Unofficial translation from Finnish.
Legally binding only in Finnish and Swedish.

REGULATION STUK S/7/2021

Radiation and Nuclear Safety Authority Regulation on Measurements of Ionizing Radiation

Adopted in Helsinki on 27 April 2021

In accordance with a decision of the Radiation and Nuclear Safety Authority, the following provisions are issued by virtue of section 59, subsection 2 and section 63, subsection 3 of the Radiation Act (859/2018):

Section 1
Scope of application

This regulation applies to the measurements of ionizing radiation carried out under the Radiation Act.

In rescue operations and civil defense referred to in the Rescue Act (379/2011), this regulation applies to radiation measurements with portable meters.

Section 2
Definitions

For the purposes of this regulation, the following terms have the following meanings:

1) *measuring instrument* means a radiation meter measuring external radiation other than a contamination meter, and which is calibrated or the calibration of which is checked by means of a reference instrument;
2) *expanded uncertainty of measurement* means the product of combined uncertainty of measurement and coverage factor;
3) *uncertainty of measurement* means a quantitative assessment of the quality of the measurement result that describes the presumed variation in the values of the measured quantity;
4) *measurement system* means a system intended for measurements, comprising radiation meters, radiation detectors, a reader or readers, peripheral equipment and computer programs and operating instructions;
5) *reference conditions* mean the radiation type and radiation quality stated in the standard pertaining to the measuring instrument and the stated environmental conditions where the reference values have been defined;
6) *intrinsic error* means a defined error in reference conditions;
7) *radiation quality* means the energy distribution of a radiation type;
8) *radiation type* means the physical form of radiation;
9) *reference instrument* means a measuring instrument that is calibrated using measurement standards;
10) *error* means the difference between a measurement result and the correct value of the measured quantity after all the known corrections have been made;
11) *environmental conditions* mean conditions other than those resulting from ionizing radiation that may affect the measurement result.

Council Directive 2013/59/Euratom (32013L0059); OJEU L 13, 17.1.2014, p. 1
Reported to the Commission in accordance with Article 33 of the Treaty establishing the European Atomic Energy Community.

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Section 3
Quantities and units to use

The following shall be used in measurements:
1) the base units set out in the Government Decree on Units of Measurement (1015/2014) and other SI units;
2) the quantities and measurement units used in the determination of radiation exposure set out in the Government Decree on Ionizing Radiation (1034/2018);
3) the quantities and measurement units defined in Annex 2.

Section 4
Reliability of radiation measurements

The radiation meter shall be suitable for the measurement with the values, radiation types and radiation qualities of the quantity being measured. If the dose rate of the radiation being measured is pulsed, the measuring instrument and the measuring system shall be capable of measuring both continuous and pulsed radiation. Additionally, the radiation meter shall be suitable for the environmental conditions prevailing in its place of use.

The metrological traceability of a measurement result shall be demonstratable based on the information provided in the calibration certificate of the measuring instrument and measurement system and the description of the method of measurement used.

To demonstrate the metrological traceability of the measuring result of the measuring instrument, the calibration data referred to in section 14 may be provided in the data of the user's management system instead of a calibration certificate.

An uncertainty assessment shall be conducted on the measurement results of measurements concerning radiation practices and radon concentration measurements of a workplace, dwelling or other premise used by people.

The reliability, measuring instrument and measurement system of radiation measurements shall meet the requirements specified in Annex 1, Tables 1.1—1.3.

Section 5
Measurement quantities for occupational exposure and public exposure

The measurement quantities set out in Annex 1, Table 1.1 and 1.3 shall be used in radiation measurements conducted for radiological surveillance and individual monitoring and in radiation measurements conducted to ensure the safety of population.

Section 6
Radiation measurements conducted for radiological surveillance and public exposure

In radiation measurements conducted for radiological surveillance and public exposure, the effect of radiation on the response of the radiation meter shall be known.

If the dose rate in the measurements referred to in subsection 1 may exceed the operating range of the meter, the meter shall in such cases indicate overloading.

Section 7
Radiation measurements for individual monitoring

When the accuracy of the dosimetry system used for determining the individual dose of a radiation worker is determined, the radiation type and quality, variation range of dose rate and dose as well as the pulsed form of the radiation shall be taken into account.

In determining the dose from internal exposure, activity measurements must consider the nuclides to be measured.

