

# RADIATION SAFETY IN PRACTICES CAUSING EXPOSURE TO NATURAL RADIATION

1	GENERAL	3
2	RADON AT WORKPLACES AND IN PUBLIC PREMISES	3
2.1	Radon concentrations are restrained with action levels	3
2.2	Radon at conventional workplaces and in public places	4
2.2.1	The responsible party has an obligation to conduct measurements	4
2.2.2	How is a radon measurement conducted?	4
2.2.3	When shall STUK be notified and when are additional measures necessary?	4
2.2.4	When does radiation exposure need to be monitored at conventional workplaces?	5
2.3	Radon in underground mines and quarries	5
2.3.1	STUK shall be notified of underground mining and quarrying work	5
2.3.2	STUK carries out periodic inspections	6
2.3.3	When does radiation exposure need to be monitored in mines and quarrying sites?	6
2.4	Radon in tunnels and other comparable places underground	7
3	UTILIZATION OF NATURAL RESOURCES AND PROCESSING OF MATERIALS	7
3.1	Some materials may contain exceptionally large amounts of naturally occurring radionuclides	7
3.2	When shall STUK be notified of utilization of natural resources?	8
3.3	Investigation and limitation of exposure of workers and the public	8
3.3.1	The radiation exposure of workers shall be investigated if the action level might be exceeded	8
3.3.2	When shall radiation dose to the public be investigated and limited?	9

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3.4	When shall the monitoring of the radiation exposure of workers be arranged in the utilization of natural resources?	9
3.5	When shall medical surveillance be arranged for workers in the utilization of natural resources?	11
3.6	STUK asserts regulatory control on radiation exposure caused by the utilization of natural resources	11
3.7	The responsible party shall take care of the waste and releases caused by the practice	11
APPENDIX A	DEFINITIONS AND CONCEPTS	
APPENDIX B	CALCULATION OF THE DOSE CAUSED BY RADON EXPOSURE	
APPENDIX C	RADIOLOGICAL BASELINE STUDY AND ENVIRONMENTAL RADIATION MONITORING	

## 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. L 159, 29.6.1996, p. 1.

# 1 General

The responsible party shall investigate the radiation exposure caused by natural radiation if it is discovered or there is reason to suspect that practices or circumstances are such that the exposure of human beings to natural radiation causes or may cause a health hazard. If necessary, the exposure shall be limited.

This Guide specifies the action levels to be applied for the purpose of limiting radiation exposure in practices causing exposure to natural radiation, and the relevant operational guidelines. The Guide also prescribes how to organize monitoring of radiation exposure and medical surveillance in a practice causing exposure to natural radiation. Furthermore, guidelines are given to limit the exposure of the public.

This guide applies to the following practices, in particular:

- work in underground mines, underground quarries and other underground workplaces where the radon concentration in inhaled air, or radiation exposure otherwise caused by naturally occurring radioactive substances, is significantly high
- work, in other such workplaces, where the radon concentration in inhaled air, or radiation exposure otherwise caused by naturally occurring radioactive substances, is significantly high
- processing or storage of materials containing exceptionally large amounts of naturally occurring radionuclides
- any practice producing waste containing substantial amounts of naturally occurring radioactive substances or causing significant releases of naturally occurring radionuclides into the environment.

*Provisions concerning the investigation of practices liable to cause exposure to natural radiation are laid down in section 45 of the Radiation Act (592/1991).*

*The requirements regarding the exposure of flight personnel to cosmic radiation are presented in Guide ST 12.4, the requirements regarding the exposure of users of household water containing radioactive substances are presented in Guide ST 12.3, and the requirements*

*regarding the exposure caused by the radioactivity of building materials and ash are presented in Guide ST 12.2.*

*The Nuclear Energy Act (990/1987) and any statutes given in accordance with the Nuclear Energy Act shall apply to mining and enrichment operations aimed at producing uranium or thorium, and to the export or import of ores or ore concentrates containing uranium or thorium.*

## 2 Radon at workplaces and in public premises

### 2.1 Radon concentrations are restrained with action levels

The action level for the radon concentration in inhaled air is 400 Bq/m<sup>3</sup> in workplaces where people work on a permanent basis. *Radon concentration* refers to the annual mean of the radon concentration during working time.

If the work is not performed on a permanent basis, the mean radon concentration in inhaled air may be higher than 400 Bq/m<sup>3</sup>. The action levels for the radon concentrations for different working times are given in the table below. Working time shall be estimated on the basis of the hours of the worker whose annual working time on the premises is the longest.

