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Implementation of the dose limit for members of the public for the sum of exposures from all authorised practices

Recommendation by the German
Commission on Radiological Protection

Adopted at the 274th meeting of the German Commission on Radiological Protection on 19 and 20 February 2015

The German original of this English translation was published in 2015 by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety under the title:

Umsetzung des Dosisgrenzwertes für Einzelpersonen der Bevölkerung für die Summe der Expositionen aus allen zugelassenen Tätigkeiten

Empfehlung der Strahlenschutzkommission

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1 Introduction

The new Directive 2013/59/Euratom was passed on 5 December 2013 and subsequently published in the Official Journal of the European Union (Euratom 2014) on 17 January 2014. The Member States are required to implement this Directive into national law by 6 February 2018.

Directive 2013/59/Euratom merges five previous Directives (89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom) with the aim of unifying radiation protection regulations in all exposure situations. The main changes in Directive 2013/59/Euratom are due to the implementation of ICRP 103 (ICRP 2007) as the ICRP introduced a new System of Radiological Protection and emphasised the equivalence of radiation exposures from a wide range of different naturally occurring and man-made sources. ICRP 103 (ICRP 2007) replaced the previous basic recommendation ICRP 60 (ICRP 1990) and incorporated the current state of science.

To this end, ICRP recommendation 103 emphasises the stability of the basics of radiation protection. The nominal risk coefficients for cancers remain practically unchanged, while those for hereditary diseases were significantly reduced. The three fundamental principles of radiation protection, namely justification, optimisation, and the application of dose limits, are confirmed in ICRP 103. The system of limits remains unchanged with the exception of the limit for the lens of the eye and the reference level for exposure due to radon in houses which have been adjusted to incorporate more recent scientific findings.

The editorial in ICRP 103 includes the following text: "*New scientific data have been published since Publication 60, and while the biological and physical assumptions and concepts remain robust, some updating is required. The overall estimate of deterministic effects remain fundamentally the same. The estimates of cancer risk attributable to radiation exposure have not changed greatly in the past 17 years, whereas the estimated risk of heritable effects is currently lower than before. The new data provide a firmer basis on which to model risks and assess detriment.*

The 2007 Recommendations evolve from the previous process-based approach of practices and interventions to an approach based on the characteristics of radiation exposure situations. The System of Radiological Protection applies in principle to any situation of radiation exposure. Similar procedures are used for deciding on the extent and level of protective actions, regardless of exposure situation. Specifically, the principles of justification and optimisation apply universally. ICRP is of the opinion that by focusing more on optimisation, the implementation of protection for what has until now been categorised as interventions could be enhanced."

Recommendation ICRP 103, which is also reflected in the IAEA Basic Safety Standards (IAEA 2014), forms the basis of Directive 2013/59/Euratom and is, in conjunction with with other ICRP recommendations, an instrument to interpret Directive 2013/59/Euratom.

The System of Radiological Protection as set out in the German Radiation Protection Ordinance (StrlSchV) issued in 2011 and the German X-ray Ordinance (RoeV 2003) has also proven successful in the Federal Republic of Germany as it guarantees a high level of protection. The implementation of Directive 2013/59/Euratom requires some changes to the regulatory framework, but no fundamental changes in terms of radiation protection.

The 2001 revision of the German Radiation Protection Ordinance (StrlSchV) already took a major step towards the conceptional equivalence of naturally occurring and man-made radioactivity and radiation sources which is now legally binding throughout Europe as a result

of Directive 2013/59/Euratom. There is still a major difference between exposure from naturally occurring and man-made sources in that it is not possible to optimise and limit naturally occurring radioactivity and radiation present in our natural environment to the same extent that it is possible with man-made radiation sources.

2 Advisory mandate and procedure

In preparation for implementing Directive 2013/59/Euratom, on 31 January 2014 the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) issued the German Commission on Radiological Protection (SSK) with the following advisory mandate, excerpts of which are as follows:

"... in accordance with the basic recommendations set out in ICRP Publication 103 and the IAEO's revised International Basic Safety Standards based thereon, the recently passed Euratom basic radiation protection standards directive follows the approach that the dose limits for individual members of the public should be seen as the sum of doses resulting from practices. Pursuant to Directive 2013/59/Euratom, the effective dose limit of 1 mSv per year for an individual member of the public should apply to all practices subject to official licensing and notification requirements (Article 12(1) Directive 2013/59/Euratom).

The sum should therefore include all exposures resulting from such practices, excluding occupational or medical exposure, in particular

- *Discharges from previous practices (Germany currently has separate limits of 0.3 mSv per year for discharge exposures involving exhaust air and waste water),*
- *Exposures from activities involving NORM subject to surveillance (e. g. dust),*
- *Direct radiation from facilities and within publicly accessible facilities (the current limit of 1 mSv per year and any discharges apply here). This applies, for example, to constructional radiation protection, e. g. in the medical field; and*
- *"Non-medical imaging exposures", i. e. all applications used to perform tests on humans that are not of a medical nature.*

However, exposures involving materials released from regulatory control (Article 25(4) of Directive 2013/59/Euratom) and practices exempt from regulatory control (e. g. activities involving materials below the exemption levels) do not need to be taken into consideration.

Potential exposures for various cases are currently determined using very different methods and, therefore, varying levels of conservatism. This ensures that limits are complied with, but fails to provide comparable estimates.

A challenge that arises when determining the sum is the fact that a number of different, possibly overlapping groups of people may be exposed via the pathways stated above.

Directive 2013/59/Euratom provides dose constraints as a key aid in this regard since dose constraints serve as a tool for optimising a radiation source or practice and are not a limit. However, the sum of the dose constraints should be stipulated such that it is compatible with the dose limit of 1 mSv per year for the total exposure (point (b) of Article 6(1) of Directive 2013/59/Euratom), thus contributing to compliance. Prior to implementing this concept, the use and significance of dose constraints and the method with which they are included in limit considerations should be subject to expert scrutiny.

I therefore request a recommendation from the German Commission on Radiological Protection as to how the limit for the sum of exposures from all authorised practices can be taken into account when authorising practices, what influence it should have on estimating doses for members of the public (Article 66 of Directive 2013/59/Euratom), and how results should be evaluated (e. g. within the scope of writing reports). Please suggest the following in particular:

- *How the sum can be carried out,*
- *How dose constraints for members of the public can be set and how they can contribute in terms of demonstrating compliance with the limit,*
- *How the group of people to be taken into account can be stipulated, and*
- *Whether an overall change of method is required to estimate exposure via the pathways stated above.*

The new requirement set out in Directive 2013/59/Euratom has a direct impact on the administrative procedures of the German state authorities. In view of the tight schedule for implementing the Directive and the anticipated need for discussion with the German states (Länder), I would ask you to commence work as soon as possible. Due to the interdisciplinary nature of these tasks, I would suggest forming a task group consisting of SSK members."

Due to the urgent need to handle this advisory mandate, the SSK formed a task group from among its members. This task force consisted of members of the SSK committees "radioecology", "radiation protection technology" and "radiation protection at facilities", and the SSK received regular updates on the task group's progress.

3 Recommendations

Recommendation 1:

In implementing the requirement set out in Directive 2013/59/Euratom, which states that the effective dose limit of 1 mSv per calendar year for a member of the public should apply to all practices subject to official licensing and notification requirements (Article 12(1) Directive 2013/59/Euratom), the SSK recommends that the information required to estimate or determine doses and the methods used to collect said information should be set out in the German regulatory framework. Corresponding requirements governing the rules for estimating or determining the dose to individual members of the public for comparison with the quantitative limit should also be specified in the regulatory framework.

Recommendation 2:

As set out in Article 22(3) of Directive 2013/59/Euratom, the SSK recommends excluding justified practices involving non-medical imaging exposure using medical radiological equipment from the requirement for dose constraints according to point (b) of Article 6(1) and from the dose limits set out in Article 12. The SSK also recommends that non-medical imaging procedures be subject to stringent justification processes.

Recommendation 3:

In existing exposure situations, only the additional exposures resulting from remedial measures set out in Article 12 should be taken into account. The SSK holds the opinion that the failure of remedial measures is not covered by Article 12 as it is in fact an optimisation measure for an existing exposure situation, albeit an unsuccessful one.

Recommendation 4:
Based on investigations into the introduction of residue regulations in the current German Radiation Protection Ordinance (StrlSchV) (Brenk 1999) and a reassessment of exposure scenarios as a result of procedural changes, the SSK recommends investigating the circumstances under which refractories, grit, potassium salts and any other materials may be of concern as per Article 100 (3) of Directive 2013/59/Euratom.

Recommendation 5:

Based on the GRS investigations (Sentuc and Schwarz 2008) and the dosimetric cut-off criteria (Chapter 4.13 / recommendation 15), the SSK recommends excluding exposures to individual members of the public as a result of transporting radioactive materials when calculating the sum of exposures from all authorised practices.

Recommendation 6:

The SSK recommends comparing the positive list for NORM industries set out in Directive 2013/59/Euratom with the positive list in the German Radiation Protection Ordinance (StrlSchV). The modified condition whereby regulatory radiation protection measures are to be applied when workers are exposed to 1 mSv per calendar year rather than 6 mSv per calendar year also needs to be taken into consideration. The SSK's statement from 1997 "Radiation exposure at working places due to naturally occurring radionuclides" (SSK 1997) should also be reassessed. Either way, terms in keeping with § 96(5) and § 102 of the German Radiation Protection Ordinance (StrlSchV) that act as 'opening clauses' and enable activities to be taken into account that are not included in positive lists should be retained if radiation exposures could occur during said activities which cannot be ignored from a radiation protection perspective.

Recommendation 7:

The SSK recommends introducing a graded approach for prospectively and retrospectively modelling radiation exposure that consists primarily of a realistic yet sufficiently conservative estimation and secondarily of a realistic estimation of the effective doses of individual members of the public (cf. SSK 2013). The regulatory framework should specify cases in which realistic estimations should always be performed. To this end, both generic and case-specific approaches should be permitted. Statements with regard to limits being exceeded should only be made on the basis of realistic, case-specific estimates. In general, retrospective estimations should be performed as realistically as possible so long as the work required to do so can be considered proportionate.

Recommendation 8:

When estimating and determining the effective dose of members of the public, the SSK recommends the application of the representative reference person concept as set out in ICRP 101 (ICRP 2006). The SSK considers it reasonable to only include the three age categories 1 year old (representative for the age category 0 to 5 years), 10 years old (representative for the age category 6 to 15 years) and adult (representative for 16 to 60 years), and to use the dose coefficients specified by the ICRP.

Recommendation 9:

The SSK recommends starting with the drafting of "General Administrative Provisions relating to practices" that are in line with the requirements set out in Article 66 of Directive 2013/59/Euratom and consistent in terms of handling naturally occurring and man-made radioactivity while also complying with the realism requirements of Article 66 in terms of the SSK's recommendation on determining radiation exposure (SSK 2013).

Recommendation 10:

When implementing Directive 2013/59/Euratom, the SSK recommends the drafting of a regulatory framework pertaining to the necessity of collecting source data with regard to the properties of sources used to estimate radiation exposure resulting from authorised practices. It also recommends the specification of requirements in terms of an appropriate scope for said data collection.

Recommendation 11:

The SSK recommends choosing the representative person such that the exposure scenarios and characteristics (period of stay in one place either as a resident or for other practices, behaviour during leisure activities, partial agricultural self-supply, using public roads, spending time near x-ray machines and accelerator facilities, etc.) maximise the potential radiation exposure based on realistic assumptions. The exclusion of exposure scenarios should be possible on a case-by-case basis if the requirements for these scenarios are not given.

Recommendation 12:

The SSK recommends taking account of all the exposure pathways set out in the table below (Table 3.1) when estimating the radiation exposure of individual members of the public from authorised practices.

Table 3.*1: SSK proposal for the exposure pathways to be taken into consideration in a "General Administrative Provisions relating to practices"*

External exposure
Direct radiation (x-ray, gamma, neutron)
Beta and gamma radiation within the exhaust air plume
Gamma radiation of the ground including sediment
Exposure due to inhalation
Radioactive material (gaseous and aerosol-bound)
Radon and its decay products
Exposure due to ingestion
Radioactive material with locally produced foodstuffs
– Air ⟶ plant
– Air ⟶ feed plant ⟶ cow ⟶ milk
– Air ⟶ feed plant ⟶ animal ⟶ meat
– Water ⟶ fish
– Cattle watering trough ⟶ cow ⟶ milk
– Cattle watering trough ⟶ animal – meat
– Rain/spray irrigation ⟶ feed plant ⟶ cow ⟶ milk
– Rain/spray irrigation ⟶ feed plant ⟶ animal ⟶ meat
– Rain/spray irrigation ⟶ plant
– Ground ⟶ plant
– Ground ⟶ feed plant ⟶ cow ⟶ milk
– Ground ⟶ feed plant ⟶ animal ⟶ meat
Direct ingestion of soil

Recommendation 13:

When estimating the effective dose to the representative reference person due to ingestion, the SSK recommends using the mean consumption quantities for the three age categories of the representative reference person as set out in the table below (

Table 3.2). The SSK also recommends stipulating the level of locally grown foodstuffs required for calculations. This should be done realistically by including the necessary areas and yields required for the corresponding consumption of foodstuffs. There can be no ingestion dose from foodstuffs if there is no agricultural or horticultural use. Drinking water consumption, which according to the German Drinking Water Ordinance (TrinkwV 2001) must not exceed a total indicative dose parameter of 0.1 mSv per year, may be disregarded when calculating the effective dose from ingestion.

Table 3.*2:* SSK proposal for the annual consumption of the reference person for various *foodstuffs* to be taken into consideration in *"General Administrative Provisions relating to practices". The data set out in the table below are taken from the Calculation Guide Mining (BglBb, BfS 2010) for the age categories 1 to 2 years, 7 to 12 years and >17 years. They are used here as a suggestion for the three age categories: infant (1 year old, representative for 0 to 5 years), child (10 years old, representative for 6 to 15 years) and adult (representative for 16 to 70 years). However, the representativeness of these data for the three age categories as per ICRP 101 (ICRP 2006) should be validated by evaluating current consumption studies, e. g. the DONALD (DOrtmund Nutritional and Anthropometric Longitudinally Designed) study for children.*

Foodstuff	**Annual consumption**		
	1 year	**10 years**	**>17 years**
Drinking water from water supply facilities[1]	100 l	150 l	350 l
Freshwater fish	3 kg	4.5 kg	7.5 kg
Milk (including milk products)	125 kg	170 kg	130 kg
Meat (including meat products)	13 kg	65 kg	90 kg
Vegetable products	138 kg	259 kg	253 kg
of which:			
– Grain, grain products	30 kg	95 kg	110 kg
– Fresh fruit, fruit products, juices	45 kg	65 kg	35 kg
– Potatoes, root vegetables, juices	40 kg	55 kg	55 kg
– Leafy vegetables	6 kg	9 kg	13 kg
– Vegetables, vegetable products, juices	17 kg	35 kg	40 kg

Recommendation 14:

The SSK recommends the drafting of a regulatory framework pertaining to periods of stay for "General Administrative Provisions relating to practices" as set out in the table below (Table 3.3). The data set out in this table are taken from the Calculation Guide Mining (BglBb) and need to be checked to make sure they are up to date. The values stated there should be taken as maximum values for periods of stay in the given areas. The SSK recommends always using maximum values for periods of stay (8,760 h per year) and including sites of exposure where there is no (additional) exposure.

[1] Although the consumption of drinking water from water supply facilities is not included in this recommendation, consumption quantities for drinking water are suggested here because they are required for other calculation guides, e. g. for deriving clearance values. Drinking water consumption quantities are also required to estimate doses in existing and emergency situations, which is why they should also be stipulated.

Table 3.3*: Stipulation of periods of stay for the representative person for "General Administrative Provisions relating to practices": Annual exposure time for various sites of exposure and representative persons. A period of stay must not exceed a total of 8,760 h per year.*

Place of exposure	Age category	Exposure time [h]
1. Indoors		7,000
2. Outdoors:		2,000
Where, depending on local conditions, the following values may contribute to the overall outdoor exposure of a member of the public		
2.1 Uncultivated areas	1 year	100
	10 years	250
	>17 years	100
2.2 Garden areas		1,000
2.3 Streets, squares, etc.		1,000
2.4 Children's play areas, parks, etc.		1,000
2.5 Public roads		200
3. Staircases and corridors in clinics and surgeries, waiting rooms and changing rooms		200
4. Members of the public on facility premises		200

Recommendation 15:

The sum of the effective dose is to be formed as per $E_{\text{Summe}} = \sum_i E_i$, where "at the location[2] where E_{Summe} is the maximum" applies as a constraint. In order to form the sum in a feasible manner and ensure the convergence of the sum of the doses, the SSK proposes the following cut-off criteria:

a) Dosimetric cut-off criterion:
Sources contributing less than several 10 µSv per calendar year can in principle be disregarded. Sources that together account for less than 10% of the total of effective doses can also be disregarded.

b) Spatial cut-off criterion:
   – Radiation exposure caused by direct radiation: Sources can be disregarded if the representative person is more than 500 m away from nuclear power plants and facilities and more than 100 m away from other facilities.
   – Radiation exposure due to discharges of man-made radionuclides in exhaust gas or releases into the air: Sources where the representative person is more than 5,000 m away

[2] The location of maximum dose should not be considered a mathematical point, but rather an area, e. g. with a radius of 50 m or 100 m.

from the plant/facility can be disregarded if the discharges or releases occur at effective emission heights in excess of 100 m. At lower emission heights, sources can be disregarded if the representative person is more than 500 m away from the plant/facility. This criterion depends on the effective emission height, which incorporates both the chimney height and thermal superelevation. Within the scope of drafting "General Administrative Provisions relating to practices", cut-off criteria for naturally occurring radionuclide discharges from other industries, e. g. NORM industries, still need to be clarified.

c) Cut-off criterion for the specific activity of materials from NORM industries[3]:
   - Radiation exposure due to the use or storage of solid materials can be disregarded without limiting the quantity if the maximum specific activity for all U-238 and Th-232 series radionuclides are collectively below the monitoring limits to be defined. These monitoring limits should be less than or equal to 1 Bq/g for all U-238 and Th-232 series radionuclides and less than or equal to 10 Bq/g for K-40 (radionuclides and IAEA 1998)[4]. Higher values may be justified for materials in which Pb-210 and Po-210 are enriched.
   - With small quantities of up to several (i. e. 3) thousand kilos, radiation exposure due to the use or storage of solid materials can be disregarded if the maximum specific activity for all U-238 and Th-232 series radionuclides are collectively below a multiple of the monitoring limits to be defined.

Recommendation 16:

The SSK recommends limiting the implementation of Article 12(1) of Directive 2013/59/Euratom to the effective dose. Organ doses do not need to be taken into consideration.

Recommendation 17:

The SSK recommends retaining the previous general requirements in terms of optimising radiation protection. Dose constraints may be of use in the regulatory framework as sole optimisation tools. The SSK advises against stipulating dose constraints for exposures of members of the public in the statutory framework.

Recommendation 18:

The SSK recommends regular reports on the latest situation, i. e. on compliance with the dose limit for individual members of the public set for exposures from authorised practices.

Recommendation 19:

The SSK reaffirms its recommendation that consistent "General Administrative Provisions relating to practices" are urgently required. Due to the relatively short period of time available

[3] Materials (and soil) contaminated due to naturally occurring or man-made radionuclides from licensed discharges or releases constitute an existing exposure situation and are not to be taken into account when forming the sum, as is the case with goods for which there are already other provisions (Annex XVII of Directive 2013/59/Euratom).

[4] These are the new exemption levels for NORM in Directive 2013/59/Euratom. However, the previous stipulations show that exemption levels of 0.2 Bq/g to approx. 0.5 Bq/g would also be appropriate (cf. Appendix XII Part A of the German Radiation Protection Ordinance (StrlSchV) and RP 122/II (EC 2002)).

to implement Directive 2013/59/Euratom, work on this regulation should commence as soon as possible.

