The Way of CEN

Tools for Dose Assessment of Building Products and Constructions

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CEN/TC 351/WG 3
Construction products: Assessment of release of dangerous substances - Radiation

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19st EAN Workshop Innovative ALARA Tools

Athene, Greece

26. - 29. 11. 2019

Background Euratom-BSS

- ▸ 1 mSv per year (in add. to nat. background)
- ▸ national list of materials
  - ▸ natural materials (alum-shales, igneous rock)
  - ▸ residues from NORM-Practices (PG, fly ashes, slags, ...)
- ▸ activity index I, notification, ...

Official Journal of the European Union

L 13

English edition

Legislation

Volume 57

17 January 2014

Contents

II Non-legislative acts

DIRECTIVES

★ Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom 1

Price: EUR 4

EN

Background EU-CPR

- Regulation 305/2011 of the European Parliament and the Council
- Harmonized conditions for the marketing of construction products
- to avoid barriers of trade

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English edition — Legislation — Volume 54, 4 April 2011

Contents

I Legislative acts

REGULATIONS

- ★ Regulation (EU) No 304/2011 of the European Parliament and of the Council of 9 March 2011 amending Council Regulation (EC) No 708/2007 concerning use of alien and locally absent species in aquaculture 1
- ★ Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (1) 5
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DIRECTIVES

- ★ Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare 45

(1) Text with EEA relevance

Price: EUR 4

(Continued overleaf)

EN

Acts whose titles are printed in light type are those relating to day-to-day management of agricultural matters, and are generally valid for a limited period.

The titles of all other acts are printed in bold type and preceded by an asterisk.

Background EU-CPR

- Regulation 305/2011 of the European Parliament and the Council
- Harmonized conditions for the marketing of construction products
- to avoid barriers of trade
- basic requirements: no threat to health, i.e.
  - emission of dangerous substances
  - emission of dangerous radiation
- CE Marking, Declaration of Performance

ANNEX I

BASIC REQUIREMENTS FOR CONSTRUCTION WORKS

Construction works as a whole and in their separate parts must be fit for their intended use, taking into account in particular the health and safety of persons involved throughout the life cycle of the works. Subject to normal maintenance, construction works must satisfy these basic requirements for construction works for an economically reasonable working life.

3. Hygiene, health and the environment

The construction works must be designed and built in such a way that they will, throughout their life cycle, not be a threat to the hygiene or health and safety of workers, occupants or neighbours, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition, in particular as a result of any of the following:

(a) the giving-off of toxic gas;

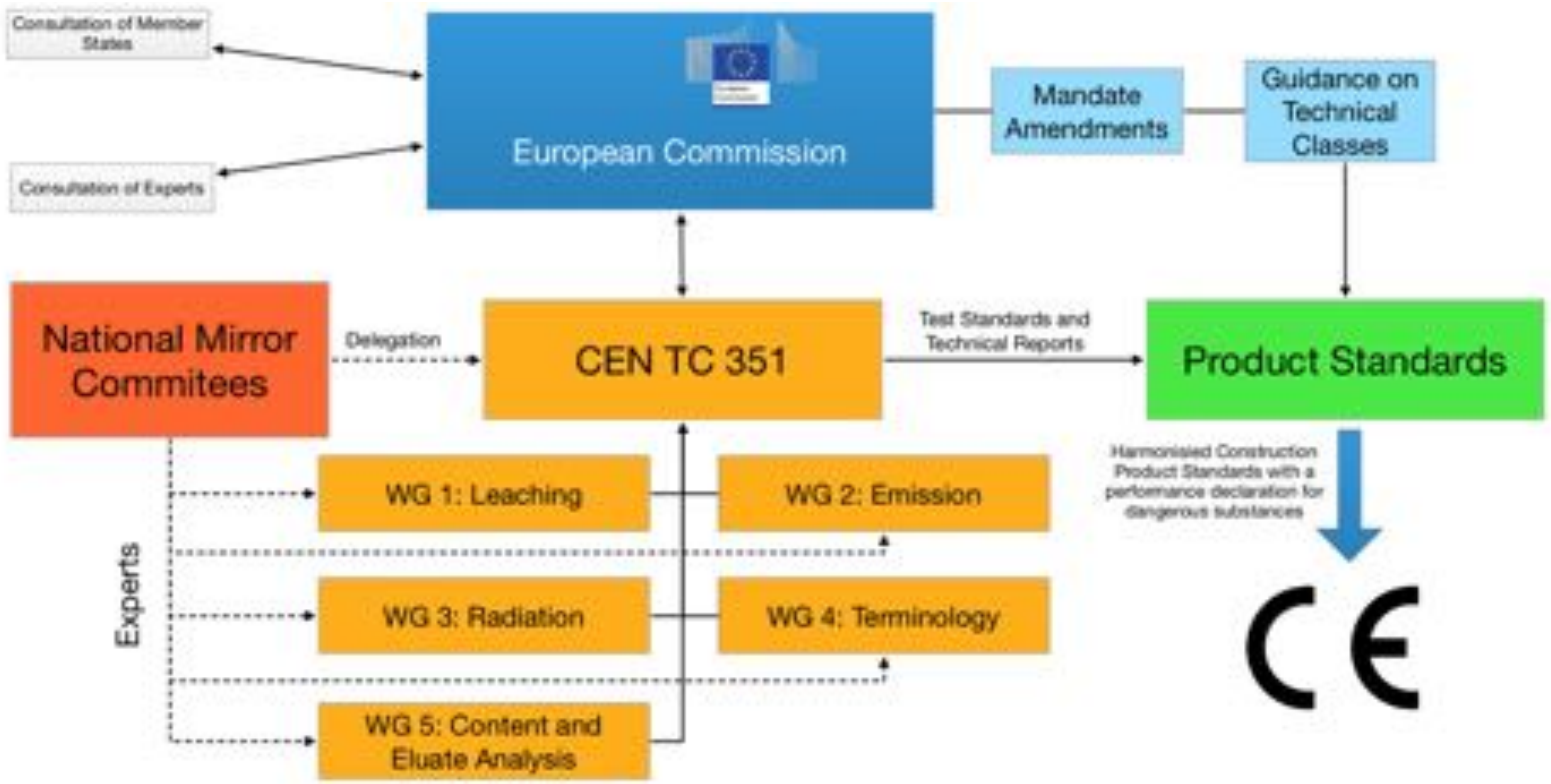
(b) the emissions of dangerous substances, volatile organic compounds (VOC), greenhouse gases or dangerous particles into indoor or outdoor air;

(c) the emission of dangerous radiation;

CE

CEN/TC 351 Construction products: Assessment of release of dangerous substances (established 2006)

- the aim to harmonize assessment methods for CE marking purposes (Declaration of Performance) under CPR (Mandate M/366)



- WG3 TG31: Test Standard (CEN/TS 17216)
- WG3 TG32: Standard for Assessment (CEN/TR 17113)

The CPR - BSS Connection

- Ionizating Radiation part of Mandate M/366 ➜ Link between EURATOM BSS Directive and EU CPR
- BSS Directive (2013/59/EURATOM) issued officially on January 2014
- EU Member States have 4 years time for implementation
- Ionizing Radiation = the first pan-European “Dangerous Substance”
- Pan-European content: Ra, Th, K
- Pan-European reference value: 1 mSv per year (in addition to the background)

Under the Framework of CPR - some FAQs:

- What to measure? National requirements ➜ product standards (e.g. EN 450 - Fly ash for concrete)
- How to measure? Technical Specification (TS) ➜ European Standard (EN)
- How to assess? Technical Report (TR) ➜ European Standard (EN)
- How often? AVCP (Assessment and Verification of Constancy of Performance) 1+, 1, 2+, 3 or 4; EC Deligated Act, not yet decided
- Who can measure? Only notified bodies (NANDO-CPR Database)
- What to declare? Activity concentrations? Doses? Classes? National requirements ➜ EC Deligated Act

Specifications for a dose assessment

- Graded approach!
- Be compatible to Euratom-BSS!
- But use the standard room of WG2 (Emission in indoor air)!
- But without windows and doors!
- Consider the individual thickness (d) and density (ρ)!
- It would be nice to have the mass per unit area (ρ·d) as parameter!
- And the result should be the annual dose and not an index!
- Keep it simple!