**Table.** Action levels for the radon concentration in inhaled air for different working times.

Annual working time	Action level for radon concentration in inhaled air (Bq/m <sup>3</sup> )
Work performed on a permanent basis (more than 600 hours per year)	400
Max. 600 hours	1000
Max. 300 hours	2000
Max. 100 hours	6000

The action levels listed in the table are applied in conventional workplaces and in mines, quarries and tunnels.

The action level in daycare centres, schools and other public places is 400 Bq/m<sup>3</sup> regardless of lengths of stays or working times.

*The annual average concentration of radon in inhaled air in regular work where action must be taken to limit the exposure, is given in section 27 of the Radiation Decree (1512/1991). A provision is laid down in the same section concerning STUK's right to impose regulations for limiting the radon concentration of breathing air in working premises in which work is performed only occasionally or for short periods.*

## **2.2 Radon at conventional workplaces and in public places**

In this Guide, *conventional workplaces* refer to workplaces other than underground mines, underground quarries and tunnels. Requirements presented in items 2.2.1–2.2.3 shall apply to daycare centres, schools and other public places in addition to conventional workplaces.

### **2.2.1 The responsible party has an obligation to conduct measurements**

The responsible party shall investigate radiation exposure due to radon in the workplace if there is reasonable cause to suspect that the radiation exposure of workers exceeds the action level (see item 2.1).

The radon concentration in inhaled air in a conventional workplace shall be measured if the workplace is situated in a region where over 10 per cent of the annual mean values of the radon concentration measured earlier exceeds 400 Bq/m<sup>3</sup>. On its web pages ([www.stuk.fi](http://www.stuk.fi)), STUK issues a list of municipalities where radon measurements shall be made in workplaces.

In addition to the above regions, the radon concentration shall also be measured in other parts of Finland in workplaces situated on eskers or other gravel or sand formations which are readily permeable to air. The radon concentration shall also be measured in all underground workplaces where work is performed on a permanent basis.

However, the measurement requirement does not concern workplaces in which the radon concentration due to the location or construction of the working premises, or for other comparable reasons, is in all probability lower than 400 Bq/m<sup>3</sup> (such as workplaces situated in rooms on the upper floors and on the floors not adjoined to the ground by a floor or wall).

*Provisions concerning the investigation of radiation exposure are laid down in section 45 of the Radiation Act.*

### **2.2.2 How is a radon measurement conducted?**

A radon measurement of inhaled air in a workplace shall be conducted using an integrating method. The measurement shall be made during the heating season (November–April), and the measuring must last no less than two months. Radon concentrations vary according to season, and they usually are higher in winter than in summer.

In large premises, radon measurements must be made at various points where people work on the premises. In the case of office buildings, one measurement for each 200 square metres is recommended. In industrial halls and comparable premises, it is usually sufficient to make 1 to 2 measurements. The measurement shall be made in each separate building where people work.

The measuring methods used for determining the radiation exposure of workers shall be approved for this purpose by STUK, and the instrument shall be properly calibrated.

*Provisions concerning the approval of measuring methods used for monitoring the radiation exposure of workers are laid down in section 12 of the Radiation Decree. The requirements for the approval of measuring methods and calibration are presented in Guide ST 1.9.*

### **2.2.3 When shall STUK be notified and when are additional measures necessary?**

STUK shall be notified of the radon concentration measurement result if the concentration exceeds 400 Bq/m<sup>3</sup> or if the measurement was conducted under orders from STUK. The notification shall include the identification information of the measurement location as well as information on working hours, ventilation, repairs, and any other relevant issues.

On the basis of the investigation and the measurement result, if necessary, STUK will issue orders on actions to reduce the radon concentration or to have additional investigations conducted. An additional investigation may include, for example, investigating the annual

average radon concentration or the radon concentration during working hours.

The remedial method shall be chosen on the basis of e.g. the radon concentration and the constructional solutions used in the building, as well as the type of soil, especially its permeability. The most suitable method shall be determined individually in each case, expert advice being usually required. Guidelines for the reduction of radon concentrations are presented in bibliographic reference 3.

The impact of the measures taken to reduce exposure shall always be ascertained by appropriate measurements, unless the impact can be verified by other means. When necessary, the permanence of the effects of the remedial measures shall be monitored by periodic measurements.

