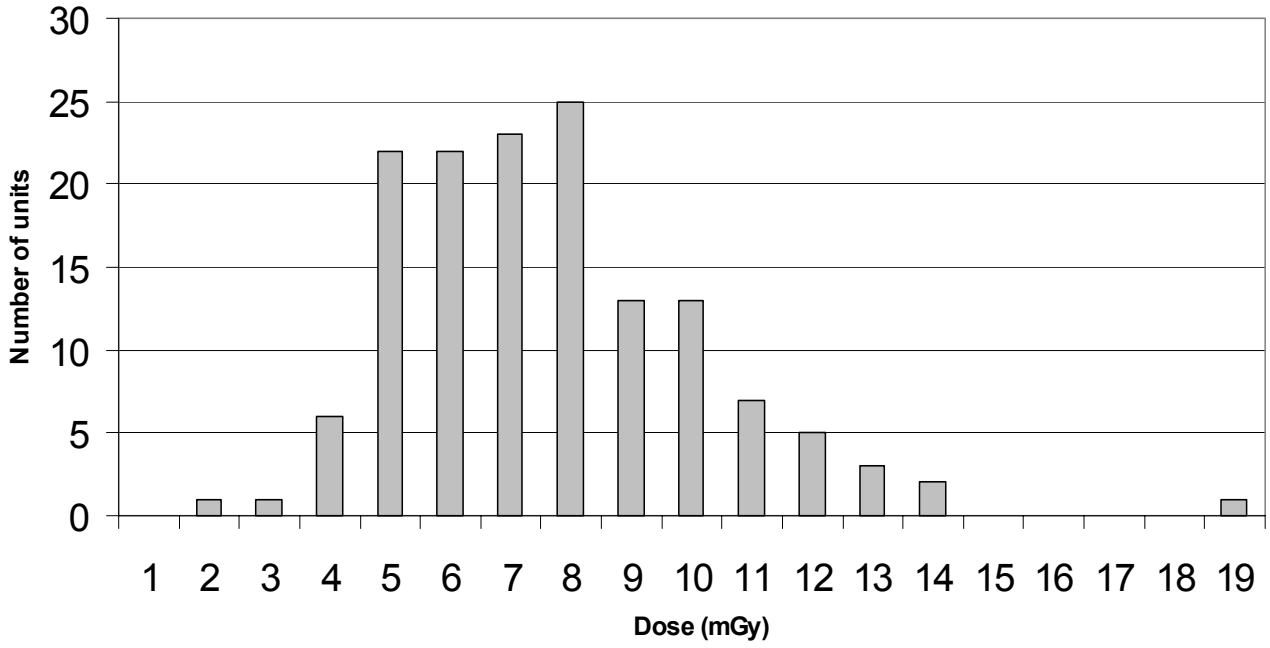

Figure 5. Dose distribution of mammography measurements, 2000–2002.

Research

STUK involved in the DIMOND III project (financed by the European Community) which deals with digital radiography, radiological measures and dosimetry. This project seeks to develop clinical, technical and physical quality criteria and assessment parameters for X-ray photographs and to study the determination of patient doses, reference dose levels to be issued in various examinations and specific problems involved in interventional radiology and mammography. In 2002, data was gathered on patient doses of X-ray examinations in cardiology in Finland and factors having an influence on these doses. This was done by measuring some parameters of patient doses and imaging techniques of the centres performing cardiologic examinations. STUK also further developed the mathematical method to be used in analyzing the quality of fluoroscopic images and, in order to be able to compare patient doses with reference levels, made a proposition to develop patient dose determination methods. Personnel exposure to radiation in interventional radiology was measured in various examinations and the applicability of diode based sensitive dosemeters for individual monitoring was tested. The results of the DIMOND III project were presented in the European Radiology Congress, the congress of the IRPA (International Radiation Protection Association), the meeting reports of the project, the ordinary meeting of the Nordic Society for Radiation Protection and the annual meeting arranged together by STUK and the Radiological Society of Finland.

A programme developed for the calculation of patient doses (surface doses) in X-ray examinations was completed and sent for test use to X-ray clinics. The programme was presented in the quality seminar of X-ray diagnostics and in the ordinary meeting of the Nordic Society for Radiation Protection.

A new, improved version (1.5) of the PCXMC programme was completed. This programme is sold by STUK and meant for the calculation of tissue doses and effective doses caused by X-ray examinations. The method for the assessment of radiation risk and the related computer programme were also further developed.

STUK´s earlier measurements of radiation doses in X-ray examinations of children were compiled. Co-operation studies with hospitals aimed for diminishing radiation doses were continued. The results were presented in the ordinary meeting of the Nordic Society for Radiation Protection and in other meetings.

2.5 Radiotherapy

General

Radiotherapy seeks to eradicate a local tumour with minimum damage to the surrounding healthy tissue. For this aim to be achieved, the prescribed radiation dose must be administered to the target volume as precisely as possible. According to international recommendations, e.g. those issued by the ICRU (International Commission on Radiation Units and Measurements), the uncertainty of the dose to the patient should not exceed an average of 5%. Regulatory activities to ensure proper implementation of the principles of justification and optimization at hospitals therefore focus on factors affecting the accuracy (i.e. correct value and targeting) of the dose to the patient.

To ensure high accuracy of this dose, quality assurance (QA) programmes are required in radiotherapy departments. The Ministry of Social Affairs and Health Decree on the Medical Use of Radiation, issued in 2000, assigns a number of new responsibilities to users. Implementation of these requirements at radiotherapy clinics requires that attention be paid to quality management of the entire radiotherapy process as well as technical QA programmes. This is equivalent in practice, to establishing a quality system that complies with international quality standards. In the regulatory control of radiotherapy, therefore, attention is also focused on the development of comprehensive quality systems for radiotherapy.

Inspections

The functioning and results of QA programmes are regularly evaluated by STUK inspections. All departments had implemented and were running the QA programmes in accordance with STUK requirements in 2002. A detailed quality control programme approved by STUK has been established

for each item of radiotherapy equipment that has been in use for at least 1 year.

A total of 40 devices were inspected in radiotherapy departments in 2002. Two of these inspections concerned the approval of new equipment. Based on the inspections and related measurements of radiation protection, it can be concluded that the radiation safety of staff and patients has remained good. Furthermore, the results of the inspections and comparative measurements of the characteristics of radiotherapy equipment (treatment equipment and simulators) indicate that the procedures applied and the characteristics of equipment affecting patient dose accuracy have, in general, met established requirements. Five remarks were recorded pertaining to shortcomings in radiation safety arrangements, radiotherapy equipment or quality-control methods. In comparative measurements of therapy doses, the acceptable levels for photon (1%) and electron (2%) beams were not exceeded. No deviation of more than 5% between the measured and calculated doses was observed in inspections of 22 treatment planning systems. Findings for the accuracy of dose delivery indicate that implementation of the principles of justification and optimization in radiotherapy can be considered good.

Research

STUK is currently participating in a research project entitled "A Code of Practice for Dosimetry of Boron Neutron Capture Therapy (BNCT) in Europe", which is partly financed by the European Community. The aim of the project is to create and publish European measurement recommendations for harmonizing the dosimetry of BNCT. STUK´s responsibilities in the project are mainly to establish a metrologically acceptable method of BNCT dose measurements and to be responsible for preparing the recommendations for publication. The project has continued with the planning of a test and comparison programme for methods of measurement. The European recommendations are scheduled for completion by late 2003.

In dose measurements of external radiotherapy, comparison measurements were started with a new measurement method based on the absorbed dose to water (IAEA TRS 398, 2000).

Training and co-operation with national counterparts

The annual meeting with radiotherapy physicists was arranged in 2002 in Lappeenranta, eastern Finland. The main topics were the implementation of new therapy techniques, clinical auditing and radiotherapy statistics, and education of hospital physicists. Changes in the regulatory control of radiotherapy and the research projects of STUK were also discussed.

International co-operation

STUK representatives are involved in the work of WG 1 and WG 3 of SC 62C at the IEC (International Electrotechnical Commission).

A representative of STUK participated in the work of the ESTRO (European Society for Therapeutic Radiology and Oncology) Physics Committee and in a working group appointed by the ESTRO and funded by the European Community to develop comparative measurements in radiotherapy.

During 2002, STUK experts participated as experts invited by the IAEA to evaluate the radiotherapy department in Tallinn. Additionally, inspections were performed in three Norwegian radiotherapy clinics with the Norwegian radiation protection institute as part of Nordic co-operation.

2.6 Individual Monitoring

General

Radiation work is defined as work in which the annual effective dose of an exposed worker may exceed 1 mSv, or where the equivalent dose to the lens of the eye is more than 15 mSv or the equivalent dose to the skin exceeds 50 mSv. The Radiation Act stipulates that the undertaking shall arrange monitoring of radiation exposure for exposed workers. Monitoring must be individual for category A workers. For practical reasons, monitoring in category B has also often been arranged as individual monitoring. Category A includes any radiation work in which the annual effective dose is or may be higher than 6 mSv, or the annual equivalent dose to the lens of the eye, the skin or hands and feet is or may be higher than 3/10 of the dose limits stipulated for these tissues or or-

gans. Category B includes all other radiation work.