Stakeholder acceptance
(Producers, Planners, Authorities, Regulators)

Basic Idea

STUK-B-STO 32
NOVEMBER 1995

Radiation Dose Assessments for Materials with Elevated Natural Radioactivity

Mika Markkanen
Department of Radiation Safety

FINNISH CENTRE FOR RADIATION AND NUCLEAR SAFETY
P.O.Box 14, FIN-00881 HELSINKI
FINLAND
Tel. +358 0 759 881

European Commission

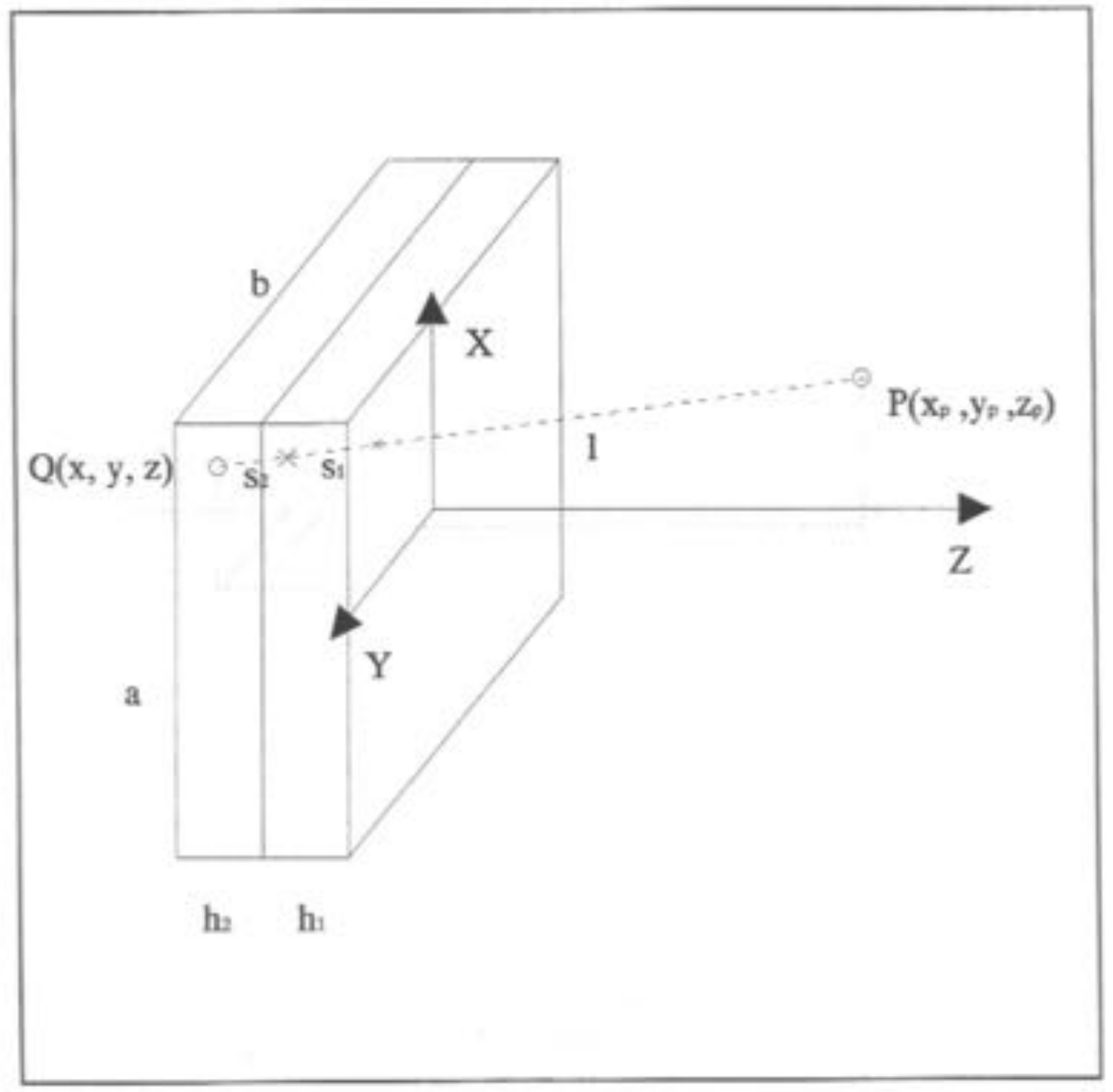
Radiation protection 112

Radiological Protection Principles concerning the Natural Radioactivity of Building Materials

1999

Directorate-General
Environment, Nuclear Safety and Civil Protection

Basic Idea



Point Kernel Integration, Buildup Factor, Self Attenuation, Model Room, nat. Background, Averaged Energies, ...

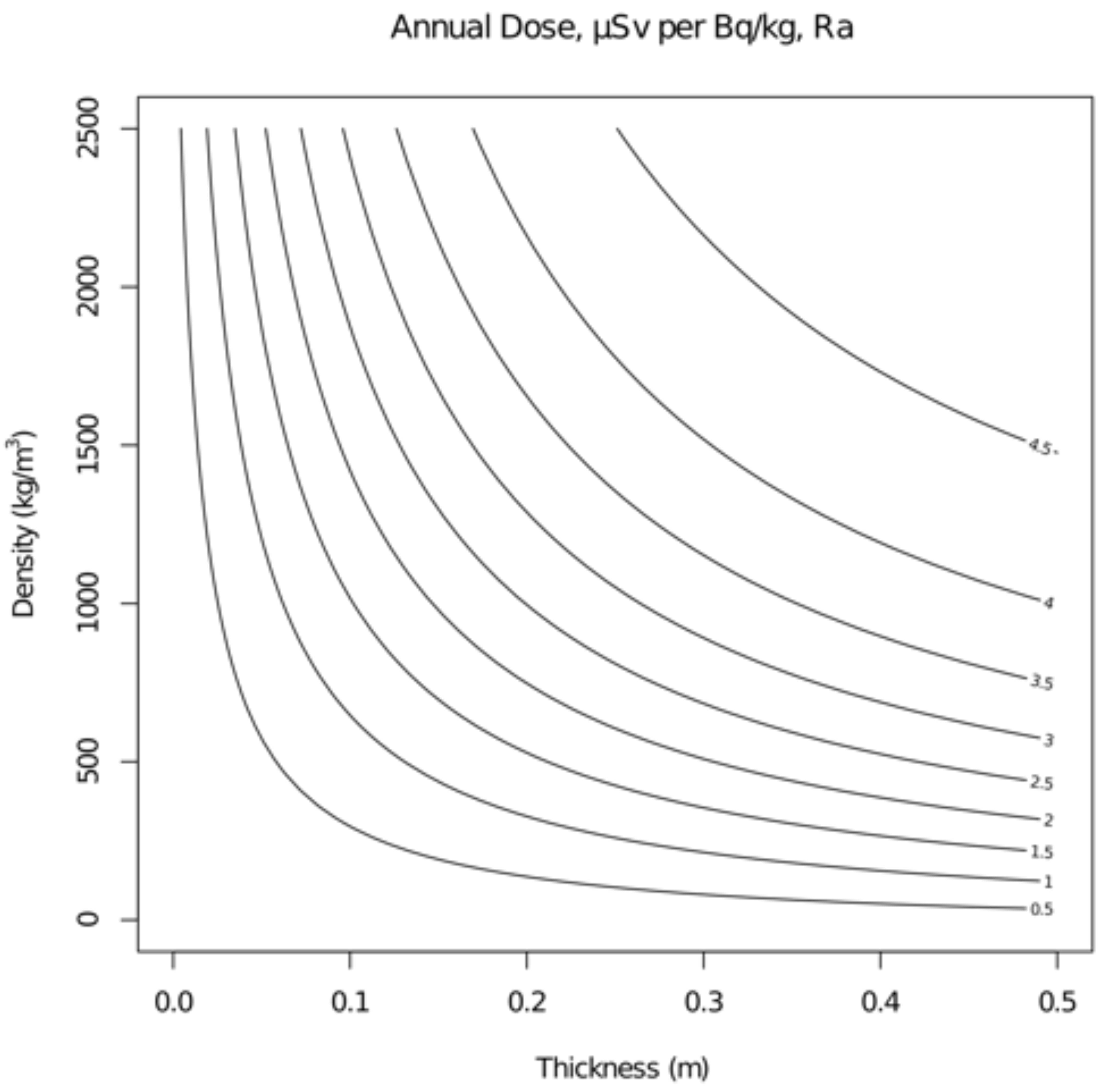
$$D_1 = 5.77 \cdot 10^{-7} \frac{C_1\ \rho_1}{4\pi} \sum \gamma_i \left(\frac{\mu_{en}}{\rho}\right)_i E_i \int B_i(1) \frac{e^{-\mu_i(1)s_1}}{l^2} dV$$

