**STUK**

GUIDE **ST 7.2** / 8 AUGUST 2014

# APPLICATION OF MAXIMUM VALUES FOR RADIATION EXPOSURE AND PRINCIPLES FOR THE CALCULATION OF RADIATION DOSES

This Guide is valid as of 1 October 2014 until further notice. It replaces Guide ST 7.2, Application of maximum values for radiation exposure and principles for the calculation of radiation doses, issued on 9 August 2007.

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# Authorization

The Radiation Act stipulates that the party running a radiation practice is responsible for the safety of the operations. The responsible party is obliged to ensure that the level of safety specified in the ST Guides is attained and maintained.

Under section 70, paragraph 2, of the Radiation Act (592/1991), STUK – Radiation and Nuclear Safety Authority (Finland) issues general instructions, known as Radiation Safety Guides (ST Guides), concerning the use of radiation and operations involving radiation.

Translation. In the event of any differences in interpretation of this guide, the Finnish and Swedish versions shall take precedence over this translation.

This Guide includes the requirements relating to the implementation of Council Directive 96/29/Euratom; OJ No. 159, 29 June 1996, p. 1.

# 1 General

The harmful effects of ionizing radiation on an organism may be divided into two types: deterministic and stochastic. Deterministic harmful effects include radiation sickness, grey cataracts, foetal abnormalities, hair loss and radiation burns. Deterministic harmful effects of radiation may result as typical side effects from radiation therapy and sometimes also in interventional radiograpy. Deterministic harmful effects of radiation may also result from large radiation doses sustained accidentally. Stochastic harmful effects of radiation include cancer and hereditary defects (genetic adverse effect).

The quantities employed in radiation protection to assess exposure are the equivalent dose and the effective dose. Maximum values (dose limits) are set for these quantities, and the exposure shall not exceed them.

This ST Guide presents the definitions and calculation criteria of equivalent dose and effective dose, and instructions for applying their maximum values. The limits (Annual Limit on Intake and Derived Air Concentration) derived from dose limits are also presented for the monitoring of radiation exposure caused by internal radiation. The calculation of radiation doses caused to a patient from medical examinations and treatments involving exposure to ionizing radiation is beyond the scope of this ST Guide.

*The maximum values for radiation exposure (annual dose limits) are prescribed in chapter 2 of the Radiation Decree (1512/1991). Section 7 of this Decree contains provisions concerning the Radiation and Nuclear Safety Authority's (STUK) right to issue further instructions on the application of maximum values and on the calculation of radiation doses. Guide ST 7.1 discusses monitoring of radiation exposure and Guide ST 7.3 describes the calculation of doses caused by internal radiation. Guide ST 1.9 discusses other quantities used in radiation protection in addition to effective dose and equivalent dose, and describes the measurement of radiation.*

# 2 Dose limits are set separately for workers and members of the public

## 2.1 General

The dose limits apply to exposure of workers and members of the public due to:

- the use of ionizing radiation or nuclear energy
- activities that involve exposure to natural radiation and that STUK has classified as radiation practices.

The dose limits do not apply to exposure arising from radon gas in dwellings, cosmic radiation at ground level, or radiation emitted by radioactive substances in the undisturbed crust of the earth or occurring naturally in the human body. Neither do the dose limits apply to exposure arising from the procedures listed in item 2.4 pertaining to the medical use of radiation.

The definitions of the equivalent dose and effective dose are presented in Appendix A to this Guide. The definitions of committed equivalent dose and committed effective dose, which are the corresponding quantities for exposure to internal radiation, are also presented in Appendix A.

If a person is exposed to both external and internal radiation, then the dose caused by external radiation and the committed dose caused by radioactive substances which have entered into the body shall be added together. Particular care shall be taken in such cases to ensure that the total radiation exposure does not exceed the prescribed dose limits.

