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

1. **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;
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

- Ionizing Radiation part of Mandate M/366 → Link between EURATOM BSS Directive and EU CPR
- 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 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)
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 \((\rho)\)!
► It would be nice to have the mass per unit area \((\rho \cdot d)\) 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

Radiation Dose Assessments for Materials with Elevated Natural Radioactivity

Mika Markkanen
Department of Radiation Safety

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, ...

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

\[
B_i(1) = 1 + C(E)_{\mu_i(1)} s_1 \exp(D(E)_{\mu_i(1)} s_1)
\]

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

\[
I = \frac{C_{Ra}}{300} \frac{Bq}{kg^{-1}} + \frac{C_{Th}}{200} \frac{Bq}{kg^{-1}} + \frac{C_K}{3000} \frac{Bq}{kg^{-1}}
\]
Let's do some number crunching!
Table 2 — Specific dose rate in air from the different structures in the room of Figure 1

<table>
<thead>
<tr>
<th>Mass per unit area * of wall, ceiling or floor material</th>
<th>Wall, ceiling or floor material (top layer)</th>
<th>20 cm thick concrete behind the wall, ceiling or floor material</th>
<th>Shielding factor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/m²</td>
<td>$^{226}$Ra</td>
<td>$^{232}$Th</td>
<td>$^{40}$K</td>
<td>$^{226}$Ra</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>25</td>
<td>15</td>
<td>17</td>
<td>1,2</td>
<td>140</td>
</tr>
<tr>
<td>50</td>
<td>30</td>
<td>34</td>
<td>2,4</td>
<td>130</td>
</tr>
<tr>
<td>100</td>
<td>58</td>
<td>66</td>
<td>4,6</td>
<td>100</td>
</tr>
<tr>
<td>150</td>
<td>81</td>
<td>93</td>
<td>6,5</td>
<td>82</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
<td>120</td>
<td>8,1</td>
<td>64</td>
</tr>
<tr>
<td>300</td>
<td>130</td>
<td>150</td>
<td>10</td>
<td>37</td>
</tr>
<tr>
<td>500</td>
<td>160</td>
<td>180</td>
<td>13</td>
<td>12</td>
</tr>
</tbody>
</table>

Wall W₁: Dimensions 4.0 m x 2.5 m, distance to room centre 1.5 m
Let's do some maths!

\[ D = f(\text{total activity, room dimension, all the rest}) \]
\[ = f(C_{Ra}, C_{Th}, C_K, m, ...), \text{ with } m = \rho d A \]
\[ = f_1(\rho d, ...)C_{Ra} + f_2(\rho d, ...)C_{Th} + f_3(\rho d, ...)C_K \]

\( f_i \) is smooth \( \rightarrow \) Polynomial expansion

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

\[ \text{fit } \rightarrow a_i \]

For \( \rho d < 500 \text{ kg/m}^2 \): 2nd order
\[ D = \left[ \frac{281 + 16.3 \rho d - 0.0161(\rho d)^2}{+319 + 18.5 \rho d - 0.0178(\rho d)^2} \cdot C_{Ra} \right] \cdot 10^{-6} - 0.29 \text{ mSv} \]

for \( \rho d < 500 \text{ kg/m}^2 \)

\[ [C] = \text{Bq/kg} \]

\[ [D] = \text{mSv per year} \]

\( \triangleq 60 \text{ nSv/h} \)

\( \approx \text{surface area weighted average of all 23 countries} \)

(7000 h, 0.7 Sv/Gy)
Technical remarks

- **R** ([https://www.r-project.org](https://www.r-project.org))
- **cubature: Adaptive Multivariate Integration over Hypercubes** ([https://cran.r-project.org/web/packages/cubature/](https://cran.r-project.org/web/packages/cubature/))
- **Jupyter** ([https://jupyter.org](https://jupyter.org))
• 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
CEN/TR 17113 Dose Assessment

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![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](Image)
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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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Consulting with

JRC EU-LCI WG, SGDS
Euratom Art 31 GoE
RASSC

Outlook

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

For WG 3: CEN/TR 17113 → EN
Radiation Dose Assessments for Materials with Elevated Natural Radioactivity

Mika Markkanen
Department of Radiation Safety
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

\[(0.92 \cdot C_{Ra} \cdot 70) \cdot 10^{-6} \text{ Gy h}^{-1} \cdot 0.7 \text{ Sv Gy}^{-1} \cdot 7 \text{ 000 h a}^{-1} = 10^{-3} \text{ Sv a}^{-1} \]

\[=> C_{Ra} = 270 \text{ Bq kg}^{-1} \]

The activity concentrations \(C_{Th} = 226 \text{ Bq kg}^{-1}\) and \(C_{K} = 3 \text{ 069 Bq kg}^{-1}\) are calculated similarly, leading to the activity index \(I_1\) for building materials presented in Section 2.3.
The Background of the Background in the Index Formula (RP112)

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:

\[
(0.92 \cdot C_{\text{Ra}} - 70) \cdot 10^3 \text{ Gy h}^{-1} \cdot 0.7 \text{ Sv Gy}^{-1} \\
7000 \text{ h a}^{-1} = 10^3 \text{ Sv a}^{-1}
\]

\[
=> C_{\text{Ra}} = 270 \text{ Bq kg}^{-1}
\]

The activity concentrations \(C_{\text{Th}} = 226 \text{ Bq kg}^{-1}\) and \(C_{\text{K}} = 3069 \text{ Bq kg}^{-1}\) are calculated similarly, leading to the activity index \(I_1\) for building materials presented in Section 2.3.
Conclusion: Every national regulation based on the RP112 index formula considers the mean natural background of Finland!