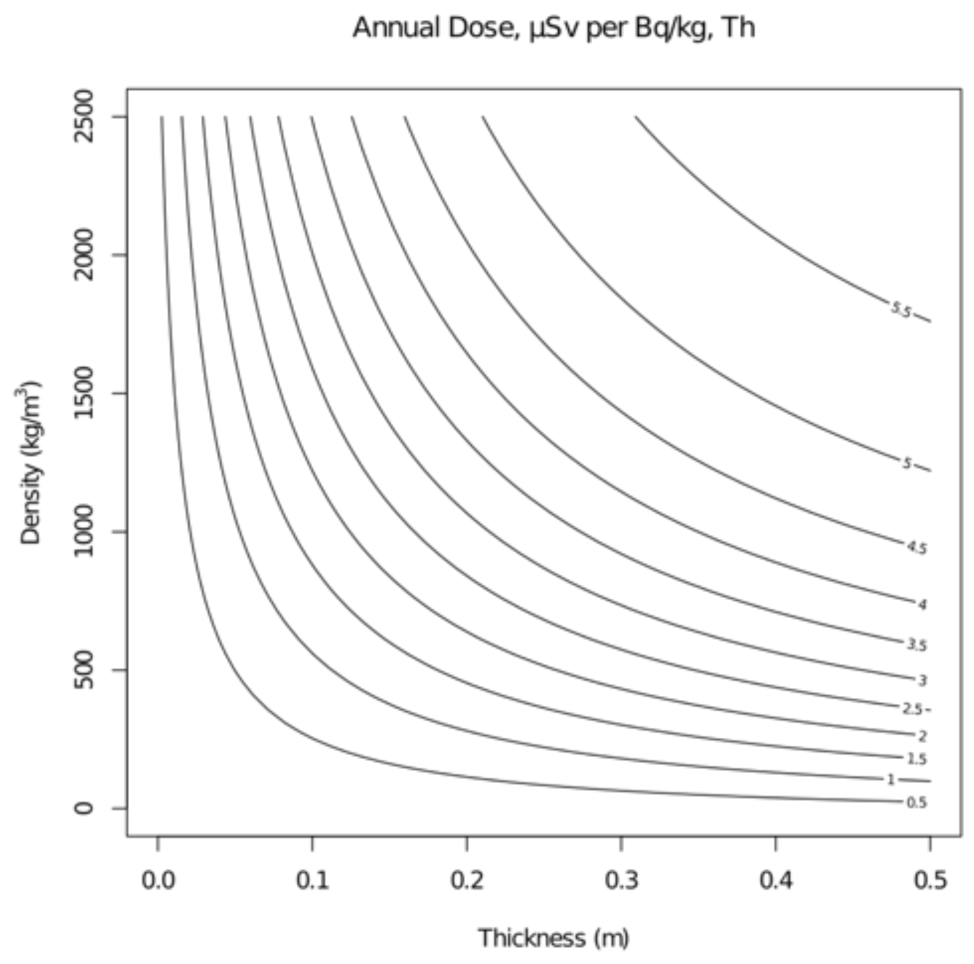
$$B_i(1) = 1 + C(E_i)\mu_i(1)s_1 e^{D(E_i)\mu_i(1)s_1}$$

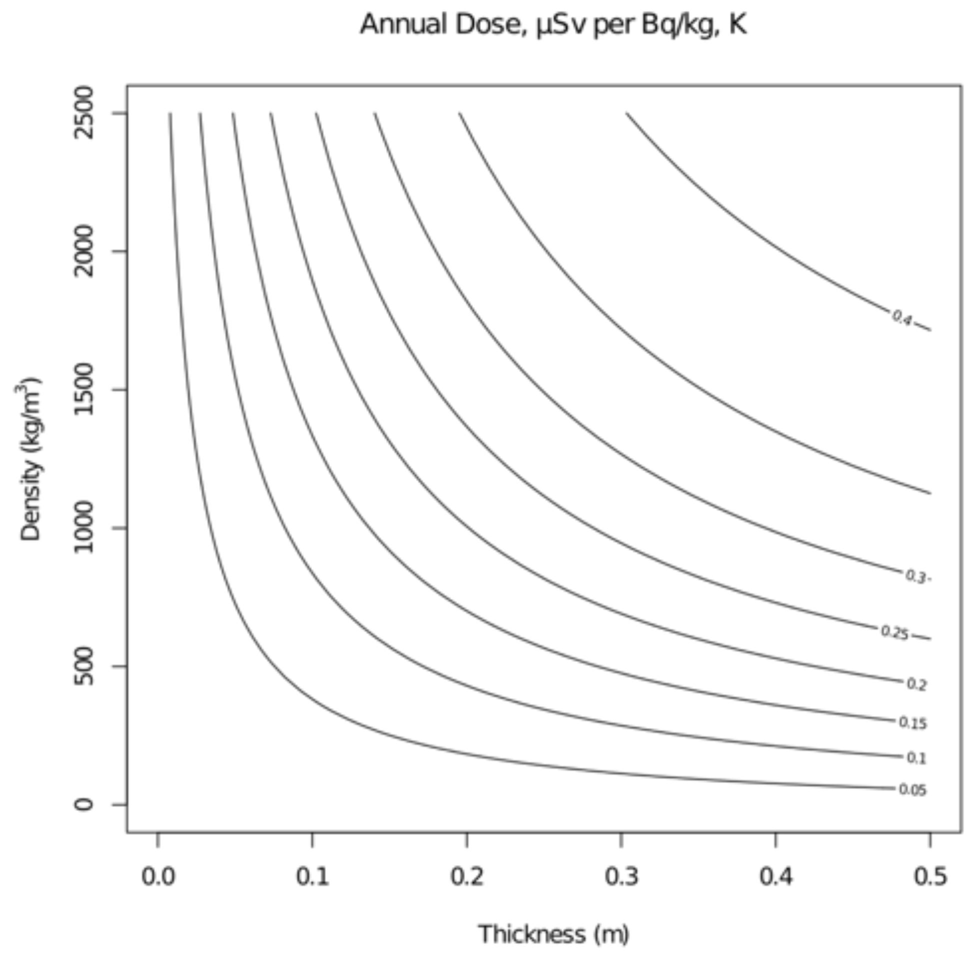
$$s_1 = \left|\frac{z}{z_p - z}\right| l \qquad l = \sqrt{(x_p-x)^2+(y_p-y)^2+(z_p-z)^2}$$

$$I = \frac{C_{Ra}}{300\ Bq\ kg^{-1}} + \frac{C_{Th}}{200\ Bq\ kg^{-1}} + \frac{C_K}{3000\ Bq\ kg^{-1}}$$

Let's do some number crunching!







Result

Table 2 — Specific dose rate in air from the different structures in the room of Figure 1

Mass per unit area [a] of wall, ceiling or floor material	Wall, ceiling or floor material (top layer) [b] pGy/h per Bq/kg			20 cm thick concrete behind the wall, ceiling or floor material pGy/h per Bq/kg			Shielding factor [c]		
kg/m^2	^{226}Ra	^{232}Th	^{40}K	^{226}Ra	^{232}Th	^{40}K	^{226}Ra	^{232}Th	^{40}K
Wall W_1 : Dimensions 4,0 m × 2,5 m, distance to room centre 1,5 m									
0	0	0	0	150	180	13	1,0	1,0	1,0
25	15	17	1,2	140	160	12	0,93	0,89	0,92
50	30	34	2,4	130	150	11	0,87	0,83	0,85
100	58	66	4,6	100	120	8,9	0,67	0,67	0,68
150	81	93	6,5	82	99	7,3	0,55	0,55	0,56
200	100	120	8,1	64	79	6,0	0,43	0,44	0,46
300	130	150	10	37	49	3,9	0,25	0,27	0,30
500	160	180	13	12	19	1,6	0,08	0,11	0,12

Let's do some maths!

$D = f(\text{total activity, room dimension, all the rest})$

$= f(C_{Ra}, C_{Th}, C_K, m, ...)$, with $m = \rho dA$

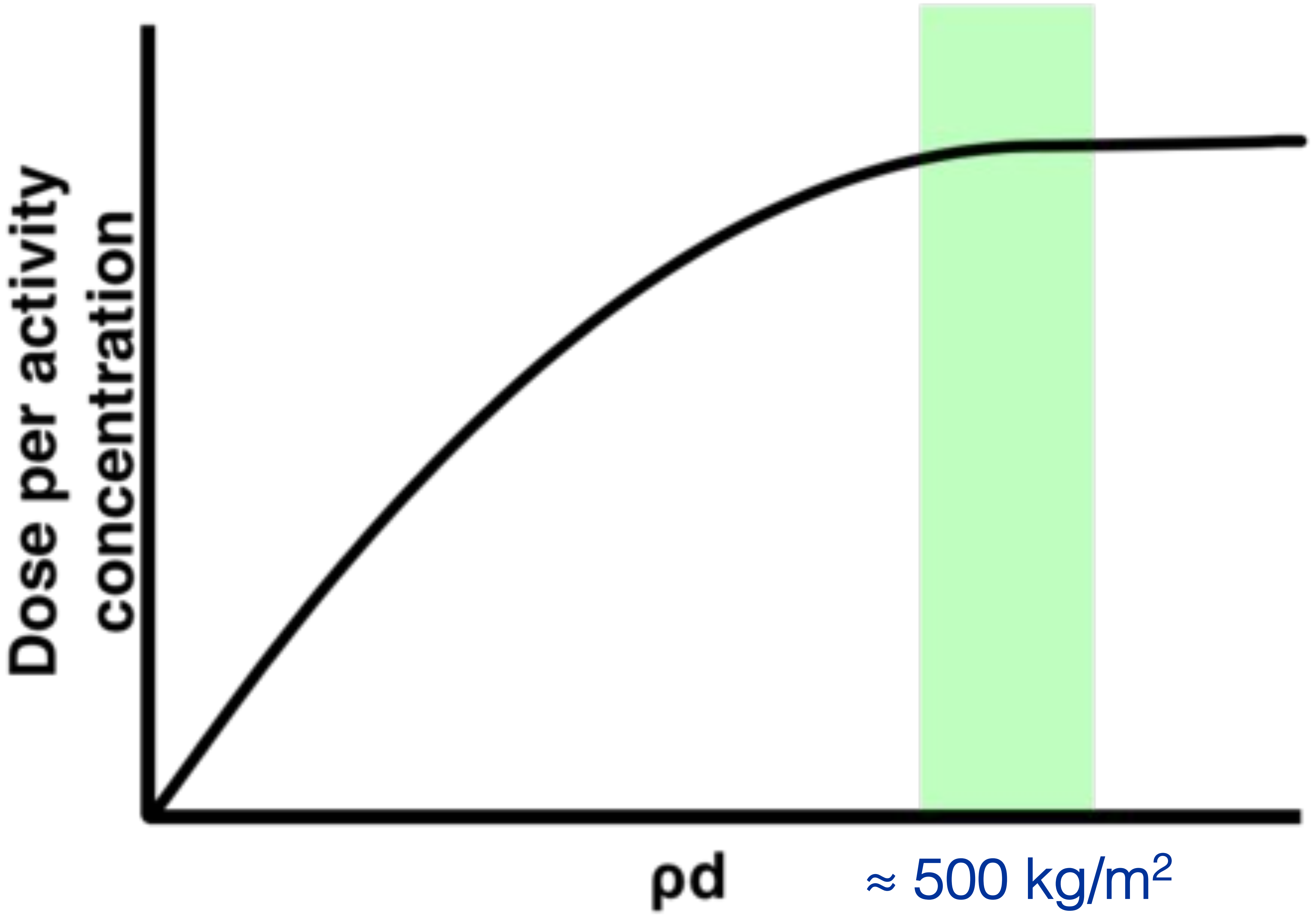
$= f_1(\rho d, ...)C_{Ra} + f_2(\rho d, ...)C_{Th} + f_3(\rho d, ...)C_K$