Section 8
Dosimetry system and the measurement system used for determining internal exposure

Specifications shall be available of the characteristics and performance of the dosimetry system intended for individual monitoring, including test results on the dependency of the response of the dosemeter on the measured dose, radiation energy and energy distribution, the direction of radiation, the detection threshold of the measurement system and the effect of environmental conditions on the measurement result.

The dosimetry system intended for individual monitoring and the meters included in it shall be capable of measuring the personal dose equivalent $H_p(d)$.

Specifications shall be available of the characteristics and performance of the measurement system used for determining occupational and internal public exposure, and with regard to the test results, reference shall be made to the standards used for demonstrating the reliability of the measurements, or a description of the testing method shall be provided. When the dose arising from internal exposure is determined, the time of the exposure, the ways of exposure, the absorption class, the particle size and any prior exposure shall be taken into account.

Section 9
Radiation meters used in rescue operations and civil defence

A portable dose rate meter used in rescue operations and civil defence shall have a continuously operating audio signal for detecting the dose rate and any changes in it. The measuring instrument shall be provided with instructions for use. The power source used in the measuring instrument shall be of a commonly used type.

Section 10
Meters for measuring radon concentration and radon-induced exposure

A meter for measuring radon concentration and radon-induced exposure shall be a reference instrument.

Specifications shall be available of the characteristics and performance of the meter and the measuring system for measuring radon concentration and radon-induced exposure. With regard to the test results, reference shall be made to the standards used for demonstrating the reliability of the measurements, or a description of the testing method shall be provided.

Section 11
Reliability of medical exposure measurements

When the medical exposure in X-ray examinations and procedures and in external radiotherapy and brachytherapy is measured, the measurement quantities set out in Annex 1, Table 1.2 shall be used.

If a quantity other than that referred to in subsection 1 is used in the display of an instrument used in X-ray examinations and procedures, the operator shall know the relationship of this quantity to the quantity referred to in section 1 and the metrological traceability of the measurement results.

The requirements of sections 13 and 15(4) shall apply to any computational displays used for determining medical exposure in X-ray examinations and procedures.

Section 12
Reliability of activity measurements of radiopharmaceuticals

In nuclear medicine examinations and treatment, the measured quantity in the measurement of the radiopharmaceutical shall be activity.

The intrinsic error of the measurement may not exceed 10% with activity in excess of 3.7 MBq. When the activity is not more than 3.7 MBq, the intrinsic error may be higher than 10%, but its highest possible value shall be estimated. If the radioactive substance being measured has daughter isotopes whose activity is measured and that are not in equilibrium with their parent nuclides, the effect of this in the measurement result shall be taken into account.

The deviation of an individual measurement result from the average of the results in a series of ten measurements may not exceed 5%. The activity used in the measurement shall be the activity of a typical radiopharmaceutical administered to a single patient.

If the activity meter is used for measuring gamma radiation with energy not exceeding 100 keV, beta radiation or alpha radiation, the effect of the ampoule and the measurement geometry on the measurement result shall be taken into account.

The linearity deviation of the response of the activity meter may not exceed 5% with an activity not exceeding 5 GBq. The linearity of the response of the activity meter shall be measured with at least one radionuclide. With activity in excess of 5 GBq, the activity meter shall be calibrated with the activity used.

Section 13
General requirements for calibration

The radiation meter and the measuring system shall be calibrated prior to their commissioning.

The radiation meter and the measuring system shall be calibrated based on an applicable standard. If there is no such standard, the calibration shall be carried out using other standardized methods and international good practices.

By way of derogation from the calibration requirements set out in subsection 2 of this section, the calibration of a measuring instrument may be based on a procedure which is in accordance with the general calibration principles.

Section 14
Calibration of the radiation meter and the measurement system

The dosimetry system used for individual monitoring and the reference instruments for radiation practices and rescue operations shall be calibrated by a laboratory accredited for calibrations of radiation meters or a national metrological laboratory.

The meter and the measurement system used for determining radon concentration in the air and radon-induced exposure shall be calibrated by laboratory accredited for radon concentration measurements.

The presentation of the calibration results shall meet the requirements of ISO/IEC 17025 for calibration and testing laboratories and the specific requirements for a calibration laboratory. However, the calibration results of a radiation meter that is only used as a measuring instrument can be limited to only include the calibration procedure, the calibration quantity, the numerical result and its unit and uncertainty.

Measuring instruments shall be calibrated using a reference instrument.