Under Section 34 of the Radiation Act (Amendment 1142/1998), STUK maintains a Dose Register of exposure to ionizing radiation of workers engaged in radiation work. Exposure data for individually monitored workers are recorded in the Dose Register. Recorded data were obtained in 2002 from nuclear power plants and Doseco Oy (formerly the STUK Personal Dosimetry Service, privatized at the end of 2001) as well as from the Finnish airline company Finnair which has reported the doses from cosmic radiation to its aircraft crews since 2001. Data are also recorded from Radiological Monitoring Documents of persons who have been working abroad, and from reports of the Swedish Dose Register.

Individual doses due to external radiation are measured using individual dosemeters. Results are reported in terms of the quantity personal dose equivalents $H_p(10)$ and $H_p(0.07)$, which are approximations (usually sufficiently accurate) of the effective dose and the equivalent dose to the skin. If the personal dose equivalent is high, then the conditions leading to the exposure are determined and the effective dose or the equivalent dose to the skin is estimated. Individual doses caused by internal radiation are determined from samples of excrement or from whole-body activity measurements. The effective dose to the worker is calculated on the basis of the measured activity and recorded in the Dose Register. Doses to aircraft crew caused by cosmic radiation are determined by calculations based on their flying hours.

The minimum registered dose (recording level) for $H_p(10)$ for nuclear power plant workers is 0.1 mSv/month, and for other workers either 0.1 mSv/month or 0.3 mSv/3 months, depending on the monitoring period. Respectively, the recording level for $H_p(0.07)$ is 2 mSv/month or 6 mSv/3 months.

Workers travelling to the European Community Member States to work in Category A radiation work need a Radiation Passbook. The Radiation Passbook comprises a Radiological Monitoring Document (extract from the Dose Register) issued by STUK and a certificate supplied by the medical practitioner responsible for medical surveillance of the worker. The Radiological Monitoring Document is supplied to the foreign undertaking, which enters therein data on the duration of the radiation work, any radiation exposure during the work, and the findings of the worker's medical surveillance, if any. After the radiation work abroad has ended, the Radiological Monitoring Document is returned to STUK, which transfers the data recorded in the Document into the Dose Register.

Individual monitoring in 2002

Individual monitoring covered 11 190 workers in 2002. About 32% of these employment relationships are assigned to category A and 67% to category B. The category has not been reported in 1% of these relationships.

Table XIII shows the number of workers in various occupational categories. The number of workplaces having individual monitoring was 1176. The number of workers exposed to doses exceeding the recording level was 2979 (27%). The sum of the doses (total dose) recorded in the Dose Register was 6.35 Sv, of which nuclear power plant workers (i.e. Finnish workers in Finnish and foreign nuclear power plants, and foreign workers in Finnish nuclear power plants) accounted for 4.12 Sv (65%) (Table XIV). Table XV shows the number of monitored workers in 2002 in selected occupational groups and the total and mean doses in these groups. Doses to aircraft crews are shown in item 4.2 in Table XIX.

The total dose to workers in Finnish nuclear power plants was 3.7 Sv. The dose of outside workers (i.e. those employed by subcontractors) was 3.0 Sv and that of power company operatives was 0.7 Sv. The number of power plant own workers being monitored was 891, of whom 435 received doses exceeding the recording level. The number of outside workers monitored was 2337, of whom 1422 received doses exceeding the recording level. Nineteen nuclear power plant workers and 2 workers in industry were exposed to internal radiation so that their doses exceeded the recording level. The sum of the internal doses was 4.7 mSv.

No worker received a dose in 2002 exceeding the annual dose limit for the effective dose

(50 mSv). Over the period from 1998 to 2002, no worker received a dose exceeding 100 mSv, which is the dose limit for a 5-year period.

The highest $H_p(10)$ measured in 2002 was 55.4 mSv. This dose was measured from the dosemeters of a hospital cardiologist. Due to appropriate protective measures in this case, the annual dose limit for the effective dose was not exceeded, however. The highest effective dose during the 5-year period from 1998 to 2002 was 84.6 mSv. The person in question was engaged in cleaning duties at a nuclear power plant.

STUK issued 45 Radiological Monitoring Documents from the Dose Register in 2002.

Table XIII. Number of monitored workers in various occupational categories by specific dose ranges in 2002.

Dose range (mSv)	Occupational category and number of workers					
	Health care	**Veterinary**	**Industry**	**Research**	**Nuclear energy**	**All**[*)]
< 0.3	4855	257	1057	1173	1632[**)]	8864
0.3– < 0.5	185	10	29	10	206	426
0.5– < 5.0	459	26	85	23	979	1556
5.0– < 10.0	51	2	7	0	147	206
10.0– < 20.0	26	1	3	2	89	123
≥ 20.0	12	0	0	1	2	15
Total	**5588**	**296**	**1181**	**1209**	**3055**	**11 190**

[*)] Since some workers were involved in more than one category, the number given in this column is not necessarily the same as the sum of the numbers in other columns in the same row.
[**)] 1262 workers received less than 0.1 mSv.

Table XIV. Total doses received in various occupational categories in 2002.

Occupational category	Total dose (Sv)
Health care	1.82
Veterinary	0.07
Industry	0.24
Research	0.09
Nuclear energy	4.12
Total	**6.36**

Table XV. Data on certain occupational groups in 2002.

Group	**Number of monitored workers**	**Total dose (Sv)**	**Mean dose (mSv)**		**Highest dose (mSv)**
			Workers whose doses exceed recording level[*)]	**All monitored workers**	
Radiologists	598	0.48	1.9	0.8	25.1
Cardiologists	140	0.63	5.2	4.5	55.4
Interventional radiologists	22	0.18	8.5	8.1	42.8
Surgeons	248	0.09	2.5	0.3	31.0
X-ray assistants	2515	0.14	0.5	0.1	3.0
Industrial radiographers	343	0.10	1.0	0.3	9.4
Researchers	953	0.04	1.8	0.0	23.4
Nuclear power plant workers					
• mechanical work	773	1.24	2.2	1.6	13.2
• material testing	239	0.47	2.4	2.0	16.0
• operational personnel	231	0.11	0.9	0.5	6.5
• cleaning	184	0.59	5.3	3.2	20.8
• insulation work	82	0.45	6.2	5.5	19.1
• radiation protection	72	0.29	4.5	4.0	14.7

*) Recording level for nuclear power plant workers is 0.1 mSv/month and for other workers either 0.1 mSv/month or 0.3 mSv/3 month depending on the monitoring period.

The effective dose of a worker in radiation work can be assessed from the personal dose equivalent $H_p(10)$ measured using an individual dosemeter. In practice, $H_p(10)$ as such is a good upper approximation to the effective dose. Medical X-ray examinations form an exception to this, because the doses of the workers performing these examinations are measured on lead aprons that provide good protection. This means that when assessing the effective doses of workers exposed to X-rays in health care and veterinary medicine, the measured $H_p(10)$ values must be divided by a factor of 10–60.

International Co-operation

During 2002, STUK participated in an EURADOS (European Radiation Dosimetry Group) working group seeking to harmonize methods of measuring the individual doses of exposed workers. The tasks of the group include formulating recommendations for harmonizing individual dosimetry in the European Community and for implementing quality standards, the most important of these being the ISO 17025.

2.7 Radioactive Waste

STUK maintains a national storage facility for solid, low-level radioactive waste awaiting final disposal. The facility is adjacent to the intermediate- and low-level nuclear waste repository of the Olkiluoto Nuclear Power Plant owned by Teollisuuden Voima Oy, forming a separate part of the Olkiluoto repository that has been reconstructed for housing low-activity waste and leased to STUK. The facility was taken into use in spring 1997 and by late 2002 had received a total of 147 waste containers. The activities or mass of the principal wastes housed in this facility are shown in Table XVI.

Before waste is taken to the Olkiluoto facility, it is transported to an interim storage unit in STUK´s premises at Roihupelto in Helsinki. Radiation regulations specify that the user of the radiation source is responsible for such transport and, in general, for ensuring that radioactive waste is rendered harmless through proper safety procedures. Waste transport complies with regulations governing the transport of hazardous materials (the regulations of ADR agreement).

STUK interim storage received 65 batches of low-level waste in 2002, comprising a total of 156 packages. Table XVII shows the activities or mass of the wastes received by STUK in 2002.

Table XVI. The principal low-level radioactive wastes in the Olkiluoto facility (December 2002).

Radionuclide	Activity (GBq) or mass
H-3	19 020
Co-60	227
Kr-85	835
Sr-90	144
Cs-137	1564
Ra-226	229
U-238	164 kg
Pu-238	1383
Am-241	616

Table XVII. Low-level radioactive wastes received by STUK in 2002.