*As regards individual cases, section 11 of the Radiation Act (592/1991) contains provisions concerning STUK's right to determine whether practices are considered to be radiation practices.*

## 2.2 Dose limits for workers, students and members of the public

Dose limits are prescribed for the following classes of individuals:

- workers engaged in radiation work
- students and apprentices over 16 but under 18 years of age involved in the use of radiation sources as part of their vocational training
- members of the public.

Radiation work shall denote work in which the worker's radiation exposure may exceed any of the dose limits prescribed for members of the public.

The dose limits for various classes of individuals are set out in Table 1.

The dose limits for workers engaged in radiation work apply to workers engaged in both category A and category B. Students and apprentices older than 18 are also bound by the dose limits for workers engaged in radiation work.

A dose limit is a maximum value for total exposure in a calendar year. The five-year period refers to a period of five consecutive calendar years.

The equivalent dose is estimated at a reference depth of 3 mm for the lens of the eye and 0.07 mm for the skin. The dose limit for the equivalent dose of the skin refers to an average dose calculated for an area of 1 cm$^2$, regardless of the exposed surface area.

*The maximum values for radiation exposure (annual dose limits) are prescribed in chapter 2 of the Radiation Decree. Radiation work is defined in section 9 of the Radiation Decree. Categories A and B are defined in section 10 of the Radiation Decree. The classification is explained in more detail in Guide ST 1.6.*

## 2.3 Protection of the foetus, and accident situations

### Protection of the foetus

The foetus must be protected in the same way as any member of the public. After a woman engaged in radiation work has announced her pregnancy, her work shall be arranged so that the equivalent dose of the foetus is as low as reasonably achievable, and it must not exceed 1 mSv for the remainder of the pregnancy.

### Accident situations

In accidents, except where the matter concerns the saving of human lives, the effective dose of a person performing necessary and immediate measures to limit radiation hazard and bring a radiation source under control shall not exceed 0.5 Sv and the equivalent dose on the skin shall not exceed 5 Sv.

*Section 5 of the Radiation Decree contains provisions for the protection of the foetus, and section 8 describes the actions and dose limits during accident situations.*

## 2.4 Medical use of radiation

The dose limits do not apply to exposure sustained in procedures involving the medical use of radiation:

- by a person undergoing the procedure (i.e. a patient)
- by a volunteer who, otherwise than as part of his/her occupation, assists a person undergoing the procedure, for example accompanying a child or an elderly person
- by a person who is subject to radiation for other than diagnostic or therapeutic purposes, including persons taking part in scientific research and persons exposed in the course of medico-legal procedures.

*Section 7 a of the Radiation Decree contains provisions regarding the dose limits not being applied to the patient or a voluntary assistant in the medical use of radiation. Sections 10 and 11 of the Decree of the Ministry of Social Affairs and Health on the Medical Use of Radiation (423/2000) prescribe the grounds for protecting voluntary assistants and persons involved with patients in the context of the use of radiopharmaceuticals. The limitation of doses to persons assisting patients, family members, next of kin and other persons are also discussed in Guides ST 3.3 and ST 6.3. Sections 6–8 of the above Decree of the Ministry of Social Affairs and Health also contain provisions for limiting the doses of persons who are subjected to radiation for reasons not related to a medical examination or treatment of a disease.*

**Table 1.** Dose limits for workers, students and members of the public.

| **Dose limit** | **Workers engaged in radiation work** | **Students and apprentices over 16 but under 18 years of age** | **Members of the public** |
|---|---|---|---|
| Effective dose (mSv/year) | | | |
| • five-year average | 20 | - | - |
| • single year period | 50 | 6 | 1 |
| Equivalent dose (mSv/year) | | | |
| • lens of the eye | 150 | 50 | 15 |
| • skin | 500 | 150 | 50 |
| • hands and feet*) | 500 | 150 | - **) |

*) Palms, backs of hands, fingers, wrists and forearms, feet and ankles.

