MONITORING HARMFUL GASES IN MINES

Are you protected? Know the risks and how to select the right measurement device for optimal safety.

RISK FACTORS

WHY DO I NEED TO MEASURE RADON?

Radon is a naturally occurring radioactive gas, which has no smell, colour or taste. It comes from the radioactive decay of radium, which is present in small amounts in rocks and soil. Radon is chemically inert, so it can easily escape from the ground into the air where it can be inhaled. Radon can have lasting long-term health effects and is the second leading cause of lung cancer after smoking.

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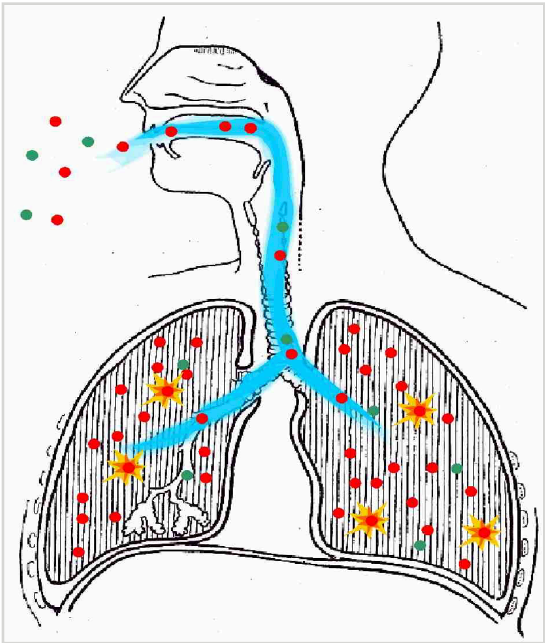
HOW DOES RADON AFFECT THE LUNGS?

Radon releases radioactive particles when it decays. When we breathe in radon these particles can cause damage to the lung tissue. Such damage can lead to lung cancer.

There is a delay of many years between the initiation of a cancer by radiation and its growth to a size which can be observed clinically.
(source: ARPANSA)



(Image credit: sarad.de)

WHAT DOES SENSITIVITY MEAN? HOW IMPORTANT IS IT?

The higher the sensitivity, the lower the statistical uncertainty of the measurement result and the minimum measurable radon concentration.
So does a device with higher sensitivity always deliver the more precise values? No. Under field conditions, devices without real spectroscopy must compensate for background signals, which results in an increase in statistical uncertainty and detection limit.

Spectroscopic devices with significantly lower sensitivity then provide equally good or better measurement results.

DANGEROUS IMPACT OF RADON DAUGHTERS

- No impact by Radon gas
- Deposition of daughter products within the lung
- Decay directly at the surface of the epithelium
- Emitted Alpha radiation damages cell nucleus and cause genetic defects

GOAL: Assessment of the injurious impact of inhaled radon daughter products.

MEASUREMENT DEVICES

WHAT TO PAY ATTENTION TO WHEN CHOOSING A DEVICE.

The measurement of radon is complex, each measuring principle has its advantages and disadvantages. We explain the four most common measurement methods and help you select the optimal device for your application.

RADON MEASURING DEVICES

Radon measuring devices are available for a few hundred to a few thousand dollars. However, advertising and even data sheets often reveal too little about the properties of the devices and the associated restrictions. It is only after purchase that you realise that a device is unsuitable for the intended application.

All radon measuring devices have a closed measuring chamber into which the radon is diffused or pumped. There it decays and produces radioactive daughter nuclides which, since they are all heavy metals, remain in the measuring chamber and gradually decay there until they have become no longer radioactive lead. The number of all within a time interval — we speak of counting interval — decays recorded in 'radioactive equilibrium' is proportional to the radon activity concentration of the measured air. The radioactive equilibrium only sets in for each daughter nuclide after a certain time, which depends on its half-life; you usually calculate with five times the half-life. It therefore always takes a certain amount of time until the measurement signal has reached its end value; we speak of the response time. In addition, the counting interval must be long enough for a sufficiently high number of decay events to be registered in the measuring chamber. Both are different things — if a device displays a measured value after ten minutes, it does not mean that it already represents the true value.

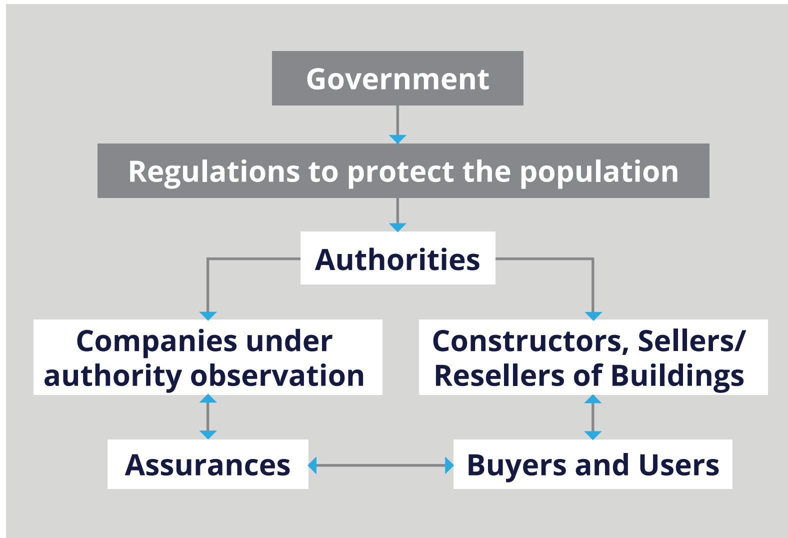
The daughter nuclides relevant for radon measurement only reach radioactive equilibrium after approximately **three hours**.

