RADON MEASUREMENTS IN THERMAL WATERS AND SPAS – CZECH REPUBLIC

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- **Legislative and methodological framework**

- **Methods (similar as for radon in houses)**

Neznal M., Ženatá I. Evaluation of Occupational Exposures to Natural Radiation in the Czech Republic, 5th Conference on Protection against Radon at Home and at Work, Radiation Protection Dosimetry, Vol. 130, No 1, 30 – 33, (2008)

Atomic Act (Act No. 18/1997 Coll., as amended

Decree of the S.O.N.S. No. 3007/2002 Coll. on radiation protection, amended by Decree of the S.O.N.S. No. 499/2005 Coll.

Workplaces with potential risk of increased exposure to natural sources are specified as follows:

(a) aircraft boards in flights at an altitude over 8 km;

(b) mines, caves and other underground workplaces;

(c) workplaces where underground water is handled by pumping, collecting or by other methods, namely pumping stations, spa facilities, filling rooms and water treatment plants;

(d) all workplaces where radon concentration of 400 Bq/m^3 has been demonstrably exceeded; and

(e) workplaces performing: (1) solid coal combustion products treatment at facilities with heat output higher than 5 MW; (2) production of building materials from coal combustion products; (3) mining, transport piping and treatment of petroleum and gas; (4) phosphate raw material treatment; (5) treatment and production of materials based on titanium minerals; (6) treatment and production of materials based on zirconium minerals; (7) treatment of raw materials containing noble earths; (8) metallurgical metal production; (9) production, treatment and utilisation of materials containing thorium and uranium; (10) treatment of underground water supply sediments; (11) treatment of materials, in which the content of natural radionuclides exceeds clearance levels, or causes an increase of photon dose equivalent rate higher than 0.5 μSv/h.

Note: The measurements and the determination of effective doses are not made at workplaces where total working time of physical persons performing work does not exceed 100 hours per year.

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The owners of properties, in which the above mentioned workplaces are located, or the workplaces owners are obliged to ensure the measurements of natural radioactivity and the determination of effective doses of workers.

The measurements and the determination of effective doses of workers shall only be done by an approved dosimetric service in compliance with the methods approved by the S.O.N.S. as a part of the issue of a licence.

The exposure evaluation consists of three steps: **At workplaces (b), (c) and (d), the average radon concentration in air in time of a work activity of persons is measured as the first step. Measurement results are compared with the investigation level IL = 400 Bq/m^3.**

At workplaces (e), where not only radon and its short-term decay products, but also other natural radionuclides may cause an increased exposure, two investigation levels are used: IL_1 = 400 Bq/m^3 of the average radon concentration in air in time of work activity, and IL_2 = 1 mSv of the effective dose above natural background caused by external gamma irradiation, by inhalation of natural radionuclides and by skin contamination.

The repeated, more detailed measurement is made at workplaces, where an investigation level has been exceeded. Determination of personal doses of workers and comparison with the guidance level GL = 6 mSv per year represent the second step of the exposure evaluation. The question is if the guidance level can be exceeded, not if it has been exceeded.

The third step is represented by a repeated measurement in each calendar year at workplaces, where the guidance level 6 mSv per year can be exceeded.

At such workplaces, radiation exposure to natural sources is significantly increased.

The radiation protection of workers is then ensured in the scope and the manner that is applied for controlled areas of workplaces where radiation activities are performed: The workplace or its parts are delineated. The persons who can perform work, as well as the method and the scope of their annual demonstrable instructions on radiation risks and their protective work aids are determined. Monitoring and medical examinations are secured, records are kept. Countermeasures corresponding to the optimisation of radiation protection are applied.

