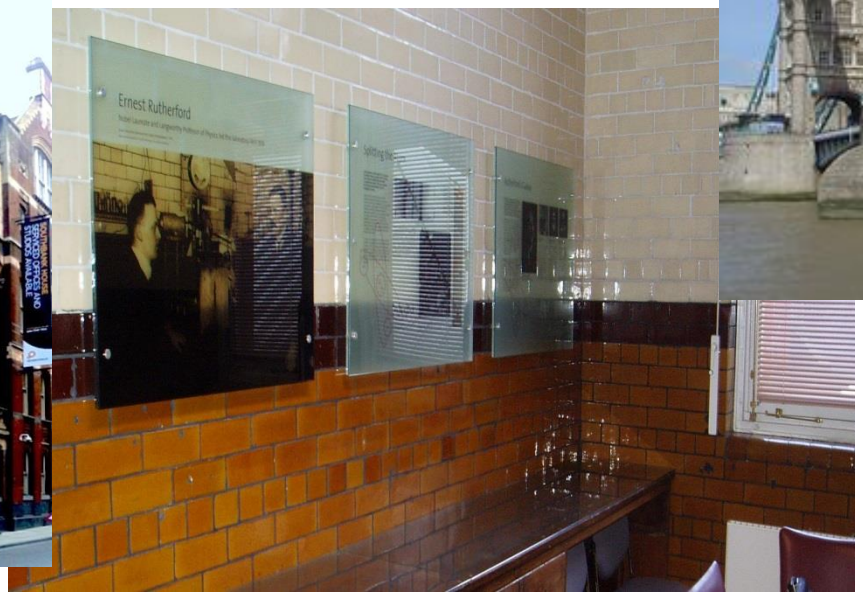
Public Health England

Protecting and improving the nation's health

Building materials in UK and application of the EU BSSD 2013 activity concentration index

Kelly Jones and Tracy Gooding

Existing UK Buildings



How to identify ‘materials of concern’?

PHE on behalf of UK Govt is:

- Identifying commonly used material in UK buildings (bulk and superficial)
- Reviewing published data on Ra-226, Th-232 and K-40 and radon-222 exhalation
- Reporting on estimated ACI and radon exhalation values for range of building materials

Current thinking on BSSD Implementation for UK

Introduction of legislation which puts duty on Secretary of State to set a reference level

Accompanying guidance on the implementation of the reference level

- Emphasize that reference level not a limit but rather a means of optimising exposure
- Use of Activity Concentration Index as screening tool
- Consideration of other factors in assessment of dose

Current thinking on control of ‘materials of concern’?

Use of Building Regulations – however, only appropriate for certain materials and applications ie does not apply to materials typically used in DIY jobs and buildings such as underground stations