Radionuclide	**Activity (GBq) or mass**
H-3	148
Co-60	31.7
Ni-63	0.33
Kr-85	351
Cs-137	679
Pm-147	61.0
Ra-226	0.01
U-238	160 kg
Pu-238	258
Am-241	84.5

3 Use of Non-Ionizing Radiation

3.1 Regulatory Activities

The regulatory control of equipment emitting non-ionizing radiation is governed by the Radiation Act (592/1991), the Decree on the Regulation of Non-Ionizing Radiation (1306/1993), the Ministry of Social Affairs and Health Order (1474/1991) and the Ministry of Social Affairs and Health Decree (294/2002).

In 2002, regulatory control and safety evaluations included particularly sunbeds, transformer substations, metal detectors and mobile phone base stations.

The Ministry of Social Affairs and Health Decree (294/2002) on the Limitation of Public Exposure to Non-Ionizing Radiation entered into force in 2002. In this Decree, the annual UV dose obtained from sunbeds was lowered and the use of appliances of other types than UV-3 for tanning purposes was prohibited. These new regulations were informed to the media when the Decree was published and they are also presented in a poster designed to sunbed users. The posters were delivered to sunbed facilities either by mail or in the inspections.

For the surveillance of the radiation properties of mobile phones on the market, a SAR testing equipment was purchased jointly by STUK and the HUT (Helsinki University of Technology). The equipment was placed in the NIR Laboratory in a testing room which was provided with an absorbing material and shielding against electromagnetic interference. The equipment is technically ready for tests to be started in 2003.

32 inspections (on-site and market surveillance inspections) were performed for regulatory purposes in 2002. One decision and 4 statements were also issued.

In 2002, STUK investigated one abnormal occurrence in the use of non-ionizing radiation. Misuse of UVC lamps meant for sterilization caused sunburns to skin and ceratitis to eyes of young boys (see chapter 6).

3.2 Research Activities

Main part of the research and development work in the NIR Laboratory was carried out within research projects financed jointly by STUK and external parties. The projects are presented below.

Development of systems for irradiating animals (CEMFEC)

Partly financed by the European Community, the CEMFEC project sought to develop for the University of Kuopio, a 900 MHz exposure device for rats, allowing a large number of test animals to be simultaneously exposed while each animal could move freely in its cage and the whole-body SAR of the animals could be accurately determined. Quality control measurements as planned were performed on the installation site. In addition, technical support was given to resolve problems.

Development of cell exposure chamber (LaVita)

The NIR Laboratory participated in the LaVita project of STUK´s Department of Research and Environmental Surveillance (TKO). The new horizontal exposure chamber for cell cultures was improved by changing the material of the heat and humidity shield from plexiglass to styrofoam which enabled the extension of the exposure time from hours to days. A numerical model based on FD was prepared to study the temperature distribution in cell cultures. The SAR dosimetry of the old vertical chamber was improved by more accurate numerical models and temperature measurements. The main objective was to find out why the computed SAR values were threefold compared to the measured SAR values. The writing of the manuscript for a scientific article was started

dealing with the dosimetry of the vertical chamber. The manuscript can be completed only after the problems of the SAR determinations are solved.

The study of exposure caused by magnetic fields from pulsed battery currents of mobile phones (AMEST)

The study was connected to AMEST project and partly financed by TEKES (National Technology Agency). A portable calibrator was designed to transfer the calibration of SAR probes from STUK to laboratories carrying out SAR tests. A numerical realistic head model was developed and the development of computation software was started for the assessment of the exposure caused by magnetic fields from pulsed battery currents of mobile phones. The results of this study were reported in a manuscript submitted to Health Physics.

The development of practical methods for quality control of UV phototherapy devices

In 2002, the project, partly financed by the National Agency for Medicines, proceeded as planned. UV phototherapy lamps were tested and questionnaires were mailed to phototherapy clinics. Processing of data is underway. UV meters used at hospitals were calibrated. The development of a spectroradiometric measurement method was continued.

Other research work

In addition to projects jointly financed by STUK and external parties, research and technical development are basic activities of STUK itself. Pertaining to this, the first prototype of a low-frequency magnetic field meter was designed, constructed and tested. Experiences from measurements of the fields from transformer substations and metal detectors indicated that the meter operates as planned.

The study of the development of the radiation safety in sunbed facilities was started. The study is based on data collected from STUK inspections and the reports of municipal health authorities.

3.3 Other Activities

Information and education

STUK assisted the Ministry of Social Affairs and Health in informing of the new Decree on the Limitation of Public Exposure to Non-Ionizing Radiation. STUK also played a significant role in the preparation of this Decree and the expert report related to it. Articles of the Decree and its implementation were written to the journal "Ympäristö ja Terveys" (Environment and Health) and the ALARA journal published by STUK.

Interviews were given and articles provided to the media on the safety of electromagnetic fields from mobile phones and power lines, and on sunbeds and solar UV-radiation. Information was provided in writing, by telephone and via the Internet to members of the public, NGOs, radiation users and politicians.

In association with the STUK Public Information Unit, a poster "For sunbed user" was prepared. It was delivered to about 500 sunbed facilities and sunbed importers. Some posters were delivered in the inspections of sunbed facilities. The poster replaces earlier instruction manuals of sunbed facilities which were very scarce and diverse. The intention of the poster is to assure that sunbed users get correct information on the harmful effects of UV radiation and instructions which meet the requirements given in the Ministry of Social Affairs and Health Decree and in the European sunbed standard (EN 60335-2-27).

The website service started in 2000 continued in 2002. This service shows the UV index from the previous day to the observation time over the period from May to September. The index is based on the precisely determined erythemal effective irradiance of UV radiation measured on the roof of the STUK building in Roihupelto in Helsinki.

Preparation of radiation protection books on issues of non-ionizing radiation continued. The manuscript of the book dealing with electromagnetic fields was completed for the most part.

In association with the STUK Public Information Unit, leaflets on current topics and a publica-

tion of “Non-ionizing radiation and man” were prepared. A review on mobile phones and base stations has been delayed but its preparation is underway. Instead, a manuscript for a review on the measurement of magnetic fields in buildings was composed. The completed reviews can also be consulted on the STUK website (www.stuk.fi).

Experts of the NIR Laboratory gave lectures on the safety of non-ionizing radiation (Tampere University of Technology), safety of magnetic resonance imaging (Joint Authority for the Hospital District of Helsinki and Uusimaa), effects of UV radiation (annual meeting arranged together by STUK and the Radiological Society of Finland), safety of the use of UV phototherapy devices (Central Organization for Psoriasis Societies) and radiation safety and regulatory control of sunbeds (municipal health authorities). In addition, the director of the Laboratory gave a course “Biological effects and measurements of electromagnetic fields and optical radiation” in the Helsinki University of Technology.

International and national co-operation

Representatives of STUK participated in the following international meetings in 2002:

- NEWRAD conference in Washington
- UVNet 5 Workshop in Halkidiki
- Annual meeting of the Bioelectromagnetic Association in Quebec
- Meeting of the Sunbed Working Group in London
- Meeting of the Nordic Ozone and UV Working Group in Borås, Sweden
- Ordinary meeting of the Nordic Society for Radiation Protection in Turku.

In the preparation of standards on exposure and devices in the field of non-ionizing radiation, STUK participates in international IEC and CENELEC committees and working groups such as IEC TC 61/MT 16, IEC TC 106 and CENELEC TC 106X, and in national SESKO committees such as SK 106, SK 76 and SK 61. A STUK representative is also involved in the work of the ICNIRP (International Commission on Non-Ionizing Radiation Protection) standing committee SC 3.

4 Natural Radiation

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.

4.1 Radon

Radon in workplaces

Indoor radon is the most significant source of exposure to natural radiation in workplaces. STUK monitors radon in mines, excavation works and other underground workplaces, and in other workplaces where high radon concentrations occur. The action level for radon in workplaces with regular working hours is 400 $Bq \cdot m^{-3}$.

In 2002, there was a total of 145 workplaces having radon concentrations in excess of 400 $Bq \cdot m^{-3}$. Employers running these workplaces made a total of 1053 measurements using track detectors and 50 measurements using continuously monitoring instruments to monitor the concentrations during working hours. In most of these workplaces the measurements were the first attempts to monitor the radon concentrations, but in some cases the measurements were made to supplement the results of earlier measurements. Most of the measurements made for the first time were advised by local labour protection authorities.

Based on the results of radon measurements, a total of 180 inspection reports were sent to employers. The reports called for reductions in radon concentrations or for measurements of radon concentrations during working hours to be performed in 132 work areas, and for verification measurements in another season to determine the annual mean concentrations in 36 work areas. Although radon concentrations were more than 400 $Bq \cdot m^{-3}$ in 66 work areas, no reductions or measurements were called for, because annual working hours were less than normal. Based on the reductions or measurements (measurements during working hours or of the mean concentrations), monitoring was ended in 62 work areas. For other reasons, monitoring was ended in 20 work areas. Decommissioning of the area or the workers working in their own homes with no employed persons were some of the reasons. 13 employers were reminded to take remedial actions already requested or to notify STUK of such action already performed. In order to monitor the radiation exposure of workers, recording of working hours and regular concentration measurements were requested in one workplace. There were a total of 95 workplaces and 143 work areas under STUK control at the end of the year.