f_i is smooth → Polynomial expansion

$f_i = a_0 + a_1(\rho d) + a_2(\rho d)^2 + a_3(\rho d)^3 + ...$

fit → a_i

For $\rho d < 500$ kg/m^2: 2nd order



Result

$$D = \left[\begin{array}{r} [281 + 16.3\rho d - 0.0161(\rho d)^2] \cdot C_{Ra} \\ +[319 + 18.5\rho d - 0.0178(\rho d)^2] \cdot C_{Th} \\ +[22.3 + 1.28\rho d - 0.00114(\rho d)^2] \cdot C_K \end{array} \right] \cdot 10^{-6} - 0.29\ \mathrm{mSv}$$

for $\rho d < 500\ \mathrm{kg/m^2}$

[C] = Bq/kg

[D] = mSv per year

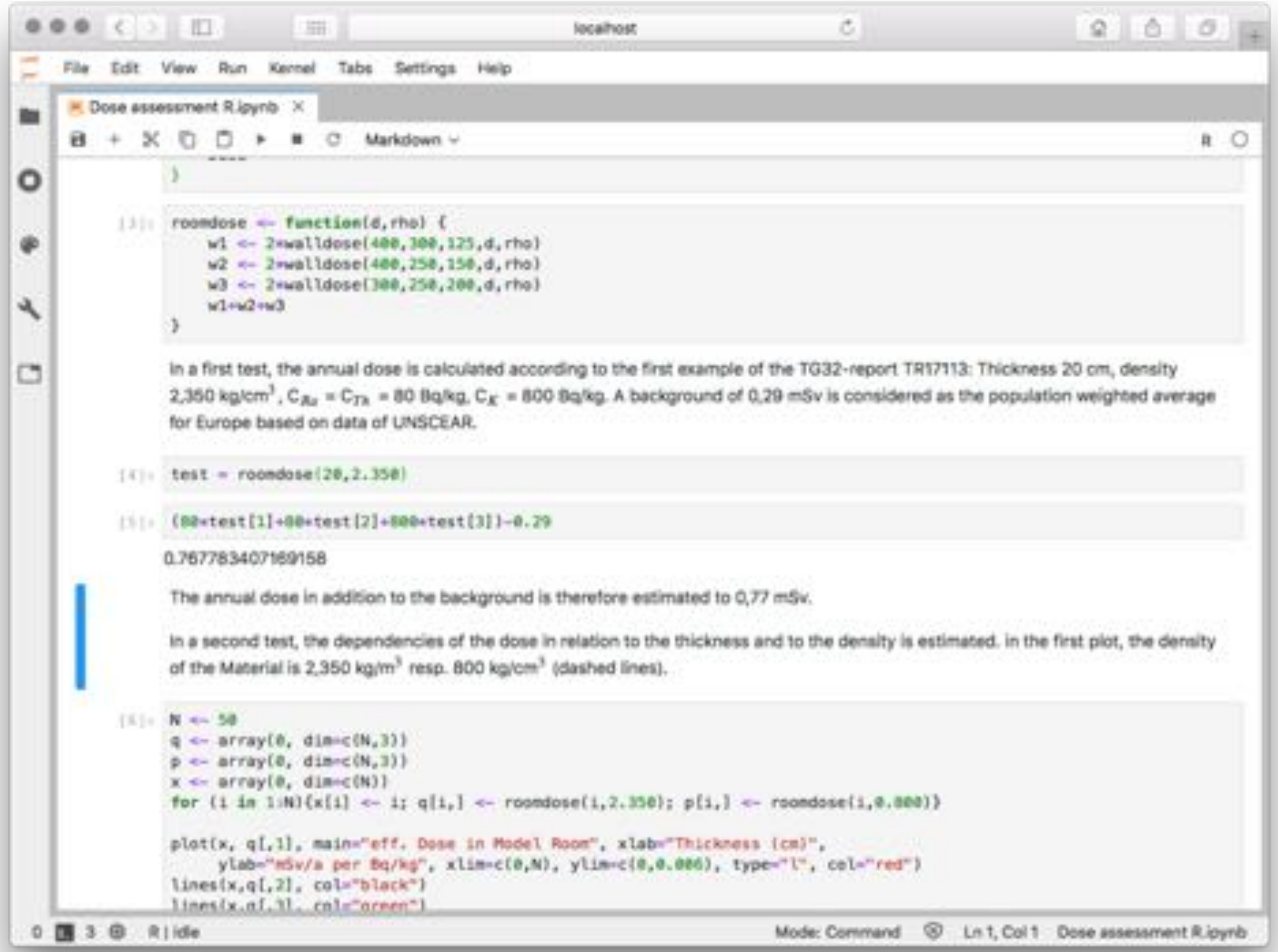
≙ 60 nSv/h

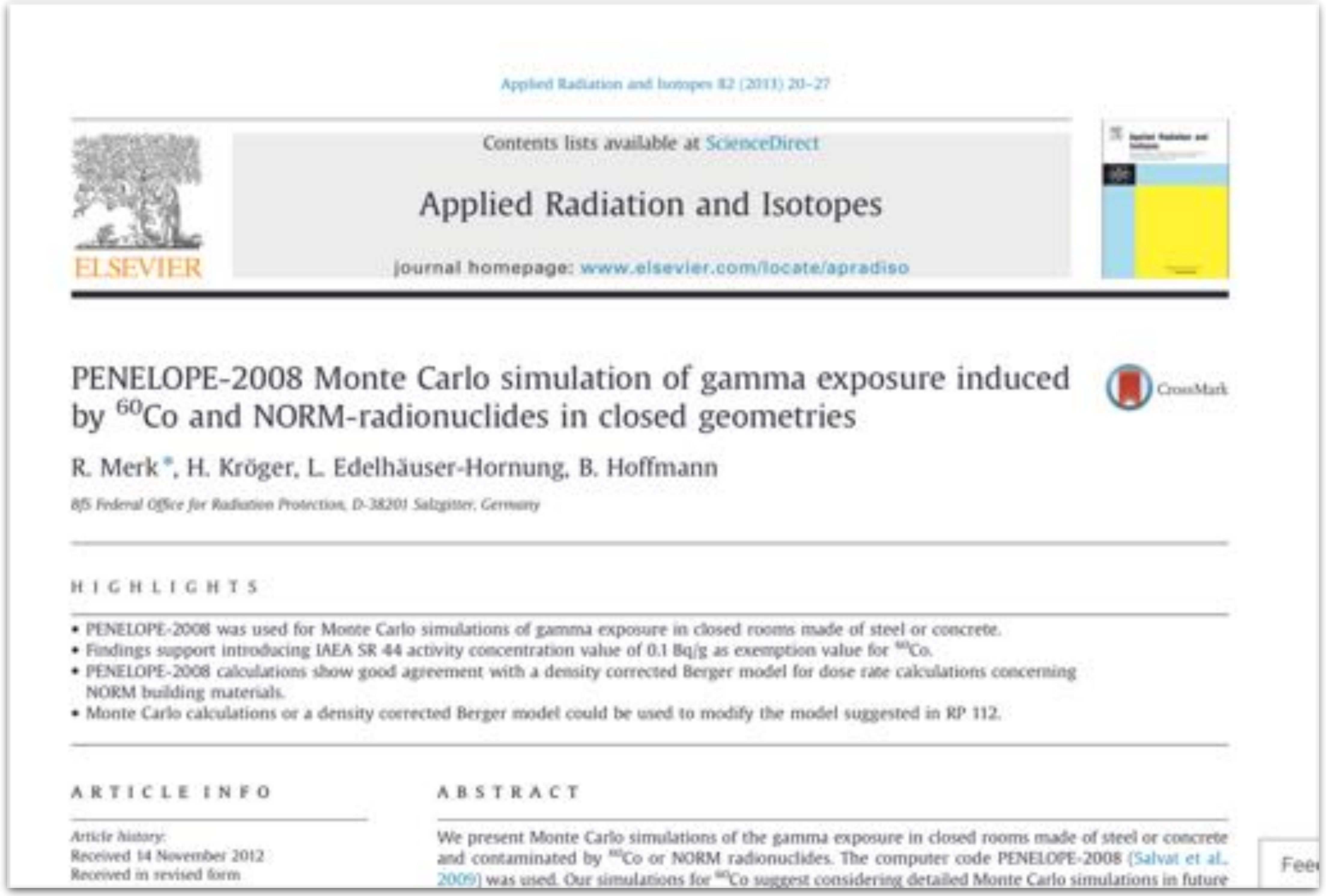
≈ surface area weighted average of all 23 countries