The responsible party shall inform the workers and the occupational safety officer of the measurements and investigations.

*Provisions concerning the duty to report the results of the investigation to STUK are laid down in section 26 of the Radiation Decree. Provisions concerning actions to limit radiation exposure are laid down in section 27 of the Radiation Decree. Provisions are laid down in section 46 of the Radiation Act concerning STUK's obligation to issue instructions, where necessary, on limiting the exposure to radiation.*

#### **2.2.4 When does radiation exposure need to be monitored at conventional workplaces?**

The responsible party shall arrange the monitoring of the radiation exposure of its workers if, even after actions taken to limit their exposure, the action level is exceeded. The monitoring of exposure may be ordered also in the case that the radon concentration in the first measurement was exceptionally high. The purpose of monitoring radiation exposure is to determine the magnitude of the radiation exposure of workers and to ensure that the exposure remains as low as is reasonably achievable. All operations shall be arranged so as to ensure that dose limits are not exceeded. The dose limits must not be exceeded, irrespective of the fact that radon concentrations could not be reduced. If necessary, the exposure shall be

limited through limiting working hours.

Radiation exposure is determined on the basis of the radiation measurement results obtained on the working site and the working hours log of each worker (an example is provided in Appendix B of this Guide). Radiation exposure shall be determined separately for work conducted on different premises if the radiation concentrations on these premises clearly differ.

At conventional workplaces in general, radiation concentration shall be measured twice a year, one measurement during the heating season and one at some other time of the year. If the measurements are made using a radon detector giving the long-term mean radon concentration, the relationship between the measurement result and the actual concentration during the working time shall be adequately demonstrated. Therefore, it is recommended that at least one of the measurements during the radiation exposure monitoring period be performed using a continuously operating measuring instrument.

The workers' working hours in premises subject to radiation exposure monitoring shall be recorded in such a way that the total working hours of any worker on these premises can be reliably assessed during the monitoring period.

The results from the radiation exposure monitoring including the radon measurement results and the individual working hours of each worker shall be sent to STUK.

*Provisions concerning radiation exposure monitoring are laid down in section 28 of the Radiation Decree. The maximum values for radiation exposure (dose limits) are given in chapter 2 of the Radiation Decree. Provisions concerning STUK's right to obtain information are laid down in section 53 of the Radiation Act.*

## **2.3 Radon in underground mines and quarries**

### **2.3.1 STUK shall be notified of underground mining and quarrying work**

The responsible party shall notify STUK of the commencement of underground mining operations intended in the Mining Act and of quarrying work carried out primarily underground or in confined spaces and lasting over two months. In addition, STUK shall be notified of all post-quarry

equipping and building work. The notification shall be made in writing before the practice is commenced.

The following information shall be given in the notification:

- the nature of the practice
- the volume of materials planned to be handled
- planned schedules of the underground mining and quarrying operations (including post-quarry building and equipping work)
- the main types of rock to be excavated to the extent that these are known
- information on the radioactivity of the rock materials to be mined to the extent that they are known (e.g. uranium and thorium concentration)
- estimated number of workers and their working hours.

*Provisions concerning the duty to notify are laid down in section 29 of the Radiation Decree. Mining operations are regulated by the Mining Act (503/1965)\*).*

### 2.3.2 STUK carries out periodic inspections

STUK carries out periodic inspections in underground mines and at underground quarrying sites. In principle, these inspections are carried out every second year. Should a specific need arise, the inspection interval may be shorter.

In addition, a new inspection may be necessary during post-quarry building and finishing work particularly if ventilation is essentially poorer than during excavation.

When necessary, STUK will issue orders on limiting radon concentration. The impact of the measures taken to reduce exposure shall always be ascertained by appropriate measurements, unless the impact can be verified by other means.

In planning and organising the measures to reduce radon concentrations, the possible impact of such measures on other aspects of mine safety and occupational safety shall be taken into account. With respect to aspects other than radiation safety, safety in mines is, according to the Mining Act, subject to regulatory control by

\*) The situation when this Guide enters into force. A new Mining Act is likely to enter into force during 2011.

Finnish Safety and Chemicals Agency (Tukes)\*\*).

The responsible party shall inform the workers and the occupational safety officer of the measurements and investigations.

