Radon

Measurement and Evaluation

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

Bavarian Environment Agency

UPPER AUSTRIA

AGES

AUTONOME PROVINZ BOZEN - SÜDTIROL
Landesagentur für Umwelt

PROVINCIA AUTONOMA DI BOLZANO - ALTO ADIGE
Agenzia provinciale per l'ambiente

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement des Innern EDI
Bundesamt für Gesundheit BAG

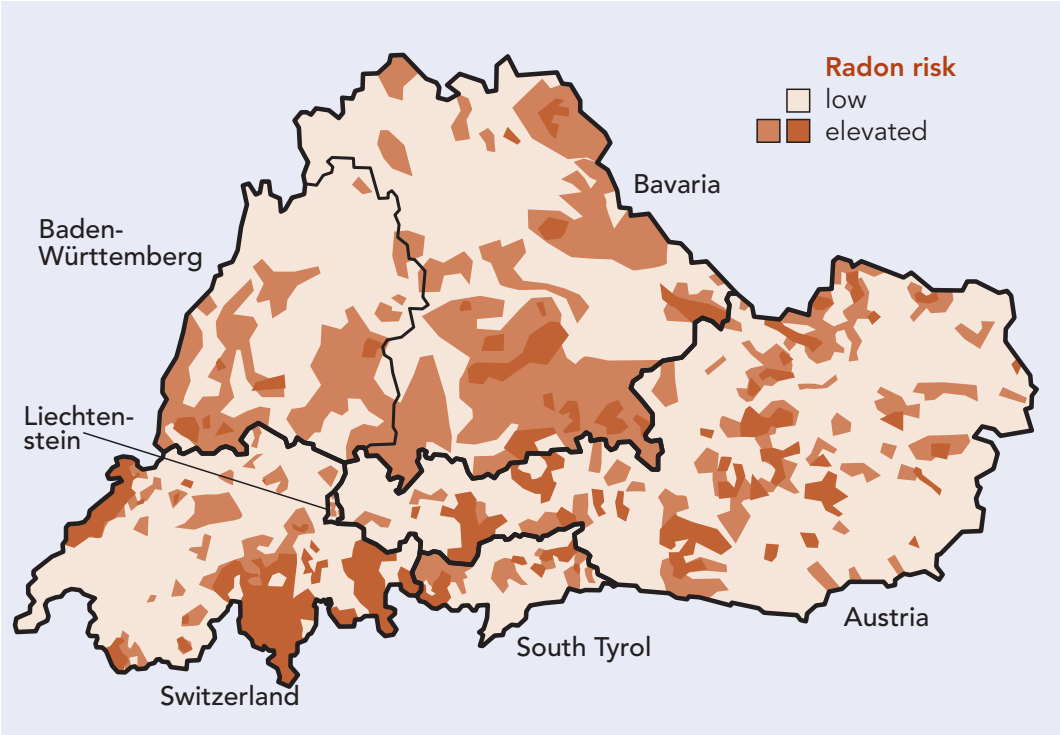
Properties, Occurrence and Effect of Radon

Properties and occurrence

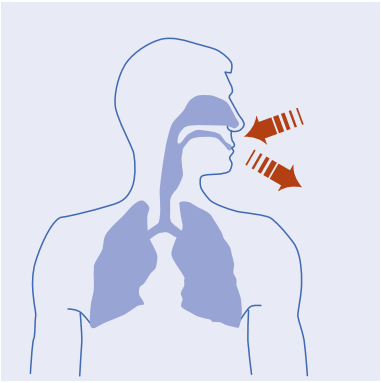
Radon is a natural, ubiquitous radioactive noble gas that is colourless, odourless and tasteless. It is a decay product of the radioactive heavy metal uranium, which is found in soil and rocks. Radon can escape relatively easily from soil and rocks, from where it is transported by soil gas or dissolved in water. By means of those processes radon can also enter buildings.

Radon potential maps and radon risk maps give initial information about the likelihood of elevated indoor radon concentrations in your region.

The illustration below is a greatly simplified representation of radon risk regions in Austria, southern Germany, South Tyrol, Liechtenstein and Switzerland.
More detailed information about radon can be found on the websites hosted by the individual countries. The corresponding internet addresses are on the back of this brochure.



Health impact



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

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

When a person inhales, the free decay products and aerosols are deposited in the lungs. Once inside the lungs, they emit ionising radiation which can damage the surrounding lung tissue and can ultimately lead to lung cancer.

Guideline and limit values

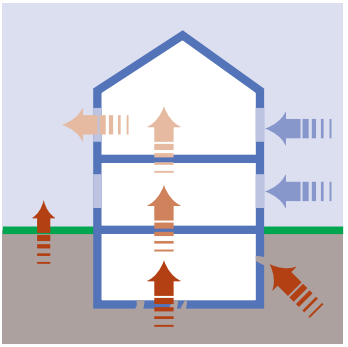
The following table shows the guideline and limit values for the annual mean radon concentration of inhabited rooms currently in force in various states.