**) No separate dose limit is prescribed, but the dose limit for the equivalent dose in the skin also applies to the skin of the hands and feet.

# 3 Dose is defined by using measurable and calculated quantities

There is no way to measure the effective dose or the equivalent dose directly. They must be estimated on the basis of measurable or calculated quantities.

The measurable quantities personal dose equivalent $H_p(10)$ (deep dose) and personal dose equivalent $H_p(0.07)$ (shallow dose) are used for estimating the effective dose and the equivalent dose when a person is exposed to external radiation.

When a person is exposed to internal radiation, the committed effective dose can be calculated using the activities of the ingested or inhaled radioactive substances and dose conversion factors.

*Personal dose equivalent $H_p(10)$ (deep dose) and personal dose equivalent $H_p(0.07)$ (shallow dose) are discussed in Guide ST 1.9, and dose conversion factors are discussed in Guide ST 7.3.*

# 4 Application of dose limits

## 4.1 Use of radiation

**External radiation**

The dose limit for the effective dose is not exceeded if the measured deep dose does not exceed the dose limit.

In X-ray diagnostics using personal protective devices the deep dose is generally measured using a dosemeter placed on top of these devices. In such cases the measured deep dose is not a reliable assessment of the effective dose, because important parts of the body are shielded. The effective dose must always be separately determined from the deep dose in each individual case.

If no precise dose estimates are available for a point-like source emitting beta radiation in contact with the skin, then it may be assumed that the equivalent dose for the skin does not exceed the dose limit of 500 mSv for the hands, feet or any part of the skin prescribed for a worker engaged in radiation work if the total beta emission does not exceed $10^9$ beta particles during the exposure period. For example, a 0.28 MBq beta source produces an emission of this size in one hour. This assumption is quite crude. With low energy beta radiation the exposure will clearly fall below 500 mSv.

The annual equivalent dose for the lens of the eye and for the hands and feet is assessed on the basis of the deep dose and shallow dose, or by means of separate measurements where necessary.

If a person is surrounded by a radioactive nobel gas or other radioactive gas that is only minimally absorbed into the body, the effective dose caused by the external radiation is usually greater than the commited effective dose caused by the inhalated radionuclide. The nuclides $^{39}$Ar, $^{85}$Kr, $^{83m}$Kr and $^{133}$Xe are such nobel gases for which the limiting factor in terms of dose limits is the annual equivalent dose for the skin or the lens of the eye of a worker.

If a person is working surrounded by the radioactive nobel gas, the effective dose caused by external radiation is calculated from the activity concentration of the gas as presented in item 4.2 in Guide ST 7.3. The values of conversion factors needed in calculation for nobel gases argon, krypton and xenon are provided in Table H of Guide ST 7.3. For other nuclides such as $^{11}$C, $^{13}$N, $^{15}$O and $^{18}$F, the effective dose caused by external radiation is calcualated similarly, and the required conversation factors are available in Table A.1 of report NCRP 123 I (column “Atmospheric Submersion”).

If the deep dose sustained by a pregnant woman does not exceed 1 mSv over the remainder of the pregnancy after it has been announced, then the equivalent dose to the foetus shall also be deemed not to exceed 1 mSv.

**Internal radiation**

When radionuclides enter the body through inhalation or orally, the annual dose limit of 20 or 50 mSv for the effective dose is not exceeded if the calculated committed effective dose does not exceed the annual dose limit of 20 or 50 mSv.

*The calculation of the committed effective dose is discussed in Guide ST 7.3.*

## 4.2 Practices causing exposure to natural radiation

**External radiation**

The exposure of aircrews to cosmic radiation depends on flight time, altitude, route and solar activity. Exposure is determined by calculation programmes that appropriately allow for these factors.

The dose limits are applied according to item 4.1 when a person is exposed to external radiation in practices involving exposure to natural radiation other than aviation.

