SLOVENSKI STANDARD
kSIST-TP FprCEN/TR 17113:2017

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Gradbeni proizvodi - Ocenjevanje sproščanja nevarnih snovi - Sevanje gradbenih proizvodov - Ocena odmerka gama sevanja

Construction products - Assessment of release of dangerous substances - Radiation from construction products - Dose assessment of emitted gamma radiation

Bauprodukte - Bewertung der Freisetzung von gefährlichen Stoffen - Festlegung des Verfahrens zur Beurteilung der Strahlendosis und Klassifizierung von emittierter Gammastrahlung

Produits de construction - Evaluation de l'émission de substances dangereuses - Détermination de l'estimation dosimétrique et classification en fonction de l'émission de rayonnement gamma

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Construction products - Assessment of release of dangerous substances - Radiation from construction products - Dose assessment of emitted gamma radiation

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This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/TC 351.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Page

European foreword

This document (FprCEN/TR 17113:2017) has been prepared by Technical Committee CEN/TC 351 “Construction products: Assessment of release of dangerous substances”, the secretariat of which is held by NEN.

This document is currently submitted to the Vote on TR.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

Introduction

The aim of this report is to propose a dose assessment methodology that accounts for factors such as density or thickness of the material as well as factors relating to the type of construction and the intended use of the material (bulk or superficial) as required by Annex VIII of the Euratom-BSS [1]. This approach is specially needed for building materials and construction products with an index exceeding 1 but that nonetheless may comply with the 1 mSv per year reference level established in the Euratom-BSS [1].

NOTE Although the methodology is centred around the reference level of 1 mSv established in the Euratom-BSS, the methodology is also applicable if a reference value other than 1 mSv per year is selected. In that case, the selected dose value *D* and its corresponding index value *I* is adjusted accordingly.

In 1996, natural radiation sources were already included in the standards established by Euratom as well as those established by the IAEA [2]. Since then, the European Commission has moved ahead publishing, on a regular basis, technical support guidance and recommendations on Naturally Occurring Radioactive Material (NORM) issues. In 1997, for instance, recommendations [3] were published to help deal with "significant increase in exposure due to natural radiations". In 1999, the European Commission published radiological protection principles concerning the natural radioactivity of building materials [4] and reference levels for workplaces processing materials with enhanced levels of naturally occurring radionuclides [5]. Lastly, in 2001 the European Commission published recommendations dealing with exemption and clearance levels for NORM residues [6].

These recommendations have provided Member States with criteria and a sound technical framework to help establish national regulations for NORM and building materials. Some Member States have already included all or parts of these recommendations in their regulatory framework anticipating the new EU directive.

Subsequently, the European Commission decided to harmonize, promote and consolidate the main recommendations, introducing them into a new Council directive (2013/59/Euratom; Euratom-BSS [1]) laying down basic safety standards for the protection against the danger arising from exposure to ionising radiation. This BSS directive was officially issued in January 2014. Member States have four years to transpose and implement this directive and according to the Euratom treaty, these members will before then, communicate to the Commission their existing and draft provisions. The Commission will then make appropriate recommendations for harmonizing the provisions amongst member States.

Requirements of this directive (Euratom-BSS, [1]) dealing with building materials are hereby presented. They should be taken into account along with the 2011 EU regulation laying down harmonized conditions for the marketing of construction products (EU no 305/2011) [7], so called CPR, containing many relevant articles which complement the aforesaid directive.

Both EU regulatory documents constitute the new basis for building material radiation protection regulation and should be soon followed by more detailed EU guidance and standards of which this document (FprCEN/TR 17113) should be part.

The European Commission (EC) has mandated the CEN to establish EU harmonized standards regarding dose assessment of emitted gamma radiation from construction products. The EC has also informed CEN (CEN/TC 351, Berlin 11 February 2013) that the aim is to establish one test method per product, or product type, that the method should be demonstrably robust and should be adopted by all Member States as soon as the Euratom-BSS comes into force.

This document can help Member State regulators to complete the Euratom-BSS and CPR regulatory framework covering a screening tool, dose modelling, and related technical information about radiation protection. Amongst others, the following recommendations were discussed by the CEN and the EC for the content of this document:

— The scope will exclude radon and thoron exhalation from building materials because this exhalation is dealt with in a different manner in the EU regulation. Regulatory explanations are given in Clause 3.