4 Explanatory statement

4.1 Current legal basis

4.1.1 Overview

The current legal basis with regard to defining, limiting and calculating public exposure is set out in Part 1 of the German Radiation Protection Ordinance (StrlSchV), insofar as it affects general provisions, and in Parts 2 and 3 (each including their respective Appendices) with regard to specific use while performing practices and naturally occurring radiation sources during work activities. A similar basis can also be found in the German X-ray Ordinance (RoeV 2003), and both of these legal foundations will be elaborated on in Chapters 4.1.2 to 4.1.6. A number of pertinent provisions are also available in the regulatory framework which are listed in Chapter 4.1.7. The contents of each section of the framework will only be covered to the extent necessary for this recommendation. Conclusions resulting from individual parts of the framework will be drawn in Chapter 4.1.7.

4.1.2 Legal basis from Part 1 of the German Radiation Protection Ordinance (StrlSchV) (general provisions)

§ 3 of Part 1 of the German Radiation Protection Ordinance (StrlSchV) contains definitions[5] that are of particular relevance within this context. There are the definitions for the following key terms:

– Discharge,
– Installations,
– Practices/activities,
– Dose, including the terms dose equivalent, effective dose, body dose, tissue or organ absorbed dose, local dose, local dose rate and personal dose equivalent,
– Receiving point, most unfavourable,
– Members of the public,
– Exposure pathway,
– Clearance,
– Exemption levels,
– Person, occupationally exposed,
– Reference person,
– Residues,
– Radiation exposure,
– Practices.

[5] Definitions and explanations of the terms are indexed in the glossary.

4.1.3 Legal basis from Part 1 of the German X-ray Ordinance (RoeV) (general provisions)

As is the case with Part 1 of the German Radiation Protection Ordinance (StrlSchV) (Chapter 4.1.2), § 2 of the German X-ray Ordinance (RoeV) contains a number of definitions that are particularly important within this context:

– Dose, including the terms dose equivalent, effective dose, body dose, tissue or organ absorbed dose, local dose rate and personal dose equivalent,

– Radiation exposure,

– Occupational radiation exposure,

– Medical radiation exposure,

– Practices.

4.1.4 Legal basis from Part 2 of the German Radiation Protection Ordinance (StrlSchV) (practices)

The following sections of Part 2 of the German Radiation Protection Ordinance (StrlSchV) are of particular relevance within this context:

4.1.4.1 Basic requirements and limitation of doses

– § 4 Justification: Justification represents the weighing up of economic, social or other benefits in relation to the health detriment that may occur. Justification forms the basis of all practices.

– § 5 Limitation of doses: The effective dose for members of the public is limited to 1 mSv per calendar year.

– § 6 Avoidance of unnecessary radiation exposure and dose reduction: When planning or performing a practice, any unnecessary radiation exposure or contamination of man and environment should be avoided, even if below the respective limit, taking into consideration the state-of-the-art of science and technology and taking into account all circumstances of individual cases.

4.1.4.2 Licences and exemption from licensing

– §§ 7 to 9 govern the handling of radioactive substances requiring a licence including licensing requirements, as well as the handling and possession of nuclear fuels not requiring a licence.

– §§ 11 to 14 govern the construction and operation of facilities for the generation of ionising radiation requiring a licence and notification as well as the accompanying licensing requirements and exemption from licence and notification.

§§ 7 to 9 and §§ 11 to 14 are relevant within this context as the implementation of Directive 2013/59/Euratom will lead to changes to the licensing and notification requirements.

4.1.4.3 Clearance

– § 29 Requirements for clearance: § 29 contains basic clearance requirements and creates the link to the effective dose constraint of several 10 µSv per calendar year.

– Appendix III table 1 lists the clearance values for the various clearance options set out in § 29 in columns 4 to 10a.

– Appendix IV, Part A, No. 2 contains the stipulations for the reference person with regard to confirmation in individual cases. These are the assumptions laid down in Appendix VII Parts B and C, in particular the specifications of Appendix VII, Part B, Table 1, columns 1 to 7. The requirements set out in Appendix VII will be covered in Section 4.1.4.4.

4.1.4.4 Protection of the general public and the environment in the event of radiation exposure resulting from practices

– § 46 Limitation of the radiation exposure of the general public: The effective dose for members of the public as a result of practices is limited to 1 mSv per year. The organ absorbed dose limit for the eye lens is 15 mSv per calendar year, while the organ absorbed dose limit for the skin is 50 mSv per calendar year.

– § 46 also stipulates calculation of the effective dose. For facilities or installations outside the operating site, the limit of 1 mSv per calendar year for the effective dose for the sum of the radiation exposure from direct radiation and the radiation exposure from discharges shall apply. For the assessment of radiation exposure from direct radiation a permanent stay shall generally be assumed for the periods of stay unless it is possible to make deviating stipulations on an individual basis.

– § 47 Limitation of the discharge of radioactive substances: The effective dose is limited to 0.3 mSv per calendar year for discharges of radioactive substances from facilities or installations by means of air or water. Other limits of 0.3 mSv to 1.8 mSv per calendar year apply to organ absorbed doses and are set out in three groups.

– § 47 also stipulates the requirements to be applied for a reference person when planning facilities or installations. The locations of highest exposures should be determined in each case. The exposure pathways, living habits of the reference person and other assumptions are based on Appendix VII, Parts A to C.

– § 48 Emissions and pollution monitoring: Emissions and pollution monitoring as well as the requirements specified here shall form the basis of assessments to ensure compliance with the limits set out in § 47.

– Appendix VII, Part A stipulates the exposure pathways to be used as a basis when estimating exposure due to the discharges pursuant to § 47. This list of individual exposure pathways covers both discharges by means of exhaust air and waste water. Local characteristics of the location may lead to individual pathways that do not need to be taken into consideration or additional pathways that do need to be taken into consideration.

– The median consumption rates specified in Appendix VII, Part B, Table 1 multiplied by the factors specified in column 8 shall be used.

– Appendix VII, Part B stipulates the living habits of the reference person. The consumption rates for the 6 age groups set out in columns 2 to 7 are median consumption rates. When applying exposure calculations as per § 47, these median consumption rates multiplied by the factors specified in column 8 shall be used.

– Appendix VII, Part C describes the remaining assumptions (dose coefficients, model type, parameter value stipulation, avoidance of underestimating radiation exposure, etc.).

4.1.5 Legal basis from Parts 1a to 3 of the German X-ray Ordinance (RoeV)

The following sections of the German X-ray Ordinance (RoeV) are of particular relevance within this context:

4.1.5.1 Section 1a – Principles of radiation protection

– § 2b Limitation of doses: Obligation to comply with dose limits stipulated in the German X-ray Ordinance (RoeV).

– § 2c Avoidance of unnecessary radiation exposure and dose reduction: When planning or performing practices pursuant to the German X-ray Ordinance (RoeV), any unnecessary radiation exposure of man and environment should be avoided, even if below the respective limit, taking into consideration the state-of-the-art of science and technology and taking into account all circumstances of individual cases.

4.1.5.2 Section 2 – Supervision provisions

– §§ 3 and 4 govern the operation of x-ray facilities requiring a licence and notification. § 3 also includes the requirements for granting a licence and the requirements for ensuring a minimisation of the dose when using x-rays on people.

4.1.5.3 Section 3 – Provisions for operation

– § 15 Duties of the radiation protection supervisor and the radiation protection officer: This includes the duty to avoid any unnecessary human exposure and to minimise this exposure, even below existing limits.

– § 25 Principles of application: This provision contains additional principles on limiting human exposure when using x-rays.

– § 31a Dose limits for occupational radiation exposure: § 31a contains the dose limits for occupationally exposed individuals.

– § 32 Limitation of radiation exposure of members of the public: The effective dose for individual members of the public is limited to 1 mSv per calendar year. The organ absorbed dose limit for the eye lens is 15 mSv per calendar year, while the organ absorbed dose limit for the skin is 50 mSv per calendar year.

– § 33 Ordering of measures and authorised exemptions: § 33 governs scenarios from which the limits stipulated in § 32 may be deviated.

4.1.6 Legal basis from Part 3 of the German Radiation Protection Ordinance (StrlSchV) (work activities)

The following sections of Part 3 of the German Radiation Protection Ordinance (StrlSchV) are of particular relevance within this context, although flying personnel are not included here:

– § 93 Limitation of dose: § 93 refers to the individual limitations of dose set out in §§ 95 and 96.

– § 94 Reduction of dose: Radiation exposure should be kept as low as possible taking into consideration every circumstance of the individual case.

– § 95 Naturally occurring radioactive substances at workplaces: With regard to radiation exposure, § 95 stipulates that notification is required from an estimated effective dose of 6 mSv per calendar year. Should notification be required, the Rn-222 exposure or the potential exposure to alpha energy and the body dose should be determined in a suitable manner by measuring the local dose, the local dose rate, the concentration of radioactive substances or gases in the air, the contamination of the workplace, the individual dose, the body activity or the activity of excretion.

- § 97 Residues requiring surveillance; impermissible shipment: This provision governs how to deal with residues resulting from work activities. The effective dose reference figure triggering the introduction of measures to protect the general public from the utilisation or disposal of residues is 1 mSv per calendar year. The residues according to Appendix XII, Part A require surveillance unless it is assured that in the disposal or utilisation thereof the surveillance limits in Appendix XII, Part B and the disposal and utilisation methods specified therein will be observed.
- § 98 Release of residues from surveillance: In this provision, the reference applied is such that a reference figure for the radiation exposure of members of the public as a result of such disposal or utilisation is not to exceed an effective dose of 1 mSv per calendar year.
- § 102 Surveillance of other materials: This provision enables the competent authority to take appropriate measures for materials that are not residues in terms of Appendix XII, Part A if radiation exposure of members of the public is significantly increased.
- Appendix XI (to §§ 93, 95, 96): Fields of work where significantly higher exposure due to natural terrestrial radiation sources may occur: This appendix lists the fields of work where exposures may exceed the limits set out above in § 95.
- Appendix XII (to §§ 97 to 102): Recycling and disposal of residues requiring surveillance: Part A of this appendix contains a list of residues requiring surveillance. Part B stipulates the surveillance limits for residues that do not require surveillance even if the limits are exceeded as long as they are disposed of in certain ways. Part D provides the principles for the determination of radiation exposure of residues in accordance with Part A that are based on the exposures pathways in accordance with Appendix VII, Part A, along with the living habits and consumption rates based on the assumptions specified in Appendix VII, Part B, Table 1, Columns 1 to 7 and table 2 (in conjunction with the application of § 47). However, the consumption rates are to be applied without the factors specified in Appendix VII, Part B, Table 1, Column 8.

4.1.7 Legal basis arising from the regulatory framework

Only the regulations required to calculate radiation exposure are set out below:

- General Administrative Provisions relating to Section 47 of the Radiation Protection Ordinance (StrlSchV) (BMU 2012),
- Calculation Guide Mining (BglBb, BfS 2010),
- Guideline for Monitoring Radiation Exposure during Work Activities pursuant to Part 3, Chapter 2 of the Radiation Protection Ordinance (StrlSchV) (Work Activities Guideline) dated 15 December 2003 (BMU 2003).

4.1.7.1 General Administrative Provisions relating to Section 47 of the Radiation Protection Ordinance (StrlSchV)

Derived limits for discharging radioactive substances by means of exhaust air and waste water are calculated using the model set out in the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) (BMU 2012) unless specific activities for discharging radioactive substances in the air or water set out in Appendix VII, Part D of the German Radiation Protection Ordinance (StrlSchV) are applied as annual mean values pursuant to § 47 para. (4) of the General Administrative Provisions for facilities or installations not requiring a licence granted under §§6, 7 or 9 of the Atomic Energy Act or a plan approval notice granted under § 9b of the Atomic Energy Act.

The main section of the general administrative provisons describe the following basis for estimating exposure:

> "*2.2: Radiation exposure for the reference person of the age groups stated in Appendix VII, Part B, table 1 of the Radiation Protection Ordinance (StrlSchV) is calculated at the most unfavourable receiving points. The most unfavourable receiving points are the locations and/or vicinities of plants or facilities which discharge radioactive substances into the environment where the highest radiation exposure of the reference person is expected due to spending time or consuming food that was produced there. (...)*
> *3.2: … Considering real potentials of use, the points with the highest effective dose or highest organ doses are to be taken as a basis. For the dose from external radiation exposure and inhalation, the point where the sum of both doses is highest should be used."*

Core parameters that describe the exposure circumstances include, in particular, exposure time and consumption rates that provide full coverage, i. e. period of stay and extremely high foodstuff quantities (95th percentile for each foodstuff).

Prior contamination caused by other initiators that may affect the location also need to be taken into consideration. Discharges via waste water are particularly important as flowing waters carry radionuclides over long distances, meaning that they can affect downstream facilities, while airborne discharges can only lead to noteworthy prior contamination within a radius of several kilometres.

4.1.7.2 Calculation Guide Mining (BglBb)

The Calculation Guide Mining (BglBb, BfS 2010) provides a method for calculating radiation exposure due to mining. It "*serves to determine mining-caused radiation exposure of members of the public and of workers. It is applicable for the use, decommissioning, remediation, and reuse of mining plants and installations as well as for the use, remediation, and reuse of land contaminated as a result of mining plants and installations*."

The following exposure scenarios are considered pursuant to Section 5: Indoors (dwellings and public buildings, commercial buildings), underground workplaces (only inhalation of radon and its short-lived decay products), outdoors, ingestion of breast milk and locally produced foodstuffs (vegetable and animal products, as well as water).

The following exposure pathways are considered: external exposure due to gamma radiation from the ground, exposure due to inhalation of dust, exposure due to inhalation of radon and its short-lived decay products, exposure from ingestion of breast milk and locally produced foodstuffs (drinking water, fish, milk and milk products, meat and meat products, leafy vegetables, other vegetable products), and exposure due to direct soil ingestion.

Core parameters that reflect the basic assumptions relating to exposure circumstances are exposure times indoors, outdoors, at workplaces and consumption rates. Parameter values are oriented towards real-life circumstances (indoors max. 7,000 h/a, outdoors max. 2,000 h/a, at workplaces 2,000 h/a). Consumption rates accord with the values in Appendix VII, Part B, Table 1 of the German Radiation Protection Ordinance (StrlSchV) without application of the factors in column 8. It is also stipulated that only 50% of the annual consumption of agricultural products (fish, milk and milk products, meat and meat products, leafy vegetables, other vegetable products) is covered by foodstuffs contaminated by mining residues (proportion of local production).

The Calculation Guide Mining (BglBb) does not however provide any models or calculation guidelines for determining radionuclide concentrations in groundwater and surface water.

4.1.7.3 Work Activities Guideline

The Work Activities Guideline (BMU 2003) stipulates the type, scope, methods and administrative approaches for estimating Rn-222 exposure or body dose for workers that can be attributed to one of the fields of work activity specified in Parts A and B of Appendix XI of the Radiation Protection Ordinance (StrlSchV), and for estimating Rn-222 exposure and body dose for persons engaged in work activities subject to notification. The guideline is used for national administrative procedures within the scope of Part 3 Chapter 2 of the Radiation Protection Ordinance (StrlSchV).

4.1.8 Conclusions

The following key conclusions can be drawn from sections 4.1.2 to 4.1.6 of the framework:

– Practices have a defined limit for exposure to members of the public, while for work activities a constraint is stipulated. Both values are identical, i. e. 1 mSv per calendar year.

– With practices, staff should be monitored if the effective dose of 1 mSv per calendar year is exceeded, while with work activities this should only happen if the effective dose of 6 mSv per calendar year is exceeded.

– The models for the respective reference persons from the general public vary significantly in terms of stipulations for calculating exposure.

  - Calculation of exposure as a result of discharges pursuant to § 47, the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) in conjunction with Appendix VII of the German Radiation Protection Ordinance (StrlSchV): The most unfavourable receiving points, period of stay at these points, and very high consumption rates are assumed.

  - Calculation Guide Mining (BglBb): Graded approach for determining radiation exposure, realistic exposure times, average consumption rates, in general only 50% of foodstuffs consumed comes from local production.

  - Calculation of exposure to members of the public due to residues from work activities has still not been stipulated. In practice it is applied in keeping with the Calculation Guide Mining (BglBb) (according to the principles set out in Appendix XII, Part D of the Radiation Protection Ordinance (StrlSchV).

  - Clearance pursuant to § 29 of the German Radiation Protection Ordinance (StrlSchV): Oriented towards realistic exposure times and – where relevant to the respective scenario – mean consumption rates.

4.2 Need for change based on Directive 2013/59/Euratom

Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation was approved on 5 December 2013 and must be introduced into national law by 6 February 2018. This Directive takes account of recent recommendations by the International Commission on Radiological Protection (ICRP) as well as recent scientific findings and practical experience. Key points of this new Directive include full integration of protection from naturally occurring radiation sources in the general requirements, exposure of aircraft crew as a planned exposure situation, and non-medical imaging exposures. The sum of exposures from all authorised practices should also be used to observe the dose limits for members of the public.

Below are the main articles from Directive 2013/59/Euratom that apply to the advisory mandate from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), together with a brief interpretation of each. The main aim here is to point out the potential effects the articles may have on the German Radiation Protection Ordinance (StrlSchV).

4.2.1 Chapter II – Definitions

Chapter II of Directive 2013/59/Euratom defines the main terms set out in Directive 2013/59/Euratom that have not all been incorporated into § 3 of the German Radiation Protection Ordinance (StrlSchV). These new terms and their definitions are outlined below.

- Dose constraint: means a constraint set as a prospective upper bound of individual doses, used to define the range of options considered in the process of optimisation for a given radiation source in planned exposure situation.
- Non-medical imaging exposure: means any deliberate exposure of humans for imaging purposes where the primary intention of the exposure is not to bring a health benefit to the individual being exposed.
- Representative person: means an individual receiving a dose that is representative of the more highly exposed individuals in the population, excluding those individuals having extreme or rare habits.
- Radiation source: means an entity that may cause exposure, such as by emitting ionising radiation or by releasing radioactive material.
- Radioactive material: means material incorporating radioactive substances.
- Radioactive substance: means any substance that contains one or more radionuclides the activity of which cannot be disregarded from a radiation protection point of view.
- Radioactive source: means a radiation source incorporating radioactive material for the purpose of utilising its radioactivity.

4.2.2 Chapter III – System of Radiological Protection

According to Article 5 of Council Directive 2013/59/Euratom "General principles of radiation protection", member States are obligated to establish legal requirements and an appropriate regime of regulatory control which, for all exposure situations, reflect a System of Radiological Protection based on the principles of justification, optimisation and the application of dose limits: These principles have already been introduced in §§ 4 to 6 of the German Radiation Protection Ordinance (StrlSchV). In contrast to the German Radiation Protection Ordinance (StrlSchV), Directive 2013/59/Euratom states that the sum of doses to an individual from all approved practices shall not exceed the dose limits laid down for public exposure.

Section 1 of this Chapter presents tools for optimisation that should allow individual doses, exposure probability and the number of exposed people to be kept to a minimum as per the ALARA principle. Dose constraints may constitute one such tool.

- Article 6 "Dose constraints for occupational, public, and medical exposure" provides the option of establishing dose constraints for occupational, public and medical exposure for the purpose of prospective optimisation. It must, however, be ensured that the dose constraints for public exposure are consistent with the dose limit for the sum of doses to the same individual from all authorised practices. Up to now the term "reference figure" was used in §§ 97 and 98 of the German Radiation Protection Ordinance (StrlSchV) for

residues within the meaning of the public effective dose limit of 1 mSv per calendar year. The newly introduced dose constraints set out in Article 6 of Directive 2013/59/Euratom have not been introduced into the German Radiation Protection Ordinance (StrlSchV). Part of this advisory mandate involves looking into the significance of these dose constraints and their potential incorporation into national law, which is covered in Chapters 4.6 and 4.15 of this recommendation.

Section 2 of Chapter III of Directive 2013/59/Euratom includes the basic dose limitation requirements along with the stipulation of dose limits. The main articles for this advisory mandate are Articles 12 and 13.

– Article 12 "Dose limits for public exposure" corresponds to § 46 of the German Radiation Protection Ordinance (StrlSchV), which stipulates an effective dose limit of 1 mSv per calendar year as well as an equivalent dose of 15 mSv for the eye lens per calendar year and an equivalent dose of 50 mSv for the skin per calendar year. A major change to the current German ordinance involves stipulating the effective dose limit as the sum of annual exposures from all authorised practices. In the future, these practices will also include exposures involving naturally occurring radioactive substances. Chapters 4.4 and 4.5 of this recommendation include a description of the practices to be taken into consideration in the future along with the practices that can be excluded.