*The determination of aircrew exposure is handled in greater detail in Guide ST 12.4.*

**Internal radiation**

When a person is exposed to radon gas in inhaled air, the effective dose is calculated using the radon concentration determined by measurement, the time of exposure to this concentration, and the dose conversion factors. The maximum radon concentration in the breathing air of places where work is performed regularly, derived from the dose limit for the effective dose (five-year average of 20 mSv), is 3000 Bq·m$^{-3}$.

The dose limits are applied according to item 4.1 when a person is exposed to internal radiation other than that caused by radon.

Radon inhaled by a pregnant woman causes no significant dose to the foetus.

*Application of the action levels and maximum values for radon concentration and calculation of dosage are discussed in greater detail in Guide ST 12.1.*

# 5 The exposure of the public is limited by means of source-related dose constraints and action levels

The exposure of members of the public cannot be controlled by measurements in the same way as the exposure of workers, as the practicalities of measuring would be very difficult to manage and one and the same person may be exposed to radiation from various practices. Exposure of the public is therefore primarily limited by imposing source-related dose constraints. Remaining of the exposure below these constraints may then be verified either by direct measurement or using quantities that are derived from the constraints. Examples of such derived quantities may include the dose rate outside of premises where a radiation source is used or the activity of radioactive substances that are released from a radiation practice to the surroundings.

In order to account for exposure from different radiation sources, STUK imposes source-related dose constraints. For example, dose constraints have been imposed for the design of premises where radiation sources are used. The dose limit for members of the public is not considered to be exceeded if the source-related dose constraint is not exceeded.

Dose limits for members of the public are generally not applied to exposure caused by natural radiation, although in certain cases there is cause to restrict the exposure of the public to natural radiation arising in radiation practices by means of action levels. Examples of this include exposure due to building materials, household water or waste disposal areas.

*Section 7 of the Radiation Decree contains provisions concerning STUK right to impose dose constraints. Guide ST 1.10 discusses the design of premises where radiation sources are used. Action levels for natural radiation exposure are provided in Guides ST 12.2 and 12.3.*

# Literature

1. International Commission on Radiological Protection. The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Annals of the ICRP 2007; 37 (2–4).
2. International Commission on Radiological Protection. 1990 recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Annals of the ICRP 1991; 21 (1–3).
3. International Commission on Radiological Protection. General principles for the radiation protection of workers. ICRP Publication 75. Annals of the ICRP 1997; 27 (1).
4. International Commission on Radiological Protection. Compendium of dose coefficients based on ICRP Publication 60. ICRP Publication 119. Annals of the ICRP 2012; 41(s).

# Appendix A

## Definitions

### Equivalent dose

The equivalent dose $H_{T,R}$ in tissue or organ $T$ is obtained by multiplying the average absorbed dose $D_{T,R}$ in the tissue or organ by a radiation weighting factor $w_R$:

$$H_{T,R} = w_R D_{T,R} \ , \qquad \text{(A1)}$$

where

$w_R$ is the radiation weighting factor for radiation quality $R$

$D_{T,R}$ is the average absorbed dose in tissue or organ $T$ caused by radiation quality $R$.

If the radiation is composed of several radiation qualities with different $w_R$ values, the equivalent dose $H_T$ is:

$$H_T = \sum_R w_R D_{T,R} \ . \qquad \text{(A2)}$$

The unit of equivalent dose is the sievert (Sv).

Subsequent references to tissue herein shall denote a tissue or an organ.

### Effective dose

The effective dose $E$ is the sum of the equivalent doses $H_T$, multiplied by the tissue weighting factors $w_T$:

$$E = \sum_T w_T H_T = \sum_T w_T \sum_R w_R D_{T,R} \ . \qquad \text{(A3)}$$

The unit of effective dose is the sievert (Sv).

The $w_R$ and $w_T$ factors required for calculating the equivalent dose and effective dose are presented in Appendix B of this Guide. The average absorbed dose that is used in the definitions of these quantities is defined in Guide ST 1.9.