Four mines were inspected for the presence of radon. Mean radon concentrations were found to be less than 400 $Bq \cdot m^{-3}$ in all of these mines. Seven underground excavation sites were also inspected for the presence of radon. The mean radon concentration in two sites exceeded the action level. Remedial actions and remeasurements to verify the results of the actions were requested to be done in these sites. One of the sites was also requested to monitor the radiation exposure of workers by recording their working hours.

In 2002, a study*) of exposure to radon of miners in Finland during three decades was done. Regular radon measurements in underground mines were started in the early 1970´s. Ventilation in mines at that time was not very good, and therefore radon concentrations tended to be very high. Nowadays, radon concentrations in mines are regularly quite low, the mean value being about 110 $Bq \cdot m^{-3}$. However, experiences from the Mullikkoräme mine, among others, have proved that regular radon measurements are still necessary. This mine was decommissioned in 2000, and radon concentrations in the mine at that time ranged from 1000 to 2000 $Bq \cdot m^{-3}$ (STUK-B-STO 44). Inspections for the presence of radon in underground mines are regularly carried out every two years. Figure 6 shows the annual mean radiation doses of miners due to radon in Finnish mines in 1972–2001.

Approval of radon-measuring instruments

Instruments and methods used for determining the radon exposure of workers must be approved by STUK. An instrument may only be approved if it is properly calibrated. Regularly, the calibration has to be done every two years. The organizations (enterprises, communities, institutes etc.) with instruments that have been approved for determining the radon exposure of workers and where these instruments are correctly calibrated are shown in Table XVIII. The Table also shows the dates by which the instruments must be recalibrated if the approvals are to remain valid.

*) Annanmäki M, Venelampi E, Markkanen M. Radon in Finnish mines – regular monitoring since 1972. Book of Abstracts. Seventh International Symposium of Natural Radiation Environments (NRE VII), Rhodes, Greece, 20-24 May 2002:250.

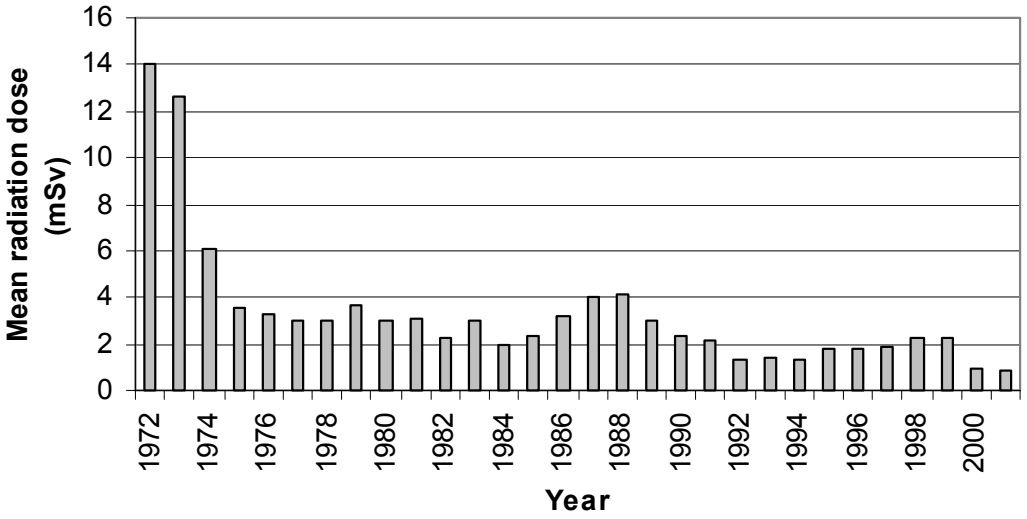

Figure 6. Annual mean radiation doses of miners due to radon in Finnish mines in 1972–2001.

Table XVIII. Organizations with instruments that have been approved for determining the radon exposure of workers.

Organization	Instrument	Calibration valid until	Notes
Gammadata Mätteknik i Uppsala AB/Gammadata Finland Oy, Helsinki	Alpha track detector	1 Jul 2003	A detector with which long-term averages of radon concentrations can be determined. The detector is not suitable for registering variations in radon concentrations over time. The detector is also approved for radon measurements in homes.
Kata-Electronics Oy	Radon-Box 10	25 Mar 2003	An instrument with which short-term averages (7 days) of radon concentrations can be determined. The instrument is not suitable for registering variations in radon concentrations over time.
• Etelä-Karjala Polytechnic • Municipality of Janakkala • Kuopio University • Kymenlaakso Polytechnic • City of Lahti • Turku Polytechnic • Tampere Polytechnic	• Pylon AB-5 • Ionization chamber • Pylon AB-5 • Pylon AB-5 • Pylon AB-5 • Pylon AB-5 • Pylon AB-5 and Alpha Guard	• 28 Oct 2004 • 16 Mar 2003 • 9 Feb 2003 • 22 Aug 2003 • 18 Jul 2004 • 13 Jun 2004 • 23 Oct 2004 23 Oct 2004	Continuously monitoring instruments with which variations in radon concentrations over time can be registered. The instruments are suitable for measuring radon concentrations during working hours.

4.2 Cosmic Radiation

Pursuent to Section 28 a of the Radiation Decree (1512/1991, Amendment 1143/1998), monitoring of radiation exposure and health surveillance must be arranged for aircraft crews in line with the principles applicable to those engaged in radiation work if the effective doses of crew members may exceed 1 mSv per year.

The radiation exposure of aircraft crews due to cosmic radiation has been monitored in Finland since 1992. The Finnish airline company Finnair annually estimates the effective doses from cosmic radiation on its flight crews and cabin crews. These doses are calculated on the basis of flight routes and flying hours for various persons, together with changes in the dose rate of cosmic radiation at flight altitudes of 8 to 12 km.

The doses of 692 flight crew members and 1799 cabin crew members working for Finnair in 2002 have been assessed. The results are shown in Table XIX.

The maximum annual dose of both flight crew members and cabin crew members was 4.2 mSv. The mean annual dose of fight crew members was 1.5 mSv and that of cabin crew members 1.6 mSv. The total dose was 1.07 Sv for flight crew members and 2.93 Sv for cabin crew members.

Table XIX. Effective doses from cosmic radiation to Finnair aircraft crew members in 2002.

Task	Average flying hours	Maximum flying hours	Number of persons	Effective doses		
				Total dose (Sv)	Mean dose (mSv)	Maximum dose (mSv)
Flight crew (pilots and co-pilots)	434	884	692	1.07	1.5	4.2
Cabin crew (among others: pursers, service chefs and flight attendants)	461	889	1799	2.93	1.6	4.2
Total	**452**		**2491**	**4.00**	**1.6**	

4.3 Other Sources of Natural Radiation

STUK monitors the radioactivity of drinking water in accordance with Guide ST 12.3. This Guide applies to water utilities supplying for more than 50 persons or for more than 10 households and, as well, such commercial food and drink manufacturers who use their own wells or water supplies. In 2002, inspection reports on the radioactivity measurements of 54 water samples were prepared for 31 water utilities and three canned water manufacturers. In 5 cases, undertakings were asked to reduce activity concentrations in their water. In most of these cases, the action level for radioactivity was exceeded due to radon. Measures to reduce concentrations were requested within one year.

Three statements were given concerning the handling and disposability of substances containing naturally occuring radioactive materials and one statement concerning the radioactivity of natural stone meant to be used as building material.

5 Metrology

Under Section 23 of the Radiation Act (Amendment 1334/1994), STUK is to maintain metrological standards for ensuring the reliability of radiation measurements. Radiation in this case denotes both ionizing and non-ionizing radiation. The aim of metrology work is to ensure adequate accuracy and international comparability of radiation measurements. National standards can be traced to the definitions of measurement quantities, either directly or through internationally accepted standards.

5.1 Ionizing Radiation

Standards, traceability and measurement uncertainties

The standards used by STUK for measuring ionizing radiation are ionization chambers or radiation sources. These are mostly secondary standards calibrated against primary standards by BIPM (International Bureau of Weights and Measures) or the national standards laboratories of the UK or Germany (NPL or PTB, respectively). In some cases, calibration may be traced to the national standards laboratory of the USA (NIST).

National standards are maintained for air kerma, absorbed dose, fluence rate, reference air kerma rate and surface activity. Calibrations and irradiations are also performed in terms of dose equivalent quantities which can be derived from the above mentioned quantities by calculations. The measurement uncertainties (expanded uncertainty with a coverage factor of 2) for these quantities are: air kerma 1–3%, absorbed dose 3–5%, fluence rate and dose equivalent 2–10%, reference air kerma rate 2–3% and surface activity about 10%. The traceability chains of standards, calibrations and irradiations for the dose quantities and fluence rate of ionizing radiation are shown in Figures 7 and 8.