– Article 13: According to Article 13, Member States should use appropriate "standard values and relationships" for the estimation of effective and equivalent doses. According to Article 4 (96), external exposure should involve the dose coefficients currently recommended in ICRP 116 (ICRP 2010) which were already calculated on the basis of recommendations from ICRP 103 (ICRP 2007). There are currently no such data available for internal exposure, meaning that the dose coefficients collected and used to date in ICRP 119 (ICRP 2012) are used with values updated by the Member States. The existing dose equivalents Hp(10), Hp(0.07), H*(10) and H'(0.07) are used for external radiation; Hp(3) and H'(3) can also be introduced for the dose to the lens of the eye.

4.2.3 Chapter V – Justification and regulatory control of practices

Section 1 of Chapter V of Directive 2013/59/Euratom deals with justification and prohibition of practices. As this advisory mandate refers to all practices subject to regulatory control, these practices must first be checked to determine whether they are relevant to the effective dose limit for members of the public. Chapter 4.4 of this recommendation considers practices that are not relevant to the advisory mandate, while Chapter 4.5 defines all of the relevant practices. Below is a brief description of the main articles of Chapter V of Directive 2013/59/Euratom.

– Article 19 "Justification of practices" covers the term "justification" already defined in Article 5 in more detail with regard to all practices that could lead to occupational, medical, and public exposure.

– Article 20 "Practices involving consumer products" governs the manufacture or import of consumer products as well as the prohibition of the sale or the making available to the public of consumer products if their intended use is not justified or their use would not fulfil the criteria for exemption from notification under Article 26. Within this context, the effects on public exposure by importing raw materials and substances containing naturally occurring radioactive material should be discussed.

– Article 22 "Practices involving the deliberate exposure of humans for non-medical imaging purposes" could also represent a form of public exposure to be taken into account in the future. Practices involving non-medical imaging exposure now need to be determined and

justified, taking into account the stipulated criteria; Annex V should be used as a point of reference for such practices. Up until now, these types of activity were covered by § 86 of the German Radiation Protection Ordinance (StrlSchV) and § 25(1) of the German X-ray Ordinance (RoeV). As they may lead to exposure that cannot be overlooked, these practices should be observed within the scope of all exposures that contribute towards the dose limit.

- Section 2 of Chapter V of Directive 2013/59/Euratom stipulates regulatory control where all of the practices subject to regulatory control must initially be included in the public dose limit. Registration is generally mandatory if the dose limit of 1 mSv per calendar year is exceeded for workers.
- Article 23 "Identification of practices involving naturally occurring radioactive material" governs this identification by referring to industrial sections listed in Annex VI of the Directive. In contrast to the German Radiation Protection Ordinance (StrlSchV), this Article classes as practices all work activities involving naturally occurring radioactive material (NORM) that lead to exposure of workers and or members of the public which cannot be disregarded from a radiation protection point of view. Also in contrast to the German Radiation Protection Ordinance (StrlSchV) is the fact that the term "activities" is not used. This is something that needs to be taken into account in the German regulatory framework as these practices now need to be included when calculating exposure of members of the public.
- Article 24 "Graded approach to regulatory control" governs the control of practices for the purpose of radiation protection, by way of notification, authorisation and appropriate inspections. In accordance with the general exemption criteria set out in Annex VII, regulatory control may be limited to notification and an appropriate frequency of inspections; notified practices may be exempted from the requirement of authorisation on the basis of these criteria. Notified practices which are not exempted from authorisation shall be subject to regulatory control through registration or licensing.
- According to Article 25 "Notification", prior to the practice commencing or, in the case of existing practices, each justified practice has to be notified as soon as possible once the implementation into national law has occurred and, after that, always prior to commencing practices. This also applies to workplaces pursuant to Article 54(3) "radon in workplaces", existing exposure situations pursuant to Article 100(3) "Programmes on existing exposure situations" and practices identified pursuant to Article 23 that may lead to the presence of naturally occurring radionuclides in water liable to affect the quality of drinking water supplies or affect any other exposure pathways. Human activities involving radioactively contaminated materials resulting from authorised releases or materials cleared in accordance with Article 30 shall not be managed as a planned exposure situation and, hence, are not required to be notified. This final point means that cleared radioactive materials or radioactive materials below clearance levels do not have to be taken into account when calculating the dose for the public and are therefore not Part of this advisory mandate.
- The same applies to justified practices exempted from notification as per Article 26 "Exemption from notification". The exemption criteria for practices involving radioactive material are regulated in Annex VII of the Directive. Practices involving devices with sealed sources and other electrical devices are subject to other stipulated criteria corresponding with those set out in Appendix I, Part C and Annex V, Part B of the German Radiation Protection Ordinance (StrlSchV) as well as § 5 paragraphs 2 and 4 of the German X-ray Ordinance (RoeV).

- Article 27 “Registration or licensing” requires the registration or licensing of practices involving the operation of radiation generators or accelerators, except electron microscopes, or radioactive sources for medical exposures, for non-medical imaging purposes or for other purposes. Registration or licensing may be required for other types of practices. Based on the above statements, these practices may be relevant to the advisory mandate.
- Article 28 “Licensing” lists all of the practices requiring licensing. These practices include the deliberate administration of radioactive substances to persons, the operation and decommissioning of any nuclear facility and the exploitation and closure of uranium mines, the deliberate addition of radioactive substances in the production or manufacture of consumer products or other products, including medicinal products, and the import of such products, any practice involving a high-activity sealed source, the operation, decommissioning and closure of any facility for the long term storage or disposal of radioactive waste, including facilities managing radioactive waste for this purpose, and practices discharging significant amounts of radioactive material by means of airborne or liquid effluent into the environment. According to Article 27(2), Member States may require registration or licensing for other types of practices. Pursuant to Article 12, all exposures involving practices requiring registration or licensing must be taken into consideration for the dose limit for public exposure unless they can be excluded as occupational or medical exposures.
- Article 29 “Authorisation procedure” requires the provision of information relevant to radiation protection, although the information required in Annex IX of this Directive should be taken into account for licence applications. Licences shall include, as appropriate, specific conditions and reference to requirements in national legislation as well as requirements for disposing of radioactive discharges as per the requirements set out in Chapter VIII of Directive 2013/59/Euratom.
- Article 30 “Release from regulatory control” governs the disposal, recycling or reuse of radioactive materials. The release criteria in Annex VII of Directive 2013/59/Euratom must be complied with in order to be released from regulatory control. Release from regulatory control largely corresponds to § 29 of the German Radiation Protection Ordinance (StrlSchV) and its accompanying appendices. An exception to this is the introduction of an exemption level of 10 Bq/g for K-40 compared to 100 Bq/g as per the German Radiation Protection Ordinance (StrlSchV), which impacts the NORM industry in terms of practices requiring licensing and notification and could therefore be relevant to this advisory mandate.
- Annex IV “Justification of new classes or types of practices involving consumer products as referred to in Article 20” contains specific information that companies and competent authorities should provide when determining new categories and types of practices involving consumer products.
- Annex V “Indicative list of practices involving non-medical imaging exposure as referred to in Article 22” lists practices involving deliberate human non-medical imaging exposure, although this list is sub-divided into practices involving medical radiological equipment and practices not using medical radiological equipment.
- Annex VI “List of industrial sectors involving naturally occurring radioactive material as referred to in Article 23” contains a list of industrial sectors involving naturally occurring radioactive material, including research and relevant secondary processes, to be taken into

account. This list contains the industrial sectors set out in Appendix XI, Part B of the German Radiation Protection Ordinance (StrlSchV).

– Annex VII "Exemption and clearance criteria as referred to in Articles 24, 26 and 30" governs exemption, exemption levels and clearance levels, and stipulates general exemption and clearance criteria. Table A "Activity concentration values for exemption or clearance of materials which can be applied by default to any amount and to any type of solid material" is divided into two parts, artificial radionuclides and naturally occurring radionuclides. Table B provides exemption values for total activity (column 3) and exemption values for specific activity concentration in moderate amounts of any type of material (column 2). However, Article 26(2) stipulates that Member States may exempt specific types of practice from the notification requirement subject to compliance with the general exemption criteria established in point 3 of Annex VII, on the basis of an assessment showing that exemption is the best option.
– Annex IX "Indicative list of information for licence applications as referred to in Article 29" includes basic information required for licence applications.

4.2.4 Chapter VI: Occupational exposures

Chapter VI of Directive 2013/59/Euratom governs occupational exposures. Such exposures are not initially Part of this advisory mandate, but may be of interest in terms of practices involving naturally occurring radionuclides that could now require licensing and/or notification for radiation protection reasons. For this reason, the main articles of Chapter V of Directive 2013/59/Euratom are provided below. An assessment of the potential public exposure resulting from this occupational exposure is provided in Chapters 4.4 and 4.5.

– Article 31 "Responsibilities" stipulates the responsibilities for assessing and implementing arrangements for the radiation protection of exposed workers. There must also be a clear allocation of responsibilities for the protection of workers in any exposure situation, in particular for the protection of workers involved in remediation work, or workers who are exposed to radon at work, in the situation specified in Article 54(3).
– As per Article 35 "Arrangements in workplaces", arrangements must be made as regards all workplaces where workers are liable to receive an exposure greater than the dose limits for members of the public set out in Article 12 of Directive 2013/59/Euratom. Furthermore, as per Article 54(3), workplaces where the exposure of workers is liable to exceed an effective dose of 6 mSv per calendar year or a corresponding time-integrated radon exposure value, they are managed as a planned exposure situation; if the exposure values are below this figure, exposures must be monitored continually. The same terms apply to aircraft crew, but the specific features of this exposure situation must be taken into account.
– Article 36 "Classification of workplaces" governs the classification of workplaces into different areas on the basis of an assessment of the expected annual doses and the probability and magnitude of potential exposures. Here a distinction is made between controlled areas and supervised areas in which working conditions must be continually monitored.
– Article 40 "Categorisation of exposed workers" stipulates that for the purposes of monitoring and surveillance, a distinction is made between two categories of exposed workers. This classification corresponds with § 54 of the German Radiation Protection Ordinance (StrlSchV), but differs in that a value of 15 mSv per calendar year was now determined as the category B limit for the equivalent dose for the lens of the eye.

– Article 54 “Radon in workplaces” enables national reference levels for indoor radon concentrations in workplaces, but stipulates a reference level limit of 300 Bq/m³ for the annual average activity concentration in air. This limit may however be exceeded if national circumstances give cause for justification. Radon measurements must be performed at certain workplaces. In section 3 of Article 54, in areas within workplaces where the radon concentration (as an annual average) continues to exceed the national reference level, this exposure situation must be notified in accordance with Article 25, and Article 35 shall apply. This means that workplaces are to be treated as planned exposure situations.

4.2.5 Chapter VIII – Public exposures

Section 1 of Chapter VIII of Directive 2013/59/Euratom covers protection of members of the public and long-term health protection in normal circumstances. The articles in section 1 set out the protective measures, estimation of doses to the members of the public and monitoring of radioactive discharges. These stipulations may have a direct impact on the public exposure calculation model based on the German Radiation Protection Ordinance (StrlSchV): firstly it requires a realistic dose estimate for a representative person, and secondly, the sum of doses from all authorised practices must be used to consider the limit for an effective dose of 1 mSv per calendar year for members of the public. This could require a review of previously used models and, if necessary, the drafting of a new model to calculate radiation exposure to members of the public.

– Article 65 “Operational protection of members of the public” lays down the measures to protect members of the public in normal circumstances from practices subject to licensing. The competent authority shall, where appropriate, establish authorised limits as Part of the discharge authorisation and conditions for discharging radioactive effluents. For practices subject to registration, the protection of members of the public in normal circumstances shall be ensured through appropriate national regulations and guidelines.

– Articles 66 “Estimation of doses to the members of the public” contains arrangements made for the estimation of doses to members of the public from authorised practices, the extent of such arrangements being proportionate to the exposure risk involved. Practices must be identified for which an assessment of doses to members of the public shall be carried out. A distinction is made between those practices for which this assessment needs to be carried out in a realistic way and those for which a screening assessment is sufficient. Requirements for the realistic assessment of doses to members of the public also need to be described in more detail.

– Article 67 “Monitoring of radioactive discharges” requires undertakings to monitor appropriately or, where appropriate, evaluate the radioactive airborne or liquid discharges into the environment during normal operation and to report the results to the competent authority. Reports resulting from monitoring radioactive discharges from a nuclear power plant or reprocessing plant shall be in accordance with standardised information.

– Article 68 “Tasks for the undertaking” requires additional tasks, e. g. to achieve and maintain an optimal level of protection of members of the public and to assess exposure of members of the public and radioactive contamination of the environment.

Section 2 of Chapter VIII of Directive 2013/59/Euratom deals with emergency exposure situations that are not relevant to this advisory mandate.

Section 3 of Chapter VIII of Directive 2013/59/Euratom deals with existing exposure situations that may arise as a result of, e. g. contaminated sites and residues from uranium mining, other

mining residues, indoor radon exposure or gamma radiation from building materials. The discussion surrounding considerations regarding the dose limit for members of the public include these exposure situations if, e. g. remedial measures are to be taken in contaminated areas.

– Article 73 "Contaminated areas" sets out the requirements for optimised protection strategies, including identification of the affected members of the public and control of exposure in areas with residual contamination with the aim of establishing living conditions that can be considered normal.

– Article 74 "Indoor exposure to radon" establishes national reference levels for indoor radon concentrations. The reference levels for the annual average activity concentration in air shall not be higher than 300 Bq/m³. This Article also sets out the action to be promoted to identify dwellings with radon concentrations (as an annual average) exceeding the reference level and encourage radon concentration-reducing measures in these dwellings as well as provide information on indoor radon exposure.

– Article 75 "Gamma radiation from building materials" stipulates a reference level applying to indoor external exposure to gamma radiation emitted by building materials, in addition to outdoor external exposure, of 1 mSv per year. The list of materials set out in Annex XIII of Directive 2013/59/Euratom is to be taken into consideration when identifying building materials as being of concern from a radiation protection point of view. The activity concentrations specified in Annex VIII of Directive 2013/59/Euratom must also be determined and provided to the competent authority. If the dose is likely to exceed the reference level, appropriate measures must be taken.

– Annex VIII "Definition and use of the activity concentration index for the gamma radiation emitted by building materials as referred to in Article 75" states that for the purposes of Article 75, the activity concentrations of primordial radionuclides Ra-226, Th-232 (or its decay product Ra-228) and K-40 shall be determined and provides a formula for activity concentration index I and its meaning.

– Annex XIII "Indicative list of types of building materials considered with regard to their emitted gamma radiation as referred to in Article 75" lists the building materials referred to in Article 75 sub-divided into natural materials and materials incorporating residues from industries processing naturally occurring radioactive material.

4.2.6 Chapter IX - General responsibilities of Member States and competent authorities and other requirements set for the controlling bodies

Section 6 of Chapter VIII of Directive 2013/59/Euratom deals with existing exposure situations which may include relevant practices within the sense of this advisory mandate.

– Article 100 "Programmes on existing exposure situations" stipulates that upon indication or evidence of exposures, existing exposure situations must be identified and evaluated taking into account the types of existing exposure situations listed in Annex XVII in order to determine the corresponding occupational and public exposures. Member States may decide, having regard to the general principle of justification, that an existing exposure situation warrants no consideration of protective or remedial measures. Remedial measures in existing exposure situations are subject to the relevant requirements for planned exposure situations and shall be required to be notified as specified in Article 25.

– Annex XVII "Indicative list of types of existing exposure situation as referred to in Article 100" defines the existing exposure situations to be taken into consideration. These

include exposure due to contamination of areas by residual radioactive material, exposure to natural radiation sources, and exposure to commodities excluding food, animal feeding stuffs and drinking water.

4.3 Exposure situations according to ICRP and several aspects from ICRP 103

In 2007, the ICRP issued recommendation 103 (ICRP 2007), which mostly confirms the previous principles of radiation protection. However, ICRP 103 included changes to the categorisation of radiation exposure that have a major impact on the regulative system of radiological protection.

While ICRP 103 retains the three categories relating to exposure of the general public, exposure of workers and medical exposure, it no longer categorises exposure situations by naturally occurring or man-made radioactivity (practices or work activities). Instead it simply sets out planned exposure situations, emergency exposure situations and existing exposure situations designed to cover the entire spectrum of exposure situations.

– Planned exposure situations are those that arise from the planned operation of a source, including decommissioning, disposal or radioactive waste, and remediation of previously polluted areas. Ongoing practices are planned exposure situations linked to the planned introduction and operation of sources. This type of exposure situation also includes ones that were previously classified as work activities.

– Emergency exposure situations are unexpected and arise e. g. as a result of an accident or design base accident while carrying out a planned situation (prior practices or work activities) or as a result of a malicious act requiring immediate (emergency) measures in order to avoid or reduce adverse consequences on the health, safety, quality of life and property of people and the environment. This includes situations that justify immediate action to reduce the impact of a perceived hazard.

– An existing exposure situation already exists when a decision on the need for monitoring needs to be taken and there is no (longer) need for immediate action. Examples of an existing exposure situation are naturally occurring radioactivity and radiation and the consequences of previous human activities. They also include situations arising from practices that were not however carried out in line with the current ICRP 103 recommendation. Annex XVII (a) (i) of Directive 2013/59/Euratom defines existing exposure situations as *"past activities that were never subject to regulatory control or were not regulated in accordance with the requirements laid down by this Directive."*

The three basic principles of radiation protection have been retained in ICRP 103.

– Principle of justification: Any decision that alters the radiation exposure situation should do more good than harm.

– Principle of optimisation of protection: The likelihood of incurring exposure, the number of people exposed and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.

– Principle of application of dose limits: The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits specified by the Commission.

The principles of justification and optimisation apply universally to all three categories of exposure situations (planned, emergency and existing) (ICRP 2007), whereas dose limits only

apply to planned exposure situations. In emergency and existing exposure situations the limits that apply to planned exposure situations may be exceeded or cannot be complied with. This then just leaves the application of the principles of justification and optimisation.

This entails achieving the best-possible level of protection under the given circumstances by maximising the benefits and minimising the harm. In order to avoid inappropriate optimisation method results, limits on doses or risks to people due to a certain source (dose or risk constraints as well as reference levels) should be put in place.

The ICRP uses the terms dose constraint for planned exposure situations and reference level for emergency and existing exposure situations in conjunction with the optimisation of radiation protection to limit individual doses. Individual doses are defined either as the dose constraint or as the reference level with the intention of complying with, i. e. not exceeding, the corresponding values. Notwithstanding that, the aim is to reduce all radiation exposures to values that are as low as reasonably achievable, taking into account economic and societal factors.

The dose limit for planned exposure situations stipulates the dose or risk limit which must not be exceeded. Below the dose limits, dose constraints are defined as reference levels that should not be exceeded. The principal of optimisation applies to levels below the dose constraints.

In emergency exposures or existing controllable exposure situations, the reference level indicates the dose or risk limit which, when exceeded, should be considered inappropriate exposures and, if not reached, action should be taken to optimise protection levels. The exact figures to be used as a reference level depend on the circumstances of the considered exposure.

Table *4*.1 shows the various types of dose restrictions used in the ICRP protection system (limits, constraints, reference levels) in relation to type of exposure situation and exposure category. Risk constraints are also included in planned exposure situations in order to account for potential exposures.

Figure 4.1 shows the relationship between constraints and reference levels and optimisation of radiation protection. The ICRP only recommends bands for reference levels in the event of emergency and existing exposure situations: 20 mSv to 100 mSv per year for emergency exposure situations and 1 mSv to 20 mSv per year for existing exposure situations. Within the scope of optimising protection, the long-term goal should be to achieve a reference level of 1 mSv per calendar year.

Also within this scope, the ICRP emphasises that particular emphasis should be placed on reducing the number of persons whose doses exceed the reference levels. Measures to reduce dose should be assessed on the basis of the residual dose exceeding the reference levels after implementation. Optimisation is impossible if radiation exposure estimates fail to reflect reality.