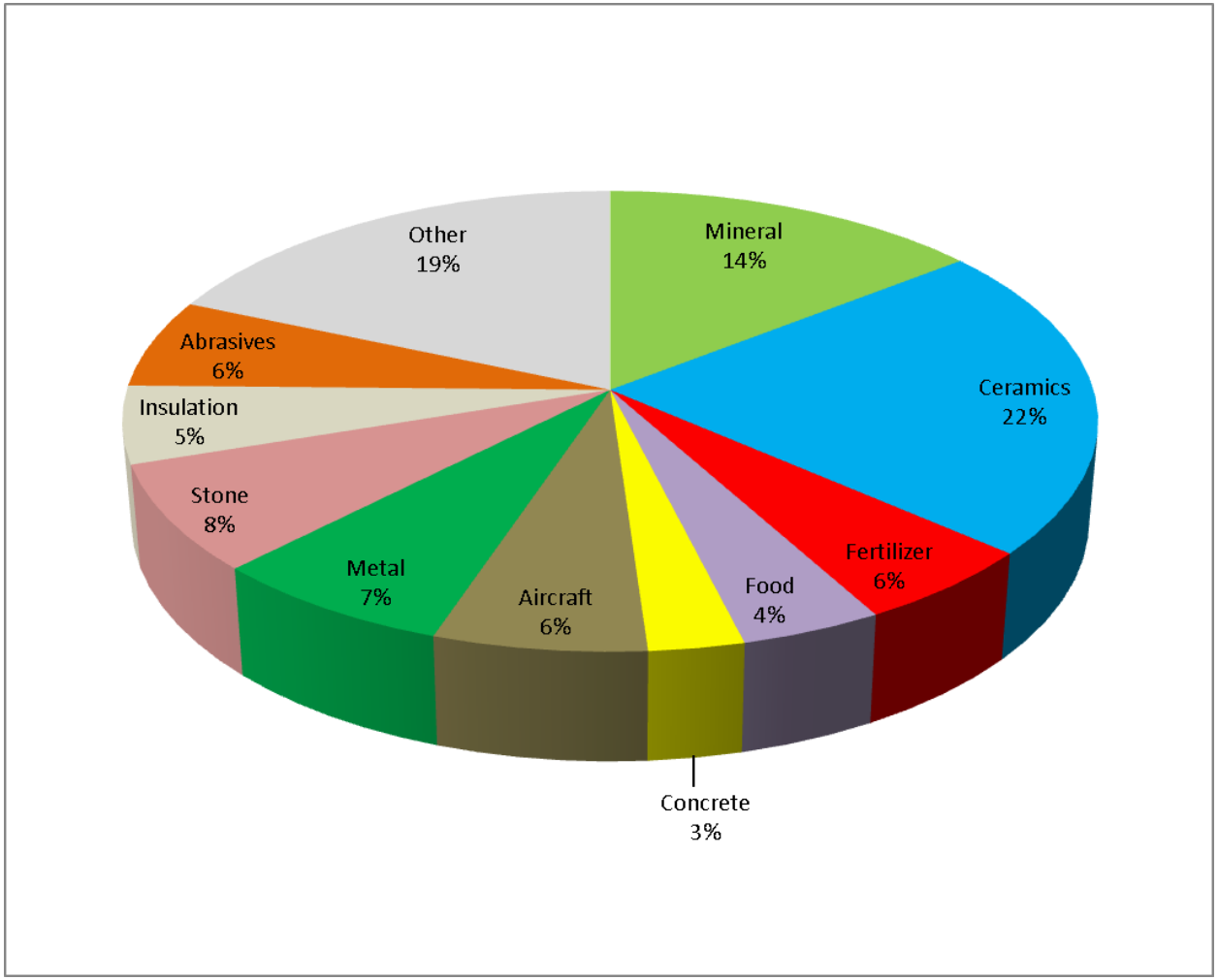
For certain materials, eg worktops might be through enforcement by local authorities

This is all being worked on currently and may be subject to change

Import of building materials

Trigger of Radiation Portals at the UK borders

Based on information reported to the Border Force RPA



Based in information kindly provided by Nuvia and UK Border Force

Example - Granite

Ra-226	170 Bq/kg
Th-232	354 Bq/kg
K-40	1592 Bq/kg

Based on density of 2640 kg/m^3

and thickness of 0.03 m

Activity Concentration Index = 2.9

Dose (mSv) = 0.7 (Hoffmann 2014)

Dose (mSv) = 0.7 (Nuccetelli 2015)

Activity concentration data taken from Pavlidou et al, Natural radioactivity of granites used as building materials, 2006

Example - Ceramics

Ra-226	780 Bq/kg
Th-232	145 Bq/kg
K-40	850 Bq/kg

Based on density of 2400 kg/m^3 and thickness of 0.07 m

Activity Concentration Index = 3.6

Dose (mSv) = 0.3 (Hoffmann 2014)

Information taken from Righi et al, Natural radioactivity in Italian Ceramic Tiles, 2009

Guidance on other factors to take into account

Thickness and density

Self-absorption – important for some materials but what advice to provide?

Type of building – residential, workplace, educational, civic

Intended use of material (bulk or superficial)

- What is the definition of bulk?
- Will large tiles for example be treated as bulk?