— Main assumptions, coefficients and conversion factors are taken into account.

— The methodology enables establishing which building materials may lead to a dose exceeding 1 mSv per year for a member of the public or which building materials can be exempted from further restrictions.

— Mass per unit area (kg/m^2) of the material will be considered in the approach keeping a dose estimate model based on similar room models as the one used to establish the index mentioned in the Euratom-BSS.

— Additional sensitivity analysis regarding the room geometry is presented in Annex E to demonstrate that there is no more than 10 % of influence of such geometry upon the determination of doses.

Lastly, it is important to underline that the EU regulatory philosophy is to ensure that gamma doses from building materials to a member of the public remain under 1 mSv per year in addition to outdoor external exposure (Euratom-BSS Article 75) [1]. A simplified model, so called "index" in the Euratom-BSS is also proposed as a conservative screening tool ensuring that materials with an index *I* less than 1 do not present any risk exceeding 1 mSv per year of indoor gamma radiation, in any construction, to a member of the public.

Annex VIII of the Euratom-BSS Directive presents such an index asking determination of three radionuclides of gamma radiation. For the purposes of this determination, CEN/TC 351 has developed a test method to be published first as a Technical Specification (TS) and later after completed validation as a European Standard (EN). In certain cases, there is a need to assess dose more precisely as described in Annex VIII of the Euratom-BSS Directive. This TR presents such a formula for more sophisticated calculation of dose. It could serve as basis for a European approach supporting the implementation of the Euratom-BSS Directive taking place in member states, also from a harmonized approach point of view.

As determination of three radionuclides of gamma radiation according to an EN (TS) will be part of obligations of product manufacturers and will be referred to in harmonized product standards under the Construction Products Regulation (CPR; EU 305/2011) (hEN) it is proposed that assessment of dose could be consequently described in an EN.

This Technical Report presents the state-of-the-art on dose assessment presented in RP 112 [4] and now further developed into the form of a more sophisticated formula. It has been noticed that for credibility reasons exact correctness of all background data must be further checked. It is proposed that this could take place when developing a European Standard.

1 Scope

The aim of this Technical Report is to propose a methodology to determine indoor gamma dose from building materials and to help classify such a product as required in the Construction Products Regulation [7]. This first technical approach could be a precursor for the development of a harmonized European Standard based on this methodology.

NOTE 1 In this Technical Report, doses from radon and thoron exhalation are excluded. However, in 3.3, information is given on how radon exhalation is dealt with in (EU)2013/59/Euratom, the Basic Safety Standards Directive (Euratom-BSS) [1].

NOTE 2 Building materials considered in this Technical Report are the construction products used for buildings. Other construction products used for any other construction works (civil engineering...) are not relevant and out of the purpose of the scope of this Technical Report.

NOTE 3 Compliance with national exemption levels for NORM nuclides remains.

2 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 16687 [8] and the following apply.

2.1
authorization
registration or licensing of a practice

[SOURCE: Euratom-BSS, chapter II, Article 4, (7) [1]]

2.2
building material
any construction product for incorporation in a permanent manner in a building or parts thereof and the performance of which has an effect on the performance of the building with regard to exposure of its occupants to ionizing radiation

[SOURCE: Euratom-BSS, chapter II, Article 4, (9) [1]]

Note 1 to entry: Building materials considered in this Technical Report are the construction products used for building works. Other construction products used for any other construction works (civil engineering, etc.) are not relevant and out of the purpose of the scope of this Technical Report.

2.3
competent authority
authority or system of authorities designated by Member States as having legal authority for the purposes of the Euratom-BSS [1]

[SOURCE: Euratom-BSS, chapter II, Article 4, (16) [1]]

2.4
effective dose
E
sum of the weighted equivalent doses in all the tissues and organs of the body from internal and external exposure

Note 1 to entry: It is defined by the expression:

$$E = \sum_T w_T H_T = \sum_T w_T \sum_R w_R D_{T,R} \qquad (1)$$

where

$D_{T,R}$ is the absorbed dose averaged over tissue or organ T, due to radiation R [-];

w_R is the radiation weighting factor [-];

w_T is the tissue weighting factor for tissue or organ T [-].

