STRATEGY FOR THE ASSESSMENT OF THE RADIATION EXPOSURE AT WORKPLACES DUE TO RADON AND RADON DECAY PRODUCTS

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INTRODUCTION

According to the future EU basic standards the exposures to radon decay products have to be taken into consideration. Therefore it is necessary to investigate

* which working operation could be connected with an increased exposure to radon decay products,
* which workplaces have to be considered,
* how many employees could be afflicted,
* which methods should be applied for the investigation and - as for as necessary - for supervision.

On the basis of the current radiation protection legislation in the new Federal Lands working operations which are connected with radon exposures have already been monitored. For instance, in 1994 3095 persons were supervised, 2422 of them were engaged in clean-up operations at Wismut facilities (including underground work) and 673 at non-uranium mines and facilities (conventional mining), water treatment plants, show caves and spas /1/. The extension of the monitoring to similar workplaces in the old Federal Lands is going to discussed in implementation of the EU standards.

Beyond it further workplaces affected by radon and radon decay products exist. Therefore it is helpful to get an overview about the kinds of workplaces and the number of afflicted employees.

DIMENSION OF THE PROBLEM

In regions with increased radon potential especially in the mining regions of East German Federal Lands measurements of the indoor radon concentration with an exposure time of 24 hours were conducted from 1991 to 1993. 2447 institutions participated in these investigations and more than 8000 measurements were made there. The measurements were conducted in 716 producing firms (especially small and middle-class institutions which are typically for the investigation regions), 237 education and research departments, 525 social institutions, 651 public utilities and 318 shops, banks etc..

The investigations included a broad spectrum of working rooms in different institutions like conventional bureaus, lecture rooms, production rooms etc..

Although the information by the voluntary participants about the realistic exposure conditions were often insufficient, the results are useful for an overview assessment. Table 1 shows the evaluation of measured results related to typical workplaces. It should be taken into account that these results represent an overestimation of the long-term situation because short-term measurements are made under stringent conditions (closed windows and doors). It has been shown that factors between 4 and 10 (ratio of short-term against long-term measurents in the range of higher radon concentrations) observed at dwelling measurements. They will be used for the further analysis /2/.

Because the aim of the screening measurements was the area-wide analysis of the situation in regions with a high radon potential, only a rough characterization of the investigated rooms was necessary, particularly there were no influence on their selection by the institutions.

Therefore the number of "other" is high, a majority of these rooms has occupancy times below 3 - 5 hours per day.
Against the expectation the results show that production rooms can not be neglected in the investigations.

Table 1: Results of short-term measurements of the radon concentration in radon potential regions at typical workplaces independent of the institution /3/

Using of rooms	Number of investigations	Average Bq/m³	Maximum Bq/m³	Median Bq/m³	Share of workplaces with short-term radon concentration above 4000 Bq/m³ %	Share of workplaces with short-term radon concentration above 10000 Bq/m³ %
office	1246	390	79000	110	1,4	0,5
production	696	430	13000	120	1,6	0,7
store	719	460	26000	130	1,9	0,1
other*	4002	700	170000	140	2,5	0,7

* class rooms, waiting-rooms, shops, workshops, engineering rooms etc.

To estimate the number of afflicted employees, it was assumed that

1. the percentage of investigated workplaces (rooms) with higher radon concentrations can be transferred on the number of employees who are working in these rooms and
2. only about 10% of the German area have a higher radon potential and the distribution of employees is uniformly.

Outgoing from these assumptions and measured results, the information of the Statistisches Bundesamt Wiesbaden on the total number of employees in Germany (36 mill.) and on the distribution of occupation, it can be estimated that nearly 20000 up to 60000 employees are working at places of different categories with long-term radon concentrations higher than 1000 Bq/m³, recommended by the IAEA Basic Safety Standards for a chronic exposure at workplaces. This rough estimation justifies and requires a detailed investigation of the relevance of radon exposure at these types of workplaces.

APPLICATION OF AN ACTION LEVEL

The ICRP in the publication 65 as well as the IAEA in its Basic Safety Standards recommend to establish an action level for workplaces. If the long-term radon concentration exceeds the action level, remedial measures should be initiated to reduce the radon exposure.
In the international literature there was a consent to a complex evaluation of radon concentrations in institutions (schools, stores, hospitals hotels, kindergarten etc.). However, in recent British and Finnish publications the individual workplaces or kind of workplaces in an institution, respectively, are considered /3/. This objective of the analysis of radon exposures at workplaces seems to be supported by our measurements at different kinds of workplaces and determines further investigations.
According to the current standard of measuring techniques, measurements of the annual average of radon concentration at all workplaces could be done effectively only by means of

integrating methods. However, these methods imply an overestimation of the real exposure, because the measurements result in a mean radon concentration for 24 hours but the time, in which the worker is exposed, is lower - normally 8 hours. That means an unjustified high expense of remediation or number of employees to be included into a supervision.

A first investigation shows that the parameters working time, daytime and using behaviour connected with ventilation rate are the main parameters requiring the detailed study of typical workplaces. The results of radon concentration measurements at some different kinds of workplaces (schools, police stations etc.) show deviations of mean working time exposure and integrated 24 hour exposure hitherto by factors of two to five. One example is a teacher room in a primary school:

daily average (24 hours):	290 Bq/m^3
working time average (7 a.m. to 4 p.m.):	120 Bq/m^3
night time average (4 p.m. to 7 a.m.):	315 Bq/m^3

Taking into account the variation of the above mentioned parameters, it can be assumed that even factors >10 are possible caused by the individual behaviour at the workplace. Because at present only long-term integrating radon measurements are feasible for broad investigation the methods should be adopted to ensure a realistic assessment of the radon exposure at workplaces.

A classification of workplaces into groups of similar features may be useful to estimate the ratio between working time average and daily average of radon concentration. The integral measured exposure can then be adjusted to a real exposure by correction factors which are typical for these groups. Existing regulations related to dusts, vapours, chemical noxious substances and air-conditioning will be taken into account, too, and their relevance to the radiation exposure due to radon and radon decay products is investigated.

If the approach to estimate the real working time exposure due to radon by correction factors on the basis of long-term measurements for classified workplaces is unsuitably then specific measuring methods have to be developed to monitor the radon concentration during the working time for a multitude of working places.

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