Conclusions (part 1)

UK keeping watching brief on materials of concern

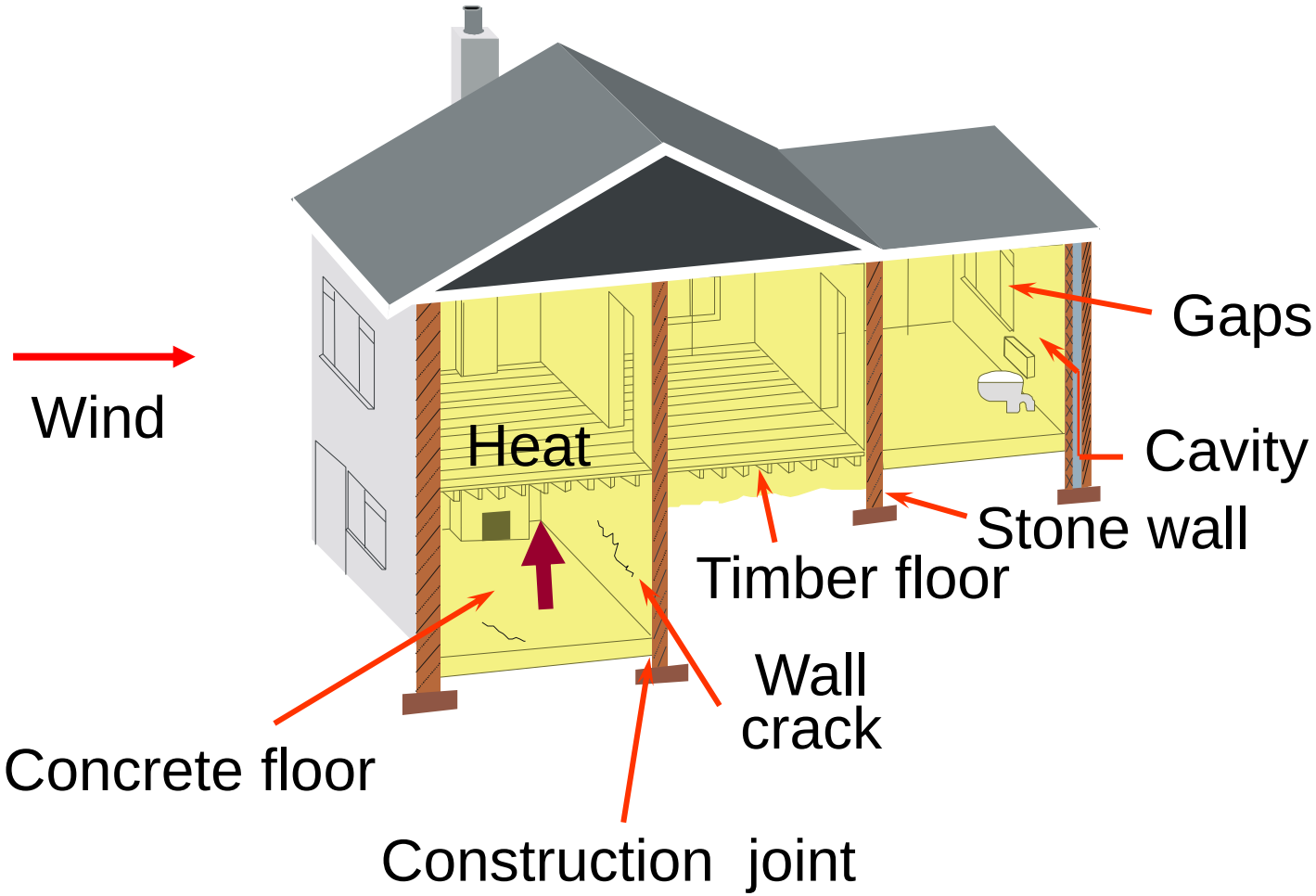
Current plan is to implement reference level in legislation with accompanying guidance

Guidance will stress that reference level **not** a limit and that the ACI is a screening tool

More help is needed on advice on how to apply factors which may modify dose

Be aware that the radiation dose is usually dominated by the radon contribution from the ground rather than building materials

Radon ingress from the ground



Radon levels in UK homes

Radon concentration, Bq m^{-3}		Estimated annual dose, mSv
20,000	Very few at this level	1,000
2,000	‘Very high’ homes (~1000)	100
200	Action level (~150,000)	10
20	Average level	1

BSSD 2013/59/Euratom Annex XVIII

National Radon Action Plan

(8) Strategy, including methods and tools, for preventing radon ingress in new buildings, including identification of building materials with significant radon exhalation.

