Conclusion

As this paper is being written, new and improved MCS programs are being prepared, and the draft EIS is approaching a regional comment opportunity.

Since the main area of uncertainty and concern is still ventilation, Bonneville has expanded research and development efforts in this area. Of key concern is the effectiveness of various mechanical ventilation strategies as compared to natural ventilation.

Although many issues have been raised and subsequently laid to rest, we continue to struggle with new issues, related to both technical and cultural risk. As additional research will provide us a level of technical clarity never before achieved, Bonneville will assuredly still be faced with the problems of institutional positioning as we continue to address the cultural risks. Thus, our key objective to success in the future will be a continuing awareness and balanced response to both technical and cultural risks.

1. "Preliminary Formaldehyde Testing Results for RSDP", Reiland, McKinstry, Thor; Bonneville Power Administration; August 1985; p. 1.

2. "Preliminary Radon Testing Results for RSDP", Reiland, McKinstry, Thor; Bonneville Power Administration; August 1985; p. 1.

INDOOR AIR QUALITY: RADON AND FORMALDEHYDE

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Abstract

The WHO Regional Office for Europe organized a Working Group on Indoor Air Quality: Radon and Formaldehyde, held in Dubrovnik, Yugoslavia, 26-30 August 1985. With respect to indoor radon daughter concentrations (which are considerably higher than outdoors, and of the order of 2-5 Bq/m^3 equilibrium equivalent radon (EER) concentration), the Group recommended that, in general, buildings with concentrations of more than 100 Bq m^3 EER, as an annual average, should be considered for remedial action to lower such concentrations, if simple measures are possible. With respect to formaldehyde, it was recommended that an average daily indoor concentration of 0.12 mg/m^3 should not be exceeded.

Introduction

The WHO Regional Office for Europe has organized three meetings on indoor air quality since 1979 (1,2,3), and convened a fourth Working Group on radon and formaldehyde, in Dubrovnik, Yugoslavia, 26-30 August 1985. In the light of the anticipated and observed health problems caused by radon and formaldehyde, the Working Group was asked to review and evaluate the risks involved, and to recommend appropriate guidelines. The Group split into two subgroups, one for each pollutant. The subgroups discussed the current state of knowledge about radon and formaldehyde, respectively, and produced subgroup reports that were reviewed and approved by the Group as a whole, particularly with respect to conclusions and recommendations.

Radon

Much of the natural background radiation to which the general public is exposed comes from the decay of radium-226 which produces radon gas and other products. Because radium is a trace element in most rock and soil, indoor concentrations of radon can come from a wide variety of substances; for example, from building materials such as concrete or brick to the soil under building foundations. Tap water taken from wells or underground springs may be an additional source. Tests indicate that indoor concentrations of radon and its decay products are often higher than those outside. High indoor concentrations of radon are of concern due to the potential carcinogenicity of its decay products. (The United States EPA Office of Radiation Programs has estimated that current exposure to radon gas could account for a much as 10% of all lung cancer deaths in the United States).

The Working Group reached the following conclusions and recommendations:

Conclusions

1. Radon daughter concentrations in indoor environments are considerably higher than outdoor concentrations which are of the order of 2-5 Bq/m^3 equilibrium equivalent radon concentration (EER). Mean population averaged concentrations in houses have been found to range to 50 Bq/m^3 EER.

2. In any region, the range of indoor radon daughter concentrations is substantial, with an approximately log-normal distribution; a small number of buildings have values of 10 times the median concentrations or more.

3. The estimated risk of lung cancer attributable to inhaled radon daughter concentrations indoors is a significant fraction of the total lung cancer risk. It is estimated that at the observed mean levels indoors, about 10% of all lung cancer cases might be caused by radon daughters. Corresponding higher risk values should be expected in members of the public who are chronically exposed to higher indoor levels. At the high end of the concentration distribution, the risk is of the order of that caused by cigarette smoking.

4. Although radon daughter concentrations cannot be reduced to zero, it is possible to reduce them, especially the higher concentrations. In most existing buildings, the radon concentration can be reduced by a variety of measures. In new construction, this can be done even more effectively.

5. Reducing exposure to radon daughters is an effective approach to reduce lung cancer risks.

Recommendations

1. In general, buildings with radon daughter concentrations of more than 100 Bq/m^3 EER as an annual average should be considered for remedial actions to lower such concentrations, if simple measures are possible.

2. Remedial actions in buildings with a radon daughter concentration higher than 400 Bq/m^3 EER as an annual average should be considered without long delays (the total dose before remedial action should not be allowed to exceed 2000 $Bq.a/m^3$ EER).