*Provisions concerning STUK's right to conduct investigations are laid down in section 53 of the Radiation Act. Provisions concerning actions to limit radiation exposure are laid down in section 27 of the Radiation Decree. Provisions are laid down in section 46 of the Radiation Act concerning STUK's obligation to issue instructions, where necessary, on limiting the exposure to radiation.*

### 2.3.3 When does radiation exposure need to be monitored in mines and quarrying sites?

The responsible party shall arrange the monitoring of the radiation exposure of its workers if, even after actions taken to limit their exposure, the action level is exceeded. The monitoring of exposure may be ordered also in the case that the radon concentration in the first measurement was exceptionally high. The purpose of monitoring radiation exposure is to determine the magnitude of the radiation exposure of workers and to ensure that the exposure remains as low as is reasonably achievable. All operations shall be arranged so as to ensure that dose limits are not exceeded. The dose limits must not be exceeded, irrespective of the fact that radon concentrations could not be reduced. If necessary, the exposure shall be limited through limiting working hours.

Radiation exposure is determined on the basis of the radiation measurement results obtained on the working site and the working hours log of each worker (an example is provided in Appendix B of this Guide). Radiation exposure shall be determined separately for work conducted on different premises if the radiation concentrations on these premises clearly differ.

When monitoring radiation exposure in mines and underground quarrying sites, radon concentrations shall be measured at least quarterly.

If workplaces are frequently changed, or if the workers remain for only short periods of time at the same workplace, radiation exposure can

\*\*) The situation when this Guide enters into force.

be determined on the basis of the mean radon concentration estimated for the mine, quarrying site or a part of the mine or quarrying site. In calculating this value, the measurement result obtained for each workplace shall be weighted with the typical working time in that workplace, if necessary.

The workers' working hours in premises subject to working condition monitoring shall be recorded in such a way that the total working hours of any worker on these premises can be reliably assessed during the monitoring period.

The results from the radiation exposure monitoring including the radon measurement results and the individual working hours of each worker shall be sent to STUK.

*Provisions concerning radiation exposure monitoring are laid down in section 28 of the Radiation Decree. The maximum values for radiation exposure (dose limits) are given in chapter 2 of the Radiation Decree. Provisions concerning STUK's right to obtain information are laid down in section 53 of the Radiation Act.*

## **2.4 Radon in tunnels and other comparable places underground**

The responsible party shall notify STUK of work in underground premises not equipped with a ventilation system if the annual working hours of the workers exceed 100 hours.

The worker's total dose shall be determined if the worker works in several tunnels or other comparable underground premises in which the radon concentration in inhaled air is known to be or suspected of being unusually high. The radon concentration in all places where work is conducted shall be measured when appropriate. The measurement method depends on e.g. the duration of work and the place in which the measurement takes place. If the total exposure for a worker due to radon in a calendar year is greater than 600 000 (Bq/m<sup>3</sup>)·h, STUK shall be notified. An example of determining the dose from radon exposure is given in Appendix B of this Guide.

*Provisions concerning the duty to notify are laid down in section 29 of the Radiation Decree. Provisions concerning the duty to report the results of the investigation to*

*STUK are laid down in section 26 of the Radiation Decree.*

# **3 Utilization of natural resources and processing of materials**

## **3.1 Some materials may contain exceptionally large amounts of naturally occurring radionuclides**

In processing materials or waste that can justifiably be suspected to contain such amounts of naturally occurring radionuclides that are significant in view of the radiation exposure of the workers or the public, the responsible party shall measure the activity concentrations in the materials or waste in question and investigate the magnitude of the exposure.

Such materials or waste which may contain naturally occurring radionuclides in amounts significant in view of radiation exposure include for example:

- phosphate rock, fertilisers manufactured from it and the plaster produced as a by-product during the production process
- tin, lead and bismuth ores and concentrates
- ilmenite, rutile (production of titanium and titanium oxide)
- monazite (production of rare earth metals)
- pyrochlorine, columbite (production of niobium)
- zirconium sand (production of fireproof goods)
- waste produced in the purification of water for household use, containing naturally occurring radioactive substances (e.g. discarded filters)
- welding rods and gas-lamp filaments containing thorium
- precipitates produced in oil and gas production.

In industrial processes, naturally occurring radionuclides may become significantly concentrated at certain process stages, even if the raw material itself or the final product do not contain exceptionally large amounts of naturally occurring radionuclides.