The operation of a portable radiation meter used for rescue operations, civil defence or radiological surveillance can be checked by means of a radiation source and a reference instrument instead of calibration.

Section 15
Calibration interval

The calibration interval of a reference instrument, measuring instrument and measurement system may not exceed five years, unless otherwise provided below or otherwise decided by the Radiation and Nuclear Safety Authority when approving the method of measurement or practice or otherwise.

The calibration interval of a meter or measurement system for radon concentration in air or radon-induced exposure may not exceed two years.

In external radiotherapy, the calibration interval of radiation meters used for the dose calibration of radiotherapy equipment, and in brachytherapy, calibration interval of radiation sources and radiation meters used for the calibration of radiation sources may not exceed three years.

The calibration interval of a measuring instrument used for measuring medical exposure may not exceed two years.

Section 16
Testing of the operation of meters

A radiation meter shall be in an operating condition. The operating condition shall be verified by means of testing.

The operation of a radiation meter shall be tested at regular intervals using a suitable radiation source or reference instrument. Additionally, the operation shall be tested whenever there is a reason to suspect changes to the operating condition of the meter.

The operation of a radiation meter shall be tested under known and reproducible radiation conditions. The measurement results obtained shall be compared against the radiation values known based on similar measurements previously conducted, and the meter shall be re-calibrated if necessary.

The alarm functionalities in the radiation meter shall be tested.

Section 17
Entry into force and transitional provisions

This regulation enters into force on 1 May 2021 and it will be valid until further notice.

This regulation applies to any matters pending on the date of its entry into force.

This regulation repeals the Radiation and Nuclear Safety Authority's Regulation on Radiation Measurements (STUK S/6/2018).

In Helsinki on 27 April 2021

Director General Petteri Tiippana

Director Tommi Toivonen

Availability of the regulation, guidance and advice

This regulation has been published as part of the regulations issued by the Radiation and Nuclear Safety Authority (STUK) and it is available from the Radiation and Nuclear Safety Authority.

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ANNEX 1

Requirements for radiation measurement reliability, radiation meters and measurement systems

Table 1.1. Purpose of the measurement, measuring quantities, measurement accuracy requirements and the requirements imposed on radiation meters and measurement systems.

Purpose of measurement	Measured quantity	Maximum permissible uncertainty of measurement (%)[1)]	Radiation meter[2)] or measuring system requirements
Radiological surveillance. Dose or dose rate measurement in the working premises or their vicinity[3)]	Ambient dose equivalent Ambient dose equivalent rate	60	With photon radiation, the response of the meter[3)] may not be lower than 0.71 or higher than 1.67 in the energy range 20 keV—150 keV or 80 keV—1.5 MeV The intrinsic error of an alarming personal dosemeter may not exceed 30%
Radiological surveillance. Dose or dose rate measurement in the working premises or their vicinity[3)]	Directional dose equivalent Directional dose equivalent rate	60	The intrinsic error of an alarming personal dosemeter may not exceed 30%
Radiological surveillance X-ray diagnostics equipment leakage and scatter radiation	Air kerma rate	20	
Radiological surveillance Radioactive substance contamination in the working premises or their vicinity	Surface activity	60	
Individual monitoring. A dosimetry system shall be used for determining the worker's dose	Personal dose equivalent	42	The highest variation range of response R [4)] With photon radiation, $\overline{E}_{ph} > 10$ keV, and with beta radiation, $\overline{E}_{beta} > 0.2$ MeV $0{,}71 \cdot \left[1 - \frac{2 \cdot H_0/1{,}33}{H_0/1{,}33 + H_{ref}}\right] \leq R$ [5)] $1{,}67 \cdot \left[1 + \frac{H_0}{4 \cdot H_0 + H_{ref}}\right] \geq R$ With neutron radiation and photon radiation, $\overline{E}_{ph} \leq 10$ keV, and with beta radiation, $\overline{E}_{beta} \leq 0.2$ MeV $0{,}5 \cdot \left[1 - \frac{2 \cdot H_0/1{,}5}{H_0/1{,}5 + H_{ref}}\right] \leq R \leq 2$

Purpose of measurement	Measured quantity	Maximum permissible uncertainty of measurement (%)[1)]	Radiation meter[2)] or measuring system requirements
Determination of a radiation worker's dose from internal exposure. Activity measurement	Nuclide-specific activity	Uncertainty in accordance with the standard applicable to the method of determination	In accordance with the standard applicable to the method of determination
Determination of a radiation worker's dose from internal exposure. Dose determination	Committed effective dose	Uncertainty in accordance with the standard applicable to the method of determination	In accordance with the standard applicable to the method of determination
Building material measurements	Activity concentration	Uncertainty in accordance with the standard applicable to the method of determination	The activity concentration of building materials shall be measured using high energy resolution (HPGe) gamma spectrometry.