The ICRP is in favour of setting particular emphasis on reducing the exposure distribution percentiles above the reference levels when implementing measures to optimise protection in emergency or existing exposure situations. The priority here is to reduce the percentiles, but this requires knowledge of a dose distribution among exposed groups of people and is not possible without a realistic, probabilistic estimate of radiation exposure among an affected group of people.

Table 4.1: Dose limits, dose constraints and reference levels used in the ICRP's protection system (ICRP 103), table 4 (ICRP 2007).

Exposure situation	Occupational exposure	Exposure among the general public	Medical exposure
Planned exposure	Dose limit Dose constraint	Dose limit Dose constraint	Diagnostic reference level [d] (Dose constraint [e])
Emergency exposure situation	Reference level [a]	Reference level	N/A [b]
Existing exposure	N/A [b]	Reference level	N/A [b]

a Long-term measures should be dealt with as Part of planned occupational exposures.

b Not applicable

c Exposures resulting from long-term remediation measures or prolonged work in affected areas should be dealt with as Part of planned occupational exposures..

d Patients

e Only carers, comforters and volunteers in research

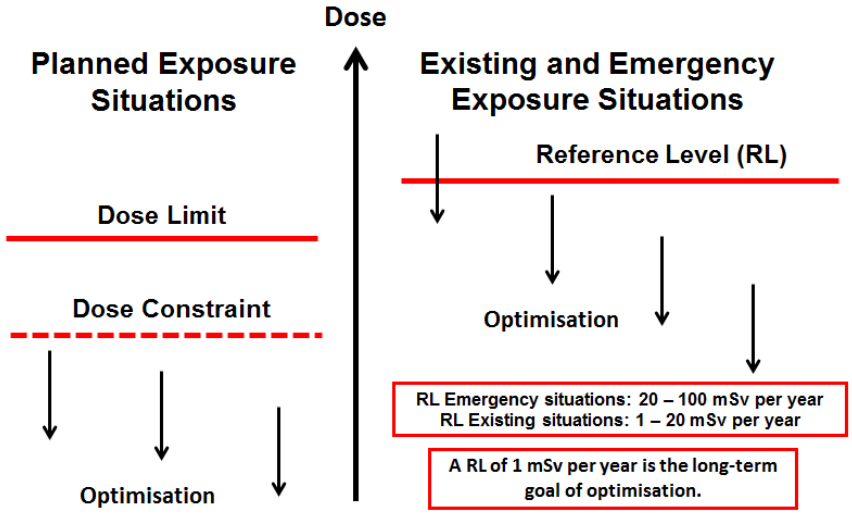

Figure 4.1: The dose limit, dose constraint, reference level system and protection optimisation as defined in ICRP 103 (ICRP 2007).

The statements made in ICRP 103 on dealing with dose limits, dose constraints and reference levels in connection with radiation exposures from multiple sources (ICRP 2007) is of particular importance to this advisory mandate. ICRP 103, 5.5 Levels of radiation protection, states the following:

"(197) In the 1990 Recommendations it was noted that, provided that individual doses are well below the thresholds for harmful deterministic effects, the effect of a contribution to an individual dose from a source is independent of the effects of doses from other sources. For many purposes, each source or group of sources could usually be treated on its own. It is then necessary to consider the exposure of individuals exposed by this source or group of sources. This procedure is called a 'source-related' approach. The Commission now emphasises the

primary importance of the source-related approach, because action can be taken on a source to assure the protection of a group of individuals from that source.

(198) For planned exposure situations, the source-related restriction to the dose that individuals may incur is the dose constraint. For potential exposures, the corresponding concept is the risk constraint. For emergency and existing exposure situations, the source-related restriction is the reference level... The concepts of a dose constraint and reference level are used in the process of optimisation of protection to assist in ensuring that all exposures are kept as low as reasonably achievable, societal and economic factors being taken into account. Constraints and reference levels can thus be described as key parts in the optimisation process that will ensure appropriate levels of protection under the prevailing circumstances.

(199) It could be argued that the source-related restriction would not provide sufficient protection where there are multiple sources. However, the Commission presumes that there will generally be a dominant source, and the selection of the appropriate reference level or constraint ensures an adequate level of protection. The Commission still considers that the source-related principle of optimisation below the constraint or reference level is the most effective tool for protection, whatever the situation.

(200) In the specific case of planned exposure situations, separate restrictions on the sums of the occupational doses and on the sums of the public doses are required. The Commission refers to such individual-related restrictions as dose limits...and the corresponding assessment of doses is called 'individual-related'.

(201) It is rarely possible, however, to assess the total exposure of an individual from all such sources. It is therefore necessary to make approximations to the dose to be compared with the quantitative limit, especially in the case of public exposure. For occupational exposures, the approximations are more likely to be accurate because the operating management has access to the necessary information to identify and control the dose from all the relevant sources."

Figure 4.2 illustrates the differences in concept between the use of individual dose limits in planned situations and constraints or reference levels for protection from a source in all situations.

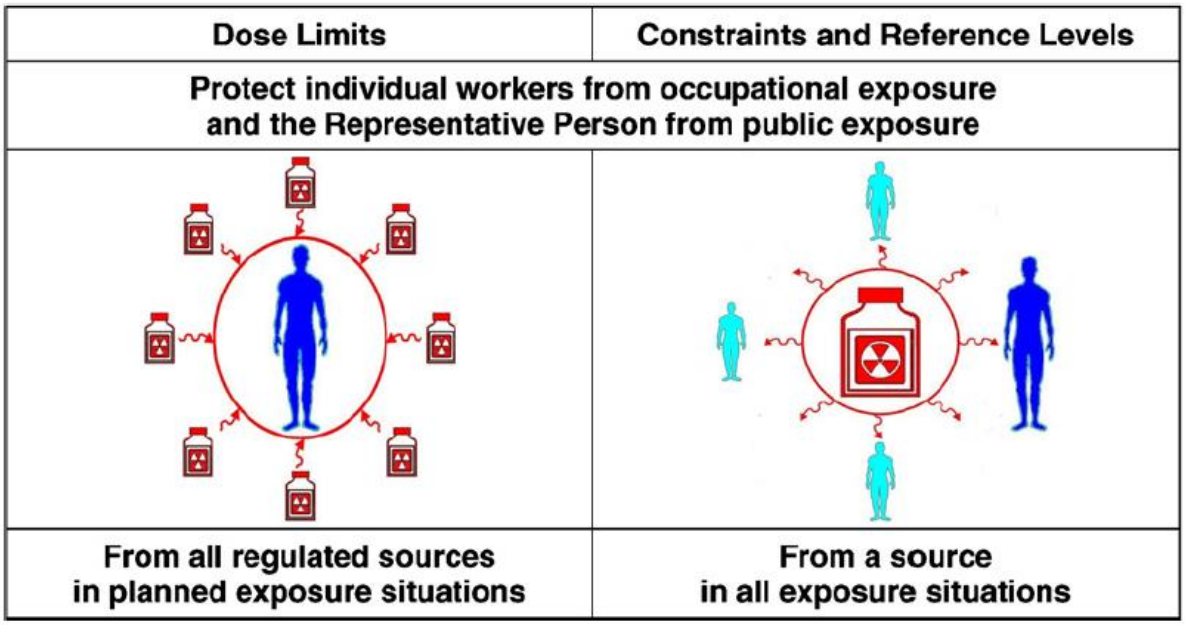

Figure 4.2: Dose limits contrasted with dose constraints and reference levels for protecting workers and members of the public (ICRP 2007).

The ICRP assumes that protective actions with regulated practices each serve to protect against a radioactive source. Only the operator of a source is in a position and obliged to provide and ensure this protection. In terms of occupational exposure of workers, the operator is also capable of ensuring protection against all of the sources within its remit. Ensuring protection against all sources relevant to public exposure is only possible if required by law, if the legislation demands such, if the supervisory authority has been supplied or collects the necessary information, and if there is a stipulation as to how dose approximations are to be determined for contrasting with the quantitative limit as per (201) of ICRP 103 (ICRP 2007).

Recommendation 1:

In implementing the requirement set out in Directive 2013/59/Euratom, which states that the effective dose limit of 1 mSv per calendar year for a member of the public should apply to all practices subject to official licensing and notification requirements (Article 12(1) Directive 2013/59/Euratom), the SSK recommends that the information required to estimate or determine doses and the methods used to collect said information should be set out in the German regulatory framework. Corresponding requirements governing the rules for estimating or determining the dose to individual members of the public for comparison with the quantitative limit should also be specified in the regulatory framework.

The SSK provides further details on the practical implementation of this Recommendation below.

4.4 Excluded and exempted practices

Pursuant to Article 12(1) of Directive 2013/59/Euratom, the Federal Republic of Germany is required to ensure that the dose limits for public exposure shall apply to the sum of annual exposures of a member of the public resulting from all authorised practices. Article 12(2) of Directive 2013/59/Euratom stipulates the following dose limits in a year:

– 1 mSv effective dose

- 15 mSv equivalent dose for the lens of the eye
- 50 mSv equivalent dose for the skin, averaged over any 1 cm^2 area of skin, regardless of the area exposed.

Consequently, only the effective dose is used as a limit reference, if the stated organ doses do not really need to be considered.

Correspondingly, when considering the limit for members of the public, all authorised practices must be included, i. e. a licence must have been granted or a notification issued for handling radioactive material or operating installations used to produce ionising radiation.

This in turn means that practices not subject to licensing or notification do not need to be considered. Directive 2013/59/Euratom states the following to this end:

1. Human activities involving radioactively contaminated materials resulting from authorised activities (Article 25(4) of Directive 2013/59/Euratom). Such contaminations are caused, e. g. by discharges by means of air or water authorised as per § 47 of the German Radiation Protection Ordinance (StrlSchV).
2. Human activities (Article 25(4) of Directive 2013/59/Euratom) involving radioactively contaminated materials resulting from releases in accordance with Article 30 of Directive 2013/59/Euratom. This corresponds with the material released from regulatory control as per § 29 or § 98 of the German Radiation Protection Ordinance (StrlSchV).

The human activities stated in points 1 and 2 are not considered planned exposures as per Article 25(4) and are therefore exempt from notification.

3. Among others, the following practices may be exempted from notification:

   - Practices involving radioactive materials where the activity concentrations (Article 26(1b) of Directive 2013/59/Euratom) do not exceed the exemption values set out in Table A of Annex VII. Part 1 of the table applies to man-made radionuclides, while Part 2 covers naturally occurring radionuclides. This relates to any amount and to any type of solid material. Compliance with the activity concentration values for naturally occurring radionuclides in Table A, Part 2 must not allow the authorised reference level of 1 mSv per calendar year for building materials to be exceeded.
   - Practices involving low quantities of radioactive materials where the activity concentrations (Article 26(1a) of Directive 2013/59/Euratom) do not exceed the exemption values set out in Table A, column 3, of Annex VII. Low quantities of radioactive material with higher concentration values are defined consistently in TECDOC 1000 (IAEA 1998) and Radiation Protection 65 (EC 1993) with a value of three tonnes per year and per facility.
   - Activities involving devices whose type has been approved.

The general exemption and clearance criteria can be found in paragraph 3 of Annex VIII of Directive 2013/59/Euratom.

4. Indoor exposure to radon (Article 74 of Directive 2013/59/Euratom).

The following exclusion criteria can be applied to practices that do not require explicit consideration when determining radiation exposure to members of the public as per Directive 2013/59/Euratom:

- Exposure of carers and comforters for patients; separate dose constraints apply to them (Article 56(5) of Directive 2013/59/Euratom).

– Exposures due to cosmic radiation in aircraft; these do not constitute Part of this recommendation as, firstly, they are considered occupational exposure within the scope of planned practices for air or space crew and, secondly, passenger radiation exposure is excluded as stipulated in Article 3.

One point should however be clarified with regard to the different categories of exposure "**occupational exposure**" and "**radiation exposure of members of the public**", both of which are handled equally in Directive 2013/59/Euratom and ICRP 103.

Directive 2013/59/Euratom (Euratom 2014) defines occupational exposure as follows: "*58. Occupational exposure: exposure of workers, apprentices and students during their work."* When it comes to occupational exposure, no distinction is made between exposure situations or between previous practices and activities. Each exposure in pursuit of a profession is considered occupational exposure. However, occupational exposures below 1 mSv per calendar year are exempt from mandatory radiation protection requirements and do not require persons receiving such exposures to be classed as occupationally exposed individuals.

As a result, the former term "occupationally exposed person" is replaced by the term "exposed worker" as per the definition provided in Directive 2013/59/Euratom: *"36. Exposed worker: Means a person, either self-employed or working under an employer, and who is subject to exposure at work carried out within a practice regulated by this Directive and who is liable to receive doses exceeding one or other of the dose limits for public exposure."* "Public exposure" is defined as follows: *"69. Public exposure: exposure of individuals, excluding any occupational or medical exposure."*

Occupational exposure is to be observed independently of public exposure. This also applies with regard to the dose limit set out in Article 12. This means that Article 12 only affects public exposure and not radiation exposure in pursuit of a profession. The latter does not form Part of this advisory mandate.

"**Non-medical imaging exposure**" also requires further clarification and is defined as follows in Directive 2013/59/Euratom: *"55. Non-medical imaging exposure: means any deliberate exposure of humans for imaging purposes where the primary intention of the exposure is not to bring a health benefit to the individual being exposed."*

Article 22 of Directive 2013/59/Euratom requires Member States to identify practices involving non-medical imaging exposure. Directive 2013/59/Euratom demands special attention be given to the justification of practices involving non-medical imaging exposure (Article 22(2) of Directive 2013/59/Euratom). It also requires such practices be subject to licensing and that implementation criteria and practice requirements be determined (Article 22(4) of Directive 2013/59/Euratom).

The SSK concurs with the stance taken by Directive 2013/59/Euratom whereby non-medical imaging exposure not intended to benefit the health of an exposed person should only be justified in accordance with stringent requirements and only in exceptional cases stipulated by law. The question of justification of non-medical imaging procedures does not form Part of this recommendation. Although there are about 40 examples where legal bases exist for non-medical imaging in Germany (e. g. law enforcement, expert opinions or occupational aptitude tests), the SSK assumes that justified measures involving non-medical imaging procedures[6] will

[6] Radiation exposures due to medico-radiological procedures used on an asymptomatic individual to detect illness at an early stage are not included in radiation exposures due to non-medical imaging procedures and are therefore to be considered separately as per Article 55 of Directive 2013/59/Euratom.

only apply to a very small proportion of the population and therefore constitute a minor contribution in terms of exposure to the general public. This is compounded by the fact that consideration of non-medical imaging in terms of total exposure due to authorised practices is not feasible as it is not possible to create a temporal or spatial link between non-medical imaging and other radiation sources.

Recommendation 2:

As set out in Article 22(3) of Directive 2013/59/Euratom, the SSK recommends excluding justified practices involving non-medical imaging exposure using medical radiological equipment from the requirement for dose constraints according to point (b) of Article 6(1) and from the dose limits set out in Article 12. The SSK also recommends that non-medical imaging procedures be subject to stringent justification processes.

The question of public exposure also has to be asked with regard to existing exposure situations, e. g. residues from previous practices, contaminated sites and uranium mines in Saxony and Thuringia. The radiation exposures originating from the existing situation are not covered by Article 12 of Directive 2013/59/Euratom, but all of the public exposures resulting from remedial measures most certainly are. Remedial measures are to be treated as planned exposure situations and therefore relevant to this advisory mandate.

Recommendation 3:

In existing exposure situations, only the additional exposures resulting from remedial measures set out in Article 12 should be taken into account. The SSK holds the opinion that the failure of remedial measures is not covered by Article 12 as it is in fact an optimisation measure for an existing exposure situation, albeit an unsuccessful one.

Exposures involving **medical research** and the **application of radioactive substances to the human body** (§§ 23 to 24 and 80 to 92 of the German Radiation Protection Ordinance (StrlSchV)): Medical exposures are still governed separately in Directive 2013/59/Euratom (see Articles 54 to 63), are of no relevance to the public limit, thus making them irrelevant to this advisory mandate.

Exposures due to **goods with the addition of radioactive substances or activation of consumer products** (§§ 105 to 110 of the German Radiation Protection Ordinance (StrlSchV): If at all justified, Article 28(c) of Directive 2013/59/Euratom requires licensing for the addition or activation of radioactive substances to consumer products. However, pursuant to § 107(1) point 1 of the German Radiation Protection Ordinance (StrlSchV), proof of compliance of the trivial dose range is required, meaning that exposure due to such consumer goods is not to be considered Part of the public limit. Article 20(4) of Directive 2013/59/Euratom requires Member States to prohibit the sale or the making available to the public of consumer products if their intended use is not justified or their use would not fulfil the criteria for exemption from notification under Article 26.

This argument also applies to any contaminated consumer products. If they are marketed with known contamination, proof of compliance of a trivial dose must be furnished. Consumer products found to be contaminated that fail to meet this requirement shall be removed from the material life cycle.

According to Article 100(1) of Directive 2013/59/Euratom, goods exhibiting specific activity of naturally occurring radionuclides above the exemption levels set out in Table A, Part 2 of Annex VII of Directive 2013/59/Euratom may be considered existing exposure situations in conjunction with Annex XVII of the Directive. The provisions relevant to planned exposure situations apply to goods that give cause for concern from a radiation protection perspective

and to which legal responsibility can almost always be assigned. As a result, notification is required for such goods under Article 25(2) (Article 100(3) of Directive 2013/59/Euratom). In such cases, exposure situations that require inclusion in the sum of exposures from all authorised practices cannot always be excluded.

Recommendation 4:

Based on investigations into the introduction of residue regulations in the current German Radiation Protection Ordinance (StrlSchV) (Brenk 1999) and a reassessment of exposure scenarios resulting from procedural changes, the SSK recommends investigating the circumstances under which refractories, grit, potassium salts and any other materials may be of concern as per Article 100(3) of Directive 2013/59/Euratom.

Exposures due to **transporting radioactive substances**: As transporting radioactive substances involves an "authorised practice", the exposure it causes should be included in limit considerations. A GRS study (Sentuc and Schwarz 2008) collected and analysed data to determine the level of exposure to transport and handling staff and the general public resulting from the normal (accident-free) transport of radiographic and other radiation sources. In terms of radiation exposure to the general public, highly conservative assumptions[7] showed that the transport-related effective annual dose *for the so-called "critical group" of the population is well below the pertinent dose limit of 1 mSv per year and generally below the so-called "trivial dose" of 10 µSv per year".*

Recommendation 5:

Based on the GRS investigations (Sentuc and Schwarz 2008) and the dosimetric cut-off criteria (Chapter 4.13 / recommendation 15), the SSK recommends excluding exposures to individual members of the public as a result of transporting radioactive materials when calculating the sum of exposures from all authorised practices.

4.5 Affected practices

Directive 2013/59/Euratom and German regulatory framework aim to ensure protection against the risks of exposure to ionising radiation under all circumstances unless they are excluded from the stipulated provisions. Directive 2013/59/Euratom stipulates the following in Article 3 "Exclusion from the scope":

"This Directive shall not apply to

a) exposure to the natural level of radiation, such as radionuclides contained in the human body and cosmic radiation prevailing at ground level;
b) exposure of members of the public or workers other than air or spacecrew to cosmic radiation in flight or in space;
c) aboveground exposure to radionuclides present in the undisturbed earth's crust."

[7] Representative person in the vicinity of the transport route during every transport (outward and return journey) performed by a service company on a regular basis (2 to 3 times per week) with a vehicle speed of 5 km/h and stopping for two minutes at a distance of 2 m during every fifth time the vehicle passes by.

The exception to this follows the principal of Roman law "*de minimis non curat lex, de minimis non curat praetor*[8]. This "*de minimis*" principle is closely linked to the term trivial dose involving several 10 μSv per calendar year.

All other practices leading to exposures among the general public and workers that cannot be ignored from a radiation protection perspective are subject to the State's regulations and require notification, registration or licensing.

Exemption levels (Part 2 of the German Radiation Protection Ordinance (StrlSchV)) and surveillance limits (Part 3 of the German Radiation Protection Ordinance (StrlSchV)) are stipulated to exempt radioactive material handling from registration or licensing. Exemption from statutory radiation protection provisions is based on the stipulation of clearance values (Part 2 of the German Radiation Protection Ordinance (StrlSchV)) and surveillance limits (Part 3 of the German Radiation Protection Ordinance (StrlSchV)). Potential radiation exposures due to cleared and released materials are therefore excluded from the regulations.

