Radon

Measurement and evaluation

Baden-Württemberg
MINISTERIUM FÜR UMWELT, NATURSCHUTZ UND VERKEHR

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Properties, occurrence and effect of radon

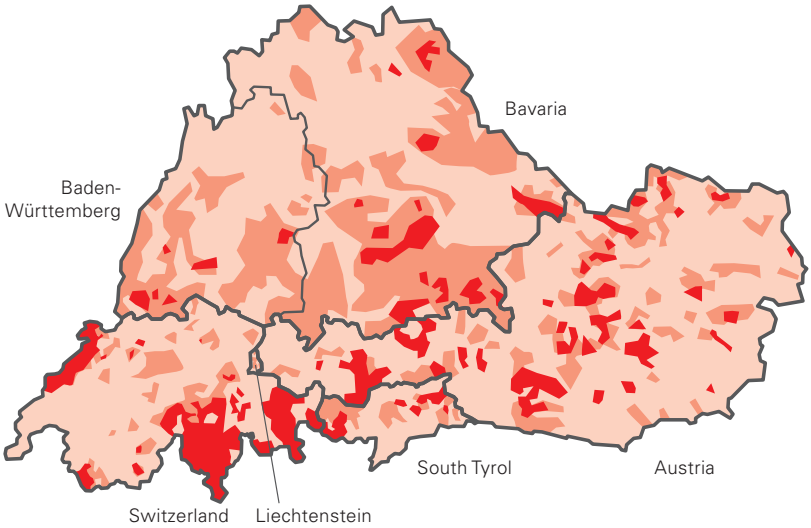
Properties and occurrence

Radon is a natural, ubiquitous radioactive noble gas that is colourless, odourless and tasteless. It is a decay product of the radioactive heavy metal uranium, which is found in soil and rocks. Radon can escape relatively easily from soil and rocks, from where it spreads through gas in the soil or in dissolved form in water. In the process it can also penetrate the air inside buildings.

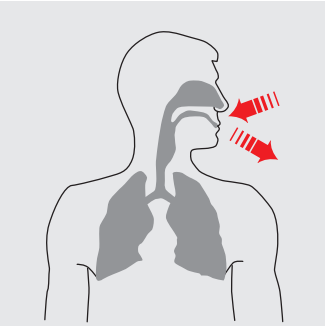
The radon potential maps and radon risk maps that have been produced for some countries will give you initial information about the likelihood of elevated radon concentrations being present inside buildings in your region.

The illustration below is a greatly simplified representation of the radon risk regions in Austria, southern Germany, South Tyrol, Liechtenstein and Switzerland.

Radon risk
low
elevated



More detailed information about radon can be found on the websites hosted in the individual countries. The relevant internet addresses are given on the back of this brochure.



Effect on health

Radon and its decay products are the second most common cause (approx. 10%) of lung cancer after smoking (approx. 85%).

Most of the radon gas inhaled in air is exhaled again straight away. The biggest risk to health is therefore not the radioactive noble gas radon itself, but its short-lived decay products – which are also radioactive heavy metals. The free decay products in the air inside rooms attach to particles floating in the air (aerosols).

When a person breathes in, the free decay products and aerosols are deposited in the lungs. Once inside the lungs, they emit ionising radiation which can damage the lung tissue in the immediate vicinity and can ultimately cause lung cancer.

Guideline and limit values

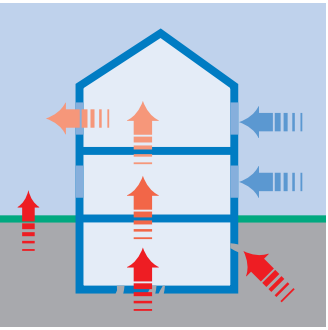
The following table shows the guideline and limit values currently in force for annual mean radon concentrations inside inhabited rooms in the various countries.