[1] Expanded uncertainty of measurement with coverage factor 2.
[2] The measuring instrument shall meet the requirements set out in the applicable standard.
[3] The requirement concerns external radiation exposure.
[4] $R = \frac{G}{H_{ref}}$ is the dosemeter response, where G is the dose determined with the dosemeter and H_{ref} is the actual dose.
[5] H_{ref} is the recording level.

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Table 1.2. Quantities and accuracy requirements used in measurements carried out for determining medical exposure.

Purpose of measurement	Measured quantity	Maximum permissible uncertainty of measurement (%)[1)]	Radiation meter requirements
X-ray examinations and procedures. X-ray equipment radiation output.	Air kerma Current time product	7	A measuring instrument that meets the criteria referred to in IAEA TRS 457[2)]
X-ray examinations and procedures	Entrance surface air kerma Air kerma-area product	25[3)]	A measuring instrument that meets the criteria referred to in IAEA TRS 457[2)]
CT scans and procedures	Air kerma-length product Volume CT air kerma index	25[3)]	A measuring instrument that meets the criteria referred to in IAEA TRS 457[2)]
External radiotherapy with photon radiation under reference conditions[4)]	Absorbed dose to water	3	A measuring instrument that meets the criteria referred to in IAEA TRS 398:n[5)]
External radiotherapy with electron radiation under reference conditions[4)]	Absorbed dose to water	4	A measuring instrument that meets the criteria referred to in IAEA TRS 398:n[5)]
External radiotherapy. Measurement in patient	Absorbed dose to water	5	
Brachytherapy with a photon radiation source under reference conditions[4)]	Reference air kerma rate	5	Applicable international standard
Brachytherapy with a beta radiation source under reference conditions[4)]	Reference dose rate for absorbed dose to water	15	Applicable international standard

[1] Expanded uncertainty of measurement with coverage factor 2.
[2] International Atomic Energy Agency (IAEA). Dosimetry in diagnostic radiology: An international code of practice Technical report series no. 457. Vienna: IAEA, 2007.
[3] The same maximum value for uncertainty shall also be used when the apparatus is equipped with a computational indication of the patient's radiation exposure.
[4] Reference conditions mean measurement in water, in reproducible and known geometry and environmental conditions, the result of which is used as the basis for the patient's dose determination and planning.
[5] International Atomic Energy Agency (IAEA). Absorbed dose determination in External Beam Radiotherapy. An international code of practice for Dosimetry Based on Standards of Absorbed Dose to Water. Technical reports series no. 398, V12, 05 June 2006 or a later edition.

Table 1.3. Measurement quantities used in rescue operations and civil defence and requirements for measuring photon radiation and for radiation meters.

Purpose of measurement	Measured quantity	Measurement range[1]	Radiation meter requirements
Rescue operations	Ambient dose equivalent rate[2)]	Minimum for dose equivalent rate 0.1 µSv/h—10 Sv/h	Meets the requirements of IEC 60846-2[2)] Protection against dust and water: Ingress protection rating IP 65 (according to SFS-EN 60529) If the radiation meter can be fitted with a separate surface contamination sensor, it must meet the requirements of IEC 60325
Civil defence	Ambient dose equivalent rate[2)]	Minimum for dose equivalent rate 1 µSv/h—100 mSv/h	Meets the requirements of IEC 60846-1[2)] Protection against dust and water: Ingress protection rating IP 54 (according to SFS-EN 60529)
Personal dose measurement	Personal dose equivalent Personal dose equivalent rate	Minimum for dose equivalent rate 0.5 µSv/h–1 Sv/h	Meets the requirements of IEC 61526 Protection against dust and water: Ingress protection rating IP 54 (according to SFS-EN 60529)

[1] If it is not possible to cover the entire measurement range with one radiation meter, several radiation meters can be used, whose combined measurement range covers the required measurement range.
[2] If the portable dose rate meter also has a dose-measuring capability, the dose-measuring capability of the dosimeter shall meet the requirements of the standard.

Table 1.4. Requirements for the measurement of radon concentration and radon-induced exposure.