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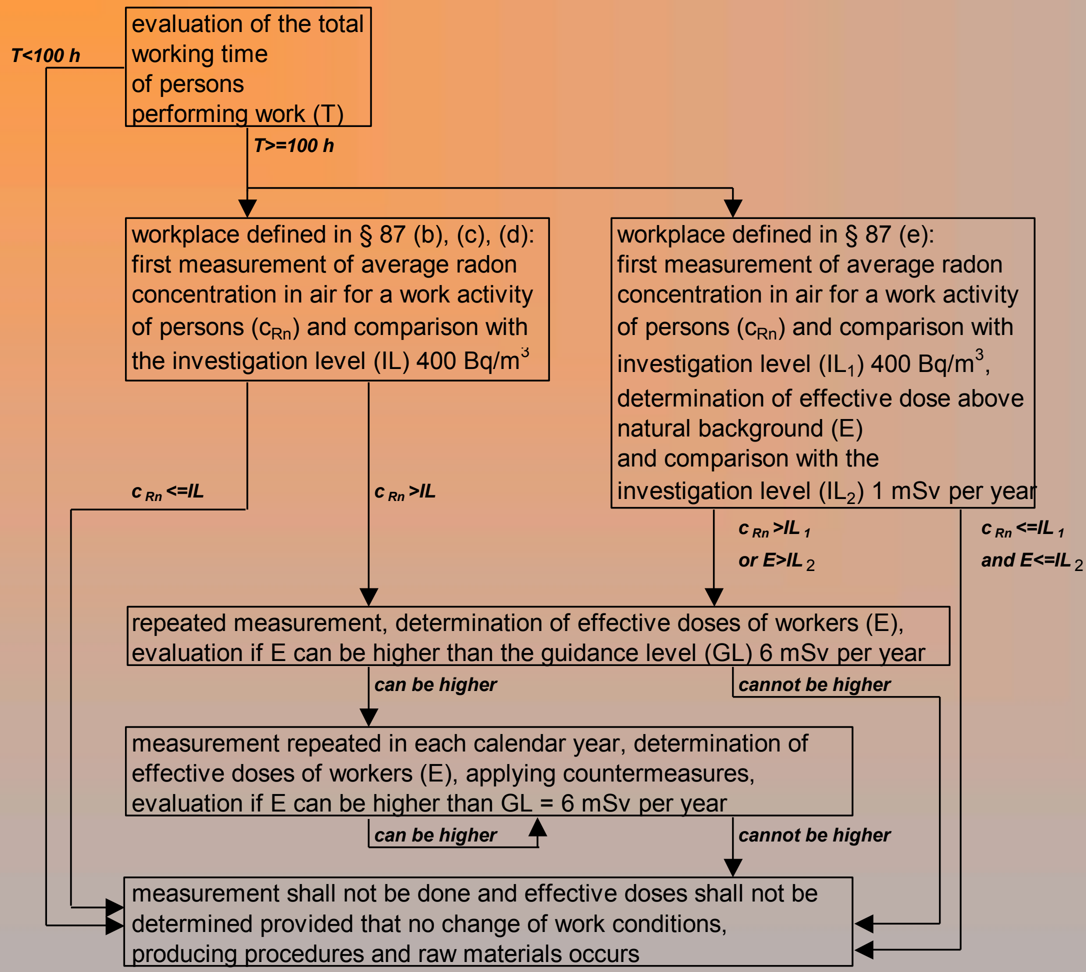
Decision making diagram



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Methods

Track etch detectors RAMARN

produced and evaluated by the laboratory of the National Institute for Nuclear, Chemical and Biological Protection, Kamenna

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RAMARN detectors are used for the first measurement of radon concentration at workplaces.

Spas (and other workplaces, where the underground water is handled):

The average radon concentration in air in time of a work activity of persons is expected to be higher than the overall average radon concentration in air.

Conservative approach: Measured values of the overall average radon concentration are multiplied by a factor of 2

and compared with the investigation level IL = 400 Bq/m^3.

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Second step (third step): Integral (RAMARN) and continual measurements

➩ different types of continual monitors
typical measuring period - 30 min
main producer: SMM - Praha (Jiri Plch)