To maintain standards and for instrument calibration, the following equipment and radiation sources are available at STUK:

- Gamma irradiation devices: ^{60}Co and ^{137}Cs gamma sources (various activities)
- X-ray equipment: 160 kV and 320 kV units
- Beta-ray secondary standard: ^{147}Pm, ^{204}Tl and ^{90}Sr/^{90}Y beta sources
- Neutron secondary standard: Am/Be neutron sources
- Wide-area alpha and beta sources: ^{90}Sr/^{90}Y, ^{36}Cl and ^{14}C beta sources, ^{241}Am alpha source.

Maintenance of standards

STUK standards for ionizing radiation were maintained as before in 2002. No deviation exceeding acceptable limits was observed in regular quality control measurements (constancy tests). Documentation of the quality manual for the standard dosimetry activities of STUK was improved.

The need to renew the radiation sources and equipment used in the calibrations of ionizing radiation was assessed and a plan to carry through the renewals was made.

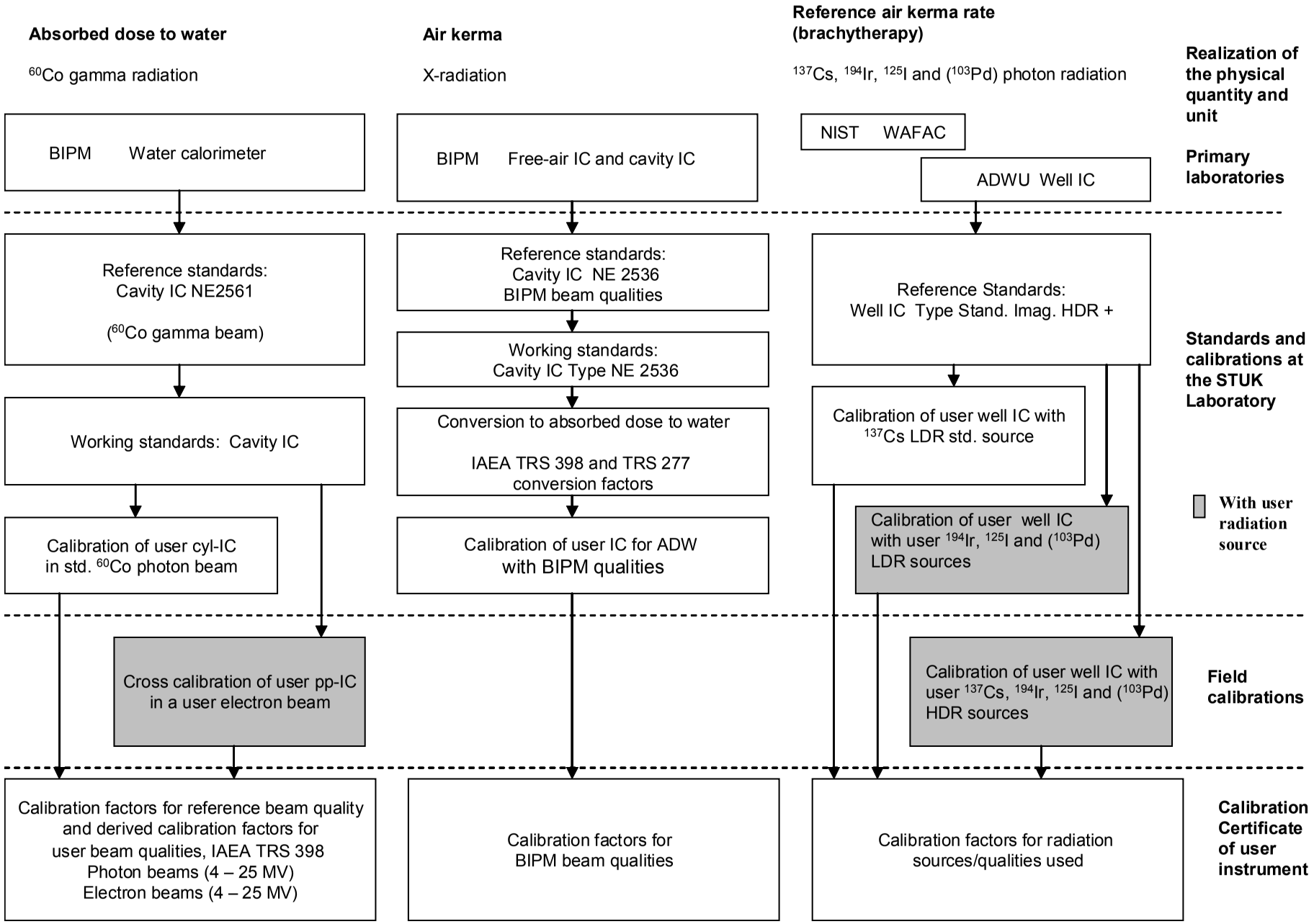

Figure 7. Traceability of standards and calibrations of STUK for ionizing radiation (dosemeters for radiotherapy).

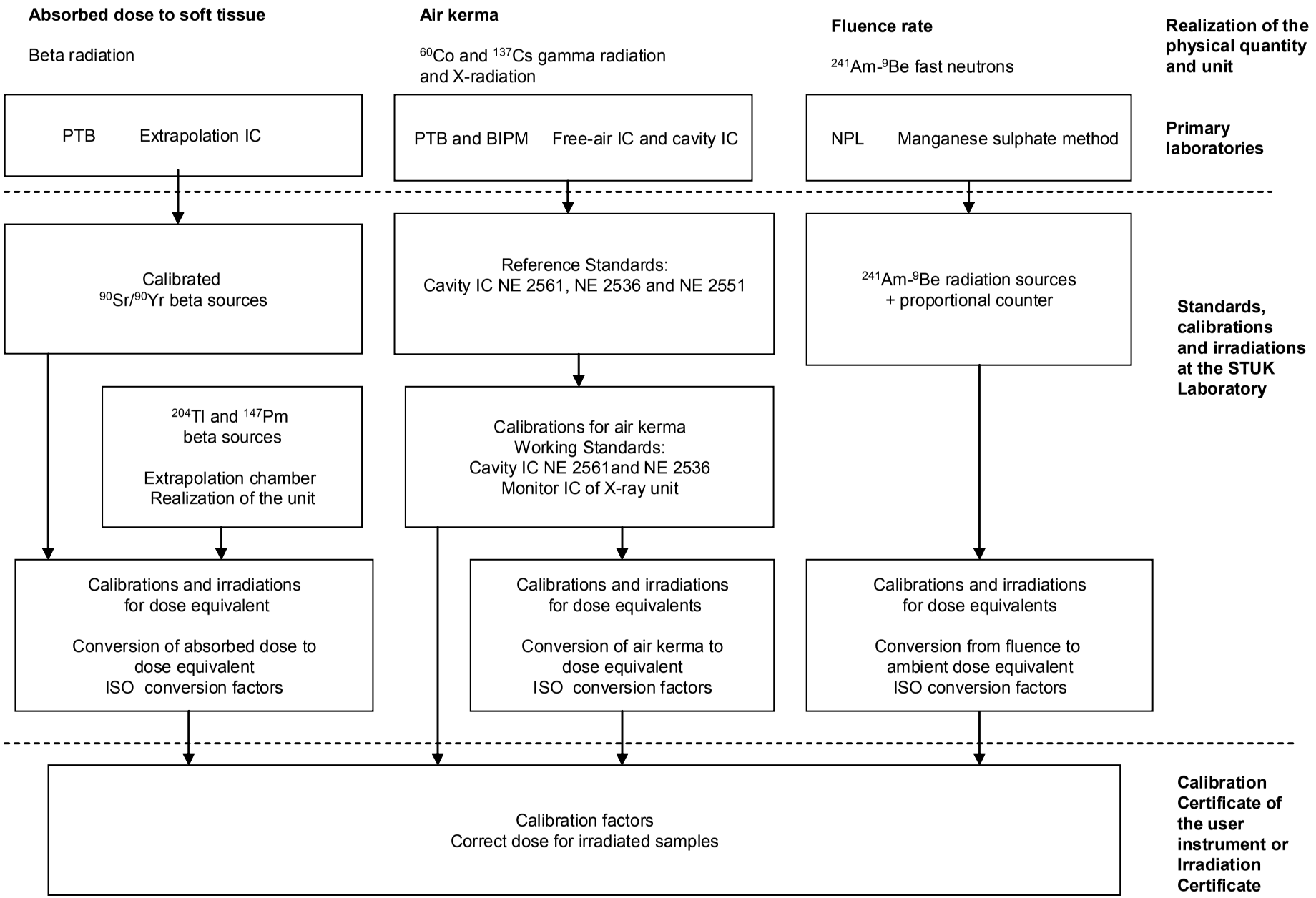

Figure 8. Traceability of standards, calibrations and irradiations of STUK for ionizing radiation (dosemeters and irradiations for radiation protection).

International comparisons

In 2002, STUK participated in an annual dose measurement intercomparison with TL detectors arranged jointly by the IAEA and the WHO (World Health Organization). The results were well within the acceptable level (3.5%). The deviation of the STUK result from the IAEA reference value was 0.5% for ^{60}Co radiation and 0.6% for 15 MV photons.

