Radon in Underground Workplaces
GUIDANCE NOTES FOR EMPLOYERS
Guidance Notes

To Provide Advice To Employers On Issues That Need To Be Considered Regarding Underground Workplaces

Radiological Protection Institute of Ireland
3 Clonskeagh Square,
Dublin 14

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What are these guidance notes?

Radon in workplaces can be a significant source of exposure to natural radiation. In May 2000, legislation[^1] (henceforth referred to as SI 125) was introduced to limit the exposure of workers in Ireland to radon. This legislation is enforced by the Radiological Protection Institute of Ireland (henceforth referred to as the RPII).

The legislation specifies a Reference Level for radon in workplaces of 400 becquerels per cubic metre (Bq/m³) averaged over a minimum period of three months. It has been known for many years that radon is a potential hazard in underground workplaces such as caves and mines where radon concentrations in excess of this Reference Level are commonly found. In these situations, employers are required to take measures to protect workers. These guidance notes provide advice on the issues that need to be considered by employers in protecting workers and in demonstrating good practice in this regard.

The adoption of an approach other than that outlined in this document is not precluded provided that account is taken of the relevant requirements of the legislation, particularly the requirement to keep radiation exposure from radon as low as reasonably achievable.

Is there a requirement to assess the level of radon in show caves and mines?

Under the Safety, Health and Welfare at Work Act 2005 every employer has a general duty to ensure, so far as is reasonably practicable, the safety and the prevention of risk to health at work of his employees relating to the exposure to ionising radiation. Additionally, SI 125 requires employers to measure radon gas concentrations in workplaces, on being directed to do so by the RPII. In the case of an employer who operates an underground workplace, the areas to be measured for radon include the underground work areas and work areas located above ground such as workshops, warehouses, offices, shops, etc. If the radon gas concentration at any of the measurement locations in the show cave is greater than 400 Bq/m³, then the Reference Level is exceeded and further action will be needed to protect the health of workers. If the workplace has radon concentrations below the Reference Level, no further action is required.

Where should radon measurements be made?

The primary purpose of the survey is to assess the level of radon to which workers are liable to be exposed. Measurements, therefore, should be made at locations which are representative of actual or reasonably foreseeable worker occupancy. When surveying a show cave, measurements should be made at each tour stop. When surveying a mine, measurements should be made at several locations underground where miners work. When surveying above ground workplaces, employers should follow the RPII guidance document “Planning Radon Surveys in Workplaces” which is available on the RPII’s website [www.rpii.ie](http://www.rpii.ie).

In order to determine if the radon gas concentration in a workplace exceeds the Reference Level, it is necessary to measure the average concentration over a minimum period of three months. Measurement over this time period is necessary as radon can vary considerably from day to day depending on factors such as building usage, ventilation rates and the prevailing weather. For such measurements, the use of passive detectors such as CR-39 is generally the most cost effective and the most straightforward approach. These detectors are small, unobtrusive and harmless. It is necessary to use an approved radon measurement laboratory to carry out radon measurements in workplaces. (A list of approved radon measurement laboratories is given on the RPII’s website www.rpii.ie).

What is required if the measured radon concentrations are above 400 Bq/m³?
Where the Reference Level is exceeded, the employer must notify the RPII using the standard “Notification of Work Activity Form”, which is available from the RPII’s website.

For all workplaces, the preferred and simplest course of action in all cases is to carry out remedial work to reduce radon concentrations to below 400 Bq/m³.

However, an employer may choose to carry out an evaluation to determine if remedial measures to reduce the radon concentration are justified. For those aboveground locations, the evaluation should follow the RPII’s “Guidance Notes on Actions an Employer May Take if High Radon Concentrations are Found in an Aboveground Workplace”, which is available on the RPII’s website. For many types of underground workplaces it may not be feasible to carry out remedial work to reduce the radon concentrations. For example, in show caves the remedial work may destroy the geological feature that is the attraction of the cave. In mines, ores are continuously being excavated and this may be opening up new entry routes for radon. In addition, a wide range of radon concentrations can be found in different work areas underground. In light of this variation in radon concentrations, the radon hazard is best assessed by arranging personal monitoring for underground workers.