3. Building codes should have sections designed to avoid levels exceeding 100 Bq/m^3 EER in new buildings and should prescribe appropriate practices.

4. All appropriate authorities should consider representative surveys of radon daughter concentrations in their building stock to identify areas that may have excessive levels.

5. Appropriate epidemiological studies should be conducted in regions of high and varied radon daughter concentrations, where cancer case registries can be used to estimate the relative and absolute risks of lung cancer related to different exposures. Specifically, countries in those regions, such as northern Europe, can separately or jointly perform case-control studies, with appropriate controls for age, sex, occupational exposure, site of exposure and tobacco smoking.

6. Appropriate animal and epidemiological studies are still required and should be conducted to develop exposure-response relationships.

7. Further studies should be conducted to investigate the dependence of indoor radon daughter concentrations on sources, ventilation rates and other factors to improve the basis for criteria to identify areas or houses with excessive concentrations and for measures to limit such concentrations.

8. Comparison and intercalibration exercises between organizations involved in the measurement of radon and its daughters should be organized at regular intervals.

Formaldehyde

Perhaps best known as an embalming fluid, formaldehyde is a common ingredient in foam insulation, furniture, carpets, curtains and other household items. Its most important use is as a component of resins used as bonding agents in plywood and chipboard. Formaldehyde is also a by-product of combustion (e.g. natural gas used in cooking and home heating). Formaldehyde can have effects on health ranging from acute nausea, eye irritation and respiratory impairment to more serious long-term effects (possibly including cancer). Formaldehyde levels have been measured in several energy-efficient research houses. Studies have shown that concentrations exceeded 0.14 mg/m^3 in a number of new residential buildings and mobile homes with fewer than 0.3 air change per hour. Some organizations have recently designated formaldehyde and urea formaldehyde foam insulation as priorities for study, in part due to the complaints about health-related problems. Several nations have proposed or adopted standards limiting formaldehyde concentrations in indoor air.

The working group reached the following conclusions and recommendations:

Conclusions

1. Formaldehyde concentrations in the indoor environment are many times higher than those outdoors. Average indoor concentrations from various surveys range from 0.1 to 1 mg/m^3 in prefabricated houses, and from 0.05 to 0.1 mg/m^3 in conventional buildings.

2. Formaldehyde has an initial odour threshold range of 0.06 - 0.12 mg/m^3, which is a level below which there is little or no concern about human discomfort. Formaldehyde, primarily an irritant, has been reported to cause discomfort (to eyes, nose and throat) above 0.12 mg/m^3. Irritant effects on the airways occur at 2 mg/m^3 and above. For all the above-mentioned effects, sensitive individuals may react to lower levels. Dermal sensitivity occurs and inhalation sensitivity is possible. Long-term pulmonary effects are possible at concentrations above 5 mg/m^3.

3. Formaldehyde is carcinogenic to rats at high concentrations (18.7 mg/m^3) and is a weak mutagen. Epidemiological studies do not clearly indicate carcinogenicity in humans, but because of the low power of the best studies to date, the possibility that formaldehyde is a human carcinogen cannot be excluded.

4. Feasible control measures, predominantly for products and processes, have been used to reduce indoor air concentrations of formaldehyde and have the potential to reduce concentrations further. Other control measures (sealing, ventilation, fumigation) are also being developed.

Recommendations

1. An average daily indoor concentration of 0.12 mg/m^3 should not be exceeded. At concentrations of 0.06 mg/m^3 of formaldehyde, there is little or no concern about human discomfort; at concentrations between 0.06 and 0.12 mg/m^3, some sensitive individuals may experience discomfort.

2. Building codes and product and process regulations should take into account the multitude of sources which may contribute to indoor formaldehyde levels.

3. Only analytical procedures with a detection limit well below the guideline value (preferably 1/10) should be used to determine indoor levels of formaldehyde. Sampling strategies for "normal" or average conditions should use passive or long-term active sampling. Peak values should be determined only in well-defined conditions of ventilation, temperature, relative humidity and occupancy.

4. Appropriately designed epidemiological studies of children and exposed adults should be performed to evaluate the effects on health of indoor exposure; health effects of concern are allergies, changes of haematological and immunological parameters, pulmonary function, and physical and mental development in children. Measurements should be made of formaldehyde and other important pollutants, especially NO_2, respiratory particles and aero-allergens.

5. Further studies should be conducted to investigate the mechanisms of carcinogenicity induced by formaldehyde.

6. Further studies (both short-term and long-term) should be conducted to investigate the effects of combined exposure to formaldehyde and other pollutants present in indoor air, such as particles and fibres.

7. Information should be made available to the public about the importance of sources of formaldehyde and their occurrence, as well as the possible contribution of tobacco smoke.

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