Measurement and its purpose	**Measured quantity and measurement unit**	**Maximum permissible uncertainty of measurement (%)[1)]**	**Requirements for radiation meter or measurement system**
Continuous integrated measurement of indoor radon concentration for at least 2 months in a workplace, dwelling and other premises used by people	Activity concentration (Bq/m^3)	30	The coefficient of variation of the results shall not exceed 10 % for an exposure corresponding to an activity concentration of 300 Bq/m^3 and 1500 hours of measurement. The coefficient of variation of the distribution of the results is determined from the readings of several integrating meters under constant conditions (homogeneity)[2)]. The upper limit of the measurement range shall be at least 5 000 Bq/m^3 if the meter is used for comparison with a radon reference level at the workplace or in the dwelling and the measurement is carried out over a period of at least 60 days. The upper limit of the measurement range shall be at least 10 000 Bq/m^3 if the measurement result is used to calculate the dose to a worker and the measurement period is at least 60 days.
Continuous measurement over a period of at least one week for investigating temporal variations of indoor radon concentrations	Activity concentration (Bq/m^3)	30	The sensitivity of the meter shall be at least 0.01 cph/(Bq/m^3). The response time of the meter shall not exceed 100 min. The upper limit of the measurement range shall be at least 9 000 Bq/m^3 if the measurement result is used to determine the radon concentration during working hours and full-time and the measurement is performed with a measurement period of at least 7 days.
Instantaneous measurement of radon in air lasting for up to 1 hour	Activity concentration (Bq/m^3)	30	The coefficient of variation of the results shall not exceed 10 % at an activity concentration of 300 Bq/m^3. The coefficient of variation of the distribution of the results is determined from the repeated readings of the measurement (repeatability)[2)]. The upper limit of the measurement range shall be at least 10 000 Bq/m^3 if the dose to a worker is calculated from the measurement result.

Measurement and its purpose	**Measured quantity and measurement unit**	**Maximum permissible uncertainty of measurement (%)[1)]**	**Requirements for radiation meter or measurement system**
Individual integrated measurement of at least 2 months to determine the worker's exposure to radon	Radon exposure (Bq h/m^3)	30	Coefficient of variation of the results shall not exceed 10% at 500 000 Bq h/m^3 exposure. The coefficient of variation of the distribution of the results is determined from the readings of several integrating instruments under standard conditions (homogeneity)[2)]. The upper limit of the measurement range of the meter and the measurement system for measuring occupational exposure to radon shall be at least 3 000 000 Bq h/m^3.
Measurement with a portable meter of less than 2 months to determine the worker's exposure to radon	Activity concentration (Bq/m^3)	30	Meter sensitivity of at least 0.01 cph/(Bq/m^3). The upper limit of the measurement range shall be at least 10 000 Bq/m^3 if the dose to the worker is calculated from the measurement result and the measurement is performed with a shorter measurement period than 60 days.

[1)] Expanded uncertainty of measurement with coverage factor 2.
[2)] The coefficient of variation does not consider statistical variation due to radon decay.

ANNEX 2

Quantity definitions

Air kerma
Air kerma (K_a) is the sum of the initial kinetic energies of the charged particles produced by uncharged ionizing particles in a small element of air, divided by the mass of that element of air.

The unit of air kerma is the gray (Gy), 1 Gy = 1 J·kg^{-1}.

Air kerma rate is the increase in air kerma over a short interval divided by that interval.

Dose equivalent
The dose equivalent H is the product of the absorbed dose D and the quality factor Q:

$H = Q \cdot D$.

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

The quality factor Q is a factor which depends on the linear energy transfer L, and which seeks to allow for the different ability of various radiation qualities to cause damage to health.

The dependency between Q and L is shown in Table 2.1.

Table 2.1. Quality factor Q as a function of linear energy transfer L.

Linear energy transfer L in water (keVμm^{-1})	**Quality factor Q (L)**
< 10	1
10—100	0.32 L - 2.2
> 100	300 / √ L

When the absorbed dose at a point in tissues is caused by particles of varying linear energy transfer, the quality factor can be calculated as a mean quality factor by considering the distribution of the absorbed dose in relation to the linear energy transfer. The linear energy transfer means the unrestricted linear energy transfer.