(7000 h, 0.7 Sv/Gy)

Technical remarks

- R (https://www.r-project.org)
- cubature: Adaptive Multivariate Integration over Hypercubes (https://cran.r-project.org/web/packages/cubature/)
- Jupyter (https://jupyter.org)
- Notebook (https://behoff.de/resources/Dateien/Dose-assessment-R.ipynb)
- Validation: CEN ➜ STUK/RP112 ➜ Monte Carlo (PENELOPE) (https://doi.org/10.1016/j.apradiso.2013.07.006)




Applied Radiation and Isotopes 82 (2013) 20–27

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journal homepage: www.elsevier.com/locate/apradiso

ELSEVIER

PENELOPE-2008 Monte Carlo simulation of gamma exposure induced by ^{60}Co and NORM-radionuclides in closed geometries

R. Merk*, H. Kröger, L. Edelhäuser-Hornung, B. Hoffmann

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HIGHLIGHTS

- PENELOPE-2008 was used for Monte Carlo simulations of gamma exposure in closed rooms made of steel or concrete.
- Findings support introducing IAEA SR 44 activity concentration value of 0.1 Bq/g as exemption value for ^{60}Co.
- PENELOPE-2008 calculations show good agreement with a density corrected Berger model for dose rate calculations concerning NORM building materials.
- Monte Carlo calculations or a density corrected Berger model could be used to modify the model suggested in RP 112.

ARTICLE INFO

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ABSTRACT

We present Monte Carlo simulations of the gamma exposure in closed rooms made of steel or concrete and contaminated by ^{60}Co or NORM radionuclides. The computer code PENELOPE-2008 (Salvat et al., 2009) was used. Our simulations for ^{60}Co suggest considering detailed Monte Carlo simulations in future

CEN/TR 17113 Dose Assessment

- **Technical Report**
- **More informal with descriptions, discussions, ...**
- **Missing Link between measurement and reference value**
- **Euratom-BSS, Art. 75: "The reference level applying to indoor external exposure to gamma radiation emitted by building materials, *in addition to outdoor external exposure*, shall be 1 mSv per year."**
- **Annex VIII: *Activity Index***
- **Annex VIII: "The calculation of dose needs to take into account other factors such as *density, thickness* of the material as well as factors relating to the type of building and the *intended use* of the material (*bulk or superficial*)."**
- **Harmonised model assumptions**
- **RP112 and TC351 documents considered**


TECHNICAL REPORT
RAPPORT TECHNIQUE
TECHNISCHER BERICHT

CEN/TR 17113

October 2017

ICS 91.100.01

English Version

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

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

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

This Technical Report was approved by CEN on 28 May 2017. It has been drawn up by the Technical Committee CEN/TC 351.

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Ref. No. CEN/TR 17113:2017 E

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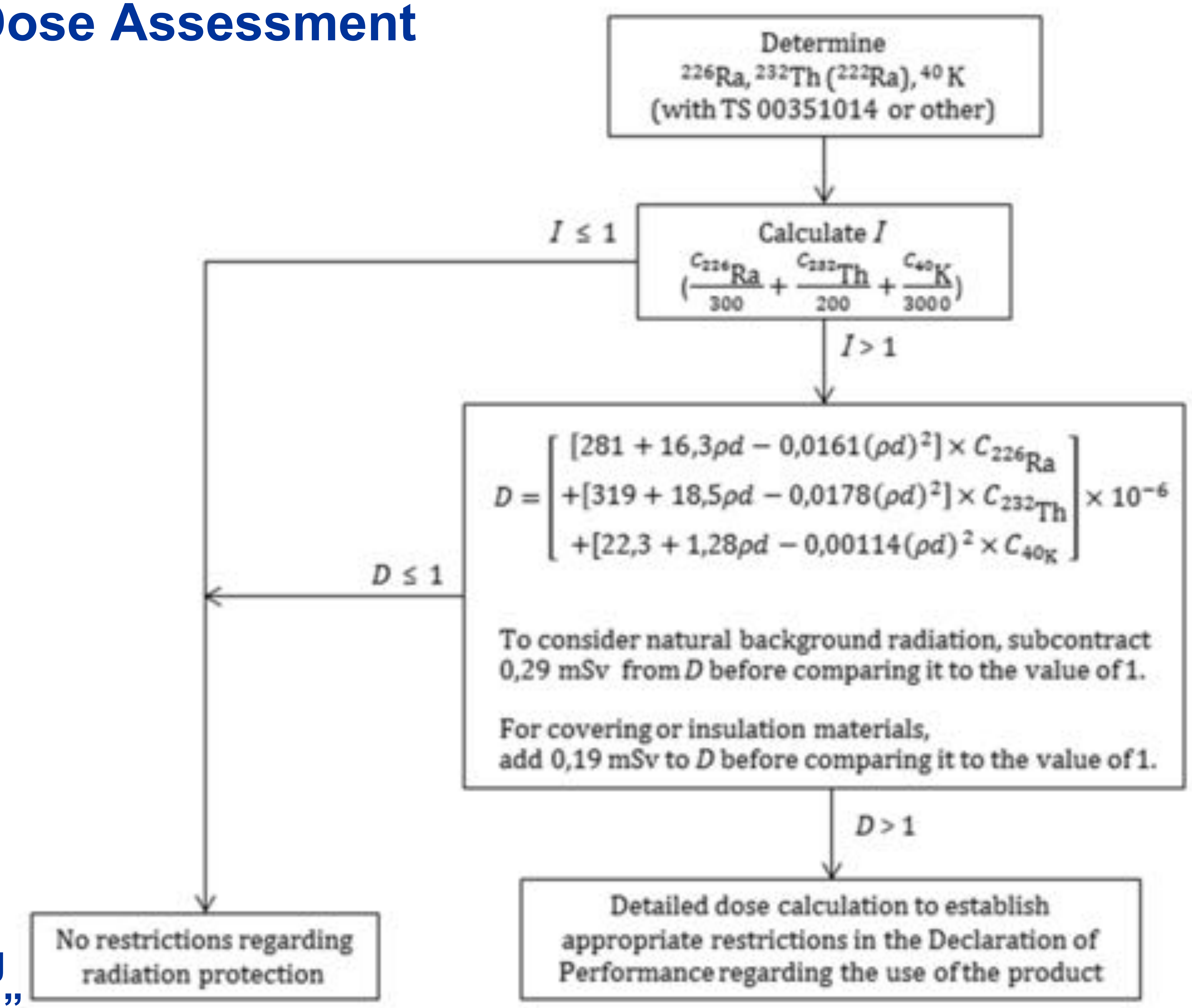

Figure 2 — Flowchart for Assessment of indoor gamma exposure due to building materials (construction products) used in their intended use as a final product in a permanent manner in a building or parts thereof

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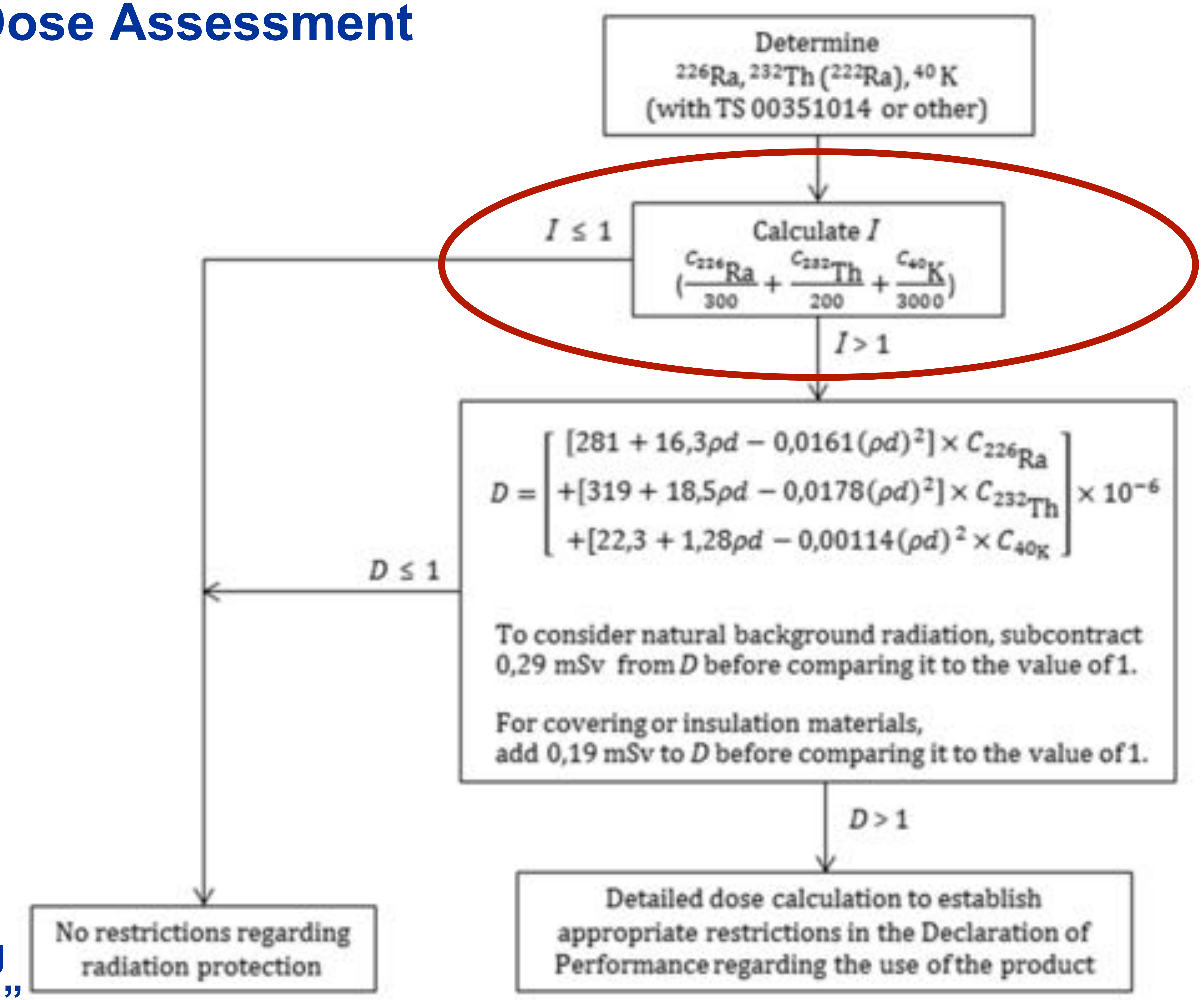