Initially this programme of personal monitoring should be carried out for a period of 12 calendar months. All workers who routinely work in those underground areas with high radon concentrations should be included in this programme.

How is personal radon monitoring used to assess the radon exposure to workers?
Personal monitoring for underground workers is carried out by providing each worker with a radon detector which is worn during the working hours. Workers (miners, guides, service personnel, etc.) who routinely work underground should be so monitored. The radon detectors are removed when staff are not in work. When not in use it is important that the detectors are stored in conditions agreed with the approved radon measurement laboratory.
At what level of radon exposure is further action necessary?

The hazard to a worker from radon is governed by the amount of time the worker spends in a particular radon concentration - in the words the exposure of that worker to radon. The radon exposure of a worker is found by multiplying the radon concentration, measured in Bq/m³ of each area that the worker occupies, by the number of hours per year spent in each area. Where personal monitoring indicates that an individual worker receives or is likely to receive a radon exposure of greater than 800 kilobecquerels per cubic metre hours (kBq/m³h) in any 12 month period then an ongoing programme of personal monitoring should be put in place. This monitoring should be continued until the highest individual exposures to radon are below this level.

Where reduction in radon exposure cannot be reasonably achieved by other means it is recommended to limit the hours spent underground so as to ensure that no worker receives an annual exposure greater than 1600 kBq/m³h. For the purpose of radon in underground workplaces, a radon exposure of 1600 kBq/m³h is interpreted as being equivalent to a dose of 6 millisieverts (mSv). SI 125 require workers who are liable to receive an annual dose greater than 6 mSv to be designated as Category A workers and therefore be subject to medical surveillance by an approved medical practitioner.

SI 125 sets an annual dose limit for workers of 20 mSv in any 12 month period. In terms of radon exposure in underground workplaces this equates to a radon exposure of 5000 kBq/m³h. When a worker reaches this dose limit all underground work activity should cease and the worker should be re-rostered.

It is recommended that cave employers with underground workplaces ensure that the radon exposure to any worker under the age of 18 years does not exceed 800 kBq/m³h in any 12 month period.

The above guidelines represent minimum radiation protection standards that should apply to underground workers. In all circumstances the dose from radon exposure should be kept as low as reasonably achievable.

What information should be provided to workers?

Where radon concentrations in any workplace are found to exceed the Reference Level, the employer must provide their workers with basic information on radon and on the health risks associated with exposure to radon. This must include information on:

- legal requirements on employers with regard to radon in the workplace,
- the results of any personal monitoring that has been carried out,
- the health risks associated with exposure to radon,
- any site specific measures to control occupational exposure (including monitoring, of areas, limitation of hours underground, etc.).

The results of all workplace measurements must be made available to the workers concerned without delay.
What records must be maintained?

**Records of personal radon monitoring**

For each worker who has been personally monitored, the employer must maintain records of the radon exposure at the end of each measurement interval. In addition, records of the cumulative radon exposure, that is, the radon exposure measured over a 12 month period, should be kept. Such records must be maintained for at least 5 years from the date on which the measurement was made.

Where the radon exposure to any worker exceeds 1600 kBq/m³h (Category A worker), in any 12 month period, then the relevant exposure and medical surveillance records must be maintained until the individual reaches, or would have reached, the age of 75 years or until 50 years from when that individual ceases to do the work in question if this is longer.

Personal radon exposure records must be made available to the workers concerned without delay. All personal radon exposure records must be made available to an RPII Inspector, if requested.
Approved Medical Practitioner means a registered medical practitioner (medical doctor) who is appointed to carry out medical surveillance by an employer in accordance with Article 25 (2) of SI 125.