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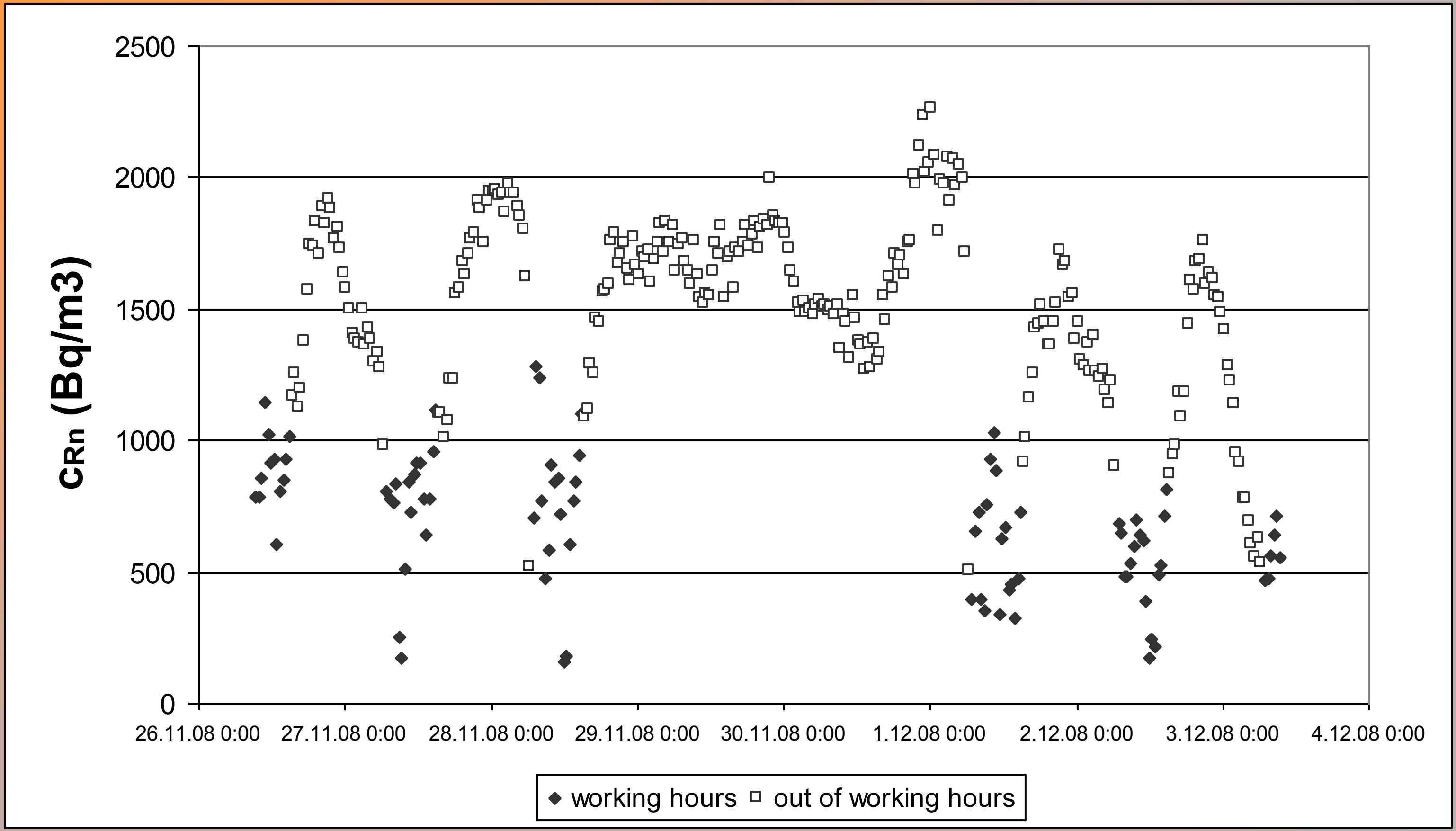
Continual measurement of radon concentration in air



⇨determination of average radon concentration in time of a work activity

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Effective dose determination (estimate):

$$E\ (mSv/year) = C_{Rn\ RAMARN}\ (Bq/m^3)\ .$$

$$.\ (\ C_{Rn\ cont,\ working\ time}\ (Bq/m^3)\ /\ C_{Rn\ cont,\ total}\ (Bq/m^3)\ )\ .$$

$$.\ (\ T_{real}\ (h/year)\ /\ 2000\ (h/year)\ )\ .\ (\ 6\ (mSv/year)\ /\ 1000\ (Bq/m^3)\ )$$

$C_{Rn\ RAMARN}$	– average annual radon concentration (integral method)
$C_{Rn\ cont,\ working\ time}$	– average radon concentration in time of a work activity, short-term continual measurement (1 – 2 weeks)
$C_{Rn\ cont,\ total}$	– average radon concentration during the whole short-term continual measurement (1 – 2 weeks)
T_{real}	– real number of working hours per year

Assumption: 2000 h in 1000 Bq/m^3 correspond to 6 mSv

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Example:

Kamenné lázně Teplice:

Source of thermal water: about 300 kBq/m^3

Radon concentration in water coming to balneotherapy:
200 - 250 kBq/m^3

Old building with no isolation against radon, two basements.
The second basement: technical background.
Balneotherapy is situated in the first basement and in the gound floor.

Thermal water may not be the only (or most important) source of radon.

Several measurement campaigns were carried out in the past.

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2005 – 2006:

one-year measurement, RAMARN detectors, 7 workplaces in the first basement and in the ground floor

$C_{Rn\ RAMARN}$: 155 - 1513 Bq/m^3

2007 – 2008:

one-year measurement, RAMARN detectors, 21 workplaces in the first basement and in the ground floor (not only balneotherapy)

$C_{Rn\ RAMARN}$: 78 - 4025 Bq/m^3

+ one-week continual measurements, 4 chosen workplaces

$C_{Rn\ cont,\ working\ time}$ (Bq/m^3) / $C_{Rn\ cont,\ total}$: 0.49 – 1.37

annual effective doses of workers: 0,3 – 5,3 mSv

countermeasure: reduction of working hours of selected personnel at selected workplaces

2011:

testing of the efficiency of the ventilation system in the second basement - two-weeks continual measurements

radon concentrations in the second basement are about two-times lower, when the ventilation system is in operation

+ spot measurement of radon concentration in air samples collected in places of potential leakages between the second and the first basements

high radon concentrations observed

2012:

testing of the efficiency of following remedial measures (sealing of potential radon pathways between the second and the first basements)

two measurement campaigns (continual measurements)

inconsistent results

Thank you