### Committed equivalent dose

The committed equivalent dose $H_T(\tau)$ in tissue $T$ is the equivalent dose in this tissue resulting from an intake of a radioactive substance:

$$H_T(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(t)dt \ , \qquad \text{(A4)}$$

where

$\dot{H}_T(t)$ is the equivalent dose rate in tissue $T$ at time $t$

$t_0$ is the time of the intake.

The unit of committed equivalent dose is the sievert (Sv).

The integration time $\tau$ is expressed in years from the time of the intake. If no integration time is specified, then the integration time is assumed to be 50 years for an adult and (70-n) years for a child, where n is the age of the child.

### Committed effective dose

The committed effective dose $E(\tau)$ is the sum of the committed equivalent doses $H_T(\tau)$, multiplied by the tissue weighting factors $w_T$:

$$E(\tau) = \sum_T w_T H_T(\tau) \ . \qquad \text{(A5)}$$

The unit of committed effective dose is the sievert (Sv).

The committed equivalent dose and the committed effective dose are quantities used for estimating the equivalent dose and the effective dose resulting from intakes of radioactive substances. A radioactive substance which has entered the body may cause exposure long after the intake. Even over a long period, however, the dose arising from an intake is deemed to be sustained in the year of the intake.

## Literature

1. International Commission on Radiological Protection. The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Annals of the ICRP 2007; 37 (2–4).
2. International Commission on Radiological Protection. 1990 recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Annals of the ICRP 1991; 21 (1–3).
3. International Commission on Radiological Protection. Conversion coefficients for use in radiological protection against external radiation. ICRP Publication 74. Annals of the ICRP 1996; 26 (3–4).
4. International Commission on Radiation Units and Measurements. Measurement of dose equivalents from external photon and electron radiations. ICRU Report 47. Bethesda, MD: ICRU; 1992.
5. National Council on Radiation Protection and Measurements. Screening models for releases of radionuclides to atmosphere, surface water, and ground. NCRP Report 123 I. Bethesda, MD: NCRP; 1996.

# Appendix B

## Factors used in calculating the equivalent dose and effective dose

Subsequent references to tissue herein shall denote a tissue or an organ.

### 1 General

The probability that radiation will have stochastic harmful effects on tissue depends e.g. on the average absorbed dose in the tissue and on the quality of radiation (radiation type and energy). Radiation weighting factors ($w_R$) are applied in order to allow for the effect of radiation quality when calculating the equivalent dose in tissue. The aim has been to select the radiation weighting factor for a given radiation quality so that it is proportional to the biological effect of radiation at small doses.

The stochastic harmful effects of radiation on an individual also depend on the type of tissue that is exposed. The probability of radiation damage is different for various tissues. A tissue weighting factor ($w_T$) seeks to allow for this when calculating the effective dose.

### 2 Radiation weighting factors required for calculating the equivalent dose

The radiation weighting factors $w_R$ shown in Table B1 are used for calculating the equivalent dose.

For radiation qualities other than those shown in the table, the approximation of $w_R$ is estimated by calculating $\bar{Q}$ the effective quality factor at a depth of 10 mm in the ICRU Sphere (see Guide ST 1.9).

In addition to the values in Table B1, the continuous function defined in the following mathematical expression may be used for calculating the equivalent dose from neutron radiation:

$$w_R = 5 + 17e^{-(\ln(2E))^2/6} , \tag{B1}$$

where $E$ is the neutron energy (MeV).

Figure B1 shows the weighting factors for neutron radiation. The dashed curve calculated using expression (B1) may be regarded as an approximation of the step function shown in accordance with the values in Table B1.

### 3 Tissue weighting factors required for calculating the effective dose

The effective dose may be used to estimate stochastic harmful effects of radiation on individuals regardless of whether the radiation dose distribution in the body is even or uneven.