State	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	1.000 Bq/m³
South Tyrol	200 Bq/m³	400 Bq/m³	500 Bq/m³ (at workplaces)

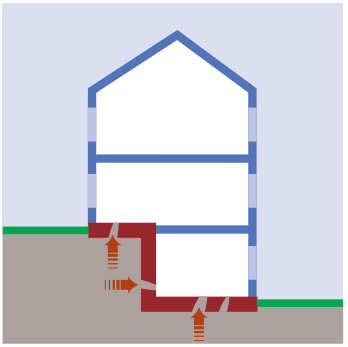
Annual mean radon concentrations are typically in the range of 50 to 500 Becquerel per cubic metre (Bq/m³) of air. However, concentrations may reach several thousand Bq/m³, especially in radon risk regions.

Factors Affecting the Indoor Radon Concentration

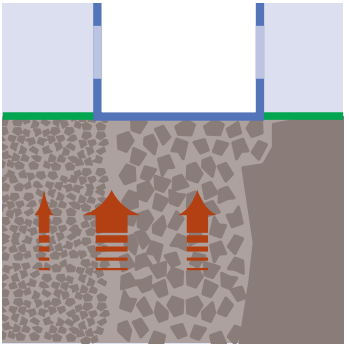
The indoor radon concentration depends on a number of factors:



- **Air exchange in the building:**
  The rate at which indoor air is replaced by outdoor air has a major effect on the radon concentration. Windows and doors which are not air-tight lead to a greater air exchange rate. If air exchange is reduced, however – for example by fitting windows and doors which close tightly – the concentration of radon in indoor air may increase substantially.



- **The condition of the building:**
  The fundamental factor is the permeability of the building to soil gas around the foundations and in walls which are in contact with the soil. Soil gas can penetrate through cracks, gaps and along wire and pipe conduits into the building. Radon-containing soil gas is sucked into the building by the depression zone that develops inside the building (stack effect as a result of temperature differences between indoor air and oudoor 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 soil. Very compact soil and clay soil require less caution.

When are Radon Measurements Required?

The indoor concentration of the noble gas radon can be measured in a simple manner using specific measuring devices.

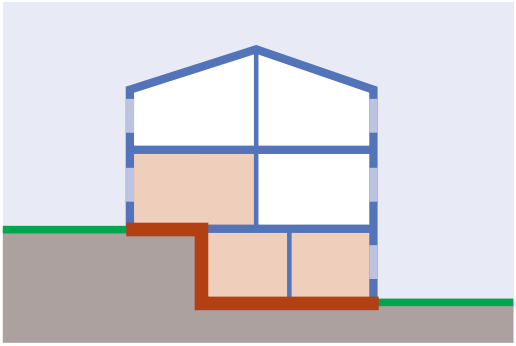
Studies have shown that the annual average value for radon in a building depends principally on the construction design (design of the foundations, basement, tightness of the building) and on the occupiers' habits (ventilation).

Consequently, even neighbouring dwellings often have very different radon concentrations.

Only a measurement can give certainty about the radon concentration in a building. For this reason radon measurements are recommended for dwellings with inhabited rooms that are in contact with the soil (for example houses on a slope, houses without a basement or with an inhabited basement), or in buildings that are located in radon risk regions.

If structural alteration is to be undertaken 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 recommended.

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



Areas with soil contact
Inhabited rooms with soil contact

Becquerel per cubic metre (Bq/m^3)

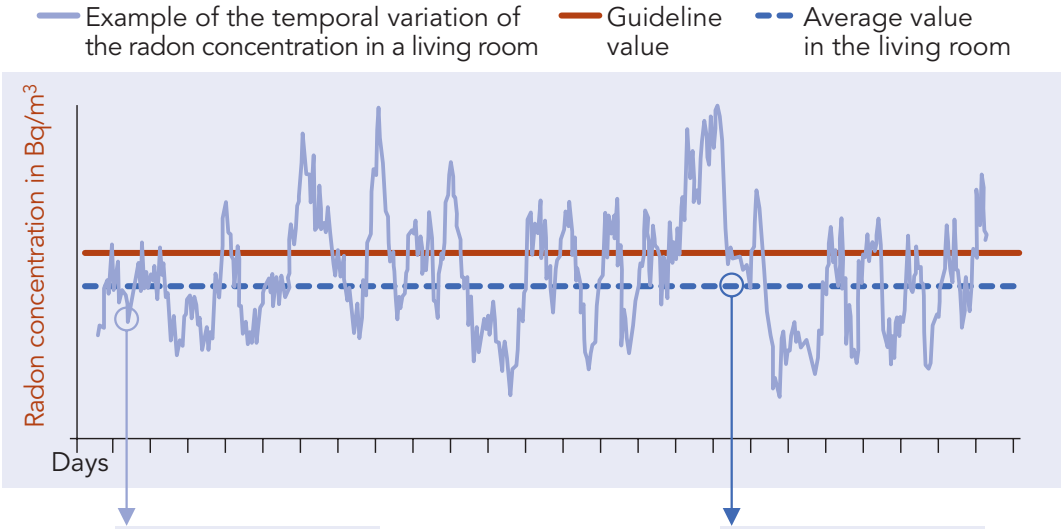
The radon concentration is measured in Becquerel per cubic metre (Bq/m^3).