Note 2 to entry: The values for w_T and w_R are specified in Annex II of the BSS [1].

Note 3 to entry: The unit for effective dose is the sievert (Sv).

[SOURCE: Euratom-BSS, chapter II, Article 4, (25) [1]]

2.5
exemption level
value established by a competent authority or in legislation and expressed in terms of activity concentration, total activity at or below which a radiation source is not subject to notification or authorisation

[SOURCE: Euratom-BSS, chapter II, Article 4, (34) [1]]

2.6
practice
human activity that can increase the exposure of individuals to radiation from a radiation source and is managed as a planned exposure situation

[SOURCE: Euratom-BSS, chapter II, Article 4, (65) [1]]

2.7
^{226}Ra
radionuclide ^{226}Ra and its progenies in secular equilibrium

2.8
radon
radionuclide ^{222}Rn and its progeny, as appropriate

[SOURCE: Euratom-BSS, chapter II, Article 4, (82) [1]]

2.9
reference level
level of effective dose or equivalent dose or activity concentration above which it is judged inappropriate to allow exposures to occur, even though it is not a limit that may not be exceeded

Note 1 to entry: Exposure to gamma radiation from building materials is ranked by the EU BSS among the existing exposure situations.

[SOURCE: Euratom-BSS, chapter II, Article 4, (84) [1]]

2.10
regulatory control
any form of control or regulation applied to human activities for the enforcement of radiation protection requirements

[SOURCE: Euratom-BSS, chapter II, Article 4, (87) [1]]

2.11
Sievert
Sv
special name of the unit of equivalent or effective dose

Note 1 to entry: One sievert is equivalent to one joule per kilogram: 1 Sv = 1 J/kg.

[SOURCE: Euratom-BSS, chapter II, Article 4, (91) [1]]

Note 2 to entry: 1 Gy is also 1 J/kg.

2.12
^{232}Th
radionuclide ^{232}Th and its progenies in secular equilibrium

2.13
thoron
radionuclide ^{220}Rn and its progeny, as appropriate

[SOURCE: Euratom-BSS, chapter II, Article 4, (97) [1]]

3 European Regulatory Framework

3.1 Provisions on radiation protection

Some new requirements have been established for building materials in the Euratom-BSS [1] but they derive from earlier EU or IAEA principles and recommendations given in references [4], [5], [6], [9], [10], [11], [12], and [13]. Such principles and recommendations were taken into consideration by some Member States but further harmonisation and consistency throughout Europe were to be established. Existing principles and recommendations were then reviewed and enhanced by EU Member States to be turned into proper harmonized EU regulations (Euratom-BSS, [1]) which was officially issued in January 2014.

Building materials of concern, which are to be identified by individual Member States, whether from natural origin or from those in which specific residues from identified NORM industries have been incorporated, need to comply with the reference level of 1 mSv per year (compared to outdoor background dose).

If the dose resulting from a building material exceeds the reference level of 1 mSv per year, the radium concentration of this material can be quite high and this possibly leads to a significant emission (exhalation) of radon. Due to the influence of the release (emanation) and of the transport process (diffusion, convection) inside the building material, no clear correlation between the radium concentration and the exhalation of radon can be found. Even materials with a low radium concentration can release a significant and relevant amount of radon. To regulate the radium concentration is necessary but not sufficient to reduce the radon exhalation.

NOTE 1 The inhalation dose from radon is not considered in the reference level of 1 mSv per year. The radon from building materials and soil is regulated by a separate reference level for indoor radon concentration.

There are some examples where building materials have led to an increased dose for the inhabitants of buildings.

NOTE 2 Examples include lightweight concrete made with alum shale or, in some cases, the use of gypsum from the phosphate production. In addition, the use of tailings from the production of uranium, slag from the copper production or sand with high uranium concentrations can be found in formerly used building materials.

NOTE 3 A list of NORM industries is included in Euratom-BSS Annex XIII [1] and is to be taken into account by Member States when establishing theirs.

NOTE 4 In the case of composite material, like concrete, the activity concentration index can be calculated from the contribution of the constituents (see Figure 3), and not every constituent will necessarily comply with the condition $I < 1$.

The EU RP 112 principles [4] established the first non-prescriptive EU radiation protection framework concerning the natural radioactivity of building materials. This EU RP 112 was based on a publication [14] from the Finnish regulator (STUK) and provides EU Member States with a user friendly screening tool to evaluate building materials' radiation gamma emissions and help check compliance with the maximum reference level mentioned above.