The tissue weighting factors $w_T$ shown in Table B2 are used for calculating the effective dose. These factors are based on a reference population representing both sexes equally and a wide range of ages. They are used for calculating the effective dose of workers, of members of the public and of both sexes when applying the maximum values for radiation exposure.

The tissue weighting factors have been selected to enable the factor for a given tissue to indicate the relative contribution of that tissue to the overall damage sustained when the entire body is evenly exposed to radiation. The sum of the various weighting factors is therefore one.

The weighted sum of the equivalent doses for the upper and lower large intestine*) is multiplied by the weighting factor for the colon. This weighted sum calculation uses the relative masses of the walls of the upper and lower large intestine as weighting factors. The weighting factors (relative masses) are 0.57 (upper large intestine) and 0.43 (lower large intestine) [2].

The other tissues referred to in Table B2 are the following ten tissues: adrenals, brain, extrathoracic airways, small intestine, kidneys, muscle, pancreas, spleen, thymus and uterus [2]. The common tissue weighting factor assigned to these tissues is used as follows:

- The weighted average of the equivalent doses in the tissues is multiplied by the

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*) The upper large intestine comprises the beginning of the large intestine as far as the left bend (and including that bend). The lower large intestine is the remainder of the intestine.

weighting factor for other tissues. The masses of the tissues are used as weighting factors in calculating the weighted average.
- In unusual circumstances, when the equivalent dose in a single one of these ten tissues exceeds the highest equivalent dose in the twelve tissues specified in Table B2, a weighting factor of 0.025 will be assigned to the tissue in question and a common weighting factor of 0.025 will be assigned to the other nine tissues.

The list of other tissues shown in Table B2 includes tissues and organs that are known to be susceptible to cancer induction or that, under certain conditions of exposure (such as the accumulation of radioactive substances in the tissue), may sustain a larger dose of radiation than other tissues in the body.

## Literature

1. International Commission on Radiological Protection. The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Annals of the ICRP 2007; 37 (2–4).
2. International Commission on Radiological Protection. 1990 recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Annals of the ICRP 1991; 21 (1–3).

**Table B1.** Radiation weighting factors $w_R$ for various radiation qualities [2].

| **Radiation quality** | $w_R$ |
|---|---|
| Photons, all energies | 1 |
| Electrons[*)] and muons, all energies | 1 |
| Neutrons, energy: | |
| • < 10 keV | 5 |
| • 10 keV to 100 keV | 10 |
| • > 100 keV to 2 MeV | 20 |
| • > 2 MeV to 20 MeV | 10 |
| • > 20 MeV | 5 |
| Protons[**)], energy > 2 MeV | 5 |
| Alpha particles, fission fragments, heavy nuclei | 20 |

[*)] Other than Auger electrons emitted by nuclei bound to DNA molecules.
[**)] Excluding recoil protons.

**Table B2.** Tissue weighting factors $w_T$ [2].

| **Tissue or organ** | $w_T$ |
|---|---|
| Gonads | 0.20 |
| Red bone marrow | 0.12 |
| Colon | 0.12 |
| Lung | 0.12 |
| Stomach | 0.12 |
| Bladder | 0.05 |
| Breast | 0.05 |
| Liver | 0.05 |
| Oesophagus | 0.05 |
| Thyroid | 0.05 |
| Skin | 0.01 |
| Bone surface | 0.01 |
| Other tissues | 0.05 |