*Provisions concerning the investigation of radiation exposure in the utilization of natural resources are laid down in section 45 of the Radiation Act.*

### **3.2 When shall STUK be notified of utilization of natural resources?**

If natural resources are utilized for the purpose of producing uranium or thorium, a licence in accordance with the Nuclear Energy Act is required for the practice.

In the case that the practice is not carried out for the purpose of producing uranium or thorium, STUK shall be notified of extensive utilization of natural resources that contain uranium or thorium in excess of 0.1 kg per ton.

The notification shall be made in writing in good time before the practice is commenced, and it shall contain the following information:

- the nature of the practice
- the volume of materials planned to be handled
- information on the radioactivity of the materials
- an estimate of the number of workers and their working times
- an account of the quantity and type of waste and releases produced in carrying out the practice.

On the basis of such a notification, STUK will set the requirements for the radiation safety of the practice, and give orders concerning the reports and actions required.

*Provisions concerning the use of nuclear energy are laid down in the Nuclear Energy Act. Provisions concerning the special duty of notification are laid down in section 29 of the Radiation Decree. Provisions concerning the responsible party's duty to ensure that radioactive waste poses no hazard to human health or to the environment are laid down in section 50 of the Radiation Act. Provisions on mining are laid down in the Mining Act.*

### **3.3 Investigation and limitation of exposure of workers and the public**

#### **3.3.1 The Radiation exposure of workers shall be investigated if the action level might be exceeded**

The action level for the radiation exposure of workers caused by sources of natural radiation other than radon is 1 mSv per year.

When assessing the dose, both the dose caused by external radiation and the dose from naturally occurring radionuclides entering the body through the mouth and along with inhaled air shall be taken into account. Before the dose received in this way can be compared with the action level, the proportion of natural background radiation and the dose caused by radon and its short-lived decay products shall be deducted from the total dose.

Radiation exposure of workers shall be investigated unless, on the basis of the data in the notification referred to above, it is estimated to be below the action levels. In addition, the radon concentration on the working premises shall be measured if it is suspected that the processed material may emit substantial amounts of radon into the air in the workplace.

The report of the investigation, including the measurement results, shall be made available to STUK. The report shall include a description of the actions taken to limit the workers' radiation exposure. When necessary, STUK will issue other instructions on limiting the exposure (see item 3.6).

The responsible party shall inform the workers and the occupational safety officer of the measurements and investigations.

*Provisions concerning the duty to investigate radiation exposures are laid down in section 45 of the Radiation Act. Provisions concerning the duty to report the results of the investigation to STUK are laid down in section 26 of the Radiation Decree. The action level to limit the natural radiation exposure caused by sources other than radon is given in section 27 of the Radiation Decree.*

*Calculation of the dose caused by internal radiation is presented in Guide ST 7.3. The Occupational Health Care Act (1383/2001) lays down provisions on the employer's duty to provide information to occupational health care professionals and experts concerning the conditions in the workplace and the changes in these.*

### **3.3.2 When shall radiation dose to the public be investigated and limited?**

Practices causing exposure to natural radiation may increase the radiation exposure of persons other than exposed workers. The responsible party shall ensure that the radiation exposure of the public resulting from the practice is kept as low as is reasonably achievable, and that the exposure, in all circumstances, remains below the dose limits for members of the public.

In general, measures to limit radiation exposure are not needed, if the dose from operation liable to cause exposure to natural radiation is no greater than 0.1 mSv per year above the natural background radiation dose. In such a case, however, the dose from radon is not taken into account.

STUK will impose case-specific dose constraints relevant to the circumstances after receiving a notification concerning the commencement of a practice. In practices causing exposure to natural radiation, the dose constraint for members of the public for a specific radiation source may be 0.1 to 0.5 mSv per year.

The responsible party shall investigate the radiation exposure of persons other than workers if there is reasonable cause to suspect that the dose will exceed 0.1 mSv per year. The investigation shall cover an individual representing the population group whose exposure is estimated to be the highest (i.e. critical group<sup>\*\*\*</sup>). When assessing the exposure, both the dose from external radiation and, when appropriate, the dose from naturally occurring radionuclides other than radon and its short-lived decay products entering the body with food and inhaled air, shall be taken into account.

If it is probable, that the exposure of the public will be higher than 0.1 mSv per year, the responsible party shall

- submit to STUK a plan describing the measures by which radiation exposure is to be kept as low as is reasonably achievable
- organize a radiological baseline study
- arrange environmental radiation monitoring after the operation has commenced.