To establish this screening tool, a conservative dose estimate model was first created. This model considered the activity concentrations of ^{226}Ra and ^{232}Th in secular equilibrium with the members of each decay chain (progenies) and ^{40}K. The calculations were based on a hypothetical room (with dimensions of 4 m × 5 m × 2,5 m) with walls, ceiling and floor of 20 cm thick and made of a material with a fixed density of 2.350 kg/m^3 (similar to concrete). In this model, it is also assumed: an annual exposure time of 7.000 hours a year; a dose conversion factor of 0,7 Sv/Gy and a background absorbed dose rate of 50 nGy/h. The doses were calculated according to the Berger approach with empirical build-up factors and self-attenuation.

Considering all these assumptions, an activity concentration index (I) was then determined by the following simplified Formula (2):

$$I = \frac{C_{^{226}\mathrm{Ra}}}{300} + \frac{C_{^{232}\mathrm{Th}}}{200} + \frac{C_{^{40}\mathrm{K}}}{3000} \qquad (2)$$

where

C is the activity concentration of ^{226}Ra, ^{232}Th or ^{40}K naturally contained in most building materials [Bq/kg].

The dose estimate is close to 1 mSv per year only when the index value is close to 1. An index < 1 with the conditions mentioned above means a dose estimate in compliance with the maximum reference level of 1 mSv per year for a member of the public. This simplified model was deemed to be sufficiently conservative to be part of the Euratom-BSS [1] since most dwellings or buildings will not be designed to be as massive as the 'bunker' (hypothetical room) described above.

In the Euratom-BSS [1], for building materials identified by the Member States as being of concern, it is required that the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K be determined (Euratom-BSS article 75 and its annex VIII, [1]). The index can then be used as a screening tool to allow building material to be placed onto the EU market without any restrictions. National regulators and/or building codes may use this index to identify building materials which need no further analysis with respect to emitted gamma radiation.

Although this screening tool should be sufficient for most building materials, it remains much too conservative for thin materials such as tiles, for light density products or for materials used in marginal quantities. The Euratom-BSS [1] allows density, thickness and use of materials to be taken into account in an appropriate dose modelling approach if need be.

3.2 Provisions on the marketing of construction products

The CPR [7] regulates the placing on the market of construction products. It establishes, in its Chapters II, III and IV, the requirements and obligations that have to be fulfilled where a construction product is covered by a harmonised technical specification (i.e. a harmonised standard or a European Technical Assessment). Generally for such products, a 'declaration of performance', which includes health and safety aspects (CPR Recitals 15 and 16) has to be drawn up, and this permits the affixing of the CE marking. The CE marking confirms that the product complies with its declared performance, and its harmonised technical specification, and permits free trans-boundary movement across the EAA.

The manufacturer has to draw up such a declaration of performance with all related documentation and keep distributors informed. This declaration of performance should be accompanied by information on the content of all hazardous substances (Recital 25 of CPR [7] and Recitals 31-33 of EC Regulation n° 1907/2006 of the European Parliament and of the Council of 18/12/2006 – REACH [15]).

The content of the aforesaid declaration of performance (CPR article 6, [7]) should also include the construction product's uses along with its levels or classes (CPR articles 6.3d and 6.3g, [7]).

It should be added that all the supply chain dealing with these construction products is responsible for the risks: manufacturers, importers and distributors. They all need to take account, appropriately, of the health and safety of people and the environment (CPR Article 28.2, [7]) within the declaration of performance.

Moreover, such a responsibility will be monitored by "Market surveillance authorities" (CPR article 56, [7]) with technical support as appropriate (CPR articles 29-55, [7]).

3.3 Radon exhalation from building materials

Regarding radon exhalation from building materials, Member States decided not to deal with this issue in the screening process, which, in consequence, addresses gamma radiation only. However, radon exhalation might be dealt with separately, including additional requirements, in national action plans. Additional strategies and methods for preventing radon ingress in new buildings, including identification of building materials with significant radon exhalation might be added by some Member States if need be (Euratom-BSS Annex XVIII.8 [1]).