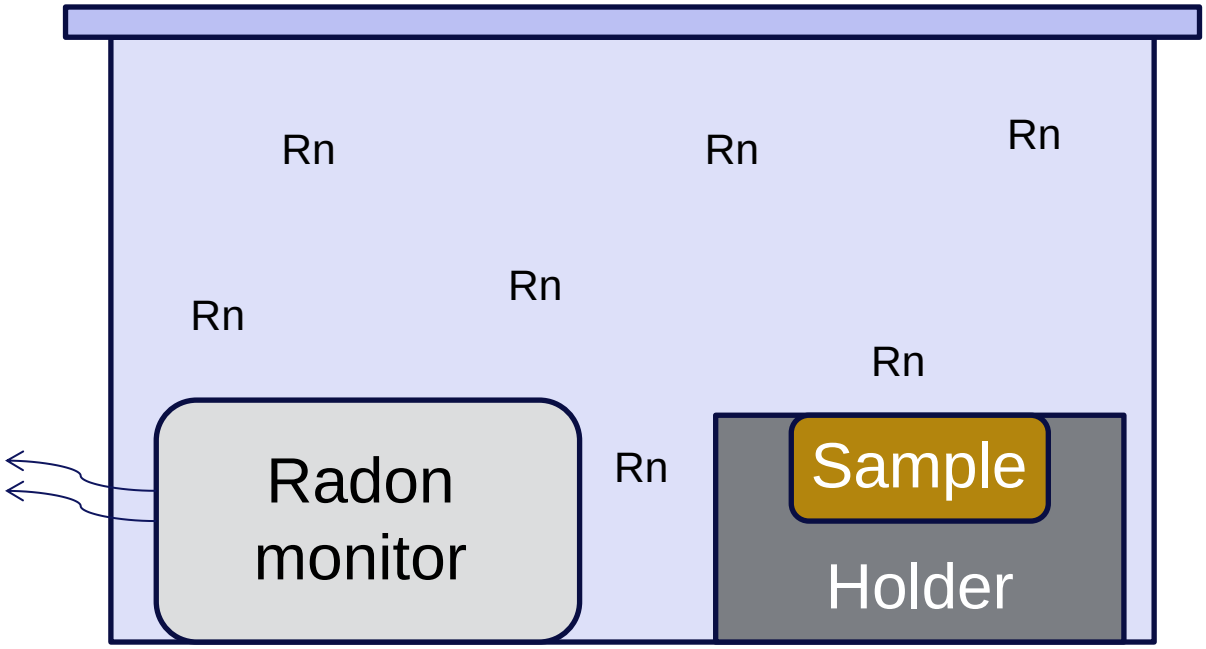
In homes at the average UK level (20 Bq m^{-3}), the contribution from building materials may be a significant fraction of the total

To date, no building material used in UK homes has contributed sufficient radon for the Action Level (200 Bq m^{-3}) to be exceeded

Radon exhalation and measurement

- Radon-222 has 3.8 day half-life – decay product of Radium-226
- Diffuses through porous media
- Transport assisted by fractures, faults and interconnected pores
- Depth of source material is important when measuring exhalation characteristics
  - thin sample for superficial materials, e.g. tiles
  - representative depth for bulk materials, e.g. concrete, brick
  - sample geometry should emulate realistic situation
  - if single block face exposed in use, prevent influence of exhalation from other sides during measurement
- Exhalation from product ≠ sum of exhalation from constituents
  - consider production processes, glazing