The contents for the radiological baseline study and environmental radiation monitoring are presented in Appendix C.

The plan submitted to STUK shall include at least the following information:

- the location of the plant or work site in the region in question (regional map)
- residential and business premises in the vicinity of the plant, including the number of persons working or living in them
- use of water and land use in the area (agricultural land, water intake plants, wells etc.)
- a description of the practice, including the quantity, type and activity concentrations of the waste and releases resulting from the practice
- a description of the treatment of radioactive waste
- a description of the measures planned to reduce the release of radioactive substances into the environment.

*Provisions concerning dose limits for members of the public are laid down in section 6 of the Radiation Decree. Provisions concerning dose constraints are laid down in section 7 of the Radiation Decree.*

### **3.4 When shall the monitoring of the radiation exposure of workers be arranged in the utilization of natural resources?**

The monitoring of the radiation exposure of workers shall be arranged if, even after actions taken to limit their exposure, the action level is exceeded. The purpose of monitoring radiation exposure is

- to determine the magnitude of the radiation exposure of workers
- to ensure that the exposure remains as low as is reasonably achievable

\*\*\*) ICRP 103: representative group.

- to ensure that the maximum values of radiation exposure are not exceeded
- to detect unforeseen variations in the factors affecting the radiation exposure of workers.

All operations shall be arranged so as to ensure that dose limits are not exceeded.

Radiation exposure monitoring, when applicable, shall be arranged in accordance with Guide ST 7.1. In addition, the principles presented hereafter shall be noted in radiation exposure monitoring for practices causing exposure to natural radiation.

Radiation exposure is generally determined on the basis of working hours and the results from measurements conducted in work sites or in their vicinities. According to the circumstances, the measured object may be e.g. the radon concentration in inhaled air, the dose rate of external radiation, or the activity concentration in inhaled air caused by radioactive substances in dust. The measurements shall be made in working conditions that are normal with respect to exposure conditions.

If workplaces are frequently changed, or if the workers remain for only short periods of time at the same workplaces, radiation exposure can be determined on the basis of the mean value of the measurement results from the different workplaces. In calculating this value, the measurement result obtained for each workplace shall be weighted with the typical working hours in that workplace, if necessary.

Before the practice or the monitoring of radiation exposure is begun, the exposure from natural background radiation shall be investigated in the workplace in order to make it possible to correctly assess the exposure due to the practice. The level of natural background radiation shall be determined by measuring the dose rate of external radiation and, when appropriate, the radon and dust concentration in inhaled air, as well.

When radiation exposure monitoring results are compared to dose limits, the doses from radon and other natural radiation sources are added

together, and the dose from natural background radiation is deducted from this total dose.

An example of determining the dose from radon exposure is given in Appendix B. In other respects, the calculation methods specified in Guides ST 7.2 and ST 7.3 shall be used for assessing the dose.

The measurements required for radiation exposure monitoring shall be conducted at the following intervals, unless it is necessary to make the measurements more frequently:

- the dose rate of external radiation at the work site at least once a year
- activity concentrations in inhaled air due to dust at least once a year
- radon concentration measurements as presented in items 2.2.4 and 2.3.3.

The measurements shall be renewed if significant changes occur in the working conditions. Such changes may include a change in the working site, a significant change in the quantities of the materials processed, a change in the material processed, or a significant change in the dustiness of the material.

The results from the radiation exposure monitoring as well as the measurement results and individual working hours of all workers shall be sent to STUK.

In addition, the responsible party shall be responsible for arranging the monitoring of the radiation exposure of outside workers as indicated in Guide ST 1.6.

*Provisions concerning radiation exposure monitoring are laid down in section 28 of the Radiation Decree. The maximum values for radiation exposure (dose limits) are given in chapter 2 of the Radiation Decree. Provisions concerning STUK's right to obtain information are laid down in section 53 of the Radiation Act. Guide ST 1.6 deals with operational radiation safety, Guide ST 7.1 with the monitoring of radiation exposure, Guide ST 7.2 with the principles for the calculation of radiation doses, and Guide ST 7.3 with the calculation of the dose caused by internal radiation.*

### 3.5 When shall medical surveillance be arranged for workers in the utilization of natural resources?

The general principles of radiation protection are primarily implemented by means of good protective measures at workplaces, not by laying down health requirements for workers.

