ENVIRONMENTAL PROTECTION DEPARTMENT

PRACTICE NOTE FOR PROFESSIONAL PERSONS

Control of Radon Concentration in New Buildings

Introduction

Radon is a colourless and odourless radioactive gas. It occurs naturally as a decay product of radium. Present in most soil and rocks, granite in particular, it decays further into a series of short-lived radioisotopes that take the form of very tiny particles. Epidemiological studies show that exposure to radon or its decay products may increase the incidence of lung cancer.

2. Granite is widely used in concrete for buildings in Hong Kong. Radon gas would enter a building from the granites in the concrete walls and floors, or from the underlying soil through cracks and openings in the basement or the ground. If the ventilation of the building is poor, then radon could accumulate to excessive levels. New buildings have a higher chance of a radon problem because their windows are more air tight than older buildings.

3. This Practice Note provides guidance to the professional persons on the reduction of non-occupational radon exposure in new buildings and sets out:

(i) the radon concentration limit for protection of the public health;
(ii) factors to be considered for the design of new ventilation systems and buildings and mitigation measures; and
(iii) the measurement protocols in the Appendices.

Some mitigation measures and the measurement protocols described in this Practice Note are also relevant to managing radon levels in existing buildings.

4. Please also note that this Practice Note mainly concerns the protection of building occupants from excessive radon exposure. For the health protection of employees at work and the related regulation requirement, please consult the Occupational Safety and Health Branch of the Labour Department.

Indoor Radon Standard

5. The World Health Organisation has recommended an annual average concentration of 200 becquerels per cubic metre (Bq/m^3) or 5.4 picocuries per litre (pCi/L) as the radon limit indoors.

6. In a territory-wide survey by the Environmental Protection Department in 1992/93, the average indoor radon concentration in Hong Kong measured was about 100 Bq/m^3. Recognising there is no known health threshold for radon, professional persons responsible for the design, construction, or management of ventilation systems and buildings should aim to keep the radon levels in a building to a minimum, and not to exceed an annual average concentration of 100 Bq/m^3.

Mitigation of Radon Concentration

7. In designing new premises or in managing radon levels in existing buildings, professional persons should endeavour to implement the following mitigation measures:

(i) Cracks in floor and walls in the basement or ground level should be sealed to stop infiltration of radon gas from the rocks and soil underlying and surrounding the building foundation. For the same reason, service pipes and entries in the basement or ground level should have airtight seals constructed around them.

(ii) Bare concrete or brick walls and ceiling slabs should be covered with less permeable wall covering such as polyurethane paint, tiles or wall paper. Floor slabs should be covered with less permeable floor covering such as mosaic tiles or wooden floor strips with polyurethane paint finish.

(iii) The use of bare granite or granite containing products should be minimised as far as possible.

8. Dilution by outdoor fresh air is an effective means to achieve acceptable radon concentration indoors. Professional persons should make every attempt to ensure the premises have adequate ventilation by natural or mechanical means, or both. Some important factors to be considered in designing ventilation systems are:

(i) the ventilation system should be so designed to achieve even dilution and removal of radon gas from the premises including common areas;

(ii) the indoor supply air grill of the system should be so located to avoid short circuiting with the return or exhaust grills of the system itself;

(iii) the outside air intake of the system should be so located to avoid short circuiting with exhaust outlets of the building itself, or those of neighbouring buildings;

(iv) any room in a building without natural ventilation should be provided with positive ventilation, and such ventilation should be put in operation whenever there is one or more occupants in the room; and

(v) where natural ventilation is the main provision for a building, the ventilation arrangement should be of a cross and sweep through design so as to avoid radon accumulation.

Professional persons should make reference to relevant international standards including the ASHRAE 62-1989 where useful guidelines are provided.

Supervision and Maintenance

9. Supervision of the operation and preventive maintenance of the ventilation systems is crucial to ensuring that the systems are performing as designed, and that the upkeep of building work is to a high standard. Cracks in the foundation floor and walls should be regularly checked for proper sealing, and the interior surface covering should be adequately maintained. A management plan on radon for the ventilation systems and the building should be devised and fully implemented.