400 Bq/m^3 means that in a volume of one cubic metre of air, 400 radon nuclei disintegrate per second emitting ionising radiation.

Fluctuation of Radon Concentration in Residential Buildings

The radon concentration in buildings usually fluctuates considerably with time and place (see diagram). 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 conditions. They are principally caused by the stack effect in the house (mentioned on page 4), i.e. when considerable temperature differences exist between the indoor air and the outdoor air.
The occupiers' habits (airing, heating etc.) even intensify these fluctuations. In addition, differences in the utilisation of rooms, the distribution of radon entry points and the air exchange contribute to considerable variations of the radon concentration in the rooms. In general, the radon concentration is lower in upper floors.



Measuring device for the temporal radon variation

Measuring devices for average values

Measurements for Comparison with Guideline and Limit Values

Measurements for comparison with guideline and limit values 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 dwellings 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 results. Consequently, in practice, a compromise is made for 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 places: rooms with the longest occupancy (at least two separate rooms); preferably those with soil contact

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

Note:
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 expenditure 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 measuring devices.
Care should be taken that the devices measure radon only.
So-called "open" measuring devices are not suitable.
Passive measuring devices are small, handy and are sent by mail.
They are very simple to operate.
The measuring devices do not emit any radiation and are non-toxic.
Measurement costs range from 50 to 150 Euros per dwelling.

For setting up the measuring device 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 measuring device has to remain in the same place for the total period of the measurement. During the measurement the dwelling should be inhabited as in everyday life.

More information with regard to measuring services can be obtained from the institutions listed on the back of this brochure.

Measuring devices for determining the radon concentration

Measurements for Planning and Controlling a Mitigation

The radon concentration as a function of time should be known in order to carry out a radon mitigation. 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 consecutively with a single measuring device.
This allows radon entry points and propagation paths to be roughly located 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-resolved measurements or with simple electronic measuring devices.

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

Once the mitigation has been finished, a measurement for 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 remedial 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 the radon situation 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 hardly allow conclusions on the annual average value, it is recommended, when possible, to carry out a measurement for comparison with the guideline and limit values (see page 7).

Recommended measurement method

A time-resolved measurement is carried out 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 (airing) and the weather, 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

Measurement of Radon in Soil Air

Principally, the radon concentration can also be measured in soil air. It is determined mainly for identifying radon risk regions 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, it is recommended that preventive measures are carried out according to the brochure „**Radon - Precautions for New Buildings**" without prior soil air measurement at the building site.

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

Facts and Notes

- Radon is the second leading cause of lung cancer after smoking
- Only a measurement can give certainty about the radon concentration inside a building
- Measurements for comparison with the guideline and limit values can be carried out in an easy, reliable and cheap manner
- Radon measurements are particularly important in radon risk regions
- Recognised measuring services provide reliable measurements

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*)

AGES - Austrian Agency for Health and Food Safety, Austrian Centre for Radon
Wieningerstraße 8,
A-4020 Linz
phone: +43-50-555-41550
e-mail: radon@ages.at
internet: www.ages.at

Bavarian Environment Agency Department 4 – Radiation Protection
Bürgermeister-Ulrich-Straße 160
D-86159 Augsburg
phone: +49-821-9071-0
e-mail: poststelle@lfu.bayern.de
internet: www.lfu.bayern.de

Environmental Agency of Bolzano Autonomous Province of South Tyrol/Italy
Amba Alagistraße 5,
I-39100 Bozen
phone: +39-0471-417101
e-mail: luigi.minach@provinz.bz.it
internet: www.provinz.bz.it

Government of Upper Austria Department Environmental Protection
Kärntnerstraße 10–12
A-4021 Linz
phone: +43-732-7720-14543
e-mail: radon.us.post@ooe.gv.at
internet: www.land-oberoesterreich.gv.at

Ministry of the Environment, Climate Protection and Energy Sector Baden-Württemberg
Kernerplatz 9
D-70182 Stuttgart
phone: +49-711-126-0
e-mail: poststelle@uvm.bwl.de
internet: www.uvm.baden-wuerttemberg.de

Federal Office of Public Health Radiological Risk Section
CH-3003 Bern
phone: +41-31-324-68 80
e-Mail: radon@bag.admin.ch
Internet: www.ch-radon.ch

Publishing details: Published jointly by the Radon Offices in Austria, Switzerland, southern Germany, South Tyrol
Contributors: Gräser Joachim (AGES, Austria), Grimm Christian (Ministry of the Environment, Climate Protection and Energy Sector, Baden-Württemberg), Gruson Martha (Federal Office of Public Health, Switzerland), Kaineder Heribert (Government of Upper Austria), Körner Simone und Heidler Michael (Bavarian Environment Agency), Minach Luigi (Environmental Agency of Bolzano, South Tyrol), Ringer Wolfgang (AGES, Austria), Valsangiacomo Claudio (SUPSI, Switzerland)
Edition: First edition, April 2011.