Country	Guideline values		Limit values
	New buildings	Existing buildings	
Baden-Württemberg Bavaria	250 Bq/m³	250 Bq/m³	—
Austria	200 Bq/m³	400 Bq/m³	—
Switzerland	400 Bq/m³	400 Bq/m³	1000 Bq/m³
South Tyrol	200 Bq/m³	400 Bq/m³	500 Bq/m³ (for workplaces)

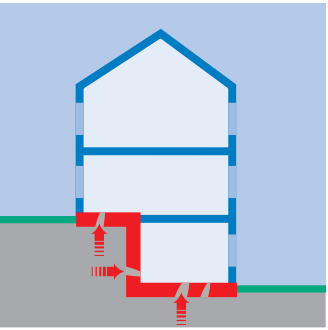
Annual mean radon concentrations normally range from 50 to 500 Becquerel per cubic metre (Bq/m³) of air. However, concentrations may reach several thousand Bq/m³, especially in regions where the radon risk is high.

Factors affecting the radon concentration inside rooms

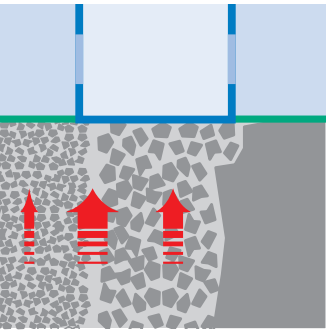
The radon concentration in the air inside rooms depends on a number of factors:



Air renewal in the building
The rate at which the air inside rooms is exchanged for outside air has a major effect on the radon concentration in rooms. Windows and doors which are not air-tight lead to a greater rate of air renewal. If air renewal is reduced, however – for example by fitting windows and doors which shut tightly – the concentration of radon in the room air may increase substantially.



The condition of the building
The fundamental issue is the permeability of the building to gas in the soil around the foundations and in walls which are in contact with the soil. Gas can penetrate through cracks and gaps and along wire and pipe conduits. Radon-containing soil gas is sucked into the building by the low-pressure zone that develops inside the building (chimney effect as a result of temperature differences between room air and external air, and due to wind pressure) – see illustration at top left.
If the basement or other soil-contacting parts of the building are open to higher storeys, this makes it particularly easy for radon to spread upwards.



Type of ground beneath the building
Apart from the composition of the soil and rock (uranium, radium content), other characteristics which play an important role are the particle size of the rock (which determines its ability to emit radon into the soil gas) and the permeability of the subsoil (which determines how the radon-containing soil gas is transported).
Particular caution is required in buildings constructed on scree or other slopes, weathered granite, karst or gravelly soils. Very compact soils and clay soils require less caution.

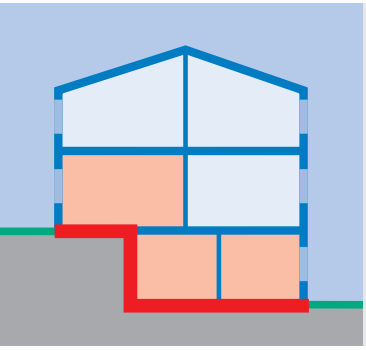
When are radon measurements required?

The concentration of the noble gas radon in interior rooms can be measured in a simple manner using specialised measuring devices. Studies have shown that the annual average value for radon in a building depends principally on the construction design (design of the foundations, basement, tightness of the building) and on the occupiers' habits (ventilation). Consequently, even neighbouring dwellings often have very different radon concentrations.

You can only be certain about the radon concentration in your building by measuring it. Consequently, radon measurements are recommended for dwellings with inhabited rooms that are in contact with the soil (for example locations on a slope, houses without a basement resp. with an inhabited basement), or in buildings that are located in regions where the radon risk is high.

If structural alteration work is planned for floors and walls in inhabited rooms in contact with the soil, for example when upgrading insulation or adding extensions, then radon protection measures can be significantly cheaper and more effectively planned and carried out than afterwards. In these cases a measurement is therefore recommended.

It is also preferable to be aware of the radon concentration when buying a property.