Approved Radon Measurement Laboratory This is a laboratory that is approved under Article 24(1) of SI 125 to carry out radon measurements including the measurement of radon concentration in air or the assessments of radiation doses due to radon.

Radon Radon-222 gas, commonly called radon, is a naturally occurring radioactive gas. It is colourless, odourless and tasteless and can only be measured with special equipment. It is formed in the ground from the radioactive decay of uranium, which is present in small quantities in all rocks and soils. Because it is an inert gas, it can move freely through gaps or cracks in bedrock and soils. Radon which reaches the open air is rapidly diluted to harmless concentrations, but underground where radon is prevented from easily escaping it can build up to high concentrations.

Radon, which is soluble in water, can travel in water some distance from where it originated. In this context, fissure water can act as an entry route for radon particularly in those underground locations receiving large volumes of fissure water.

Radon decays to form other radioactive particles (called radon progeny) that are suspended in the air. (The term “radon” is used as convenient shorthand for the gas and its progeny). These particles, once inhaled, can irradiate lung tissue and this may eventually lead to lung cancer. After tobacco smoking, radon is the most significant cause of lung cancer. In Ireland, it is estimated that some 200 lung cancer deaths can be linked to radon.

Category A Worker The legislation classifies a worker who is liable to receive a dose greater than 6 mSv per year as a Category A worker. As these workers are at increased risk, additional protection is required. For example, Category A workers are subject to ongoing personnel monitoring and routine medical surveillance. The specific requirements for Category A workers are set out in articles 25, 26 and 27 of SI 125. In terms of radon exposure a Category A worker is one who is exposed to greater than 1600 kBq/m³h of radon.

Cumulative radon exposure means the radon exposure summed over a 12 month period.

Dose Limit The dose limit for workers is 20 mSv in any 12 month period.

Natural Radiation means radiation originating from sources which occur naturally in the environment. In the context of radon the source is uranium, which is naturally occurring and found in various amounts in all rocks and soils.

Radon Concentration This is the amount of radon gas per unit volume of air. The unit of radioactivity is called the becquerel (Bq), with the activity concentration given in becquerels per cubic metre (Bq/m³). A becquerel is equal to one nuclear disintegration per second.
Radon Exposure Radon exposure of a particular worker is determined by multiplying the radon concentration, measured in Bq/m³ of each area that a worker occupies by the number of hours per year spent in each area. The unit of radon exposure is kilobecquerels per cubic metre hours (kBq/m³h). The radon exposure of an employee who works for 2000 hours per year in an area where the radon concentration is 400 Bq/m³ is 800 kBq/m³h.

Normally, the employer supplies to the Approved Radon Measurement Laboratory (ARML) the number hours each monitored worker spends underground. The ARML analyses the worker’s personal radon detector to determine the radon concentration. By combining this figure with the number of hours worked the ARML can report the radon exposure of each worker monitored.

Radiation Dose The unit of radiation dose is called the Sievert. The radiation dose from radon is usually quoted in millisieverts (mSv). There are one thousand millisieverts equals in a sievert.

Divisions of the Sievert are commonly used. One sievert (Sv) = 1,000 millisieverts (mSv).

Reference Level This is a concentration of radon above which action to reduce the radon levels is likely to be needed. In Ireland, the Reference Level for radon in workplaces as specified in legislation is 400 Bq/m³ averaged over any three month period.

Registered Medical Practitioner means a person whose name is entered on the General Register of Medical Practitioners established under section 26 of the Medical Practitioners Act, 1978.
Mission Statement

“In the three year period from 2008 to 2010 the RPII will grow the level of awareness and implementation of the measures needed to protect people in Ireland from the harmful effects of ionising (and non-ionising) radiation through scientifically based regulation, monitoring and advice.”

Contact us

Radiological Protection Institute of Ireland (RPII)
3 Clonskeagh Square
Dublin 14,
Ireland
Tel: +353 1 2697766
Fax: +353 1 2697437
Email: rpii@rpii.ie
Web: www.rpii.ie