The preliminary results from 2001 of two intercomparisons arranged by the EA (European Co-operation for Accreditation) were also available:

- Calibration of a radiation protection dosemeter (IR3).
- Calibration of a personal dosemeter for personal dose equivalent $H_p(10)$ (IR4).

In both of these intercomparisons, the STUK results were well within the reported uncertainties and action levels of the intercomparisons.

The representative of STUK participated in the evaluation of the results of a calibration intercomparison (Calibration of dosemeters used in mammography with different X-ray qualities (20 kV to 50 kV) (526)) arranged by the EUROMET (European Collaboration on Measurement Standards) in 2001. The results of this intercomparison are expected to be published in 2003. According to preliminary results, the STUK results also in this intercomparison are within the action levels.

Calibration and testing of ionizing radiation meters

A total of 75 calibration certificates and 51 irradiation certificates were issued. About 1/3 of the calibrations and the majority of the irradiations were performed for STUK´s own meters and samples.

Development of standards and calibration methods

The representatives of STUK and the Centre for Metrology and Accreditation arranged a meeting on metrology activities and the international MRA agreement (Mutual Recognition Agreement). In the meeting it was agreed that the quality system of the national metrology activities maintained by STUK will be presented for the evaluation of the EUROMET in 2003. In addition, STUK arranged an internal meeting in which the national metrology activities and the influences of the MRA agreement were discussed.

Over the period from 2001 to 2003, STUK will introduce a new method in calibrating therapy dosemeters based on the recommendations of the IAEA. In this method, air kerma as the basic quantity will be replaced by the absorbed dose to water. In connection to this, STUK started the field calibrations of ionization chambers used in hospitals in radiotherapy measurements of electron beams. The first calibrations of customer chambers were performed in December 2002.

Measurements were started to test the calibration method of the meters used to measure the product of dose and area (DAP meters) in X-ray diagnostics. A draft of the calibration method was presented in the meeting of experts of medical X-ray techniques in September 2002.

Preliminary measurements were started to test the new standard ionization chambers purchased by STUK for measuring air kerma and dose equivalent.

National and international co-operation

With regard to metrology activities, STUK is a member of the international network of Secondary Standard Dosimetry Laboratories (SSDLs), which is jointly sponsored by the IAEA and the WHO. STUK participates in the annual dose measurement audits of these laboratories.

In 2002, a STUK representative participated in the meetings of the working group for ionizing radiation and radioactivity of the EUROMET, the National Board for Metrology and the dosimetry group of the Nordic radiation protection institutes. STUK was also involved in the work of the committees and working groups of standardization organizations and gave comments to draft standards.

STUK arranged a training course on radiation protection for the Baltic customs officers. Exercises of this course were arranged and supervised by the Metrology Laboratory of STO.

5.2 Non-Ionizing Radiation

STUK maintains the measurement standards for non-ionizing radiation that are necessary for its regulatory and research role. National standards

are maintained for spectral UV irradiance and for intense electric and magnetic fields in the frequency ranges of greatest importance for safety.

The standards for spectral UV irradiance (1-kW quartz-halogen lamps) were traced in 1995 directly to the primary standard of the National Standards Laboratory of the United States (NIST) and, via an accredited laboratory (the lamp supplier), to the primary standard of PTB and, in 1998, to the primary standard of the Metrology Research Institute of the HUT (Helsinki University of Technology) (Figure 9). The latter calibration was checked in 1999.

During 2002, STUK participated in a study seeking to improve the accuracy of solar UV measurements. This study was part of a wide-ranging European Community project co-ordinated by the NPL under an SMT programme (standards, measurements and tests). The goal of the STUK sub-project is to develop, in association with the Metrology Research Institute of the HUT, a field calibrator (a transfer standard) for spectroradiometers monitoring the Sun. This calibrator will be based on quartz-halogen lamps, stabilized with semiconductor detectors and calibrated against a cryogenic absolute radiometer by using HUT filter radiometers as transfer standards. In 2002, the calibrator was calibrated by the Metrology Research Institute of the HUT, thus making the calibration chain as short as possible. In addition, two scientific articles for Metrologia and one article for UVNews were written in co-operation with the HUT (UVNews is the news magazine of the thematic network of UV measurements). The design and test results of the calibrator were presented in one of the Metrologia articles and in UVNews, and the results of testing of DXW lamps used in the calibrator were presented in the other Metrologia article. The design of an improved electronics-unit was started. The performance of the calibrator is as expected.

A transfer standard was designed for test laboratories performing SAR tests for mobile phones (see item 3.2 Research Activities).

No precise calibration chains exist for intense electric and magnetic fields because there are no sufficiently precise transfer standards. STUK employs calibration equipment of its own design (TEM chambers and calibrated antennae in a radio anechoic chamber). The accuracy of the equipment was compared to the national standards of Germany, the Netherlands, Sweden and the UK (PTB, VSL, SP, NPL, respectively) in 1992. The traceability chains of the standards for electric and magnetic fields are shown in Figure 10.

The NIR Laboratory calibrated a total of 31 meters for measurements of UV radiation and electromagnetic fields in 2002. In addition, 13 safety evaluations and radiation measurements were made.

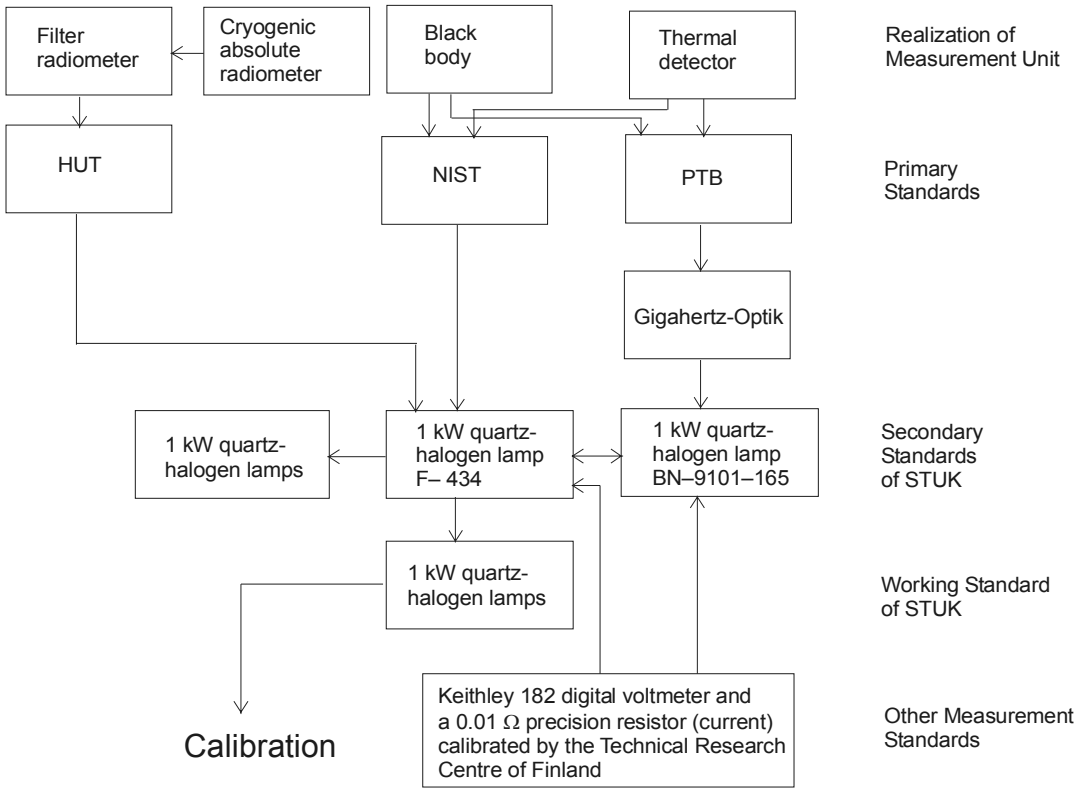

Figure 9. Traceability chains of STUK standards for UV radiation.