Radon Measurement

10. Prior to the occupation of new premises, the property developer should arrange to measure the radon concentration level by professional persons to confirm that the radon level complies with the guideline value. If it does not, mitigation measures should be taken to reduce the radon level. Appendices 1 and 2 set out the protocols for measuring radon for residential and for non-residential buildings.

Enquiries

11. Officers in the Air Services Group of the Environmental Protection Department are glad to answer any questions on the control of indoor radon concentration level in buildings. Please call the Senior Environmental Protection Officer, Air Services Group, Environmental Protection Department (Tel : 2594 6412, Fax : 2827 8040) for enquiries.

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Appendix 1

Protocol for Radon Measurement for Residential Building

A. Selection of Potential Study Tiles

1. The Study Area can be interpreted as either a residential building block or phase(s) of a residential development. Each flat unit in the Study Area is taken as one Potential Study Tile (**PST**).

2. To number the PST, start with the northernmost PST on the lowest floor of the first building block and label it as PST No.1. In a clockwise manner, assign the adjacent PST as PST No.2 and so on until all the PSTs on the lowest floor have been properly numbered. Move on to the next upper floor and continue to assign the northernmost PST sequentially with the next higher integer and so on until all the PSTs in the building block have been numbered. Repeat these steps for the second building block and so on, starting with the next higher integer.

3. Radon measurement shall be taken in 5% of the labelled PSTs, or 3 numbers, whichever is more. Any decimals will be rounded up to the next higher integer in determining the number of PSTs to be measured.

4. Randomly select a number from the total number of labelled PSTs of the building block(s). Select those PSTs to receive radon measurement by spreading out evenly the number based on the one worked out in paragraph 3 above.

5. Take radon measurement according to the Measurement Protocol and Measurement Criteria as set out below.

6. Should any of the selected PST, say the n^{th} PST, be found not suitable for measurement, a replacement should be used by trying the $(n-1)^{th}$, $(n+1)^{th}$, $(n-2)^{th}$, $(n+2)^{th}$ and so on until a suitable PST is identified.

B. Measurement Protocol

1. The PST to be measured should be maintained at 1.5 to 2 air changes per hour (ACH) for a period of 24 hours prior to and during the radon measurement.[(1)]

2. The PST should be kept clean and dry throughout the measurement period. One radon monitor should be positioned in each of the selected PSTs according to the Measurement Criteria given below.

3. Electronic real-time radon monitors complying with the competence test of the US Environmental Protection Agency or equivalent are to be used for the measurement. The radon monitor should be calibrated and operated in accordance with the manufacturer's recommendation.

4. The duration for any of the measurement should be 48 hours continuously. Each reading should be averaged over a 30-minute interval.

5. The average radon concentration of the selected PSTs during the measurement period should preferably be lower than the territory-wide mean concentration of 100 Bq/m^3 and in any case, any individual measurement must not exceed 200 Bq/m^3.

C. Measurement Criteria

1. The location of the radon monitor should be:

- more than 0.9m from any corner, window, wall, partition or other vertical surface; and
- at a height of approximately 1.1m above the floor.

2. The radon monitor should not be:

- directly under any air diffuser or in front of any electric fan and heater, etc.;
- affected directly by the draft of exhaust fan/air conditioning unit;
- under direct sunlight; and
- obstructive to the traffic of users of the premises under normal or emergency situation.

D. Report and Documentation

1. The radon measurement should be conducted under the supervision of a recognised professional in related fields.

2. All measurement report and documentation should be certified by the professional.

3. A full set of the measurement report and documentation including radon monitor calibration records should be kept for a period of three years from the completion of the measurement.

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(1) An air change rate of 1.5 to 2 ACH is deemed to have been achieved when exhaust fan(s) of suitable capacity is installed and operated in a closed environment in the PST. The number of exhaust fan to be used would base on the capacity of the individual fan(s) and the total air volume of the PST. Flexible air ducts should be installed if necessary to ensure even air extraction throughout the PST.
An air change rate in an apartment with all the windows closed and the room air-conditioner(s) operating at high fan with the vent closed would be approximately in the range of 1.5 to 2 ACH.
Source : 'Study of Effectiveness of Various Finish Materials in Reducing the Indoor Radon Level' by the Hong Kong Polytechnic University 1995.