If the radiation exposure caused by sources of natural radiation other than radon might exceed 6 mSv per year, the responsible party shall arrange medical surveillance for the workers. The purpose of the medical surveillance of workers is:

- to ensure that the workers' state of health does not prevent them from performing work resulting in exposure to radiation
- to detect such changes in the workers' state of health that would represent an obstacle to carrying out such work.

If the operation causes exposure to radon only, there is no need for medical surveillance. Neither does radon cause a foetus to receive a radiation dose during the pregnancy.

Provisions concerning the medical surveillance of workers are laid down in the Occupational Health Care Act and the statutes given in accordance with the Act. Medical surveillance shall be arranged, when applicable, in accordance with Guide ST 7.5.

In addition, the responsible party shall be responsible for arranging the medical surveillance of external workers as indicated in Guide ST 1.6.

*Guide ST 7.5 deals with the medical surveillance of occupationally exposed workers.*

### 3.6 STUK asserts regulatory control on radiation exposure caused by the utilization of natural resources

On the basis of investigations and plans presented, STUK may impose, when appropriate, requirements for the limitation of radiation exposure. For the purpose of regulatory control, STUK shall be authorized to inspect practices giving rise to natural radiation exposure, to

conduct the measurements necessary, and to obtain the notifications, data and documents needed for the control.

*Provisions concerning actions to limit radiation exposure are laid down in section 27 of the Radiation Decree. Provisions are laid down in section 46 of the Radiation Act concerning STUK's obligation to issue instructions, where necessary, on limiting the exposure to radiation. Provisions concerning STUK's right to conduct inspections and obtain information are laid down in section 53 of the Radiation Act.*

### 3.7 The responsible party shall take care of the waste and releases caused by the practice

The responsible party shall ensure that radioactive waste and releases due to practices utilising natural sources pose no hazard to health or to the environment.

The requirements concerning the investigation and limitation of public exposure to radiation are given in item 3.3.2. Discharges of radioactive substances to the environment shall be restrained effectively irrespective of the magnitude of the exposure.

If a waste area containing naturally occurring radioactive substances or a comparable area in which a practice has already ceased, causes or is suspected of causing long-term radiation exposure to the public, then the responsible party shall, when appropriate and according to the radiation hazard, do the following:

- delineate the area
- limit the use of the area and the buildings in the area
- restore the area and prevent the spread of radioactive substances into the environment
- investigate the radiation exposure of the public and act in accordance with the results of the investigation in order to reduce the radiation exposure.

*Provisions are laid down in section 50 of the Radiation Act concerning the responsible party's duty of care regarding radioactive waste.*

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## APPENDIX A

### Definitions and concepts

#### Activity

The activity  $A$  of a radionuclide is the number of spontaneous nuclear transformations  $dN$  taking place in the relevant number of nuclides  $N$  in a time interval  $dt$ , divided by this time interval:

$$A = \frac{dN}{dt}$$

The unit of activity is the becquerel (Bq). 1 Bq = 1 s<sup>-1</sup>.

#### Activity concentration

The activity concentration  $c$  is the activity  $A$  of a radioactive substance in the monitored volume or mass, divided by the said volume  $V$  or mass  $m$ :

$$c = \frac{A}{V} \text{ or } c = \frac{A}{m}$$

The unit of activity concentration is Bq·m<sup>-3</sup> or Bq·kg<sup>-1</sup>.

Activity concentration is most commonly used when measuring radioactive substances in air. The activity concentration of radon in inhaled air is generally abbreviated to radon concentration.

The quantity obtained on dividing by the volume may also be called the volume activity and the quantity obtained on dividing by the mass may also be called the mass activity.

#### Dose

In this Guide, a dose means the effective dose. The effective dose is used to assess the effects of radiation detrimental to human health. The unit of effective dose is sievert (Sv). Its multiples, millisievert (mSv) and micro-sievert (µSv), are often used. 1 Sv = 1000 mSv = 1000 000 µSv.

#### Dose limit

The maximum values for radiation exposure i.e. dose limits for workers engaged in radiation work and other persons are prescribed in sections 3–6

of the Radiation Decree (1512/1991). The purpose of dose limits is to ensure that the total exposure arising from various practices does not cause unacceptable detriment to the worker.

#### Public place

In this Guide, public places refer to places whereto people other than the relevant workers have access. The public places to which this Guide refers include, for example, schools, daycare centres, hospitals, nursing institutions, stations, libraries, parish facilities, club rooms, sports halls and other facilities for various hobbies.