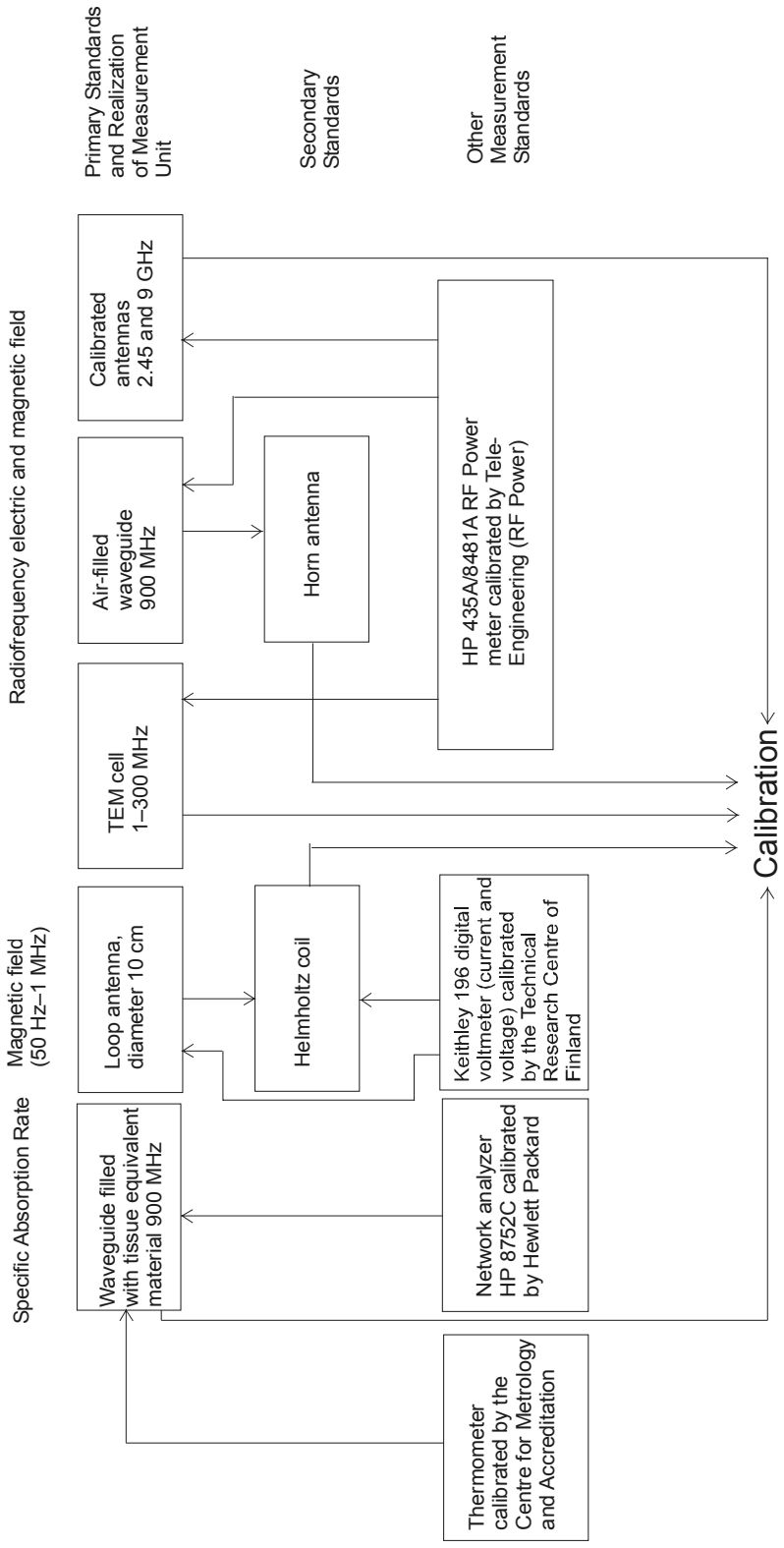

Figure 10. Traceability chains of STUK standards for electric and magnetic fields.

6 Abnormal Occurrences

Under Section 17 of the Radiation Decree, STUK is to be notified of any abnormal occurrences involving the use of radiation that substantially impair safety at the location where the radiation is used or in its environs. STUK is also to be notified of any radiation source that has disappeared, been stolen, lost or has otherwise ceased to be in the possession of the licence holder. STUK must also be notified of any abnormal observation or data with an essential bearing on the radiation safety of workers, other people or the environment.

No serious accidents involving radiation occurred in Finland in 2002, nor were there any incidents that could have led to radiation accidents. However, STUK investigated 10 incidents involving the use of radiation that were, or were suspected of being abnormal. Three of these incidents were related to the use of radiation in industry and research, five to the medical use of radiation, one to the transport of radioactive substances and one to the use of non-ionizing radiation.

Abnormal incidents investigated in 2002 have been summarized below together with the causes and consequences of the incidents and the measures taken. In describing and publishing these case histories, STUK seeks to inform radiation users of potential hazards in the use of radiation and of the need to use radiation sources properly, and of the appropriate preventive measures for precluding such cases in the future.

Case 1.
An outside company was doing corrections in a paper mill power plant. A company mechanic went to his work site, but did not close the shutter of a radiation source (185 MBq ^{137}Cs) behind the wall of the site, although his foreman had told him to do so. The mechanic spent two hours working in this site before the foreman came and noticed that the shutter was open. The dose of the mechanic was estimated to be about 0.15 mSv.

Next time the paper mill own mechanics will close all such radiation sources that may pose a hazard to outside workers.

Case 2.
During demolition work in a pulp mill a radiation source (925 MBq ^{60}Co) was taken out of the boiler of the mill. By mistake, the source got into metal scrap and was taken to a scrap yard. The source was found in the yard and taken back to the pulp mill.

To avoid such events in the future, the pulp mill revised its guidance regarding handling of radiation sources.

Case 3.
An old lead container was found in a chemical laboratory. The dose rate on its surface was 10 mSv·h^{-1}. Two persons were examining the container when crystalline substance fell from it on the table and the floor. The substance was radioactive and was found to contain isotopes of ^{137}Cs and ^{241}Am. The room, the table and the shoes of the persons were cleaned. Radioactive substance was put in plastic bags and handled together with normal radioactive wastes. Finally, the cleanness of the room and the corridors leading to it were checked with a contamination meter.

The two persons exposed to the radioactive substance were measured with a whole-body counter, but no contamination was found.

Case 4.
A nurse was injecting a radiopharmaceutical into a tumour. Because the tumour tissue was hard the needle came loose of the syringe and some of the radioactive substance (about 75 MBq ^{99m}Tc-nanocoll) was spattered on the nurse and the patient. The nurse immediately took a shower and washed her hair twice.

The handling of the event was proper and no further actions were needed.

Case 5.
A radiotherapy source got stuck in the catheter in intracavitary radiotherapy of coronary arteries. The catheter was drawn out of the patient and put into a shielding box designed to be used in such events. The supplier of the therapy equipment took both the catheter and the loading equipment and changed them to new ones.

Exposure to radiation of the staff and the patient was minor.

Case 6.
In a cardiac examination, a patient was given nearly three times as much radiopharmaceutical (2700 MBq ^{99m}Tc-tetrofosmine) as was desired. The activity of the pharmaceutical was measured using by mistake wrong settings in the dose calibrator. The patient was given food and drinks to stimulate the function of his gall bladder and potassium perchlorate to protect his thyroid gland.

The staff were advised to follow working instructions more carefully.

Case 7.
Three patients were given wrong radiopharmaceutical (700 MBq ^{99m}Tc-pertechnetate instead of ^{99m}Tc-HDP). The pharmaceutical was by mistake taken directly from the elute bottle. The patients were given potassium perchlorate to protect their thyroid glands. In addition, the events were made clear to the patients and registered in their patient records. New examination times were also reserved for them.

The events were discussed with the staff contributing to the examinations. The extra effective dose to the patients was about 8 mSv.

Case 8.
A patient in a central hospital was unnecessarily exposed to lung perfusion imaging (150 MBq ^{99m}Tc-MAA). The emergency clinic had sent the patient to the hospital with another patient´s referral. The patient was old and, due to her illness, in a confused state of mind, and her identity could not be verified.

The effective dose of the patient was about 1 mSv.

Case 9.
A package of pharmaceutical had been sent to a hospital from abroad. The radiopharmaceutical (1.37 MBq ^{131}I therapy) was given to a patient. The outer package of the pharmaceutical was thrown into a litter box. When emptying the litter box, a nurse found that the package was contaminated with radioactive substance. The activity of the package was measured to be about 40 MBq. The package was put aside to wait for the activity to decay off.

The patient was treated with a correct therapeutic dose. However, the origin of the contamination could not be found.

Case 10.
UV lamps emitting intense UVC radiation and meant for sterilizing purposes were installed as disco lights by four young boys. The boys did not know that the lamps were not suitable for this purpose. The boys sustained sunburns to their faces and acute ceratitis to their eyes. They contacted STUK and were advised to consult a medical doctor. The doctor prescribed hydrocortison treatment for the eyes and the boys were recovered.