Excluded human actions and circumstances do not form Part of the stipulations of Article 12 of Directive 2013/59/Euratom and are therefore not included in this recommendation.

Together with the statements in Chapter 4.4, the SSK considers the following exposures and practices to be of relevance to this recommendation:

a) Exposures due to direct radiation and discharges from nuclear facilities and installations pursuant to §§ 46 and 47 of the German Radiation Protection Ordinance (StrlSchV): These exposures form Part of the practices subject to licensing and are therefore to be considered Part of the public limit.

b) Exposures due to direct radiation and discharges from installations in which man-made radioactivity and ionising radiation are used for medical, technological and research purposes. These exposures form Part of the practices subject to licensing according to the German Radiation Protection Ordinance (StrlSchV) or German X-ray Ordinance (RoeV) and are therefore to be considered Part of the public limit. In Germany around 240,000 medical installations (including practising doctors) subject to monitoring including the holder of 2,770 licences (as of 2012) are to be taken into consideration as per § 7 of the German Radiation Protection Ordinance (StrlSchV). In terms of research, universities, major research installations, accelerator facilities and radionuclide laboratories must be included, while radiation installations and the manufacture of radioactive preparations and sources must be included from the technological domain.

c) Exposures due to direct radiation, discharges or releases of naturally occurring radioactive substances (e. g. NORM residues (§§ 97 to 102 of the German Radiation Protection Ordinance (StrlSchV)): Previous German regulations, in particular those set out in § 98 of the German Radiation Protection Ordinance (StrlSchV), require special interpretation in terms of the requirements of Directive 2013/59/Euratom.

As well as the NORM industries listed in Annex VI of Directive 2013/59/Euratom, the following industries may also be affected:

- Hard coal mining,
- Lignite mining,

[8] The law does not concern itself with trifles, the praetor does not concern himself with trifles.

- Aluminium oxide production (already listed under materials in Annex XIII),
- Industrial and household biomass incineration,
- Potash mining,
- Feldspar mining,
- Fertiliser production and spreading,
- Chemical industry (potassium products, glass production, etc.)

In order to ensure radiation protection for any potentially undetected yet relevant exposure situations involving naturally occurring radioactivity, an opening clause in line with § 102 of the German Radiation Protection Ordinance (StrlSchV) should be provided for.

Indoor exposure to radon is considered an existing exposure as long as the exposure to workers does not exceed 6 mSv per calendar year. Should this figure be exceeded, it must be dealt with as a planned exposure situation. If this is the case, the SSK considers it necessary to check whether any radon discharges or emissions contribute towards exposure to members of the public, thus possibly requiring them to be included in total exposure considerations.

As a general rule, when dealing with NORM in the future, radiation exposures due to discharges or emissions of radon in planned exposure situations are also to be taken into consideration for practices subject to registration or licensing. This gives rise to the problem that radon exposures resulting from practices need to be differentiated from naturally occurring background radon or existing exposure situations involving radon.

Radiation exposures in radon spas or galleries are relevant in terms of exposure to workers (cf. Appendix XII, Part A of the German Radiation Protection Ordinance (StrlSchV)). When it comes to members of the public who do not visit radon spas and galleries as patients, the SSK assumes that outdoor radiation exposures due to radon discharges and releases as a result of ventilation measures are to be considered existing exposure situations, and that indoor radon exposures are to be governed as set out in the relevant terms of Directive 2013/59/Euratom.

Article 23 of Directive 2013/59/Euratom prescribes the identification of classes or types of practice involving naturally occurring radioactive materials and leading to exposure of workers or members of the public which cannot be disregarded from a radiation protection point of view. Pursuant to Article 35(1) of Directive 2013/59/Euratom, arrangements must be made for the purposes of radiation protection as regards all workplaces where workers are liable to receive an exposure greater than an effective dose of 1 mSv per year or an equivalent dose of 15 mSv per year for the lens of the eye or 50 mSv per year for the skin and extremities.

If radiation protection arrangements need to be made, the practice must at least be registered with the authorities and potential exposures to members of the public by such a practice are to be taken into consideration in terms of compliance with the 1 mSv per calendar year limit. Exposures can result from discharges and/or direct radiation, and are possible at campus-like research institutes, medical facilities and on premises, for example.

Even though this recommendation does not involve occupational exposure, the provisions of Directive 2013/59/Euratom for occupational exposure in NORM industries also impacts on provisions related to public exposure. As exceeding a dose of 1 mSv per calendar year for workers would require registration of licensing for the practice in question, such practices are relevant for the provisions set out in Article 12 of Directive 2013/59/Euratom and public exposures resulting from these practices must be taken into account when calculating the sum of radiation exposures for comparison with the public limit of 1 mSv per calendar year.

Annex VI of Directive 2013/59/Euratom lists the NORM industries to be taken into account.

Appendix XI Part B and Appendix XII Part A of the German Radiation Protection Ordinance (StrlSchV) contain a list defining the fields of work and materials to be taken into account.

"Fields of work where significantly higher exposure through natural terrestrial radiation sources may occur

Part A: Fields of work with increased Rn-222 exposure

Working in

1. *underground mines, shafts and caves including exhibition mines for visitors,*
2. *therapeutic Radon spas and shafts,*
3. *facilities of water procurement, preparation and distribution.*

Part B: Fields of work with increased exposure through uranium and thorium and their decomposition products

1. *Grinding of and AC-arc welding with thoriated welding electrodes,*
2. *Handling and storage of thoriated gas glow mesh,*
3. *Use of thorium or uranium in the natural isotopic composition including the respective daughter nuclides, as far as existent, for chemical analytic or chemical preparatory purposes,*
4. *Handling, especially installation, dismantling, processing and inspecting of products made from thoriated alloys,*
5. *Extraction, usage and processing of pyrochlore ores,*
6. *Usage and processing of cinder from the metallurgical processing of copper shale ores.*

Annex XII (to §§ 97 to 102)

Recycling and disposal of residues requiring surveillance Part A: List of residues to be taken into account

1. *Sludge and sediments from the recovery, processing and reprocessing of oil and natural gas;*
2. *Unconditioned phosphoric plasters, sludge from their preparation as well as dust and cinder from the processing of raw phosphate (phosphorite);*
3. *a) country rock, sludge, sand, cinder and dust*
   - *from the extraction and preparation of bauxite, columbite, pyrochlore, microlyth, euxenite, copper shale, tin, rare earths and uranium ores*
   - *from the processing of concentrates and residues that occur with the extraction and preparation of these ores and minerals as well as*

   b) minerals corresponding to the above specified ores that occur with the extraction and preparation of other raw materials;
4. *Dust and sludge from the smoke gas filtering with the primary metallurgic processes in the raw iron and non-ferrous metallurgy.*

Residues within the meaning of § 97 are also

a) materials in accordance with the subparas. 1 et seq., when the occurrence of these materials is deliberately produced,

b) castings from the materials specified in subparas. 1 et seq., as well as

c) excavated or cleared ground and demolition waste from the dismantling of buildings or other structures when these contain residues in accordance with the subparas. 1 et seq. and are removed in accordance with § 101 after completion of the work activities or in accordance with § 118(5) or from properties.

No residues within the meaning of § 97 are materials in accordance with subparas. 1 to 4,

a) if their specific activity is below 0.2 becquerel through gram (Bq/g) for each radionuclide of the nuclide chains U-238sec and Th-232sec, or

b) if they are introduced into technological processes specified there as raw materials.

The daughter nuclides to be considered with the nuclide chains U-238sec and Th-232sec as well as with the Pb-210++ are listed in Appendix III, Table 2."

NORM industries are generally sectors that handle and use materials with increased naturally occurring radioactivity and where workers may be subjected to increased radiation exposure or where members of the public may be exposed to increased exposure due to discharges or releases of naturally occurring radioactive material or as a result of direct radiation. In 1997, the SSK issued a statement on radiation exposure at working places due to naturally occurring radionuclides (SSK 1997). The positive list in the German Radiation Protection Ordinance (StrlSchV) was adopted into the German regulatory framework on the basis of this statement.

Due to the ongoing development of industrial processes, e. g. geothermal energy and at water treatment plants, and the state of knowledge with regard to the occurrence of materials exhibiting increased naturally occurring radioactivity and the new criterion for occupational exposure, i. e. exceeding 1 mSv per calendar year, it appears necessary to scrutinise the positive list in the German Radiation Protection Ordinance (StrlSchV) and the SSK statement issued in 1997. In doing so, exposure of workers and members of the general public should be investigated. For the latter, direct radiation and discharges from facilities and installations should be considered along with releases, e. g. dust and groundwater contamination.

Recommendation 6:

The SSK recommends comparing the positive list for NORM industries set out in Directive 2013/59/Euratom with the positive list in the German Radiation Protection Ordinance (StrlSchV). The modified condition whereby regulatory radiation protection measures are to be applied when workers are exposed to 1 mSv per calendar year rather than 6 mSv per calendar year also needs to be taken into consideration. The SSK's statement from 1997 "Radiation exposure at working places due to naturally occurring radionuclides" (SSK 1997) should also be reassessed. Either way, terms in keeping with § 96(5) and § 102 of the German Radiation Protection Ordinance (StrlSchV) that act as 'opening clauses' and enable activities to be taken into account that are not included in positive lists should be retained if radiation exposures could occur during said activities which cannot be ignored from a radiation protection perspective.

4.6 Prospective safeguarding and retrospective proof of compliance with the limit

For planning and licensing purposes, the stipulation of a 1 mSv limit per calendar year for members of the public requires the prospective investigation of potential exposures and retrospective proof of compliance with the limit.

While the prospective investigation can only be performed using hypothetical data or requested licensing values, retrospective assessments such as legal proceedings can be performed on the basis of measured data. Either way, such considerations require modelling of the effective dose of members of the public, which cannot be measured directly.

Radiation exposure modelling may be performed as conservative or realistic estimations (cf. SSK recommendation "Determining radiation exposure" (SSK 2013)).

Directive 2013/59/Euratom provides the option of a graded approach in which a generic or case-specific estimation of additional radiation exposures from practices follows a generic investigation in the form of a conservative estimation. No further investigation is required if a conservative estimate shows that the limits were complied with. However, if a conservative estimate shows that the limit was exceeded, this does not necessarily mean that the limit was in fact exceeded as only a realistic estimate can ensure this. Directive 2013/59/Euratom encourages Member States to specify the cases in which realistic estimates are to be used. With conservative and realistic estimates, exposure to the representative reference person is to be investigated as per Directive 2013/59/Euratom and ICRP 103 in conjunction with ICRP 101; cf. Chapter 4.7.

Recommendation 7:

The SSK recommends introducing a graded approach for prospectively and retrospectively modelling radiation exposure that consists primarily of a realistic yet sufficiently conservative estimation and secondarily of a realistic estimation of the effective doses of individual members of the public (cf. SSK 2013). The regulatory framework should specify cases in which realistic estimations should always be performed. To this end, both generic and case-specific approaches should be permitted. Statements with regard to limits being exceeded should only be made on the basis of realistic, case-specific estimates. In general, retrospective estimations should be performed as realistically as possible so long as the work required to do so can be considered proportionate.

4.7 Representative reference person:

The level of conservatism deemed appropriate when investigating compliance with the limit for members of the public is stipulated in Directive 2013/59/Euratom and ICRP 103 by way of introducing the **representative person**. The dose for a "representative person" should then be estimated by receiving a dose that is representative of the more highly exposed members of the public. The dose to the representative person is equivalent to the **average dose to persons in the "critical group"** in past ICRP recommendations, and therefore replaces it. The dose to the specified person is based on the source characteristics and the link between resulting concentrations of radioactive material in the environment and the person's lifestyle and consumption habits. To keep things simple, in many cases exposure scenarios turn the representative person into a most exposed individual as set out in the American regulatory framework. This makes it relatively easy to perform deterministic dose estimates. In other cases, i. e. with probabilistic dose estimates, the representative person is determined as the 95th percentile of the population.

The physiological characteristics of the representative person are the characteristics of the ICRP's reference person for whom an effective dose is defined and for whom the dose coefficients for external exposure and for exposure due to inhalation and ingestion apply . Such physiological characteristics include air and consumption rates and are designed to reflect the characteristics of a member of the public without any extreme or rare habits as per Directive 2013/59/Euratom in accordance with ICRP 101, meaning that they should be used as mean population data values in line with the characteristics of the ICRP Reference Man (1975).

Dose estimates can be performed by means of an iterative process in which – based on somewhat conservative assumptions – individual levels are to be defined as to whether or not location-specific or realistic information is required.

ICRP's Publication 101, "Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public and the Optimisation of Radiological Protection" (ICRP 2006), contains detailed information regarding this representative reference person which can be drawn upon to interpret the stipulations contained in Directive 2013/59/Euratom.

According to definition 89 of Directive 2013/59/Euratom, the representative person "*means an individual receiving a dose that is representative of the more highly exposed individuals in the population, excluding those individuals having extreme or rare habits.*"

The representative person can be a real person or a person defined by generic criteria. Turning real people or groups of people into representative reference persons may have unwanted effects, e. g. extreme habits may impact on estimated doses, or – as actually happened in France

– may lead to such people being stigmatised. This is why a "generic" representative person should be preferred who, as a reference person, has the characteristics of the "ICRP Reference Man" (ICRP 1975) and represents this bigender hybrid being for which the definition of the effective dose, dose coefficients, organ weighting factors and detriment-adjusted, nominal risk coefficients apply. This reference person's living circumstances also suggests that this person can be expected to be representative for more highly exposed members of the public given the exposure scenarios. In this recommendation the term **representative reference person** is used to describe this representative person with the characteristics of the reference person (Figure 4.3).

The ICRP notes that the inclusion of stakeholders may play a major Part in characterising the representative person (ICRP 2006). This may be organised in very different ways by different countries due to the different cultural, social and political setting.

Depending on the specific situation and available data, the dose can be estimated using purely deterministic methods, purely probabilistic methods or a mixture of both methods.

This should provide a sufficiently robust, i. e. error-tolerant, dose estimate. To this end, the variability and uncertainties of the quantities used in the estimate should be observed. Certain parameter values can be stipulated deterministically, while distribution functions can be used for others. The regulatory authority should stipulate how exactly variability and uncertainties are to be taken into account. If a probabilistic approach is selected, the representative person as per ICRP 101 should be chosen such that their dose reflects the 95th percentile of the dose distribution.[9]

[9] "The representative person should be defined such that the probability is less than about 5% that a person drawn at random from the population will receive a greater dose. The representative person thus serves as a proxy for the 95%-quantile of exposures of the population in the contaminated territory and therefore should be regarded as a low-probability exposure."

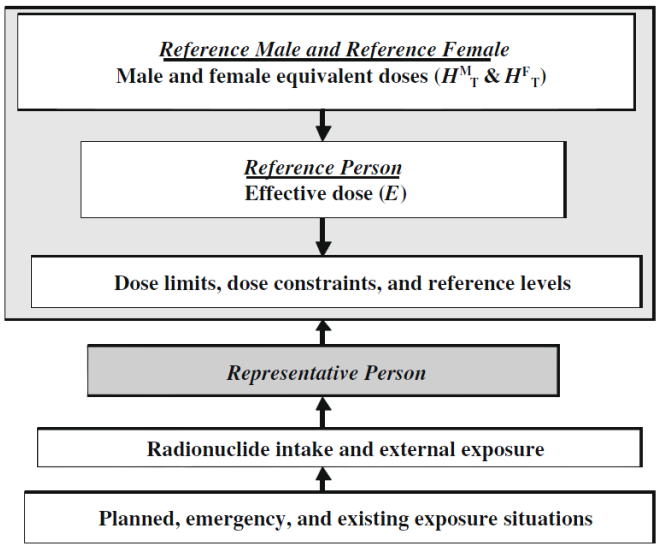

Figure 4.3: Properties of the reference person and representative person in relation to the representative reference person; from ICRP 108, Figure 1.1, p. 21: Relationships between various points of reference for protection of the public" (Pentreath 2009).

The ICRP considers it sufficient to use three age categories: infant (1 year old, representative for 0 to 5 years), child (10 years old, representative for 6 to 15 years) and adult (representative for 16 to 70 years). This is of importance to the dose coefficients used, which are particularly high for the infant <1 year (Table 4.2).

In this regard, ICRP 101 (ICRP 2006) states the following:

(76) The application of dose coefficients for the six age groups should be weighed in relation to the ability to predict concentrations in the environment from a source and the ability to account for uncertainties in habit data for individuals exposed. Uncertainties in estimates of dose, particularly for prospective calculations, are generally not reduced significantly by increasing the number of age categories for which dose coefficients have been provided. The Commission continues to believe that the precision implied by using the full set of dose coefficients is not warranted in the estimation of prospective dose to the public because of the uncertainties involved.

(77) Paragraph 20 points out that the dose constraint is set, at least in part, on the basis of exposures to individuals that are assumed to continue to occur for a number of years into the future. Most facilities are expected to operate for a period of at least 50 years. Therefore, it is the same individual being exposed for a number of years for whom compliance is being determined. This fundamental concept of continuing exposure to the same individual justifies the use of a limited number of age categories that cover several years of a person's life. In the case of disposal of long-lived radioactive waste, where dose to the public may be incurred in the far future over the entire life of the individual, the Commission has stated that '. . . it is then reasonable to calculate the annual dose/risk averaged over the lifetime of the individuals, which means that it is not necessary to calculate doses to different age groups; this average can be adequately represented by the annual dose/risk to an adult' (ICRP, 2000).

(78) The dose coefficients provided by the Commission give the committed dose from intake in a single year. This conservative accounting of dose ensures that individuals are protected over a lifetime of exposure, regardless of the number of years for which they are exposed. For

example, in the case of actinides, dose coefficients take into account the integrated commitment for a lifetime of exposure, which overestimates dose to an individual in any given year.

(79) The Commission allows averaging over a 5-year period in the evaluation of compliance with the dose Constraint (ICRP, 1991), and recommends that a similar approach is appropriate for establishing the number of age groups to be considered in prospective assessments of continuing exposure. Experience to date indicates that age categories can be combined without impacting on protection of members of the public in these situations.

(80) In view of the goals and fundamental concepts underlying the Commission's recommendations as discussed above, some consolidation of the age-specific dose coefficients for internal exposure is warranted. Annex A discusses the implications of such a consolidation. It is evident from these calculations that, with the exception of the actinides, the differences among dose to different age groups are generally small (generally less than a factor of 3) in comparison with uncertainties typically found in assessment of dose to the public.

(81) Therefore, for the purpose of compliance with the dose constraint for continuing exposure, the Commission recommends that the annual dose for the representative person should be defined by three age categories. These categories are 0-5 years (infant), 6-15 years (child), and 16-70 years (adult). The shorter time period is selected for the infant age category, when dosimetric characteristics are changing most rapidly, to avoid any unwarranted reduction in the importance attached to doses to younger age groups. Use of these three age categories is sufficient to characterise the radiological impact of a source and to ensure consideration of younger, more sensitive populations. For practical implementation of this recommendation, dose coefficients and habit data for a 1-year-old (infant), a 10-year-old (child), and an adult should be used to represent the three age categories. ....

(82) The 0-5-year age category does not include the fetus or breast-fed infant. In most cases, the dose to the fetus or breast-fed infant will not be substantially different from the assessed dose for the 0-5-year age category .... However, some radionuclides, principally isotopes of phosphorus and the alkaline earths, can deliver significantly higher doses to the fetus and breast-fed infant than to the mother (ICRP, 2001a,b). Typically, these radionuclides will also deliver relatively higher doses to the infant, so basing compliance on the doses to this age group, using the infant dose coefficient, would normally ensure that the dose to the mother and the fetus is also compliant. Nevertheless, the Commission recognises that the fetus deserves a comparable level of protection. Therefore, if assessed doses to the other age groups include significant contributions from radionuclides known to give rise to relatively high doses to the fetus, and they are approaching the value of the relevant dose constraint, the dose to the fetus or breast-fed infant should be assessed separately to ensure that the quantitative recommendations are respected. In light of the fact that this intake will only be received over a very limited proportion of the individual's lifetime, the Commission considers that an appropriate level of protection can be achieved by comparing the assessed dose to the fetus or breast-fed infant with a dose Constraint that could have a higher value than that normally applied to members of the public. The value of the constraint applied to the fetus or breast-fed infant should not, however, exceed the dose limit for members of the public.