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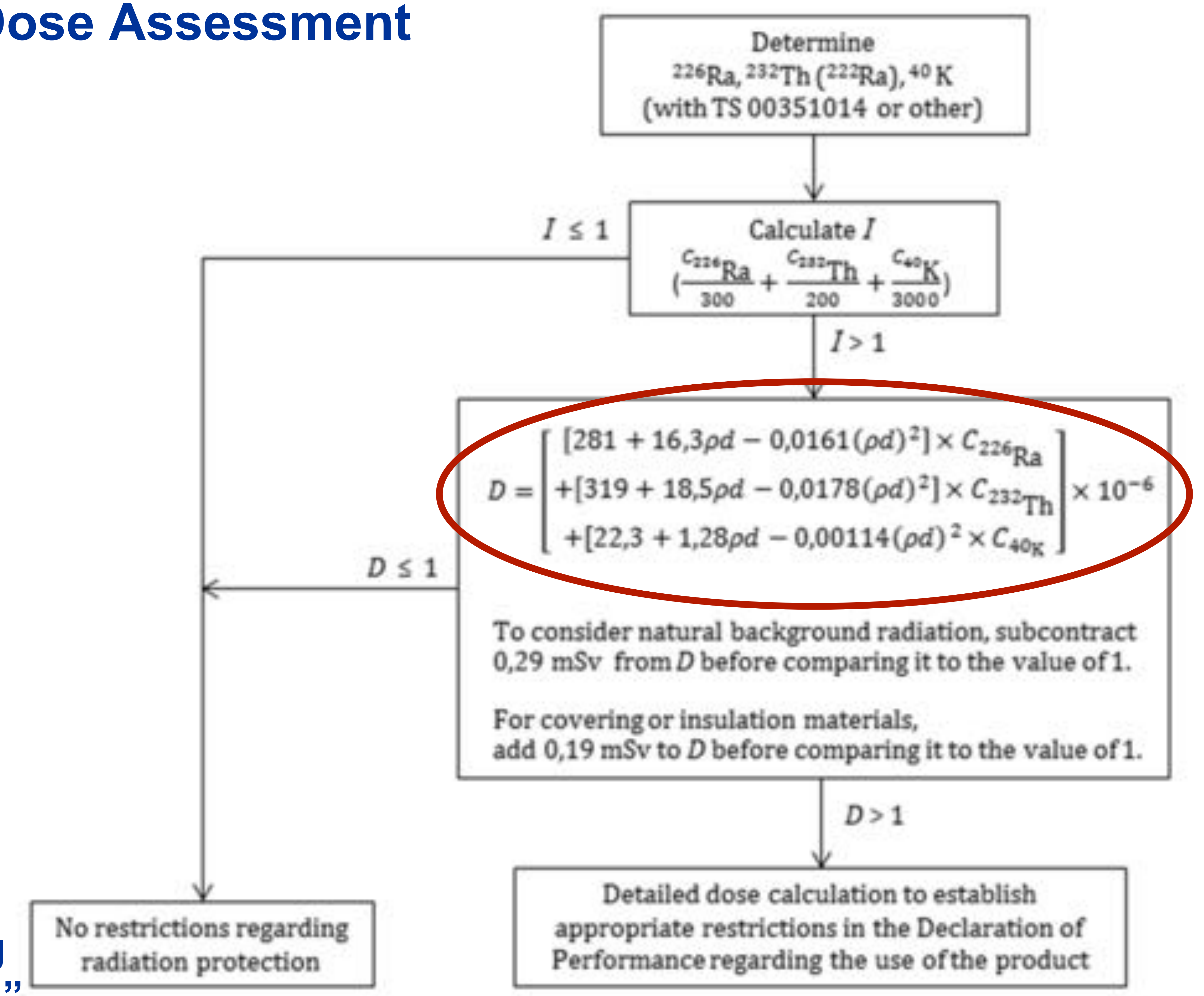

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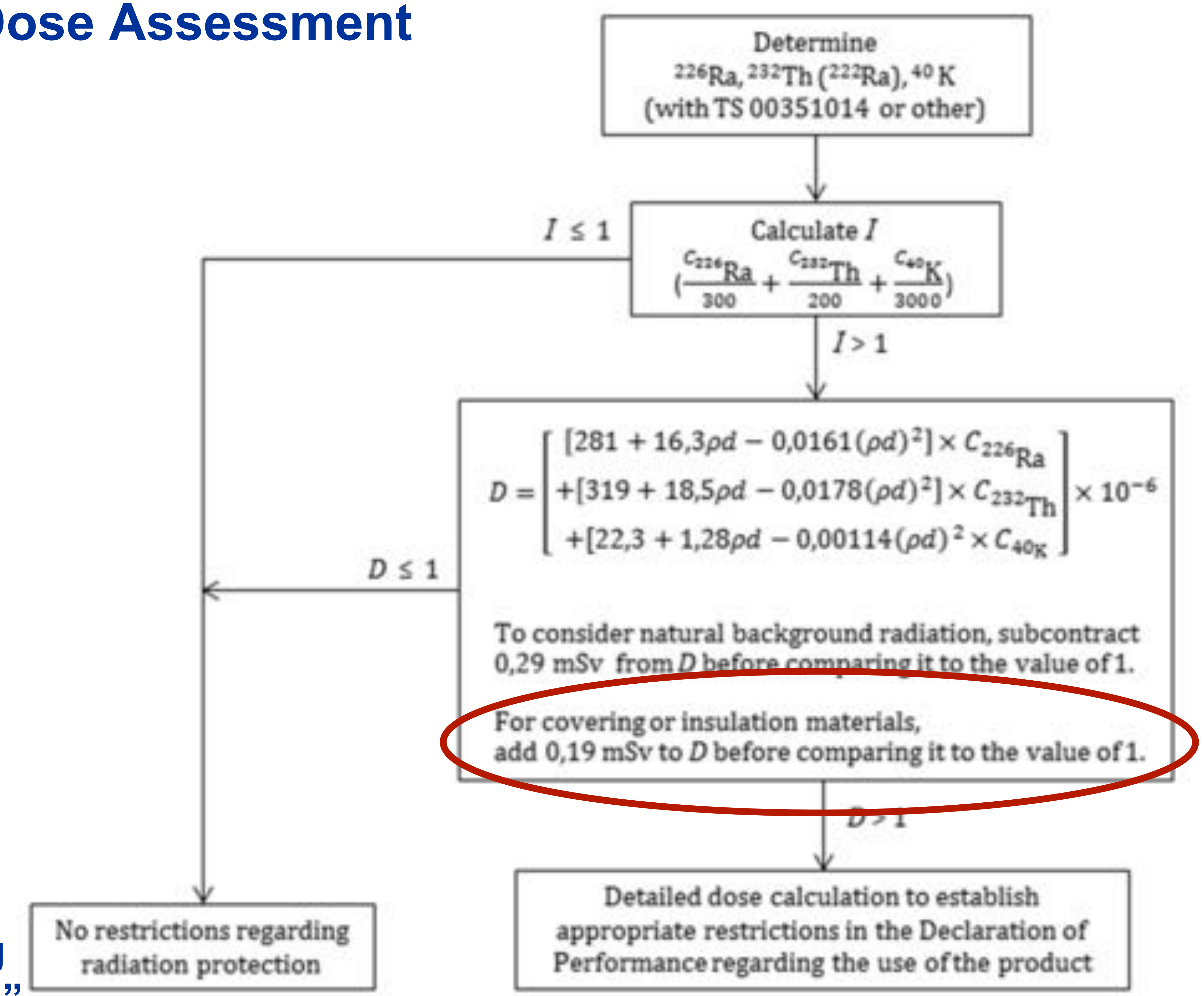