Specific Euratom-BSS parts deal with radon issues, requiring the establishment of national reference levels. These reference levels should be less than or equal to 300 Bq/m^3 for the annual average indoor concentration.

It is important and an obligation on Member States to promote actions to identify dwellings with radon concentration (as an annual average) exceeding the reference level mentioned above and to encourage, where appropriate, by technical or financial means, radon concentration-reducing measures in these dwellings (Eurtaom-BSS article 74.2, [1]). Action plans will have to be established by all EU Member States to seriously tackle this national health concern, including identification of building materials with significant radon exhalation.

4 Provisions for dose assessment

4.1 General

In order to prospectively assess indoor external gamma doses resulting from the use of a given building material, mathematical models need to be used. For that purpose, the activity concentrations of three radionuclides in the building material have to be known, and a series of assumptions need to be made regarding the room model (shape and size, thickness and densities of the walls, existence of door and windows, etc.).

The main contributors to the gamma dose are ^{226}Ra, ^{232}Th and their progeny, and ^{40}K. The activity concentrations of these radionuclides can be determined in accordance with draft TS 00351014 [16]. Hereafter, '^{226}Ra' and '^{232}Th' include all progenies in secular equilibrium (i.e. 226Ra++sec, 232Th++sec). If a disequilibrium between the nuclides of a given chain can be assumed, it is recommended to use the maximum concentration for typifying the whole chain.

The proposed method of dose assessment, together with the assumptions made on the room model, is described below.

4.2 Principle of calculation

The method used in this report for calculating the external dose from building materials is based on the approach of STUK [14], which was also the basis for the document "Radiation Protection 112" [4]. It consists of a point-kernel method that uses the Berger approximation for the build-up factor. Further details can be found in Annex A.

As suggested by the Euratom-BSS directive, this document takes into account the real intended use of the building material (such as whether it is used as superficial or as bulk material) along with its thickness and density. It is important to bear in mind that the EU regulatory philosophy is to ensure that gamma doses from building materials to members of the public remain under 1 mSv per year.

4.3 Room model

The typical room model used for gamma-radiation calculations is a rectangle parallelepiped in which all construction parts are made of 200 mm thick concrete with no windows or doors (Koblinger, 1978 [17]; Markkanen, 1995 [14]). In particular, a room of 12 m × 7 m × 2,8 m was used in the document STUK-B-STO 32 [14]. The CEN/TS 16516 [18] reference room, on the other hand, has dimensions of 3 m × 4 m × 2,5 m, a door (1,6 m^2) in one of the long walls, and a window (2 m^2) in one of the short walls.

For products used as a superficial layer with a thickness of 30 mm or less, it is assumed the layer behind is made of the reference concrete. The contribution of this concrete layer to the dose needs also to be taken into account; for this reason, the assumption of RP 112 that an index $I < 6$ for superficial material will lead to a dose < 1 mSv may not be conservative enough. The absorbed dose rate in air is usually assessed in the middle of the room. For the STUK room model, the assumption of obtaining the dose rate at the centre of the room is valid as the dose rate is fairly constant in most of the room and only increases slightly (within 10 %) for areas within 50 cm of the walls [19].

Room size and dimensions have also very limited effect on the total dose, provided that the same material is used in all structures. Risica et al. (2001) [20] reported variations of less than 6 % when the width and length of the room were varied from 2 m to 10 m. Annex E provides more details.

Exclusion of windows and doors in the room provides for a conservative approach regarding radiation protection (see Annex E). The CEN/TS 16516 reference room with no doors or windows is considered in this report (see Figure 1). Whilst keeping consistency with other CEN standards, this room model is compatible with the activity concentration index formula, as expressed in Euratom-BSS Annex VIII [1].