(83) This consolidation of age-specific dose coefficients helps provide a system of protection for the public that is robust and allows the continued development of age-specific dosimetry information as the science evolves. The Commission also believes that the use of three age categories is consistent with the derivation of the dose constraint of ICR for the public in normal and existing exposure situations, which are based on continuing exposure of an individual from a source for a number of years.

(84) However, in estimating health effects in retrospective situations, such as dose reconstruction, all of the Commission's age-specific biokinetic models and data continue to be applicable. In these cases, the quality and extent of site-specific data needed to estimate dose generally determine whether age-specific coefficients published by the Commission improve the quality of doses and reduce their uncertainty.

(85) The Commission continues to encourage the use of all available age-specific dose coefficients in planning for and responding to accidents. However, the consolidated age categories proposed by the Commission in this report may be acceptable in some accident situations, especially when prospective assessments are being made of future consequences of the accident or in determining remediation alternatives. This decision should be made by appropriate regulatory authorities."

The SSK concurs with the point of view expressed by the ICRP as it considers prospective and retrospective radiation exposure estimation of three age categories (cf. Table *4*.2) to be representative of the radiation exposure of members of the public if – in the case of this recommendation – exposures are low when compared to the variability of natural radiation exposure. All six age categories (and organ doses) only need to be taken into consideration if radiation exposures are required that are much higher than the natural exposure range, e. g. in emergency exposure situations.

Table 4.*2: Dose coefficients recommended by the ICRP to prove compliance with limits, constraints and reference levels (ICRP 2006). The habits should be used for the same 3 age categories. Table 3.1. from ICRP 101.*

Age category (years)	Name of age category	Dose coefficients and habits to be applied
0 - 5	Infant	1-year-old
6 - 15	Child	10-year-old
16 - 70	Adult	Adult

The SSK is aware that the protection of fetuses and infants is of extremely high priority due to their very high sensitivity to radiation. The SSK is also aware that deviations from previous procedures set out in the German Radiation Protection Ordinance (StrlSchV) require further substantiation.

In view of this, the SSK points out that the 1 mSv limit per calendar year for members of the public is used to limit stochastic risk and that lifetime exposure up to the age of 70 is pivotal to this limit. Doses in the first year of life are only a contribution to be taken into consideration due to the at times much higher dose coefficients for inhalation and ingestion. Doses in the first year only contribute minimally to the lifetime dose.

The SSK discussed whether or not it would make sense to account for the three age categories of the representative person as per ICRP 101 (ICRP 2006) by determining the mean of the previous six age categories in order to keep changes to current practice to a minimum. It came to the conclusion that such a mean would be feasible, but existing conservatisms (see below) would have to be removed when estimating exposure for children below the age of 1. However, Directive 2013/59/Euratom does not provide for such a mean.

The SSK, on the other hand, considers the statements made in Annex A "*Analysis of the age categories for use in assessment of dose to the public*" of ICRP 101 to be logical and coherent. Annex A contains the ICRP's investigation into the meaningfulness of the three age categories

selected against the background of general knowledge regarding the dependency on age of internal exposure as a result of inhaling and ingesting man-made radionuclides with generic breathing rates and consumption rates for milk, leafy vegetables and meat. Among other things, the ICRP compared internal exposure for two cases:

- The internal dose for a 1 year-old child (dose coefficients pursuant to Directive 2013/59/Euratom) and

- The internal dose a human receives in the first year, i. e. as a fetus[10] during pregnancy (dose coefficients pursuant to ICRP 88 (ICRP 2001)) and as a newborn during the first 3 months as a result of inhalation and ingesting breast milk (dose coefficients pursuant to ICRP 95 (ICRP 2004)). The ICRP's conclusion of this investigation showed that the calculated dose for a 1 year-old child generally constitutes a conservative estimate for the dose that a fetus receives during pregnancy and a newborn receives during the first 3 months due to ingesting breast milk.

As a result of this and when compared to radiation exposures of other age categories, the ICRP comes to the conclusion that the doses for the 1 year-old child may conservatively represent the age category ranging from the fetus to a 5 year-old child in a number of situations. The SSK concurs with this point of view.

In Annex A of ICRP 101, the ICRP does not make any statements with regard to exposure as a result of ingesting drinking water. As a result of the previous stipulations in German regulatory framework, this gives rise to a particular problem.

Pursuant to the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV), the water required for the "processed milk products" exposure pathway must be added to the ≤1 year-old child's drinking water consumption. As a result, the entire drinking water consumption of the ≤1 year-old child as per the German Radiation Protection Ordinance (StrlSchV) is around 2.2 times higher than that of the 1 year-old child. When combined with the higher dose coefficients of the 3 month-old child and when compared to the dose coefficients of the 1 year-old child, this means that a formal conservative estimate cannot be based solely on the 1 year-old child.

This effect cannot be countered by the fact that inclusion of the entire dose commitment up to the age of 70 is not realistic since a significant proportion of the dose involving long-lived radionuclides with a long biological half-life only occurs in later years.

However, when using water supply facilities pursuant to the German Drinking Water Ordinance (TrinkwV 2001)[11], this problem does not occur as a guidance level of 0.1 mSv per year must be complied with as per the German Drinking Water Ordinance (TrinkwV). The total indicative dose parameter of 0.1 mSv per calendar year represents a cumulative dose including naturally occurring radionuclides. In complying with the indicative dose, the contribution due to discharges from practices must be lower than this value. However, only the dose contribution from additional practices is of relevance to the 1 mSv per calendar year limit for the effective dose. This problem may be relevant to local water supplies from domestic wells if the 0.1 mSv per year indicative dose set out in the German Drinking Water Ordinance (TrinkwV) is

[10] The internal dose a fetus receives during pregnancy has not been included in the German regulatory framework to date.

[11] Such facilities also include domestic wells for self-sufficiency.

exceeded. Realism of the drinking water supply is represented, for example, by a study from the Federal Office for Radiation Protection (BfS) (Beyermann et al. 2009).

The SSK recommends disregarding the ingestion of drinking water as per the German Drinking Water Ordinance (TrinkwV) when estimating the effective dose of members of the public from authorised practices (Recommendation 13).

The dose coefficients for ingestion in the first year of life present a general problem. According to Article 13 of Directive 2013/59/Euratom, appropriate "standard values and relationships" should be used for the estimation of effective and equivalent doses. Such standard values also include the dose coefficients for inhalation and ingestion. However, dose coefficient investigations have only been carried out for certain ages. The ICRP has provided dose coefficients for ingestion for the embryo and fetus (ICRP 88 (ICRP 2001)), for ingestion of breast milk (ICRP 95 (ICRP 2004)) and for general ingestion and inhalation for the age categories 3 months, 1 year, 5 years, 10 years, 15 years and adults (ICRP 72 (ICRP 1995)).

If dose coefficients are required for other ages, the ICRP recommends the conservative use of the dose coefficients for the following age categories: Dose coefficients for an age of 3 months for the age category 0 to 1 year, dose coefficients for an age of 1 year for the age category >1 to 2 years, dose coefficients for an age of 5 years for the age category >2 to 7 years, dose coefficients for an age of 10 years for the age category >7 to 12 years, dose coefficients for an age of 15 years for the age category >12 to 17 years and dose coefficients for adults for the age category >17 years.

The assumption of the ICRP and the German Radiation Protection Ordinance (StrlSchV) that dose coefficients for the 3 month-old infant are generally representative of the age category $\leq$1 year is overly conservative as the dose coefficients for many radionuclides are far lower between the 3rd and 12th month (in individual cases involving alpha rays they may be up to one order of magnitude lower). This is predominantly an effect of the change in organ size during this age range. During the first year (and the fetal period), fetuses and infants change so quickly that point estimates for a certain age can only be used as rough generalisations. This means that the use of the dose coefficients for the 3 month-old infant to represent the first year of life may lead to extreme conservatisms that already caused problems with handling naturally occurring radionuclides in the past.

Consumption quantities in the various foodstuff groups also belong to the standard values to be stipulated in the framework with regard to estimating the effective dose and organ doses.

The first 12 months of life see major changes to the consumption quantities of the various foodstuff groups. Infants that are not breast-fed consume increasing quantities of drinking water up to their 3rd month of life; these quantities then drop again between the 3rd and 12th month of life. While the 3 month-old infant almost exclusively consumes breast milk or processed milk products, solid foods are gradually introduced between the age of 3 and 6 months. The amount of tap water non-breast-fed infants consume approximately halves between the 3rd and 12th month of life (Hilbig and Kersting 2003).

An interpolation of the dose coefficients for ingestion between the 3rd and 12th month of life and the link to the age-dependent consumption of tap water (as per Hilbig and Kersting 2003) leads, e. g. with Ra-228, to a dose reduction by a factor of 1.6 compared to the approach set out in the Calculation Guide Mining (BglBb), i. e. excluding the application of the conservatism factor in column 8 of Table 1, Appendix VII of the German Radiation Protection Ordinance (StrlSchV).

According to (Hilbig and Kersting 2003), the use of the data in column 8, i. e. using the consumption quantities as the 95th percentile values of all foodstuff groups rather than using the 95th percentile value of total foodstuff consumption, leads to a massive overestimate of age-dependent total consumption quantities by a mean factor of 2.6.

After weighing up the points set out above, the SSK comes to the following conclusion:

Recommendation 8:

When estimating and determining the effective dose of members of the public, the SSK recommends the application of the representative reference person concept as set out in ICRP 101 (ICRP 2006). The SSK considers it reasonable to only include the three age categories 1 year old (representative for the age category 0 to 5 years), 10 years old (representative for the age category 6 to 15 years) and adult (representative for 16 to 60 years), and to use the dose coefficients specified by the ICRP.

4.8 Realism when estimating radiation exposure

The realism requirements when it comes to "estimating dose models for members of the public" are specified in Article 66 of Directive 2013/59/Euratom which contains the following:

"1) Member States shall ensure that arrangements are made for the estimation of doses to members of the public from authorised practices. The extent of such arrangements shall be proportionate to the exposure risk involved.

"2) Member States shall ensure the identification of practices for which an assessment of doses to members of the public shall be carried out. Member States shall specify those practices for which this assessment needs to be carried out in a realistic way and those for which a screening assessment is sufficient

(3) For the realistic assessment of doses to the members of the public, the competent authority shall:

a) decide on a reasonable extent of surveys to be conducted and information to be taken into account in order to identify the representative person, taking into account the effective pathways for transmission of the radioactive substances;
b) decide on a reasonable frequency of monitoring of the relevant parameters as determined in point (a);
c) ensure that the estimates of doses to the representative person include:
    i. assessment of the doses due to external radiation, indicating, where appropriate, the type of the radiation in question;
    ii. assessment of the intake of radionuclides, indicating the nature of the radionuclides and, where necessary, their physical and chemical states, and determination of the activity concentrations of these radionuclides in food and drinking water or other relevant environmental media;
    iii. assessment of the doses that the representative person, as identified in point (a), is liable to receive;
d) require records to be kept and be made available on request to all stakeholders relating to measurements of external exposure and contamination, estimates of intakes of radionuclides, and the results of the assessment of the doses received by the representative person."

These requirements tally with the graded approach recommended by the SSK in Chapter 4.6 to prospectively safeguard and retrospectively prove compliance with the 1 mSv per calendar year limit for members of the public from authorised practices.

The SSK provided detailed recommendations on estimating radiation exposure in 2013 (SSK 2013) where it also showed the overconservatism of the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) to be completely unrealistic yet acceptable with regard to licencing procedures for nuclear installations. However, for the purpose of retrospective estimates, the SSK recommended a far more realistic approach be adopted for nuclear facilities and installations (SSK 2013).

When preparing the SSK recommendation on estimating radiation exposure (SSK 2013), it was not foreseeable that the discrepant approach for nuclear facilities and installations set out in the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) on the one hand, and for naturally occurring radionuclides set out in the Calculation Guide Mining (BglBb) on the other hand would lead to regulatory framework problems in implementing Directive 2013/59/Euratom.

The SSK considers it unacceptable for inconsistent radiation exposure estimates for members of the public to be stipulated in a regulatory framework if their results are summarised by forming a sum in order to compare them with a limit. The SSK notes that the realism requirements set out in Article 66 of Directive 2013/59/Euratom correspond with the SSK recommendations on determining radiation exposure for retrospective estimates involving nuclear facilities and installations (Table 3.11, SSK 2013) and for prospective and retrospective estimates involving contaminated sites (Tables 3.30 and 3.31[12], SSK 2013).

When defining the approach used to estimate the dose for members of the public from all authorised practices pursuant to Article 12 (Euratom 2014), the following should never be disregarded from a proportionality perspective:

- Article 66 of Directive 2013/59/Euratom requires a realistic approach proportionate to the exposure risk when estimating doses for members of the public.
- Practices may be exempted from authorisation, i. e. disregarded for dose estimates (1 mSv effective dose limit per year), if the radiation exposure generated by said practice – provided it is generated by naturally occurring radionuclides – is at a level of 1 mSv or lower (point (d) of paragraph 3 of Annex VII of Directive 2013/59/Euratom).

Recommendation 9:

The SSK recommends starting with the drafting of "General Administrative Provisions relating to practices" that are in line with the requirements set out in Article 66 of Directive 2013/59/Euratom and consistent in terms of handling naturally occurring and man-made radioactivity while also complying with the realism requirements of Article 66 in terms of the SSK's recommendation on estimating radiation exposure (SSK 2013).

4.9 Properties of sources

As the effective dose of members of the public cannot be measured directly, it must be modelled by linking source terms for direct radiation, discharges and releases or measured values of radioactive substances in environmental media with dietary and living habits of the

[12] In accordance with levels 1 and 2 of the Calculation Guide Mining (BglBb) (BfS 2010).

representative reference person. With man-made radionuclides, discharges are generally so low that it is usually impossible to measure radioactive substances in environmental media. This is why radiation or discharge values measured at the location of the source[13] generally have to be used and the radionuclide pathways via the environment to humans described by way of models. With naturally occurring radionuclides, prospective estimates can only involve assumed or measured source terms, while retrospective exposure estimates can usually be performed far more realistically using environmental radioactivity measurements.

Either way, knowledge of the source terms is essential. Source terms consist of direct radiation, including information about their geometry (point, area or volume source), discharges by means of exhaust air, waste water and NORM industries, possibly including radionuclide releases into the atmosphere and hydrosphere.

This is why regulatory framework should demand that the characteristics of relevant sources be collected in sufficient scope, e. g. by means of specification in "General Administrative Provisions relating to practices".

Recommendation 10:

When implementing Directive 2013/59/Euratom, the SSK recommends the drafting of a regulatory framework pertaining to the necessity of collecting source data with regard to the properties of sources used to estimate radiation exposure resulting from authorised practices. It also recommends the specification of requirements in terms of an appropriate scope for said data collection.

4.10 Collective effect of sources

When considered collectively, sources may have a greater impact in terms of their effect on the exposure of individuals. This is already taken into consideration in the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) by accounting for prior contamination. As a result of the requirements set out in Article 12(1) of Directive 2013/59/Euratom, the term prior contamination has been redefined and needs to be extended to include the other affected practices as per Chapter 4.5. This is why it is necessary to observe the collective effect of sources in more detail.

When considering multiple sources, it should generally be noted that the potential exposures to various sources are of an additive nature. To this end, the contributions for the individual exposure types (external irradiation, inhalation, ingestion) and the individual exposure pathways (water, ground, air) need to be considered separately. These three pathways may be of relevance at different receiving points that should cover the representative reference person where realistically feasible.

If the sources are independent of one another, i. e. if they do not overlap one another in terms of their effects:

[13] In this recommendation the term "source" is used as a short form for radiation source. According to Directive 2013/59/Euratom, a radiation source means an entity that may cause exposure, such as by emitting ionising radiation or by releasing radioactive material. This term is used in the same way in ICRP 103: An entity that releases radiation and for which radiological protection can be optimised as an integral whole, such as x-ray equipment, radiation generators, and open and sealed radioactive materials, and, more generally, the cause of exposure to radiation or radionuclides.

- External irradiation: As the external dose is determined by the time spent directly radiated by the source, and since a person cannot be in two places at the same time, the person can either spend the permitted time at the strongest source or split his or her time evenly among all of the sources. In the case of the former, the dose is that of the strongest source, while in the case of the latter, the cumulative dose is the arithmetic mean of the individual doses of the sources. $E_{\text{ext},i,\text{min}} \leq E_{\text{ext,Summe}} \leq E_{\text{ext},i,\text{max}}$ shall apply in general. The independence of sources is to be stipulated by means of a spatial cut-off criterion.
- Inhalation: If dispersion calculations show that two sources can be considered independently of one another, the argument related to the period of stay also applies as the inhalation dose is determined by Hamilton's principal function (concentration × time). $E_{\text{inh},i,\text{min}} \leq E_{\text{inh,Summe}} \leq E_{\text{inh},i,\text{max}}$ shall apply in general. The independence of sources is to be stipulated by means of a spatial cut-off criterion.
- Ingestion of locally produced foodstuffs: Independence of the sources means that the foodstuffs originate from different places. As it is only possible to eat and drink one's fill once, the time factor is complemented by the distribution of foodstuff quantities. $E_{\text{ing},i,\text{min}} \leq E_{\text{ing,Summe}} \leq E_{\text{ing},i,\text{max}}$ shall apply in general.

The independence of sources is to be stipulated by means of cut-off criteria; cf. Chapter 4.11.

If sources are not independent of one another and their effects overlap, estimates should be performed as follows (cf. recommendation 15):

- External irradiation: In this case the representative reference person should be selected such that he/she spends a reasonable amount of time at the place with the highest local dose rate based on realistic assumptions. A spatial cut-off criterion should also be determined (cf. the cut-off criteria from the Calculation Guide Mining (BglBb).
- Inhalation: If dispersion calculations show that sources overlap one another, the representative reference person should be selected such that he/she spends a reasonable amount of time at the place with the highest inhalation dose caused by the local radionuclide mixture based on realistic assumptions. The highest concentration from multiple sources may not be the same place where the highest concentration from a single source is located. A spatial cut-off criterion should also be determined (cf. the cut-off criteria from the Calculation Guide Mining (BglBb).
- Ingestion of locally produced foodstuffs: If model calculations show that sources overlap one another in terms of radionuclide concentration in foodstuffs, the representative reference person should be selected such that he/she consumes these foodstuffs based on realistic assumptions. The highest radionuclide concentration in foodstuffs from multiple sources may not be the same place where the highest concentration from a single source is located.

One particular aspect of the collective effect of sources occurs in connection with constructional radiation protection during the use of x-ray machines and accelerator facilities as well as when performing non-destructive materials testing. If such applications are to be taken into consideration when forming the sum, it is to be assumed that the representative reference persons spend time in the area affected by these sources (see recommendation 14). Periods of stay should be selected realistically.

4.11 Exposure scenarios

Exposure scenarios for the representative person are determined by the activities that a member of the public may undertake, including completely normal behaviour. The representative person spends time in houses and outdoors, eats, drinks and breathes. He/she uses public transport and visits doctor's surgeries and clinics. Based on the location and duration of stays, these activities determine the exposure scenarios for the representative reference person.

The representative reference person (for a source):

- has the characteristics of the reference person with average eating and drinking habits,
- is the person to which the ICRP dose coefficients and ICRP organ dose coefficients apply,
- lives or may in the future live in the nearest dwelling to the source,
- has realistic periods of stay in places with high exposure that do not however exceed 8,760 h per year. The outdoors exposure scenario should correspond to normal German habits and no unrealistically long periods of stay should be assumed on contact areas.
- uses the area influenced by the source such that as many real exposure pathways as possible have a maximum yet realistic and non-excessive impact.