Becquerel per cubic metre (Bq/m³)

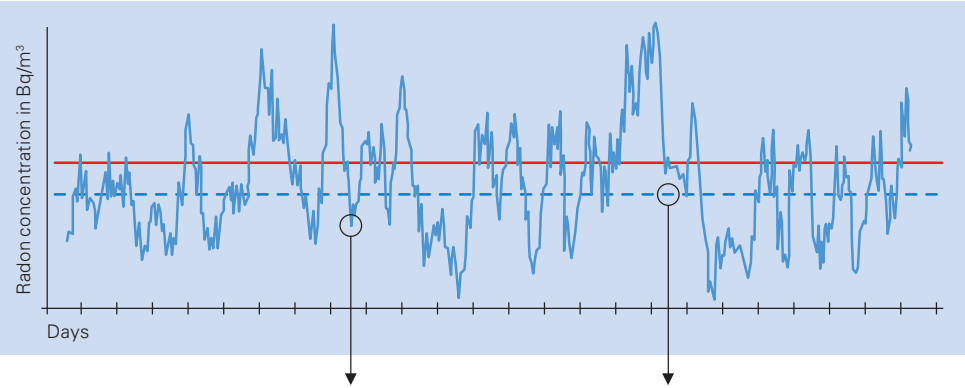
The radon concentration is measured in Becquerel per cubic metre (Bq/m³). 400 Bq/m³ means that in a volume of one cubic metre of air, 400 radon atom nuclei disintegrate per second emitting ionising radiation.

- Areas with soil contact
- Inhabited rooms with soil contact

Fluctuations of the radon concentration in residential buildings

The radon concentration in buildings usually fluctuates considerably depending on the time and the place measured (see chart). There are many reasons for this which are significant when planning measurements and interpreting the results.

Fluctuations occur depending on the time of day and the time of year as a function of the weather. They are principally caused by the chimney effect in the house (already mentioned on page 4), i.e. when considerable temperature differences exist between the interior air and the external air. The occupiers' habits (ventilation, heating etc.) intensify these fluctuations even more. In addition, the differing utilisation of rooms, the distribution of radon entry points and air exchange contribute to considerable variations in the radon concentration in the rooms. In general, the radon concentration is lower in upper floors.



— Example of the evolution of radon in a living room

— Guideline value

- - Average value in the living room

Measuring device for the radon evolution

Detectors for average values

Measurements of comparison with guideline and limit values

Measurements of comparison with guideline and limit values in interior rooms can be carried out in an easy, reliable and cost-efficient manner by recognised (or accredited) measuring services.

Guideline values and – when available – limit values are listed as the annual average values for apartments in normal use (see table on page 3). The best solution would be to carry out measurements over a year in all inhabited rooms. However, this would incur high costs and a long wait for the results. Consequently, in practice, a compromise is made between efficiency and speed.

This leads to the following requirements for a measurement:
Measurement duration: at least three months
Measurement period: at least half of the measurement period in the winter months (15 October to 15 April)
Measurement points: rooms with the longest occupancy (at least two separate rooms); preferably those with soil contact

In unfrequented or only occasionally frequented apartments (for example in weekend homes) measurements of comparison with guideline and limit values are not meaningful. If needed, in consultation with a radon consultant, measurements that are matched to individual conditions can be carried out.

Remark: National regulations can place stricter requirements for the measurement. Thus, in Italy for example, a year-long measurement is required in half of the inhabited rooms that are in contact with the soil (and must include at least two inhabited rooms), usually divided into two half year measurements (summer half year and winter half year).

The measuring practice can be reduced for reasons of cost-effectiveness when conducting measuring campaigns on a large scale. In Switzerland for example, a winter measurement with a seasonal correction is carried out in the lowest inhabited or heated room.