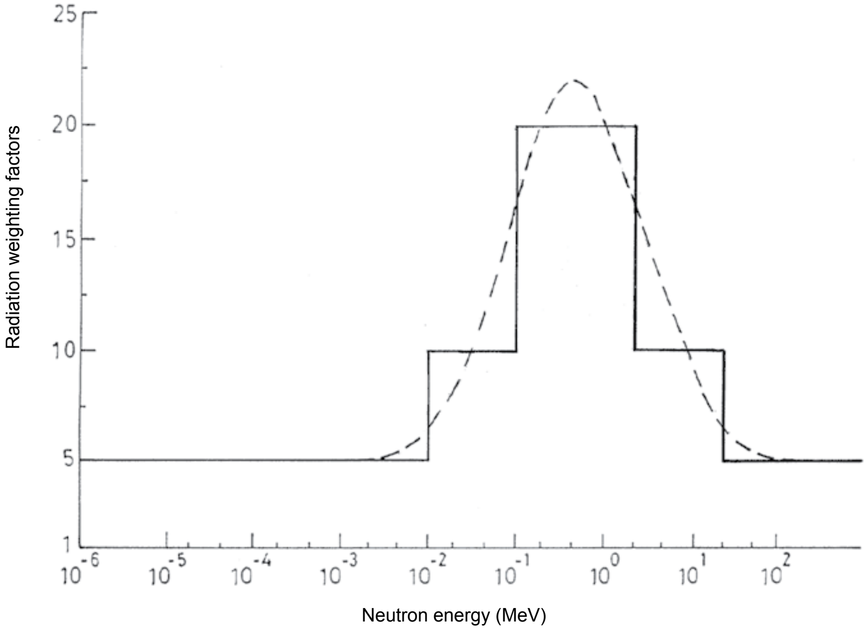

**Figure B1.** Radiation weighting factors for neutrons.

# ST GUIDES (1.4.2015)

## General guides

ST 1.1 Safety in radiation practices, 23 May 2013
ST 1.3 Warning signs for radiation sources, 9 December 2013 (in Finnish)
ST 1.4 Radiation user's organization, 2 November 2011
ST 1.5 Exemption of radiation use from safety licensing, 12 September 2013
ST 1.6 Operational radiation safety, 10 December 2009
ST 1.7 Radiation protection training in health care, 10 December 2012
ST 1.8 Qualifications and radiation protection training of persons working in a radiation user’s organization, 17 February 2012
ST 1.9 Radiation practices and radiation measurements, 17 March 2008
ST 1.10 Design of rooms for radiation sources, 14 July 2011
ST 1.11 Security arrangements of radiation sources, 9 December 2013

## Radiation therapy

ST 2.1 Safety in radiotherapy, 18 April 2011

## Diagnostic radiology

ST 3.1 Dental X-ray examinations in health care, 13 June 2014
ST 3.3 X-ray examinations in health care, 20 March 2006
ST 3.8 Radiation safety in mammography examinations, 25 January 2013

## Industry, research, education and commerce

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

## Unsealed sources and radioactive wastes

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

## Radiation doses and health surveillance

ST 7.1 Monitoring of radiation exposure, 14 August 2014
ST 7.2 Application of maximum values for radiation exposure and principles for the calculation of radiation doses, 8 August 2014
ST 7.3 Calculation of the dose caused by internal radiation, 13 June 2014
ST 7.4 The dose register and data reporting, 9 September 2008.
ST 7.5 Medical surveillance of occupationally exposed workers, 13 June 2014

## Veterinary medicine

ST 8.1 Radiation safety in veterinary X-ray examinations, 20 March 2012

## Non-ionizing radiation

ST 9.1 Radiation safety requirements and regulatory control of tanning appliances, 1 July 2013 (in Finnish)
ST 9.2 Radiation safety of pulsed radars, 2 September 2003 (in Finnish)
ST 9.3 Radiation safety during work on masts at FM and TV stations, 2 September 2003 (in Finnish)
ST 9.4 Radiation safety of high power display lasers, 28 February 2007 (in Finnish)

## Natural radiation

ST 12.1 Radiation safety in practices causing exposure to natural radiation, 2 February 2011
ST 12.2 The radioactivity of building materials and ash, 17 December 2010
ST 12.3 Radioactivity of household water, 9 August 1993
ST 12.4 Radiation safety in aviation, 1 November 2013