#### Naturally occurring background radiation

Naturally occurring background radiation refers to cosmic radiation on the surface of the earth, and to aboveground radiation arising from radioactive substances occurring within the undisturbed earth's crust and radiation from radionuclides naturally contained within the human body (e.g. <sup>40</sup>K).

#### Natural radiation

Natural radiation refers to ionizing radiation originating in outer space or in naturally occurring radioactive substances when they are not used as radiation sources.

#### Radon

Radon means isotope <sup>222</sup>Rn in the uranium series. The radon element also has other isotopes, of which <sup>220</sup>Rn in the thorium series may sometimes be of relevance from the radiation protection point of view. According to its mother nuclide (<sup>232</sup>Th), it is often called thoron. The protection principles concerning radon laid down in this Guide can, if necessary, also be applied to thoron. The differences between thoron and radon shall be appropriately taken into account in assessing radiation exposure and in considering measures to reduce exposure to radiation.

**Internal radiation**

Internal radiation means radiation that is emitted by radioactive substances that have entered the body and directed at the body itself.

**Action level**

Action levels used for the purpose of limiting exposure caused by natural radiation mean the limit values laid down in Amendment 1143/1998 to section 27 of the Radiation Decree (1512/1991). If radiation exposure exceeds the action level, the responsible party shall take the necessary measures to reduce radiation exposure.

**Responsible party**

In this Guide, a party running a radiation practice (the responsible party) refers to any business or sole trader, enterprise, corporation, or institution engaged in operations in which the exposure of human beings to natural radiation causes or is liable to cause a detriment to health.

**External radiation**

External radiation means radiation directed to the human body from outside of the body.

## APPENDIX B

### Calculation of the dose caused by radon exposure

Radon exposure is the product of the radon concentration in the air and the time spent in this concentration (unit:  $(\text{Bq}/\text{m}^3)\cdot\text{h}$ ). The effective dose to a worker due to an exposure of  $1 (\text{Bq}/\text{m}^3)\cdot\text{h}$  is  $4\cdot 10^{-9}$  Sv when the equilibrium factor between the short-lived decay products of radon and radon is 0.5.

**Example:**

During the monitoring period, the worker has worked for 300 hours in a radon concentration of  $500 \text{ Bq}/\text{m}^3$  and for 100 hours in a concentration of  $1000 \text{ Bq}/\text{m}^3$ .

The worker's exposure is

$$(300 \text{ h} \times 500 \text{ Bq}/\text{m}^3) + (100 \text{ h} \times 1000 \text{ Bq}/\text{m}^3) = 250\,000 (\text{Bq}/\text{m}^3)\cdot\text{h}.$$

The dose the worker has received during the monitoring period is

$$250\,000 (\text{Bq}/\text{m}^3)\cdot\text{h} \times (4\cdot 10^{-9} \text{ Sv} / ((\text{Bq}/\text{m}^3)\cdot\text{h})) = 0.001 \text{ Sv} = 1 \text{ mSv}.$$

## APPENDIX C

### Radiological baseline study and environmental radiation monitoring

Radiological baseline studies in the environment chart the baseline before the commencement of practices so that the effects of the practice on the environment and the respective exposures can be assessed after operations have started. The extent of the baseline study and the required sampling and measurements shall be estimated with regard to the nature of the practice and the operational environment. Generally, it is necessary to determine the uranium and thorium concentrations in the samples as well as the concentrations of their decay products. It may be necessary to conduct measurements at different times of the year or in different years, because there may be natural variation in the concentrations.

For example, the baseline study may include radiation measurements and the determination of radioactive substances in the following objects:

- external radiation
- radon in the outdoor air
- radioactive substances in the particle form in the outdoor air
- soil

- household water
- groundwater
- aquatic environment (water, sediment, water plants, benthos, fish)
- gathered products/game (berries, mushrooms, venison etc.)
- foodstuffs and pasture plants (grain, gardening products, grass, milk, meat etc.)

The purpose of environmental radiation monitoring after the commencement of a practice is to ensure that the radiation dose to the public is kept as low as is reasonably achievable and that the practice poses no hazard to the environment. Environmental radiation monitoring takes place with the same measurements as the baseline study. When possible, sampling should take place in the same places as in the baseline study.

Environmental radiation monitoring shall be regular and well-defined. The extent of radiation monitoring and the frequency of sampling may be revised, if necessary, once the practice has been in operation for a longer time.