Carrying out the measurement

Measurements are generally carried out with passive detectors. Care should be taken that the devices only measure radon. So-called "open" detectors are not suitable for this. Passive detectors are small, handy and are sent by post. They are very simple to operate. The detectors do not emit any radiation and are nontoxic. Measurement costs range from 50 to 150 Euros per apartment.
For setting up the detector in the room, an unobstructed place is to be chosen that

- is away from doors and windows and out of a draught
- is not placed next to the wall (gap of at least 10 cm)
- is not strongly heated (for example by direct sunlight or heating)
- is positioned at about breathing height
- cannot be reached by children or pets
- is not subject to condensation/moisture

Furthermore, the detector has to remain in the same place for the total period of the measurement. During the measurement the apartment should be lived in as normal.
More information with regard to measuring services can be obtained from the institutions listed overleaf.

Detectors for determining the radon concentration.

Measurements for planning and controlling a mitigation

The radon emission concentration over time should be known in order to plan a radon measurement. Measurements, in which several measuring devices are used at the same time in different rooms, provide the best information. However, it is also possible to measure several rooms one after the other with a single measuring device. This allows radon entry points and propagation paths to be better isolated and enables a better assessment of the effects of the occupiers' habits or of the efficiency of provisional measures.

A direct check of the efficiency of mitigation measures is also made with time-integrated measurements or with simple electronic measuring devices.

A certain degree of experience is required for carrying out the measurements and assessing the results. More information can be obtained from the institutions listed overleaf in this brochure.

Once the mitigation has been finished then a measurement of comparison with the guideline and limit values should be carried out by an independent measuring service (see page 7). This type of measurement should be repeated regularly (every five to ten years, depending on the radon concentration before mitigation).

Measuring devices for checking the efficiency of mitigation measures.

Indicative measurements

An indicative measurement is a rapid method, employed under time constraints – for example when selling a property or before imminent extension work. It serves primarily for the estimation of a possible radon contamination in a residential building. The measurement strategy and the evaluation of the measurement results are to be carried out by a radon consultant.

As indicative measurements allow conclusions on the annual average value to be drawn only with difficulty, it is recommended, when possible, to carry out a measurement of comparison with the guideline and limit values (see page 7).

Recommended measurement methods

A time-integrated measurement should be made over a week:

- 6 days in various inhabited rooms (for example bedrooms, children´s rooms or the living room and recreational rooms), preferably in contact with the soil; measurement period at least 1 day/room
- 1 additional day in an uninhabited room in contact with the soil, if present, and with the highest expected radon concentration (cellar, laundry room etc.), otherwise in the bathroom.

As the radon concentration is substantially influenced by the occupants' habits (ventilation) and by the weather, then for indicative measurements one should

- thoroughly ventilate prior to the measurement
- ventilate as little as possible during the measurement
- ensure that interior doors are closed during the measurement
- ensure that the building is inhabited or at least heated

Radon measurements in the soil air

In principle, the radon concentration can also be measured in the soil air. It is determined mainly for identifying radon risk areas and for other scientific purposes. In construction practice, however, a soil air measurement is very complicated, costly and not sufficiently meaningful.

Therefore, for new buildings, preventive measures are to be carried out according to the brochure "Radon - Precautions for new buildings" without any prior soil air measurement in the building site.

Facts and notes

- Radon is the second most common cause of lung cancer after smoking
- The only way to be sure about the radon concentration in a building is by measuring it
- Measurements of comparison with the guideline and limit values can be carried out in an easy, reliable and cheap manner
- Radon measurements are particularly important in areas of risk
- Recognised measuring services provide reliable measurements

Preventive measures in new buildings are more reliable and cheaper than radon measurements in the soil air

Information about radon

Brochures in this series

- Radon – Precautions for new buildings
- Radon – Measurement and evaluation
- Radon – Mitigation measures in existing buildings
- Radon – The effect of retrofitting thermal insulation

On the internet

Germany: www.bfs.de (search for *Radon*)

- Baden-Württemberg: www.uvm.baden-wuerttemberg.de (search for *Radon*)
- Bavaria: www.lfu.bayern.de (search for *Radon*)

Austria: www.radon.gv.at

- Upper Austria: www.land-oberoesterreich.gv.at/Thema/Radon

Switzerland and Liechtenstein: www.ch-radon.ch

South Tyrol: www.provinz.bz.it/umweltagentur (search for *Radon*)

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