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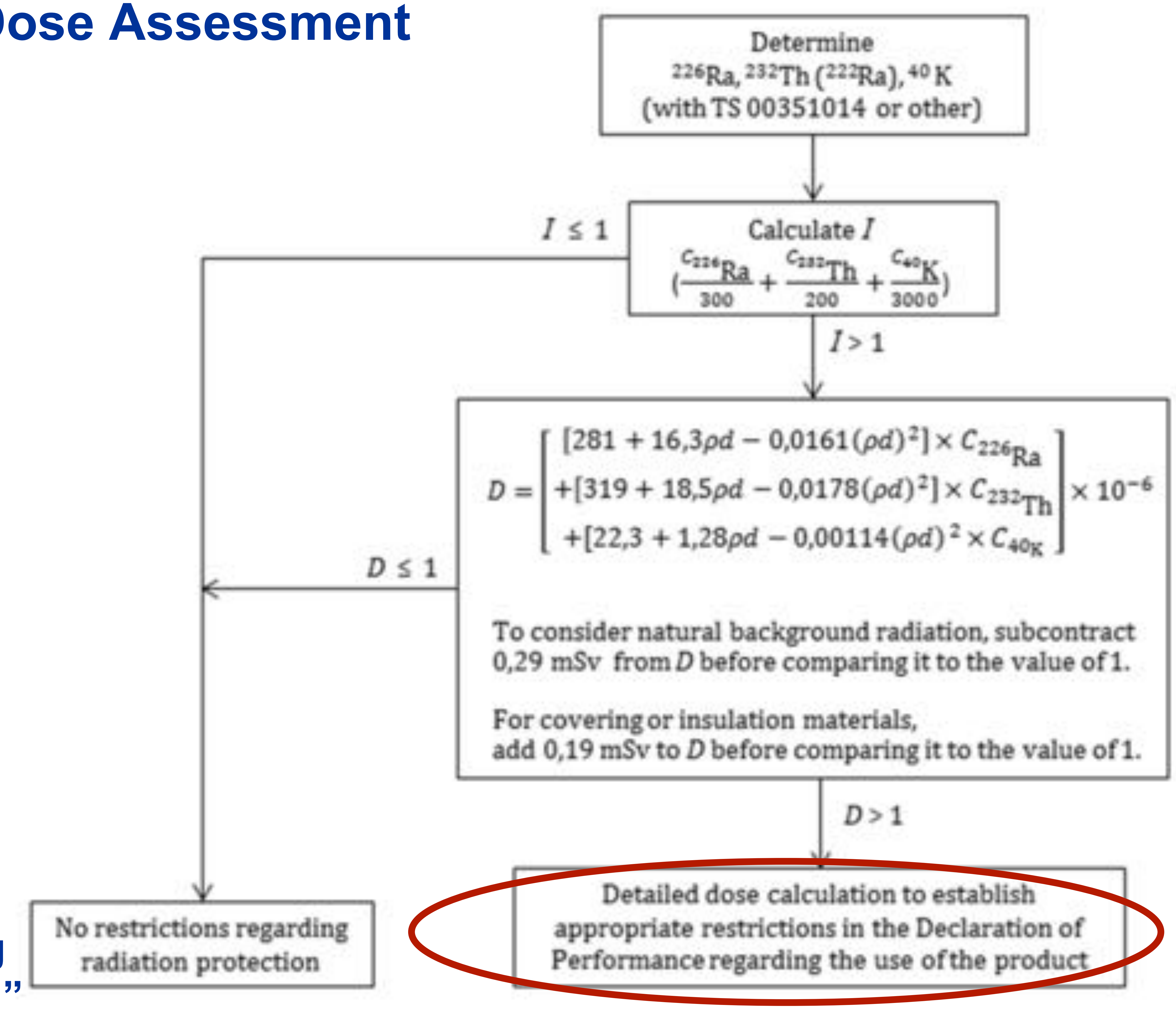

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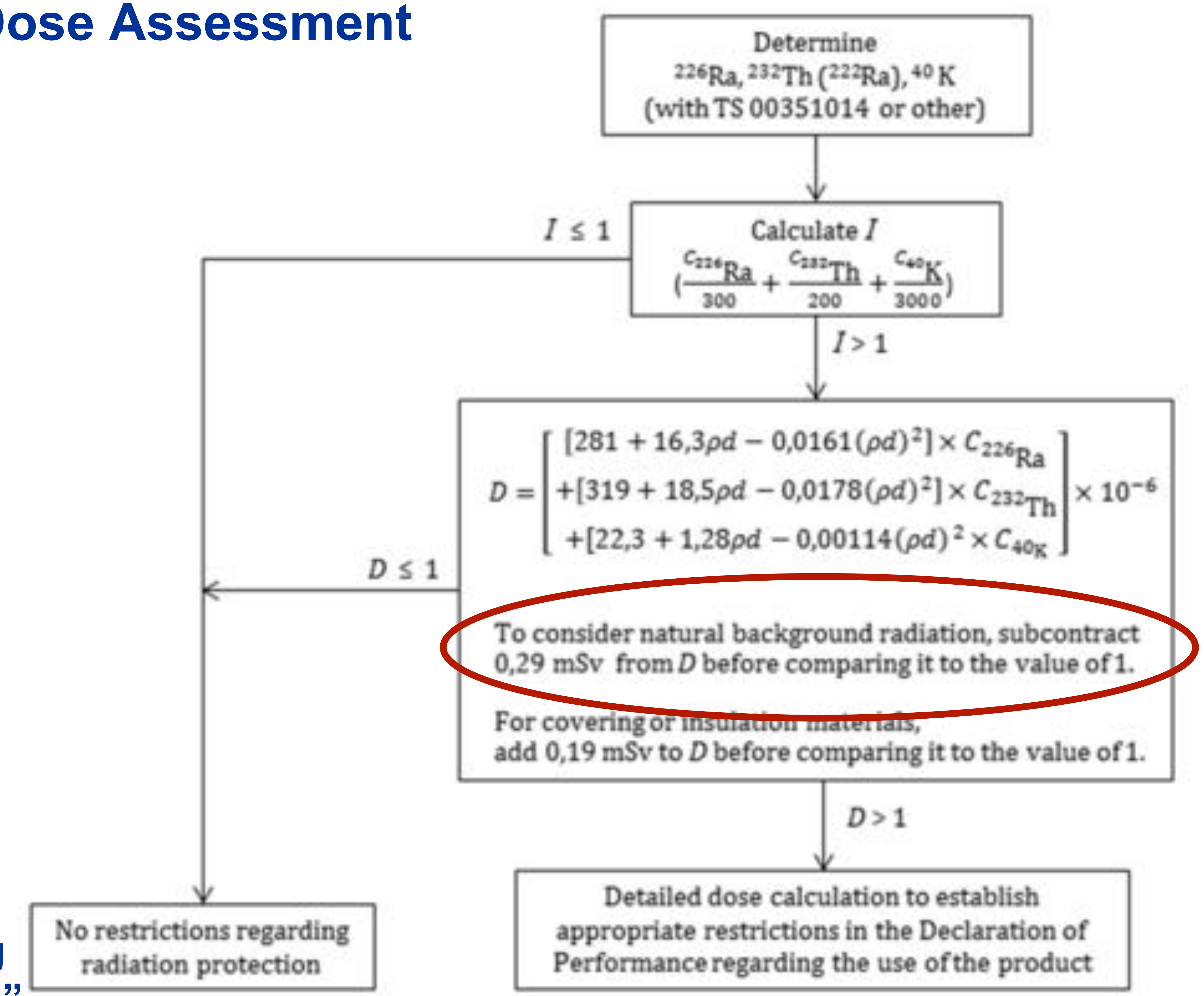