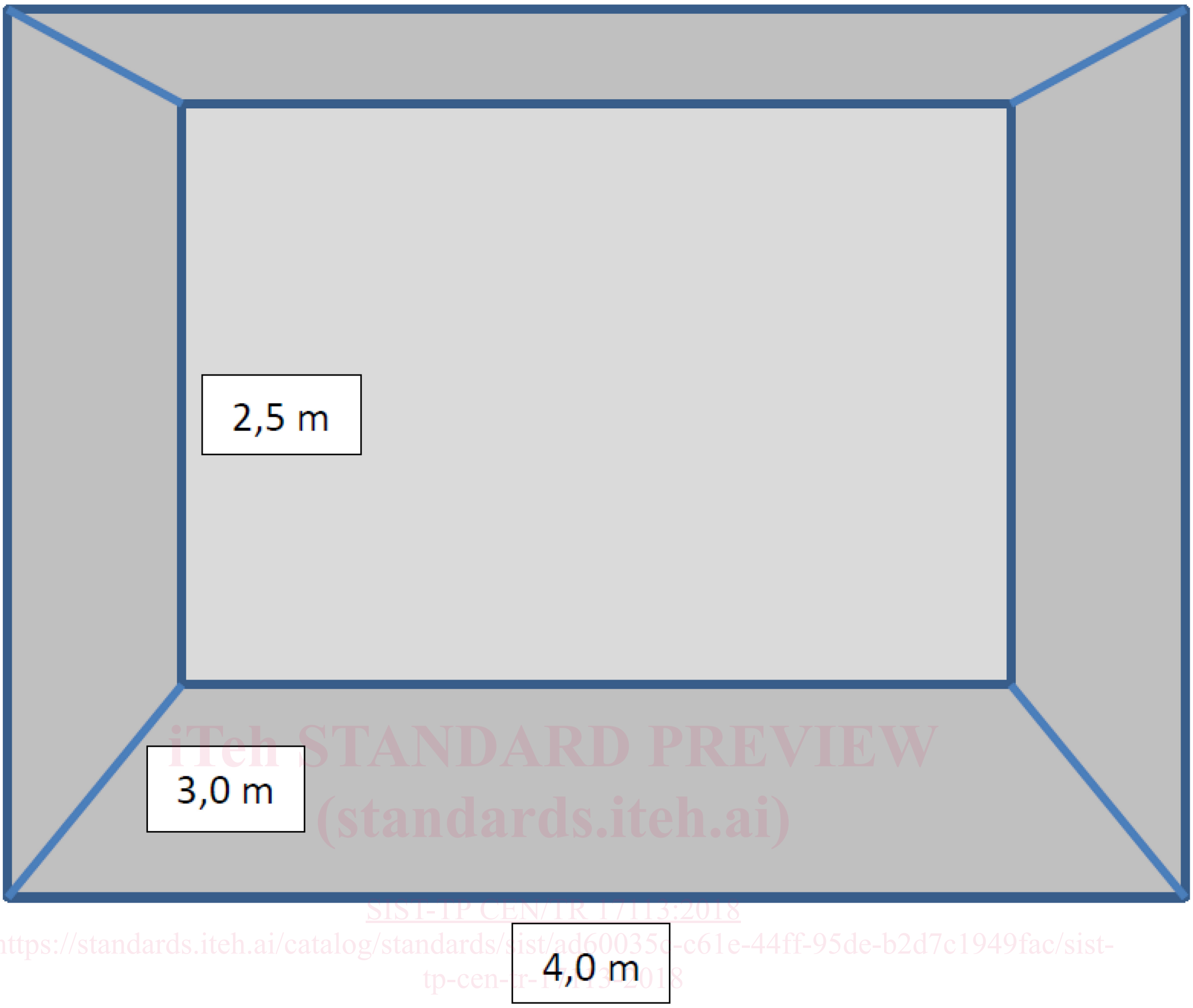

Figure 1 — Room model; dimensions of 3,0 m × 4,0 m × 2,5 m

NOTE The room model for which the activity index formula was derived [13] and the model room used in CEN/TS 16516 [18] result in nominal dose rates differing by roughly 4 %, 5 % and 6 % for ^{226}Ra, ^{232}Th and ^{40}K, respectively.

4.4 Basic assumptions

The Euratom-BSS [1] defines the reference value of 1 mSv per year as a dose in addition to the natural background (e.g. 0,29 mSv per year). Therefore, the total annual dose indoor – as sum of building materials and background – can be higher than 1 mSv, e.g. 1,29 mSv. There are two possible interpretations:

a) Building materials shield all of the natural background. The total dose resulting from the building materials can be 1,29 mSv.

b) There are no shielding effects. The dose resulting from a building material can be 1 mSv per year.

RP 112 [4] follows the philosophy of option a). Therefore the basic approach in determining the excess exposure is as follows:

1) The total exposure caused by the building is calculated;