APPENDIX 1 Legislation Governing Radiation Practices in Finland

Statute	Statute no.
Radiation Safety	
Radiation Act	592/1991
• Amendment	1102/1992
• Amendment	1334/1994
• Amendment	594/1995
• Amendment	490/1997
• Amendment	1142/1998
• Amendment	647/1999
• Amendment	744/2002
• Decree on the Enforcement of the Amendment of the Radiation Act	1597/1994
Radiation Decree	1512/1991
• Amendment	1598/1994
• Amendment	1143/1998
Ministry of Social Affairs and Health Decree on the Medical Use of Radiation	423/2000
Decree on the Regulation of Non-Ionizing Radiation	1306/1993
Ministry of Social Affairs and Health Order on the Upper Limits of Exposure to Non-Ionizing Radiation	1474/1991
Ministry of Social Affairs and Health Decree on the Limitation of Exposure of Members of the Public to Non-Ionizing Radiation	294/2002
Ministry of Social Affairs and Health Order on the Upper Limits for Radon Concentration in Places of Residence	944/1992
Regulatory Organization	
Act on the Radiation and Nuclear Safety Authority (STUK)	1069/1983
• Amendment	1106/1987
Decree on the Radiation and Nuclear Safety Authority (STUK)	618/1997
Charges	
Ministry of Social Affairs and Health Order on the Liability to and the Basis of Charges for Services Rendered by the Radiation and Nuclear Safety Authority (STUK)	580/1993
Transportation	
Legislation for transportation of dangerous materials also covers transportation of radioactive substances	

APPENDIX 2 Regulations, Decisions, Directives and Recommendations concerning radiation safety in the European Community

Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas

Commission Recommendation of 26 July 1991 on the application of the third and fourth paragraphs of Article 33 of the Euratom Treaty (91/444/Euratom)

Council Directive 92/3/Euratom of 3 February 1992 on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community

Council Regulation (Euratom) No 1493/93 of 8 June 1993 on shipments of radioactive substances between Member States

93/552/Euratom: Commission Decision of 1 October 1993 establishing the standard document for the supervision and control of shipments of radioactive waste referred to in Council Directive 92/3/Euratom

Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation

Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure, and repealing Directive 84/466/Euratom

Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz–300 GHz) (1999/519/EC)

Commission Recommendation of 20 December 2001 on the protection of the public against exposure to radon in drinking water supplies (2001/928/Euratom)

APPENDIX 3 ST Guides published by STUK, as of 1 April 2003.

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 Organization for the Use of Radiation, 24 October 1991
ST 1.5 Exemption of the Use of Radiation from the Safety Licence and Reporting Obligation, 1 July 1999
ST 1.6 Radiation Protection Measures at Workplace, 29 December 1999 (in Finnish)
ST 1.7 Radiation Safety Training in Health Care, 17 Fabruary 2003 (in Finnish)

Radiation Therapy

ST 2.1 Quality Assurance for Radiotherapy Equipment, 13 January 1993
ST 2.2 Radiation Safety of Radiotherapy Equipment and Treatment Rooms, 2 February 2001 (in Finnish)

Diagnostic Radiology

ST 3.1 Use and Regulatory Control of Dental X-ray Installations, 27 May 1999
ST 3.2 Use and Regulatory Control of Mammographic Equipment, 13 August 2001 (in Finnish)
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 (in Finnish)

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 Ionizing Radiation in the Teaching of Physics and Chemistry, 17 February 1999
ST 5.4 Trade in Radiation Sources, 2 October 2000 (in Finnish)
ST 5.6 Radiation Safety in Industrial Radiography, 17 February 1999
ST 5.8 Installation, Repair and Maintenance of Radiological Equipment Used for Medical Purposes, 17 February 1999 (in Finnish)

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 (in Finnish)

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

SS 9.1*) Radiation Safety Requirements and Type Inspection of Sunbeds and Tanning Appliances, 1 September 1989 (in Finnish)
ST 9.2 Radiation Safety of Pulsed Radars, 11 December 1991 (in Finnish)
ST 9.3 Radiation Safety during Work on Masts at FM and TV Stations, 7 April 1992 (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 Radioactivity of Construction Materials, Fuel Peat and Peat Ash, 2 February 1993
ST 12.3 Radioactivity of Household Water, 9 August 1993

*) ST Guides were formerly called SS Guides. In revising the Guides, old SS Guides are gradually changed to ST Guides.

APPENDIX 4 Training organizations authorized to perform qualification interviews for radiation safety officers and for other users of radiation, as of 1 February 2003.

Date of approval	Organization	Qualification in radiation safety
Use of radiation in health care		
20 Dec 1991	Stadia, Helsinki Polytechnic, Health Care and Social Service	Responsible Assistant
21 Jan 1992	Stadia, Helsinki Polytechnic, Health Care and Social Service	Dental X-ray, Responsible Assistant
5 May 1997	University of Helsinki, Faculty of Veterinary Medicine	Veterinary X-ray
29 Feb 1996	University of Helsinki, Physics Department	General Use of Radiation
15 Apr 1993	University of Helsinki, Department of Diagnostic Radiology	X-ray Diagnostics and Use of Radioactive Substances (Specialty in Radiology, examination)
10 Apr 1992	ARCADA, Nyland Swedish Polytechnic, School of Health Care	Dental X-ray, Responsible Assistant
20 Dec 1991	Northern Savo Polytechnic, School of Health Care	Responsible Assistant
1 Jun 1992	Northern Savo Polytechnic, School of Health Care	Dental X-ray, Responsible Assistant
10 May 1993	University of Kuopio, Department of Clinical Radiology	X-ray Diagnostics and Use of Radioactive Substances (Specialty in Radiology, examination)
6 Oct 1992	University of Kuopio, Training and Development Centre	Use of Radiation (excluding General Use)
20 Dec 1991	Oulu Polytechnic, School of Health Care	Responsible Assistant
25 Nov 1994	Oulu Polytechnic, School of Health Care	Dental X-ray, Responsible Assistant, Radiopharmaceuticals, Responsible Operator
25 Apr 1997	Oulu Polytechnic, School of Health Care	Surgical X-ray, Operator
20 Dec 1991	University of Oulu, Faculty of Medicine	X-ray Diagnostics and Use of Radioactive Substances
27 May 1993	University of Oulu, Faculty of Medicine	X-ray Diagnostics and Use of Radioactive Substances (Specialty in Radiology, examination)
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
20 Dec 1991	Pirkanmaa Polytechnic, Health Care and Social Services	Responsible Assistant
17 Aug 1993	University of Tampere, Faculty of Medicine	X-ray Diagnostics and Use of Radioactive Substances (Specialty in Radiology, examination)
20 Dec 1991	Turku Polytechnic, Health Care and Social Service	Responsible Assistant
3 Aug 1992	Turku Polytechnic, Health Care and Social Service	Dental X-ray, Responsible Assistant
26 Jan 1994	University of Turku, Faculty of Medicine	X-ray Diagnostics and Use of Radioactive Substances
8 Jun 1993	University of Turku, Faculty of Medicine	X-ray Diagnostics and Use of Radioactive Substances (Specialty in Radiology, examination)
20 Dec 1991	Vaasa Swedish Polytechnic, School of Health Care	Responsible Operator

Date of approval	Organization	Qualification in radiation safety
Use of radiation in industry, research and teaching; trade in and maintenance of radiation sources		
20 Dec 1991	AEL, Centre for Technical Training, NDT Technics	Industrial Radiography (Responsible Operator)
6 Apr 1993	Stadia, Helsinki Polytechnic	Trade in Radiation Sources, Maintenance of Radiation Sources
3 Apr 1992	University of Helsinki, Department of Physics	General Use of Radiation, Use of Unsealed Sources, Use of X-ray (excluding Industrial Radiography), Use of Radiation in Educational Demonstrations, Trade in Radiation Sources
26 Jan 1994	University of Helsinki, Lahti Research and Continuing Education Centre, Palmenia	General Use of Radiation, Trade in Radiation Sources
8 Apr 1992	University of Helsinki, Faculty of Forestry and Agriculture, 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	Industrial Radiography, Use of Sealed and Unsealed Sources, Trade in Radiation Sources, Maintenance of Radiation Sources
31 Jan 1995	University of Jyväskylä, Department of Physics	Trade in Radiation Sources, Use of Radiation Sources in Industry, Research and Teaching
6 Oct 1992	University of Kuopio, Training and Development Centre	Use of Radiation (excluding General Use), Trade in Radiation Sources, Maintenance of Radiation Sources
12 Mar 1992	Lappeenranta University of Technology	General Use of Radiation, Use of X-ray, Use of Sealead and Unsealed Sources
4 Aug 1994	University of Oulu, Department of Physics	Trade in Radiation Sources, Use of Radiation Sources in Industry, Research and Teaching
4 May 1992	University of Oulu, Department of Biochemistry	Use of Sealed and Unsealed Sources
15 May 1992	Northern Savo Nursing Care District	Trade in Radiation Sources, Maintenance of Radiation Sources
21 Jan 1992	POHTO, Institute for Management and Technological Training	Use of X-ray and Sealed Sources (excluding Industrial Radiography)
18 May 1992	Satakunta Polytechnic	Use of X-ray, Industrial Radiography, Use of Sealed Sources, Trade in Radiation Sources
21 Jan 1992	SPEK, Finnish National Rescue Association	Installation and Maintenance of Fire Detection Devices
14 Feb 1992	Tampere Polytechnic	Use of X-ray and Sealed Sources (excluding Industrial Radiography)
3 Aug 1992	Turku Polytechnic	General Use of Radiation, Industrial Radiography, Use of X-ray, Use of Sealed Sources, Trade in Radiation Sources, Maintenance of Radiation Sources
3 Aug 1992	University of Turku, Department of Physics	General Use of Radiation, Industrial Radiography, Use of X-ray, Use of Sealed Sources, Trade in Radiation Sources