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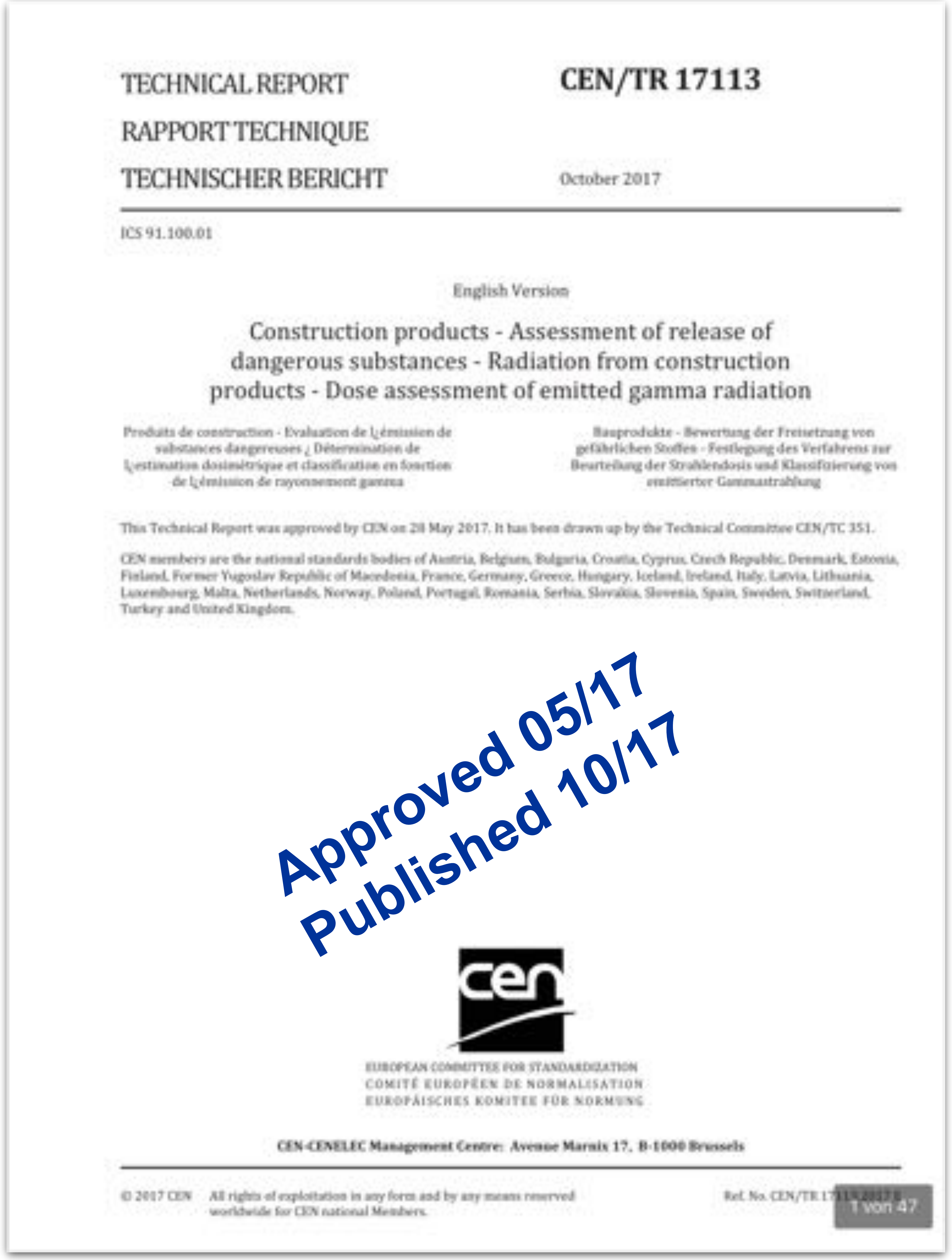
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Consulting with

Europäische Kommission

JRC EU-LCI WG, SGDS

Europäische Kommission

Euratom Art 31 GoE

HERCA
HEADS OF THE EUROPEAN RADIOLOGICAL PROTECTION COMPETENT AUTHORITIES

IAEA
International Atomic Energy Agency

RASSC

Outlook

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs

Industrial Property, Innovation and Standards
Standards for Growth

SPECIFIC AGREEMENT N° CEN/2017-12
Dangerous substance in construction products, Phase IV

For WG 3: CEN/TR 17113 ➜ EN


ευχαριστώ

The Background of the Background in the Index Formula (RP112)

STUK-B-STO 32
NOVEMBER 1995

Radiation Dose Assessments for Materials with Elevated Natural Radioactivity

Mika Markkanen
Department of Radiation Safety

FINNISH CENTRE FOR RADIATION AND NUCLEAR SAFETY
P.O.Box 14, FIN-00881 HELSINKI
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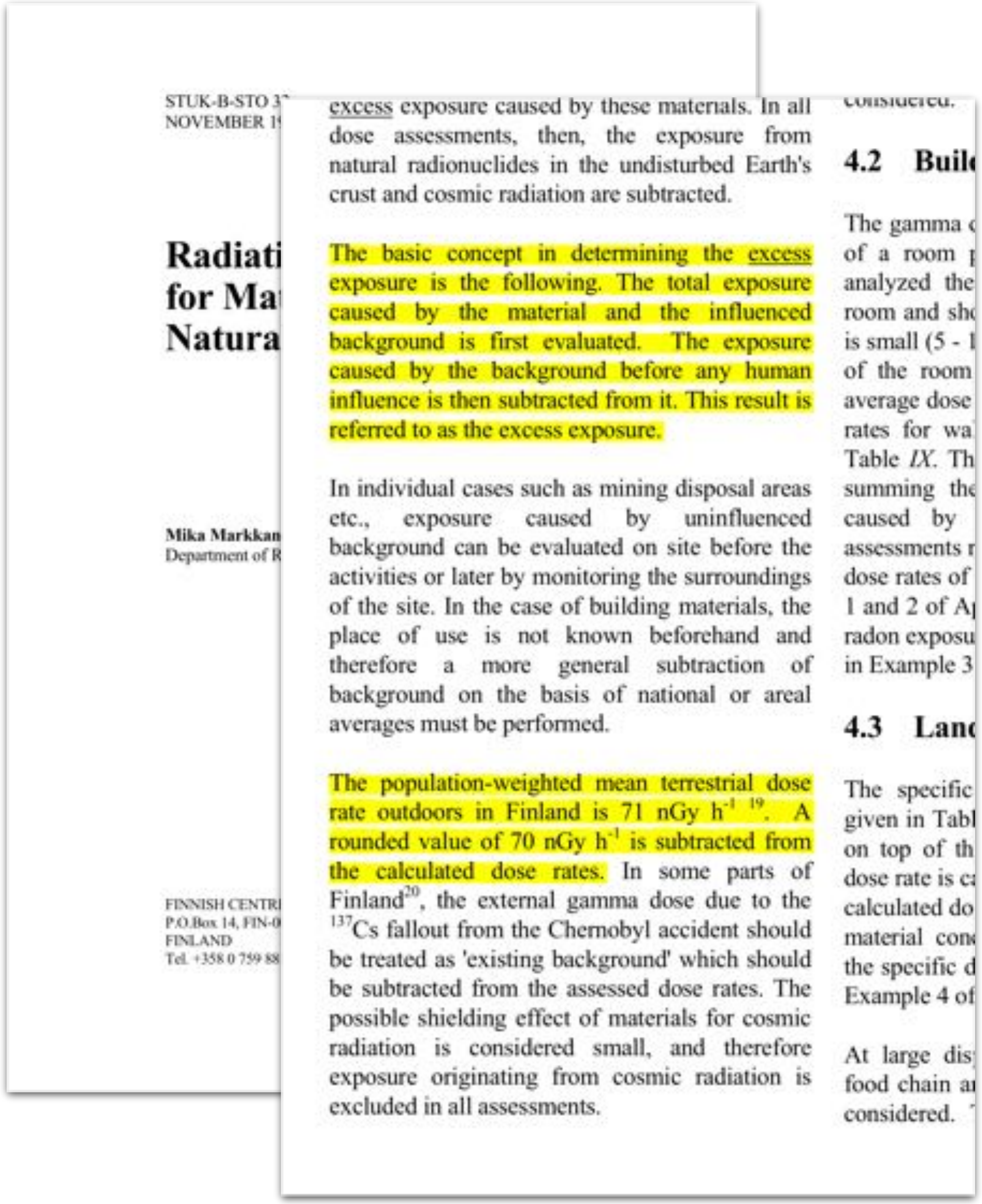

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Radiati…
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Mika Markkan…
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excess exposure caused by these materials. In all dose assessments, then, the exposure from natural radionuclides in the undisturbed Earth's crust and cosmic radiation are subtracted.

The basic concept in determining the excess exposure is the following. The total exposure caused by the material and the influenced background is first evaluated. The exposure caused by the background before any human influence is then subtracted from it. This result is referred to as the excess exposure.

In individual cases such as mining disposal areas etc., exposure caused by uninfluenced background can be evaluated on site before the activities or later by monitoring the surroundings of the site. In the case of building materials, the place of use is not known beforehand and therefore a more general subtraction of background on the basis of national or areal averages must be performed.

The population-weighted mean terrestrial dose rate outdoors in Finland is 71 nGy h^{-1} [19]. A rounded value of 70 nGy h^{-1} is subtracted from the calculated dose rates. In some parts of Finland[20], the external gamma dose due to the ^{137}Cs fallout from the Chernobyl accident should be treated as 'existing background' which should be subtracted from the assessed dose rates. The possible shielding effect of materials for cosmic radiation is considered small, and therefore exposure originating from cosmic radiation is excluded in all assessments.

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The Background of the Background in the Index Formula (RP112)

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5.1 Activity indexes for construction materials

The activity indexes given in Section 2.3 have been derived to indicate whether the safety requirements given in Section 2.2 are being fulfilled. The general criteria and parameter values used are presented in Table *XII*. The calculations in deriving the activity indexes are:

Building materials

$$(0.92 \cdot C_{Ra} - 70) \cdot 10^{-9}\ \text{Gy h}^{-1} \cdot 0.7\ \text{Sv Gy}^{-1} \cdot 7\,000\ \text{h a}^{-1} = 10^{-3}\ \text{Sv a}^{-1}$$
$$\Rightarrow C_{Ra} = 270\ \text{Bq kg}^{-1}$$

The activity concentrations C_{Th} = 226 Bq kg^{-1} and C_K = 3 069 Bq kg^{-1} are calculated similarly, leading to the activity index I_1 for building materials presented in Section 2.3.

Materials used for constructing streets and

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The activity concentrations C_{Th} = 226 Bq kg^{-1} and C_K = 3 069 Bq kg^{-1} are calculated similarly, leading to the activity index I_1 for building materials presented in Section 2.3.

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Conclusion: Every national regulation based on the RP112 index formula considers the mean natural background of Finland!