REMEDIAL MEASURES IN CZECH HOUSES WITH HIGH RADIUM CONTENT IN BUILDING MATERIAL

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Abstract

Three groups of houses built from materials having elevated natural radioactivity content were found in the Czech republic. These are:

1) about hundred old houses in Jachymov (Joachimstal) in Northern Bohemia, where residues from factory producing uranium paints were used as plaster and mortar before the World War II (radium concentration up to 1 MBq/kg, indoor gamma dose rate up to 10-100 μGy/h)
2) some 20 000 family houses built from highly emanating aerated concrete with radium content 500-1000 Bq/kg (produced from flying ash) in the period 1963-1980
3) more than 2000 family houses from slag concrete of radium content about 3 kBq/kg in average (indoor gamma dose rate up to 2 μGy/h) made in the period 1972-83

Remedy measures were undertaken with state financial support. Intervention levels were laid down 200 Bq/m^3 for EEC (equivalent equilibrium radon concentration - it is equivalent to radon gas concentration 500 Bq/m^3), 2 μGy/h for indoor gamma dose rate. Weighted sum of indoor radon and indoor gamma dose rate was used if the latter was above 0,5 μGy/h. The central heat recovery ventilation units were used largely as the remedy measures. Some houses were demolished, in some houses local contamination of plasters was removed. Other tested measures (removal of the contaminated building material in great amount, gamma shielding, wall coating, etc.) proved to be not effective or not acceptable in practice.

Introduction

The Czech Republic belongs to countries with highest indoor Rn concentration in the world. The primary cause is the high Rn concentration in the soil gas (typical range 10-100 kBq/m^3, however case above 1 MBq/m^3 are not rare). The indoor radon survey carried out in more than 100 000 houses outlined the mean radon concentration of 140 Bq/m^3, more then 15000 houses above intervention level (expected number is 60 000) and some houses with indoor Rn up to 20 000 Bq/m^3.

Beside this there were found three groups of houses with elevated radium concentration in the building materials: some houses in Joachimstal, family houses from slag concrete and family houses from aerated concrete.

Houses in Joachimstal.

Jachymov (Joachimstal), the mining town known from Middle Age thanks to silver-mines and coinage, later uranium mining industry, radium producing factory, radon spa and also epidemiological studies of lung cancer among uranium-miners. Due to silver and uranium exploration and factory producing uranium paints, the town was locally contaminated in the past. All residues from uranium paints factory were also used as additive into plaster and mortar in a lot of the Joachimstal's houses, with ^{226}Ra mass activity up to 1 MBq/kg in extreme cases and indoor gamma dose rates in the range of 10-100 μGy/h. The contamination was not uniform. The case was revealed in the seventies and there was no national legislation concerning indoor radon and indoor radioactivity in this period. The remedy measures carried out in the seventies were drastic - the worst houses were demolished and material taken away and processed in uranium ore mills. Most remaining contaminated houses were mitigated later in the nineties. Remedial measures were based on detailed radon and gamma diagnostic and targeted removal of plasters and mortar, if there was only local contamination.

Family houses from aerated concrete

In the 1980 there was found the group of family houses built from aerated concrete with typical radium mass activity of 1 kBq/kg. Because of high emanation coefficient of this materials (range 15- 30 %), the indoor radon concentration was up to 1000 Bq/m^3 in extreme cases. The indoor gamma dose rates were in the range of 0.1-0.3 μGy/h, what is the upper level of normal outside dose rate background in Bohemia. Some 20 000 houses from this material were built in the period 1963-1980. Fortunately, the aerated concrete was used in most of them only as the minor part of building material and hence indoor radon concentrations exceeded the intervention level only in about 1-2 % of these houses.

As effective mitigation were used enforced central or local ventilation systems. Different radon barriers (special painting and special wallpapers) were tested without good results.

Family houses from slag concrete

The last group was discovered in the 1987. There were found about 2000 factory-made family houses from slag concrete panels with mass activity of ^{226}Ra in the range 1-10 kBq/kg. The source of the activity was slag from a small power plant burning high radioactive local coal from a mine near Prague. The first Producer Company knew the radioactive danger of the slag from the fifties. After changes in the factory ownership the new management took no care of this danger and more than 2000 family houses were built in the period of 1972-1983 distributed all over the country, most of them in Central Bohemia around Prague. All the peripheral and supporting walls were made from this material, while some partition walls were from bricks. Because of small emanation coefficient of the material (only 1-5%) the indoor radon concentration were only in the range of 200-800 Bq/m^3 (EEC 100-300 Bq/m^3). The indoor gamma dose rates in this group of houses were in the range of 0.5-2 μGy/h; the spatial variation in rooms was characterized by a factor of 2, with highest values in the corner of peripheral walls. The first guideline for limitation of exposure in these houses was prepared in 1987. As the limit value was chosen the highest gamma dose rate in the "potential permanent used place" of the room not closer than 0.5m to the walls. The results of the measurements of the individual doses of inhabitant (by personal dosimeters) showed later, that individual doses were only about 70% of expected maximal doses.

Having in mind that people are exposed both to radon daughters and to gamma the special intervention level that summed both exposures was defined as:

$$S=D/2 + EEC/200,$$

where D is the gamma dose rate (μGy/h) and EEC is the long-term equilibrium equivalent radon concentration (Bq/m^3). This sum rule was used only if D > 0.5 μGy/h. The intervention level S = 1 was exceeded in about 75% of houses.

The owners of these houses were aware of the cause of their trouble and apply for remedial measures or the possibility to buy up these houses by the government. The government has agreed after great struggle in 1991. Most of the owners have accepted remedial measures, only 80 owners have sold their house. There was clear after some experiments, that only radon removal by enforced ventilation is the effective and reasonable measure. The ventilation system with heat recovery, controlled by a central computer, was found to be most effective countermeasure and was used in practice. Radon level was reduced to 30% of the former values in average. Other remedial measures (gamma shielding, removal of building material, wall covering by special radon proof materials, etc.) were not effective and were rejected. This case revealed the problem of risk perception.

Conclusion

Contemporary Czech legislation concerning indoor natural radioactivity and remedial measures is based on the Atomic Act No.18/1997 and Decree No. 184/1997. The intervention levels and recommended remedial measures are in the following tables.

Indoor gamma dose rate (intervention levels)	
Dose rate (μGy/h)	**Remedial measures (recommended)**
> 1	usage arrangement of the area
> 2	the restriction of the human stay
> 10	elimination of the stay of persons

Indoor Radon (intervention levels)		
EEC (Bq/m3)	**Radon gas (Bq/m3)**	**Remedial measures (recommended)**
200 – 300	500 – 750	simple mitigation (e.g. ventilation improvement)
300 – 600	750 – 1500	more sophisticated mitigation (e.g. simple building reconstruction changes or enforced ventilation)
600 - 2000	1500 - 5000	large building reconstruction
> 2000	> 5000	elimination of the stay of persons large building reconstruction