With multiple sources this means:

- External exposure (direct radiation, submersion, ground radiation): In houses and outdoors in various locations with the highest exposure. The person does not however remain in one place outdoors. A certain area needs to be defined (by the exposure situation) with the freedom to move around that is compatible with the period of stay. This results in a mean ambient dose rate for ground radiation rather than the local ambient dose rate of a potential, extremely focussed hot spot. The reduction in exposure when staying in houses is to be taken into consideration.
- Inhalation (radionuclides (gaseous or aerosol-bound and dust-bound)): Calculation of transport of substances to locations where the representative reference person is expected to spend time. Breathing rates pursuant to Appendix VII, Part B, Table 2 of the German Radiation Protection Ordinance (StrlSchV) are to be assumed. Any diffuse prior contamination from other practices should also be taken into account. The reduction in exposure when staying in houses is also to be taken into consideration.
- Ingestion of locally produced foodstuffs: With locally produced foodstuffs, the representative person will generally be a farmer or someone with an allotment. There can be no locally produced foodstuffs if there is no agricultural or horticultural use. With locally produced fish, the representative person will be an angler or fish farmer.

If the meaning of individual exposure scenarios and pathways is not clear, it may be necessary to consider the exposures of various representative reference persons.

Recommendation 11:

The SSK recommends choosing the representative person such that the exposure scenarios and characteristics (time spent in one place either as a resident or for other practices, behaviour during leisure activities, partial agricultural self-supply, using public roads, spending time near x-ray machines and accelerator facilities, etc.) maximise the potential radiation exposure based on realistic assumptions. The exclusion of exposure scenarios should be possible on a case-by-case basis if the requirements for these scenarios are not given.

4.12 Exposure pathways, dietary and living habits

Radiation exposures arise due to external irradiation and as a result of the inhalation and ingestion of man-made and naturally occurring radioactive substances. In Germany, a number of different exposure pathways are generally taken into account. The German regulatory framework does not however provide standardised guidelines on how to take exposure pathways into account. The Calculation Guide Mining (BglBb) takes direct ingestion from the ground into account, while the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) does not. Periods of stay on bank sediment is also handled in different ways.

Recommendation 12:

The SSK recommends taking account of all the exposure pathways set out in the table below (Table 4.3) when estimating the radiation exposure of individual members of the public from authorised practices.

Table 4.3: SSK proposal for the exposure pathways to be taken into consideration in "General Administrative Provisions relating to practices"

External exposure
Direct radiation (x-ray, gamma, neutron)
Beta and gamma radiation within the exhaust air plume
Gamma radiation of the ground including sediment
Exposure due to inhalation
Radioactive material (gaseous and aerosol-bound)
Radon and its decay products
Exposure due to ingestion
Radioactive material with locally produced foodstuffs
– Air ⟶ plant
– Air ⟶ feed plant ⟶ cow ⟶ milk
– Air ⟶ feed plant ⟶ animal ⟶ meat
– Water ⟶ fish
– Cattle watering trough ⟶ cow ⟶ milk
– Cattle watering trough ⟶ animal ⟶ meat
– Rain/spray irrigation ⟶ feed plant ⟶ cow ⟶ milk
– Rain/spray irrigation ⟶ feed plant ⟶ animal ⟶ meat
– Rain/spray irrigation ⟶ plant
– Ground ⟶ plant
– Ground ⟶ feed plant ⟶ cow ⟶ milk
– Ground ⟶ feed plant ⟶ animal ⟶ meat
Direct ingestion of soil

In order to be able to apply the concept of the representative reference person, their characteristics need to be determined using parameters such as consumption rates of foodstuffs. These consumption rates for different foodstuffs are stipulated in the German Radiation Protection Ordinance (StrlSchV) where the median rates for each of the 6 age groups are complemented by a foodstuff-specific factor involving multiplication of the medians to cover the 95th percentile of consumption rates. These factors represent the maximum factor of every age class, i. e. they do not apply to individual age groups. By stipulating, e. g. in the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV), that these factors are to be applied when calculating the ingestion dose leads to inappropriate conservatisms that do not correspond with the definition of the reference person set out in Directive 2013/59/Euratom (cf. Chapter 4.7). The Calculation Guide Mining (BglBb) provides consumption rates separately as mean quantities and without a "conservatism factor".

Consumption of foodstuffs gives rise to the question of whether the foodstuffs consumed by the representative reference person are locally produced and therefore possibly contaminated by discharge exposures involving exhaust air and waste water or as a result of radioactive substance releases into the atmosphere and hydrosphere. This question is also answered differently in the various German regulatory frameworks. The General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) assume, irrespective of the real growing and farming opportunity, that all foodstuffs come from the most

unfavourable receiving points, while the Calculation Guide Mining (BglBb) stipulates a foodstuff-specific proportion of locally produced foodstuffs. The SSK believes that such inconsistencies are unacceptable for "General Administrative Provisions relating to practices". Locally produced foodstuffs should only be taken into account if produced or anticipated to be produced in sufficient quantities in the foreseeable future.

Experience shows that when growing and consuming locally produced foodstuffs, agricultural production involving wholesaling has little impact on the ingestion dose, while small-scale growing involving allotments that may partially represent self-supply has a much greater impact on the ingestion dose. If ingestion constitutes a major exposure pathway, the living habits of allotment owners, hunters and fishers will often be assigned to the representative reference person.

The German Drinking Water Ordinance (TrinkwV) stipulates that radioactive substances in drinking water have to meet the total indicative dose parameter of 0.1 mSv per calendar year. If this indicative dose is exceeded, the authority has to investigate whether measures need to be taken to reduce the specific activities in drinking water. With water supply facilities it can be assumed that the ingestion dose due to the consumption of drinking water will be lower than 0.1 mSv per year. The SSK holds the opinion that the consumption of drinking water from water supply facilities can be disregarded when calculating the ingestion dose[14].

Recommendation 13:

When estimating the effective dose to the representative reference person due to ingestion, the SSK recommends using the mean consumption quantities for the three age categories of the representative reference person as set out in the table below (Table *4*.4). The SSK also recommends stipulating the level of locally grown foodstuffs required for calculations. This should be done realistically by including the necessary areas and yields required for the corresponding consumption of foodstuffs. There can be no ingestion dose from foodstuffs if there is no agricultural or horticultural use. Drinking water consumption, which according to the German Drinking Water Ordinance (TrinkwV 2001) must meet a total indicative dose parameter of 0.1 mSv per year, may be disregarded when calculating the effective dose from ingestion.

[14] This limits the effects of discharge exposures involving waste water on the ingestion dose and the effects of releases into the hydrosphere on the exposure pathways rain/spray irrigation, cattle watering trough and fish consumption.

Table 4.4: SSK proposal for the annual consumption of the reference person for various foodstuffs to be taken into consideration in "General Administrative Provisions relating to practices". The data set out in this table are taken from the Calculation Guide Mining (BglBb, BfS 2010) for the age categories 1 to 2 years, 7 to 12 years and >17 years. They are used here as a suggestion for the three age categories: infant (1 year old, representative for 0 to 5 years), child (10 years old, representative for 6 to 15 years) and adult (representative for 16 to 70 years). However, the representativeness of these data for the three age categories as per ICRP 101 (ICRP 2006) should be validated by evaluating current consumption studies, e. g. the DONALD (DOrtmund Nutritional and Anthropometric Longitudinally Designed) study for children.

Foodstuff	Annual consumption		
	1 year	10 years	>17 years
Drinking water from water supply facilities[15]	100 l	150 l	350 l
Freshwater fish	3 kg	4.5 kg	7.5 kg
Milk (including milk products)	125 kg	170 kg	130 kg
Meat (including meat products)	13 kg	65 kg	90 kg
Vegetable products of which:	138 kg	259 kg	253 kg
– Grain, grain products	30 kg	95 kg	110 kg
– Fresh fruit, fruit products, juices	45 kg	65 kg	35 kg
– Potatoes, root vegetables, juices	40 kg	55 kg	55 kg
– Leafy vegetables	6 kg	9 kg	13 kg
– Vegetables, vegetable products, juices	17 kg	35 kg	40 kg

The SSK points out that disregarding radiation exposure due to the consumption of drinking water from water supply facilities when calculating the effective dose does not mean that ground and surface water do not need to be taken into account in terms of radiation protection. The model bases required to achieve this should, depending on the type of practice, be included, e. g. in "General Administrative Provisions relating to practices".

The periods of stay play a greater Part in estimating radiation exposure than dietary habits, which are only relevant to the ingestion dose. The German regulatory framework is again extremely inconsistent when it comes to periods of stay. While § 46(2) sentence 2 of the German Radiation Protection Ordinance (StrlSchV) and the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) apply a realistically impossible permanent period of stay for exposure to beta and gamma radiation within the

[15] Although the consumption of drinking water from water supply facilities is not included in this recommendation, consumption quantities for drinking water are suggested here because they are required for other calculation guides, e. g. for deriving clearance values. Drinking water consumption quantities are also required to estimate doses in existing and emergency situations, which is why they should also be stipulated.

exhaust air plume, for gamma radiation of radioactive substances stored on the ground and for inhalation of radioactive substances at the most unfavourable receiving points, the Calculation Guide Mining (BglBb) provides other and far more realistic potential periods of stay (Table 4.5). The SSK holds the opinion that this table can be used as a template for corresponding stipulations in "General Administrative Provisions relating to practices".

It should be pointed out, however, that due to practices involving man-made radioactivity and radiation used for medical, technological and research purposes, other periods of stay need to be taken into consideration to account for other exposure options. These include periods of stay in staircases, waiting rooms and changing rooms for x-ray machines and accelerator facilities as well as periods of stay on public roads near a radioactive source both in general and in particular when performing non-destructive materials testing.

A conservative 10% of occupational working time, i. e. 200 h per calendar year, was applied to periods of stay on public roads, in staircases and on corridors at clinics and doctors' surgeries, waiting rooms, changing rooms and non-occupational stays on facility premises.

Within this context it should be emphasised that the reference person's human characteristics and habits as per Directive 2013/59/Euratom and the ICRP recommendations are designed to represent mean values, not extraordinary or abnormal characteristics (cf. Chapter 4.7).

Recommendation 14:

The SSK recommends the drafting of a regulatory framework pertaining to periods of stay for "General Administrative Provisions relating to practices" as set out in the table below (Table *4*.5). The data set out in this table are taken from the Calculation Guide Mining (BglBb) and need to be checked to make sure they are up to date. The values stated there should be taken as maximum values for periods of stay in the given areas. The SSK recommends always using maximum values for periods of stay (8,760 h per year) and including sites of exposure where there is no (additional) exposure.

Table 4.5*: Stipulation of periods of stay for the representative person for "General Administrative Provisions relating to practices": Annual exposure time for various sites of exposure and representative persons. A period of stay must not exceed a total of 8,760 h per year.*

Place of exposure	Age category	Exposure time [h]
1. Indoors		7,000
2. Outdoors:		2,000
Where, depending on local conditions, the following values may contribute to the overall outdoor exposure of a member of the public		
2.1 Uncultivated areas	1 year	100
	10 years	250
	>17 years	100
2.2 Garden areas		1,000
2.3 Streets, squares, etc.		1,000
2.4 Children's play areas, parks, etc.		1,000
2.5 Public roads		200
3. Staircases and corridors in clinics and surgeries, waiting rooms and changing rooms		200
4. Members of the public on facility premises		200

When estimating external radiation exposure, periods of stay are one of the two defining parameters. The other defining parameter is the local ambient dose rate, which may also vary greatly on a small scale. It should be noted that members of the public do not generally stay in one place for long periods of time as they move around. This means that a reasonable mean value is to be applied for the local ambient dose rate when estimating external radiation exposure. This also applies to stays in dwellings.

The SSK points out that validation of the calculation model and parameters of future "General Administrative Provisions relating to practices" should aim to meet the requirement of reproducing naturally occurring radiation exposure when applying naturally occurring background levels.

4.13 Sum formula

In application of Article 12(1) of Directive 2013/59/Euratom, the sum of the effective doses to which the representative reference person is exposed from all relevant sources is to be formed and compared with the 1 mSv per year limit. To this end, the exposures for every source *i* are to be taken into consideration separately with three contributions, namely external exposure[16], inhalation and ingestion, via the exposure pathway as per Table 4.3:

[16] External exposure comprises exposures due to direct radiation (x-ray, γ, n), gamma radiation of the ground including sediment, beta and gamma submersion.

$$E_i = E_{\text{ext},i} + E_{\text{inh},i} + E_{\text{ing},i}$$

Cut-off criteria are needed to form the sum in a reasonable and feasible manner as the number of sources to be taken into account is unknown, the need to take a source into account is dependent upon location and time, and because it is not possible to reasonably include all sources in Germany (and abroad) when forming the sum.

The following cut-off criteria examples are already common practice in Germany:

- Criteria pertaining to area- and mass-related activity when identifying contaminations,
- Formation of nuclide vectors to be taken into account during clearance,
- The cut-off criteria set out in the Calculation Guide Mining (BglBb).

Below is an excerpt from the Calculation Guide Mining (BglBb) as the cut-off criteria set out in the Calculation Guide Mining (BglBb (BfS 2010) are relevant to "General Administrative Provisions relating to practices":

" 2.6 Requirements to be met when assessing radiation exposure

The following requirements shall be observed when using the Calculation Guide:

*2.6.1 Exposure scenario "**indoors**"*

a) When the indoors exposure scenario (commercial buildings) is considered, the times assumed to be spent indoors by workers must be realistic. Part I, Para 2.3.1 b) shall be observed.

b) When calculating radiation exposure of reference persons from the general public, a maximum time of 7,000 hours per year shall be assumed to be spent indoors (residential buildings) as a general rule. However, staying indoors does not necessarily mean to spend time exclusively within a building situated at the "most unfavourable receiving point".

c) As a general rule, the indoors exposure scenario requires that the exposure pathways "external exposure to gamma radiation from soil", "inhalation of dust" and "inhalation of radon and its short-lived decay products" be accounted for. These pathways are relevant according to Part I, Para 2.2, when the buildings are situated

- *on, or at immediate proximity to mining installations and facilities (**up to a distance of 20 m**) as for the pathway "external exposure to gamma radiation from soil",*
- *on, or in the vicinity of mining installations and facilities (**up to a distance of 100 m**), as for the pathway "inhalation of dust", and*
- *on, or in the vicinity of*

mining installations and facilities, as for the pathway "inhalation of radon and its short-lived decay products". Part I, Para 2.6.1 d) shall be observed.

d) When assessing the Radon-222 concentration in ambient air (inhaled air) for the reference person of the general public, allowance must be made for:

- *inflow of Radon-222-containing soil air from the building foundation, as far as the building is **situated on, or at immediate proximity of**, a mining installation or facility (as far as this pathway might be relevant according to Part I, Para 2.2, its contribution shall be assessed based on site-specific examinations in the particular case),*
- *inflow of Radon-222-containing external air, if the building is **situated at, or in the vicinity of**, a mining installation or facility. Part I, Para 2.3.2 a) shall be observed.*

e) External radiation exposure and radiation exposure from inflow of contaminated external air into the building is calculated based on measured values or via air dispersion calculations for an outdoor receptor point adjacent to the building. Part I, Para 2.6.7 shall be observed. The shielding effect of the building has been accounted for in the calculation provisions (Part II, Paras 1 and 2). The value determined for outdoors shall be assumed when calculating the Radon-222 concentration in indoor air. The values indicated in Annex III, Table III.2 are applicable for the equilibrium factor.

…

*2.6.3 Exposure scenario "**outdoors"***

a) The outdoors exposure scenario requires realistic assumptions of times spent outdoors by workers. Part I, Para 2.3.1 b) shall be observed.

b) When calculating radiation exposure for reference persons of the general public, the time spent outdoors shall be assumed to reach a maximum of 2,000 h per year as a general rule. However, staying outdoors does not necessarily mean spending time exclusively on a site located at the "most unfavourable receiving point".

c) The outdoor scenario basically requires that the exposure pathways „external exposure to gamma radiation from soil", "dust inhalation", "inhalation of radon and its short-lived decay products" as well as "direct soil ingestion" be accounted for. These pathways are relevant according to Part I, Para 2.2, if sites of exposure of reference persons are situated

- *on, or at immediate proximity to mining installations and facilities (**up to a distance of 20 m**) as for the pathway "external exposure to gamma radiation from soil",*
- *on, or in the vicinity of mining installations and facilities (up to a distance of 100 m), as for the pathway "inhalation of dust",*
- *on, or in the vicinity of mining installations and facilities, as for the pathway „inhalation of radon and its short-lived decay products" (Part I, Para 2.6.1 d) shall be observed) and*
- *on*

  mining installations and facilities as for the pathway "direct soil ingestion".

Recommendation 15:

The sum of the effective dose is to be formed as per $E_{\text{Summe}} = \sum_i E_i$, where "at the place[17] where E_{Summe} is the maximum" applies as a constraint. In order to form the sum in a feasible

[17] The place of maximum dose should not be considered a mathematical point, but rather an area, e. g. with a radius of 50 m or 100 m.

manner and ensure the convergence of the sum of the doses, the SSK proposes the following cut-off criteria:

a) Dosimetric cut-off criterion:

Sources contributing less than several μSv per calendar year can in principle be disregarded. Sources that together account for less than 10% of the total of effective doses can also be disregarded.

b) Spatial cut-off criterion:

– Radiation exposure caused by direct radiation: Sources can be disregarded if the representative person is more than 500 m away from nuclear power plants and facilities and more than 100 m away from other facilities.

– Radiation exposure due to discharges of man-made radionuclides in exhaust gas or releases into the air: Sources where the representative person is more than 5,000 m away from the plant/facility can be disregarded if the discharges or releases occur at effective emission heights in excess of 100 m. At lower effective emission heights, sources can be ignored if the representative person is more than 500 m away from the plant/facility. This criterion depends on the effective emission height, which incorporates both the chimney height and thermal superelevation. Within the scope of drafting "General Administrative Provisions relating to practices", cut-off criteria for naturally occurring radionuclide discharges from other industries, e. g. NORM industries, still need to be clarified.

c) Cut-off criterion for the specific activities of materials from NORM industries[18]:

– Radiation exposure due to the use or storage of solid materials can be disregarded without limiting the quantity if the maximum specific activity for all U-238 and Th-232 series radionuclides are collectively below the monitoring limits to be defined. These monitoring limits should be less than or equal to 1 Bq/g for all U-238 and Th-232 series radionuclides and less than or equal to 10 Bq/g for K-40 (radionuclides and IAEA 1998)[19]. Higher values may be justified for materials in which Pb-210 and Po-210 are enriched.

– With small quantities of up to several (i. e. 3) thousand kilos, radiation exposure due to the use or storage of solid materials can be disregarded if the maximum specific activity for all U-238 and Th-232 series radionuclides are collectively below a multiple of the monitoring limits to be defined.

The SSK considers it useful to restrict the limit to the effective dose as the exposure limit of 1 mSv per calendar year for members of the public is low compared to the fluctuation of naturally occurring radiation exposure and because relevant organ-specific risks are not to be

[18] Materials (and soil) contaminated due to naturally occurring or man-made radionuclides from licensed discharges or releases constitute an existing exposure situation and are not to be taken into account when forming the sum, as is the case with goods for which there are already other provisions (Annex XVII of Directive 2013/59/Euratom).

[19] These are the new exemption levels for NORM in Directive 2013/59/Euratom. However, the previous stipulations show that exemption levels of 0.2 Bq/g to approx. 0.5 Bq/g would also be appropriate (cf. Annex XII Part A of the German Radiation Protection Ordinance (StrlSchV) and RP 122/II (EC 2002)).

expected. Organ doses do not need to be taken into consideration as they do not lead to any additional quality in terms of protection.

Recommendation 16:

The SSK recommends limiting the implementation of Article 12(1) of Directive 2013/59/Euratom to the effective dose. Organ doses do not need to be taken into consideration.

4.14 Optimisation and dose constraints

Optimisation of protection is one of the basic principles of radiation protection and is known as the ALARA principle, which stipulates that every exposure is to be kept as low as reasonably achievable while taking societal and economic factors into account. ICRP 103 specifies the role of optimisation for the three exposure situations, namely planned, existing and emergency situations. As it is not always possible to limit exposure in existing and emergency exposure situations, optimisation is the only tool available and complemented by a bandwidth system of reference levels (cf. Chapter 4.3) above which exposures are no longer deemed acceptable. Generally speaking, dose constraints are not a tool that can be used for simultaneous optimisation of protection against multiple sources as only the operator of a source can provide this optimisation, yet it is unable to influence the other sources.

Dose limits can be stipulated to limit planned exposure situations. Dose constraints are also put in place which represent upper limits of potential exposures to be applied when planning and designing practices. Should these dose constraints be exceeded, measures are required to ensure compliance with the dose constraints without having already exceeded the limit. Optimisation based on the ALARA principle is to be used at levels below these constraints.