Protocol for Radon Measurement for Non-Residential Building

A. Selection of Potential Study Tiles

1. The Study Area should include all confined areas inside the building but exclude areas where full-time occupancy is not anticipated eg. public hallway, car park, storage area, stairwell, lift lobby, washroom, machine room, utility space and access, etc.

2. To establish the Potential Study Tiles (**PST**), divide the Study Area into square tiles of 5mx5m each as far as possible. Irregular-shaped areas should be divided into smaller portions of 25 sq.m. each while any odd area of less than 25 sq.m. should be considered as one PST.

3. To number the PST, start with the PST at the northernmost corner of the lowest floor of the building and label it as PST No.1. In a clockwise and a general inward spiral direction, assign the PSTs sequentially until all the PSTs on the lowest floor have been properly numbered. Move on to the next upper floor and assign the PST at the northernmost corner with the next higher integer and so on until all the PSTs in the building block have been numbered. Repeat these steps for the second building and so on, starting with the next higher integer.

4. Radon measurement shall be taken in 5% of the labelled PSTs, or 3 numbers, whichever is more. Any decimals will be rounded up to the next higher integer in determining the number of PSTs to be measured.

5. Randomly select a number from the total number of labelled PSTs of the building block(s). Select those PSTs to receive radon measurement by spreading out evenly the number based on the one worked out in paragraph 4 above.

6. Take radon measurement according to the Measurement Protocol and Measurement Criteria as set out below.

7. Should any of the selected PST, say the n^{th} PST, be found not suitable for measurement, a replacement should be used by trying the $(n-1)^{th}$, $(n+1)^{th}$, $(n-2)^{th}$, $(n+2)^{th}$ and so on until a suitable PST is identified.

B. Measurement Protocol

1. a) For premises with mechanical outside air supply system

   The mechanical outside air supply system (and other related Mechanical Ventilation & Air Conditioning System) covering the selected PST to receive radon measurement should be operated at the design conditions, including design outside air flow rate, on a normal operating schedule for 24 hours prior to and during the measurement.

b) For other premises

The PST to be measured should be maintained at 1.5 to 2 air changes per hour (ACH) for a period of 24 hours prior to and during the measurement.[(1)]

2. The PST should be kept clean and dry throughout the measurement period. One radon monitor should be positioned in each of the selected PSTs according to the Measurement Criteria given below.

3. Electronic real-time radon monitors complying with the competence test of the US Environmental Protection Agency or equivalent are to be used for the measurement. The radon monitor should be calibrated and operated in accordance with the manufacturer's recommendation.

4. The duration for any of the measurement should be 48 hours continuously. Each reading should be averaged over a 30-minute interval.

5. The average radon concentration of the selected PSTs during the measurement period should preferably be lower than the territory-wide mean concentration of 100 Bq/m^3 and in any case, any individual measurement must not exceed 200 Bq/m^3.

C. Measurement Criteria

1. The location of the radon monitor should be:

- more than 0.9m from any corner, window, wall, partition or other vertical surface; and
- at a height of approximately 1.1m above the floor.

2. The radon monitor should not be:

- directly under any air diffuser or in front of any electric fan and heater, etc.;
- affected directly by the draft of exhaust fan/air conditioning unit;
- under direct sunlight;
- within 1m from any polluting source such as photocopier and printer; and
- obstructive to the traffic of users of the premises under normal or emergency situation.

D. Report and Documentation

1. The radon measurement should be conducted under the supervision of a recognised professional in related fields.

2. All measurement report and documentation should be certified by the professional.

3. A full set of the measurement report and documentation including radon monitor calibration records should be kept for a period of three years from the completion of the measurement.

(1) An air change rate of 1.5 to 2 ACH is deemed to have been achieved when exhaust fan(s) of suitable capacity is installed and operated in a closed environment in the PST. The number of exhaust fan to be used would base on the capacity of the individual fan(s) and the total air volume of the PST. Flexible air ducts should be installed if necessary to ensure even air extraction throughout the PST.

An air change rate in an apartment with all the windows closed and the room air-conditioner(s) operating at high fan with the vent closed would be approximately in the range of 1.5 to 2 ACH.

Source : 'Study of Effectiveness of Various Finish Materials in Reducing the Indoor Radon Level' by the Hong Kong Polytechnic University 1995.