Directional dose equivalent
The directional dose equivalent $H'(d,\Omega)$ is the dose equivalent at a point in a radiation field which would be caused by the corresponding expanded field in an ICRU sphere at a depth d on a radius in a specified direction Ω, where:
1) an expanded field is a radiation field in which the particle fluence and its directional and energy distributions are the same throughout the volume of interest as at the reference point in the actual field;
2) The ICRU sphere is a spherical tissue equivalent defined by the International Commission on Radiation Units and Measurements (ICRU), which approximately corresponds to the human body with regard to the absorption of the energy of ionizing radiation.

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

Ambient dose equivalent
The ambient dose equivalent $H^*(d)$ is the dose equivalent at a point in a radiation field which would be caused by the corresponding aligned and expanded field in an ICRU sphere at a depth d on the radius opposing the direction of the aligned field, where:

1) an aligned and expanded field is a radiation field in which the particle fluence and its energy distribution are the same as in the expanded field, but the fluence is unidirectional.
2) The ICRU sphere is a spherical tissue equivalent defined by ICRU, which approximately corresponds to the human body with regard to the absorption of the energy of ionizing radiation.

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

Personal dose equivalent
The personal dose equivalent $H_p(d)$ is the dose equivalent at a point at depth d in soft tissues of the body.

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

Surface activity
The surface activity A_s is the activity A of a radioactive substance on a given surface in the area under inspection, divided by the area S of this surface:

The unit of surface activity is $Bq \cdot m^{-2}$.

Entrance surface air kerma
The entrance surface air kerma (*ESAK*) is air kerma at the point of intersection of the central axis of the radiation beam with the entrance surface of the patient, including radiation scattered from the patient to this point.

The unit of entrance surface air kerma is the gray (Gy).

Air kerma-area product
The air kerma-area product (*KAP*) is defined as an integral

$$KAP = \int_{A_M} K(x,y)\, dxdy ,$$

where $K(x,y)$ is the air kerma on a plane perpendicular to the axis of the radiation beam and A_M is the integration area.

The unit of air kerma-area product is $Gy \cdot m^2$ (or more commonly $Gy \cdot cm^2$).

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Air kerma-length product
In tomography imaging, the air kerma-length product is defined as an integral

$$KLP = \int_{-\infty}^{\infty} K(z)\ dz,$$

where *K(z)* on the air kerma arising from the examination as a function of place *z* (the air kerma profile) in the direction of the axis of rotation of the X-ray tube.

The unit of air kerma-length product is Gy·m (or more commonly Gy·cm).

Based on the air kerma profile of an individual axial imaging or single rotation of the X-ray tube, the *KLP* is

$$KLP = N \cdot \int K_1(z)dz = N \cdot KLP_1,$$

where
$K_1(z)$is the air kerma profile of an individual axial imaging or single rotation of the X-ray tube, and
$KLP_1$the corresponding air kerma-length product;
N is the number of rotations of the X-ray tube.

Weighted air kerma-length product
The weighted air kerma-length product (KLP_w) is defined as follows:

$$KLP_w = \frac{1}{3} \cdot KLP_c + \frac{2}{3} \cdot KLP_p,$$

where KLP_c is the air kerma-length product determined in the middle of a tissue equivalent used in computed tomography and KLP_p is the air kerma-length product determined at a depth of 10 mm in said tissue equivalent.

Volume CT air kerma index
In computed tomography examinations (CT scans) consisting of several individual axial images or several individual rotations of the X-ray tube in helical scanning, the volume CT air kerma index is:

$$CTKI_{vol} = \frac{1}{d}\int_{-\infty}^{\infty} K(z)\ dz = \frac{1}{d}KLP,$$

where *K(z)* is the air kerma profile, as defined in the standard tissue equivalent used in CT scans, caused by the entire examination in the monitored area in the direction (z) of the axis of rotation of the X-ray tube and at the monitored distance from said axis;
d is the length of the examined area in the direction of said axis.

The unit for volume CT air kerma index is Gy (or more commonly mGy).

The volume CT air kerma index calculated from the air kerma profile $K(z)$ measured during a single axial imaging or one rotation of the X-ray tube in helical scanning and from the corresponding table movement $\triangle d$ is:

$$CTKI_{vol} = \frac{1}{\triangle d}\int_{-\infty}^{\infty} K(z)\ dz$$

Calculated using the weighted air kerma-length product, the CT air kerma index is:

$$CTKI_{vol} = \frac{1}{d} KLP_w$$

In practical measurements, the integration limits are finite.

Reference air kerma rate

The reference air kerma rate is the air kerma rate at a distance of one metre from a brachytherapy radiation source.