Man-made radioactivity applications involve a number of such dose constraints that are set out in statutory and regulatory framework. For discharges from nuclear facilities and installations, § 47(1) of the German Radiation Protection Ordinance (StrlSchV) stipulates limits for the effective dose of 0.3 mSv per calendar year for discharges by means of exhaust air and waste water in addition to the global limits set out in § 46. These limits have the nature of dose constraints, but are stipulated as dose limits.

There are no such dose constraints for naturally occurring radioactivity. Exposure of members of the public simply has a guidance level (within the sense of the current German legal definition) which, when exceeded, is to be investigated by the competent authority to determine whether protective actions are necessary, possible and appropriate. The reason that man-made and naturally occurring radioactivity is handled differently in the regulatory framework is because the level and fluctuation of naturally occurring radiation exposure does not render it possible to do everything that can be achieved with man-made radioactivity. This means that naturally occurring radioactivity still retains a certain privileged status.

However, it is noted that the system used to date has proven to be effective, which is why the SSK sees no need for any changes in this regard.

The option to stipulate dose constraints in the regulatory framework is derived from point (b) of Article 6(1) of Directive 2013/59/Euratom.

According to point (b) of Article 6(1) of Directive 2013/59/Euratom, dose constraints may be stated for every source during the licensing procedure. Dose constraints are source-related and source-dependent. The number of potential sources has not been determined in any way, meaning that it is not possible to generically stipulate them in advance as per the requirements

set out in Article 12(1) of Directive 2013/59/Euratom with the aim of ensuring compliance with the limit.

The SSK considers dose constraints for planned exposure situations solely as an optimisation tool and not as a limitation tool. They are a proven instrument for optimising practices (in the former sense) in the regulatory framework.

Recommendation 17:

The SSK recommends retaining the previous general requirements in terms of optimising radiation protection. Dose constraints may be of use in the regulatory framework as sole optimisation tools. The SSK advises against stipulating dose constraints for exposures of individual members of the public in the regulatory framework.

4.15 Practical implementation

It should be emphasised that the terms set out in the German Radiation Protection Ordinance (StrlSchV) have proven to be successful and reliable to date. According to a report on public radiation exposure in the Federal Republic of Germany (e. g. BMU 2013) submitted by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to the German parliament, the application of the principles or justification, optimisation and the application of dose limits result in the following situation in Germany:

- According to calculations in the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV), radiation exposure caused by direct radiation and discharges of radioactive substances by means of exhaust air and waste water from nuclear facilities and installations at the most unfavourable receiving points including prior contamination from other facilities and installations amounts to less than 10 μSv per calendar year.
- Mean radiation exposures due to applications involving ionising radiation and radioactive substances in research, technology and dwellings are less than 10 μSv per calendar year. The parliament's report does not, however, contain any statements regarding more highly exposed members of the public.
- It remains unclear how exposure of members of the public due to discharges and releases from practices involving NORM industries that will be subject to registration or licensing in the future are to be taken into account. The parliament's report does not contain any statements to this end.

By implementing Article 12(1) of Directive 2013/59/Euratom, no changes are to be expected for the following:

- Nuclear facilities that already have a licence,
- All applications involving ionising radiation and radioactive substances in research, technology and dwellings for which calculations have already been made pursuant to the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV),
- Stipulation of radiation protection areas and
- Stipulation of generic discharge levels, release levels and contamination levels,
- Stipulation of surveillance limits for residues from NORM industries.

However, the following changes are to be expected by implementing Article 12(1) of Directive 2013/59/Euratom:

– The authority must investigate new facts during licensing and registration procedures.
– When specifying specific activity from radiation protection areas in Table 4 (relating to Appendix VII, Part D, No. 1.1 and 2).
– New NORM industry practices subject to registration will be added if exposure to workers exceeds 1 mSv per calendar year.
– New NORM industry practices subject to licensing are expected.
– Operators of NORM industries will be faced with a limit and the requirement to optimise radiation protection.

The SSK points out that due to the effects of Directive 2013/59/Euratom covered in this recommendation, the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) needs to be aligned with the Calculation Guide Mining (BglBb), and the basis of estimation for design basis accidents needs to be aligned with the new exposure situations system based on Directive 2013/59/Euratom and ICRP 103 (ICRP 2007). This does not form Part of this recommendation, however.

Recommendation 18:

The SSK recommends regular reports on the latest situation, i. e. on compliance with the dose limit for individual members of the public set for exposures from authorised practices.

4.16 Calculation basis

The SSK already provided a critical appraisal of the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) in its recommendation on determining radiation exposure (SSK 2013). The previous chapters also discussed various aspects of both calculation guides.

It should also be noted that the General Administrative Provisions relating to § 47 of the German Radiation Protection Ordinance (StrlSchV) and the Calculation Guide Mining (BglBb) are also inconsistent when it comes to consideration of exposure pathways. The Calculation Guide Mining (BglBb) fails to take the groundwater pathway into consideration, for example, while the General Administrative Provisions are very conservative in terms of the water pathway. There is also no generally accepted modelling for the groundwater pathway.

Recommendation 19:

The SSK reaffirms its recommendation that consistent “General Administrative Provisions relating to practices” are urgently required. Due to the relatively short period of time available to implement Directive 2013/59/Euratom, work on this regulation should commence as soon as possible.

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Glossary

From Directive 2013/59/Euratom:

7. **Authorisation**: means the registration or licensing of a practice.

17: **Consumer product**: means a device or manufactured item into which one or more radionuclides have deliberately been incorporated or produced by activation, or which generates ionising radiation, and which can be sold or made available to members of the public without special surveillance or regulatory control after sale.

22: **Dose constraint**: means a constraint set as a prospective upper bound of individual doses, used to define the range of options considered in the process of optimisation for a given radiation source in planned exposure situation.

23: **Dose limit**: means the value of the effective dose (where applicable, committed effective dose) or the equivalent dose in a specified period which shall not be exceeded for an individual.

35: **Existing exposure situation**: means an exposure situation that already exists when a decision on its control has to be taken and which does not call or no longer calls for urgent measures to be taken.

36: **Exposed worker**: means a person, either self-employed or working under an employer, and who is subject to exposure at work carried out within a practice regulated by this Directive and who is liable to receive doses exceeding one or other of the dose limits for public exposure.

47: **Licence**: means permission granted in a document by the competent authority to carry out a practice in accordance with specific conditions laid down in that document.

52: **Medical radiological procedure**: means any procedure giving rise to medical exposure.

53: **Members of the public**: means individuals who may be subject to public exposure.

54: **Natural radiation source**: means a source of ionising radiation of natural, terrestrial or cosmic origin.

55: **Non-medical imaging exposure**: means any deliberate exposure of humans for imaging purposes where the primary intention of the exposure is not to bring a health benefit to the individual being exposed.

56: **Normal exposure**: means exposure expected to occur under the normal operating conditions of a facility or activity (including maintenance, inspection, decommissioning), including possible minor incidents that can be kept under control, i. e. during normal operation and anticipated operational occurrences.

57: **Notification**: means submission of information to the competent authority to notify the intention to carry out a practice within the scope of this Directive.

58: **Occupational exposure**: means exposure of workers, apprentices and students, incurred in the course of their work.

62: **Planned exposure situation**: means an exposure situation that arises from the planned operation of a radiation source or from a human activity which alters exposure pathways, so as to cause the exposure or potential exposure of people or the environment. Planned exposure situations may include both normal exposures and potential exposures.

63: **Potential exposure**: means exposure that is not expected with certainty but may result from an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

65: **Practice**: means a human activity that can increase the exposure of individuals to radiation from a radiation source and is managed as a planned exposure situation.

69: **Public exposure**: means exposure of individuals, excluding any occupational or medical exposure.

75: **Radiation source**: means an entity that may cause exposure, such as by emitting ionising radiation or by releasing radioactive material.

76: **Radioactive material**: means material incorporating radioactive substances.

77: **Radioactive source**: means a radiation source incorporating radioactive material for the purpose of utilising its radioactivity.

78: **Radioactive substance**: means any substance that contains one or more radionuclides the activity concentration of which cannot be disregarded from a radiation protection point of view.

84: **Reference level**: means in an emergency exposure situation or in an existing exposure situation, the level of effective dose or equivalent dose or activity concentration above which it is judged inappropriate to allow exposures to occur as a result of that exposure situation, even though it is not a limit that may not be exceeded.

86: **Registration**: means permission granted in a document by the competent authority, or granted by national legislation, through a simplified procedure, to carry out a practice in accordance with conditions laid down in national legislation or specified by a competent authority for this type or class of practice.

87: **Regulatory control**: means any form of control or regulation applied to human activities for the enforcement of radiation protection requirements.

88: **Remedial measures**: means the removal of a radiation source or the reduction of its magnitude (in terms of activity or amount) or the interruption of exposure pathways or the reduction of their impact for the purposes of avoiding or reducing doses that might otherwise be received in an existing exposure situation.

89: **Representative person**: means an individual receiving a dose that is representative of the more highly exposed individuals in the population, excluding those individuals having extreme or rare habits.

96: **Standard values and relationships**: means values and relationships recommended in chapters 4 and 5 of ICRP Publication 116 for the estimation of doses from external exposure and chapter 1 of ICRP Publication 119 for the estimation of doses from internal exposure, including updates approved by Member States. Member States may approve the use of specific methods in specified cases relating to the physico-chemical properties of the radionuclide or other features of the exposure situation or of the exposed individual.

From ICRP 103:

Practices, activities

The German-language version of ICRP 103 distinguishes between '*Arbeiten'* and '*Tätigkeiten'*. These two terms were introduced so that legislation can distinguish between actions involving ionising radiation to achieve the goal of the practice and an unavoidable side effect. Please refer to the respective national legislation for more information regarding the terms '*Arbeiten'*, '*Tätigkeiten'* and '*Umgang'*.

Exclusion

Deliberate exclusion of a certain type of exposure from the scope of a legal provision

Worker

A person in full-time, part-time or temporary employment for an employer or on a self-employed basis who has recognised rights and duties with regard to occupational radiation protection

Dose:

Effective dose E

Sum of the weighted tissue or organ absorbed doses detected in the body tissues or organs, as specified by the expression

$$E = \sum_T w_T \sum_R w_{T,R}\, D_{T,R} \; or \; E = \sum_T w_T\, H_T$$

where H_T / $w_R \times D_{T,R}$ is the tissue or organ absorbed dose in the tissue, or where organ T and w_T is the tissue weighting factor. As with the absorbed dose, the unit for effective dose is J kg^{-1}, and it is called the sievert (Sv).

Dose:

Committed effective dose E(τ) ()

The sum of the products of the committed organ or tissue equivalent doses and the appropriate tissue weighting factors (w_T), where τ is the integration time in years following the intake. The commitment period is taken to be 50 years for adults, and to age 70 for children.

Dose constraint

A prospective and source-related restriction on the individual dose from a source, which provides a basic level of protection for the most highly exposed individuals from a source, and serves as an upper bound on the dose in optimisation of protection for that source. For occupational exposures, the dose constraint is a value of individual dose used to limit the range of options considered in the process of optimisation. For public exposure, the dose constraint is an upper bound on the annual doses that members of the public should receive from the planned operation of any controlled source.

Potential exposure

Potential exposure means exposure that is not expected with certainty but may result from an accident involving a source or an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

Categories of exposure

The ICRP distinguishes between three different categories of exposure: occupational exposure, exposure to the general public and medical exposure.

Exposure situation:

Existing exposure situation

Means an exposure situation that already exists when a decision on its control has to be taken. Examples of an existing exposure situation include natural radioactivity and radiation and residues resulting from previous human activities.

Exposure situations:

Planned exposure situations

A planned exposure situation arises from the planned operation of a source, including decommissioning, disposal or radioactive waste, and remediation of previously polluted areas. Ongoing activities are planned exposure situations.

Exposure situation:

Emergency exposure situation

An unexpected situation that occurs during the operation of a practice, requiring urgent action. Emergency exposure situations may arise from practices.

Dose commitment Ec

A calculational tool, defined as the infinite time integral of the per caput dose rate ($\dot{E}$) due to a specified event, such as a year of a planned activity causing discharges. In the case of indefinite discharges at a constant rate, the maximum annual per caput dose rate ($\dot{E}$) in the future for the specified population will be equal to the dose commitment of one year of practice, irrespective of changes in the population size. If the activity causing discharges is continued only over a time period, τ, the maximum future annual per caput dose will be equal to the corresponding truncated dose commitment, defined as:

$$E_c(\tau) = \int_0^{\tau} \dot{E}(t)dt$$

Principles of protection

A set of principles that apply equally to all controllable exposure situations: the principle of justification, the principle of optimisation of protection, and the principle of application of limits on maximum doses in planned situations.

NORM (naturally occurring radioactive material)

Radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides. Material in which the activity concentrations of the naturally occurring radionuclides have been changed by some process are included in NORM.

Optimisation of protection (and safety)

The process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, as low as reasonably achievable, economic and societal factors being taken into account.

Person:

Exposed individuals

The Commission distinguishes between three different groups of exposed individuals based on the exposure category: The Commission distinguishes between three categories of exposed individuals: workers (informed individuals), the public (general individuals), and patients, including their comforters and carers (see medical exposure).

Person:

Representative person

Means an individual receiving a dose that is representative of the more highly exposed individuals in the population, excluding those individuals having extreme or rare habits (cf. Publication 101, ICRP 2006). This term is the equivalent of, and replaces, 'average member of the critical group' described in previous ICRP Recommendations.

Source

An entity that releases radiation and for which radiological protection can be optimised as an integral whole, such as x-ray equipment, radiation generators, and open and sealed radioactive materials, and, more generally, the cause of exposure to radiation or radionuclides.

Justification

The process of determining whether either (1) a planned activity involving radiation is, overall, beneficial, i. e. whether the benefits to individuals and to society from introducing or continuing the activity outweigh the harm (including radiation detriment) resulting from the activity; or (2) a proposed remedial action in an emergency or existing exposure situation is likely, overall, to be beneficial, i. e., whether the benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the remedial action outweigh its cost and any harm or damage it causes.

Reference Male and Female (Reference Individual):

An idealised male or female with characteristics defined by the Commission for the purpose of radiological protection, and with the anatomical and physiological characteristics defined in the report of the ICRP Task Group on Reference Man (Publication 89, ICRP 2002).

Reference Person

An idealised person for whom the organ or tissue equivalent doses are calculated by averaging the corresponding doses of the Reference Male and Reference Female. The equivalent doses of the Reference Person are used for the calculation of the effective dose by multiplying these doses by the corresponding tissue weighting factors.

Reference level

In emergency or existing controllable exposure situations, this represents the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection should be implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration.

Risk constraint

A prospective and source-related restriction on the individual risk (in the sense of probability of detriment due to a potential exposure) from a source, which provides a basic level of protection for the individuals most at risk from a source and serves as an upper bound on the individual risk in optimisation of protection for that source. This risk is a function of the probability of an unintended event causing a dose, and the probability of detriment due to that dose. Risk constraints correspond to dose constraints but refer to potential exposures.

Material:

Radioactive material

Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity, often taking account of both activity and activity concentration.

Radiation exposure:

Occupational exposure

This refers to all exposure incurred by workers in the course of their work, with the exception of 1) excluded exposures and exposures from exempt activities involving radiation or exempt sources; 2) any medical exposure; and 3) the normal local natural background radiation.

Radiation exposure:

Medical exposure

Exposure incurred by patients as Part of their own medical or dental diagnosis or treatment; by persons, other than those occupationally exposed, knowingly, while voluntarily helping in the support and comfort of patients; and by volunteers in a programme of biomedical research involving their exposure.

Public exposure

Public exposure means exposure of individuals, excluding any occupational or medical exposure as well as exposure due to normal levels of naturally occurring background radiation.

Practice, activity

Activities where ionising radiation is used to achieve the aim of the practice. cf. →activities →practice

Practice, activity

Practice or activity involving radioactive material means extraction, generation, storage, treatment, processing, other use and disposal of radioactive substances, insofar as it is not work activities, and the operation of irradiation devices. cf. →activities →practice

From the German Radiation Protection Ordinance (StrlSchV) dated 20 July 2001 (Federal Law Gazette/BGBl. I p. 1714; 2002 I p. 1459), last amended by Article 5(7) of the German Waste Disposal Act (KrWG) dated 24 February 2012 (Federal Law Gazette/BGBl. I p. 212)[20]:

§ 3 Definitions

(1) In order to avoid confusion and to apply this ordinance, a distinction is made between **practices** and **activities**.

1. Practices include:

a) the operation of installations for the generation of ionising radiation,

b) the addition of radioactive substances to the manufacture of certain products or the activation of such products,

c) any other practices which may increase radiation exposure or contamination

   aa) as they involve man-made radioactive substances or

[20] cf. §2 of the German X-ray Ordinance RoeV in the version published on 30 April 2003 (Federal Law Gazette/BGBl. I p. 604) and amended by Article 2 of the Ordinance dated 4 October 2011 (Federal Law Gazette/BGBl. I p. 2000); Last updated: redefined and published on 30 April 2003 I 604 and amended by Article 2 V dated 4 October 2011 I 2000.

bb) as they involve naturally occurred radioactive substances and if these practices are carried out due to the radioactivity of these substances or in order to use these substances as nuclear fuel or to produce nuclear fuel,

2. Work activities include:

operations which, without being practices, may increase radiation exposure or contamination due to naturally occurring radioactivity

a) if linked to prospecting, extracting, generation, storage, treatment, processing and other use of materials,

b) insofar as they involve materials which represent residuals of in-plant processes if and insofar as these operations are not subject to a),

c) if linked to the reprocessing or disposal of materials which represent residuals of operations pursuant to a) or b),

d) emitted by natural terrestrial radiation sources, in particular of radon 222 and radon decomposition insofar as these practices are not carried out pursuant to a) to c) and are not carried out in compliance with a purpose pursuant to a) to c), or

e) if linked to flight personnel performing their duties on board of an aircraft.

For the purposes of this Ordinance, treatment of the terrene using methods of agriculture, forestry or structural engineering is not considered as work activities insofar as these operations are not carried out in order to remove pollution pursuant to § 101.

§ 3(2) Definitions

20: Materials

Substances which contain naturally occurring radionuclides or which are contaminated by such substances. For the purposes of this definition, however, naturally occurring and man-made radionuclides which are or were used during activities or which originate from events pursuant to § 51(1) shall not be considered. Likewise, contaminations in the environment caused by nuclear arms tests and nuclear accidents not subject to the scope of application of this Ordinance shall not be considered.

23: Occupationally exposed person:

For the purposes of this Ordinance, an occupationally exposed person is

a) in relation to practices, an occupationally exposed person in compliance with Category A or B of § 54, and

b) in relation to work activities, an occupationally exposed person for whom the estimation pursuant to § 95(1) has shown that the effective dose per year may exceed 6 mSv, or for whom the determination pursuant to § 103(1) has shown that the effective dose per year may exceed 1 mSv;

25: Reference person:

Standard person on whom the determination of radiation exposure pursuant to § 47 is based. The assumptions for the determination of radiation exposure of this standard person (living habits and any other assumptions used for the calculation of doses) are specified in Appendix VII;

31: Radiation exposure, occupational:

The radiation exposure of a person who

a) has entered an employment or training contract with the person performing a practice pursuant to § 2(1), subpara. 1 or performing work activities pursuant to § 2(1), subpara. 2 or who performs this practice or work activities himself,

b) performs a task pursuant to §§ 19 or 20 of the Atomic Energy Act or pursuant to § 66 of this Ordinance, or

c) is, in compliance with § 15 or § 95 of this Ordinance, employed in third-party installations, facilities or operating sites, performs a task himself pursuant to § 15 or performs work activities himself pursuant to § 95.

Radiation exposure not related to the performance of an occupation shall remain unaffected by this;

34: Handling of radioactive substances:

Extraction, generation, storage, treatment, processing, other use and disposal of radioactive substances pursuant to § 2 of the Atomic Energy Act, insofar as it is not work activities, and the operation of irradiation devices; handling also includes the prospection, extraction and dressing of radioactive mineral resources in compliance with the Federal Mining Act.