Radon exhalation measurements

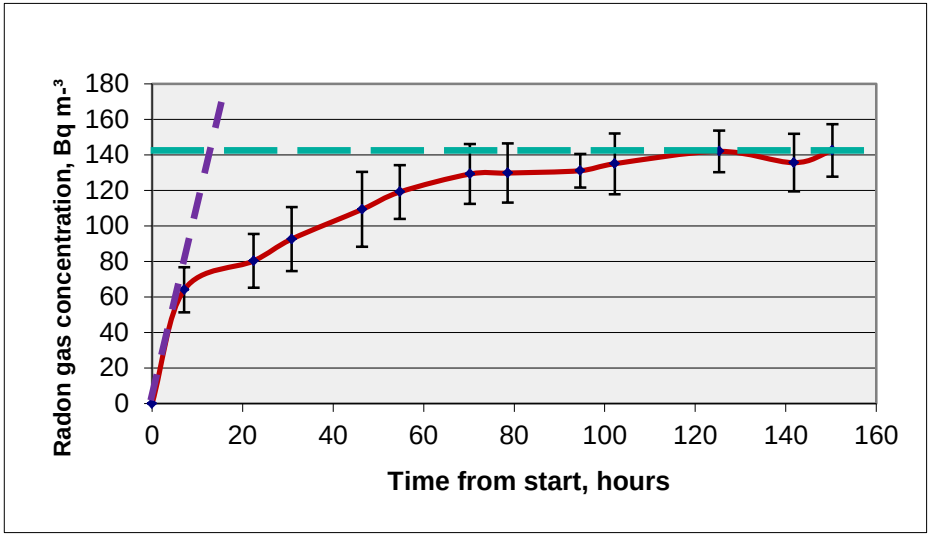


The most direct method uses a sensitive, constantly recording electronic monitor to give time-resolved radon measurements

Radon diffuses from the open face of the sample into the air of the sealed box

The radon level in the box rises until exhalation is balanced by back diffusion and radioactive decay

Radon exhalation quantities



C(t) = chamber concentration (Bq m^{-3})
E = free exhalation (Bq s^{-1})
λ = radon-222 decay constant (s^{-1})
V = net chamber volume (m^3)
A = sample open surface area (m^2)
M = sample mass (kg)
C_{Ra} = radium-226 activity mass (Bq kg^{-1})

When t is large, C(t)→E/ λV and the radon level achieves a plateau
Divide E by A for *exhalation rate* Bq $m^{-2}s^{-1}$
or/ Determine initial slope, Bq $m^{-3}s^{-1}$ and multiply by V/A
If only one free surface of sample, *exhalation factor*, f = E/(λC_{Ra}M)

Which quantity is the most useful, when you can also determine...?

Exhalation per unit volume , Bq $m^{-3}s^{-1}$
Exhalation per unit mass, Bq $kg^{-1}s^{-1}$
Derived exhalation rate, Bq $m^{-2}h^{-1}$
Normalised exhalation rate, kg $m^{-2}h^{-1}$

Radium content and radon exhalation

	Radium-226 Activity Concentration Bq kg^{-1}		Derived Radon Exhalation Rates Bq $m^{-2}h^{-1}$		Normalised Derived Radon Exhalation Rates Bq $m^{-2}h^{-1}$ per Bq kg^{-1}	
Material	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Ash	55	125	0.68	1.12	0.01	0.01
Gypsum	5	482	0.02	42.3	0.01	0.09
Concrete	13	1470	0.04	31.0	0.02	0.53
-with fly ash	10.4	107	0.76	140	0.02	1.31
Brick	10.1	82	0.01	7.20	0.00	0.18
-with fly ash	105	105	0.14	0.14	-	-
Cement	12	108	0.37	3.24	0.01	0.01
Others	6.5	5600*	0.03	9.70	0.00	0.11
-with fly ash	35	85	0.50	6.12	0.01	0.02

* Not used in UK

Conclusion (part 2)

- Radon exhalation requires Radium-226 content and porous media
- Low Activity Concentration Index implies low radon exhalation
- Measuring radon exhalation is unlike determining gamma from NORM
- Cannot use partition method for constituents; must account for product and manufacturing processes
- Literature reports radon exhalation values using many different quantities – hard to compare with ACI
- **Radon contribution from ground usually dominates that from building materials, especially with high indoor concentrations**