THE FOUR MOST COMMON METHODS IN MODERN MEASURING DEVICES:

1. **Electrostatic deposition and α-spectroscopy with a semiconductor detector**
2. **Ionisation chamber**
3. **Scintillation chamber (Lucas cell)**
4. **Photodiode**

WHO NEEDS TO MEASURE RADON/ PROGENY?

Radon is a naturally occurring radioactive gas, which has no smell, colour or taste. It is practically invisible! It comes from the radioactive decay of radium, which is present in small amounts in rocks and earth. To be sure that you are protected from exposure talk to your RSO and consult your State Authority for information.



WHAT ADVANTAGES DO I GET FROM TIME-RESOLVED RADON MEASUREMENT?

The continuous, time-resolved radon monitoring with active electronic measuring devices has considerable advantages over the use of passive radon measuring devices. The obligations resulting from the Radiation Protection Act with increased radon concentration can be expensive. By using active radon monitors, you can avoid or reduce these costs.

The Radiation Protection Act (Europe) initially provides for a measurement of the radon concentration over a period of 12 months. If the mean radon concentration exceeds the legal reference value of 300 Bq/m³. during this period, suitable measures must be taken to reduce the radon concentration. If these do not lead to success or if their implementation would become unreasonable, a dose estimate must be made for the affected work or residence. If the estimated dose is over 6mSv per calendar year, this results in even more extensive obligations regarding occupational radiation protection.

<u>Excerpt from EPA SA on Radon in water</u>: To this end, the US EPA has set an action level of 4 pCi/L. At or above this level of radon, the EPA recommends you take corrective measures to reduce your exposure to radon gas. This does not imply that a level below 4.0 pCi/L is considered acceptable, as stated in the BEIR VI study. It is estimated that a reduction of radon levels to below 2 pCi/L nationwide would likely reduce the yearly lung cancer deaths attributed to radon by 50%.

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WHICH MEASURING DEVICE FITS MY EXPECTED RADON CONCENTRATION?

Radon is a very dynamic measure. Concentrations in the range from milli-becquerel to mega-becquerel can occur in the environment. The widest measuring range is provided by devices with electrostatic collection and semiconductor detectors. Some devices have a very limited measuring range, which excludes different areas of application.

The radon concentration in the outside air is a few becquerels per cubic meter. The abbreviation of the unit is Bq/m³. Average values indoors are 10 to 100 Bq/m³. In radon-contaminated areas, however, the concentration can rise to a few thousand becquerels per cubic meter, while up to 100,000 Bq/m³ is possible at underground workplaces or in waterworks. Concentrations up to the mega-Becquerel range occur in the soil air. The legal reference value was defined as an annual average. If the measuring range were exceeded, however, the measuring range limits would be included in the calculation of the mean value instead of the actual concentration values and falsify it. In some cases, a very low concentration or the complete absence of radon should be demonstrated. The limits of the measuring range should therefore always be adapted to the application.

The measuring range limits of a device depend on the one hand on the measuring principle and on the other hand on the electronic signal processing.

Spectroscopic devices with semiconductor detectors and high-voltage separation offer by far the lowest lower limit. The background count rate of semiconductor detectors is 0.01 pulses per hour and square centimetre in the energy range of the radon progeny. This corresponds to a concentration of less than one milli-Becquerel per cubic metre for the measuring chamber used by SARAD.

Upwards, the measuring range is determined by the time required for the detection of a decay. The pulses in semiconductor detectors or in scintillation chambers are in the range of a few microseconds, so that measurements in the range of mega-Becquerel are possible without dead time effects leading to linearity errors.

Scintillation detectors require a light-sensitive detector with a large gain. Spontaneous emissions of electrons lead to an underground signal which is in the range of a few Bq/m³.

In ionisation chambers, a background signal is generated by external radiation or by spontaneous ionisation, so that here too the lower limit of the measuring range is a few Bq/m³. Ionisation chambers can only work in pulse mode at concentrations in the range of a few kBq/m³. This is due to the long collection times of the positive charge carriers in the air. After that, only a time-variant current signal is available due to superimposition. Devices that cannot process the current signal therefore have an upper-limit measuring range.

It should be noted that the detection limit and thus the lower measuring range limit for devices without real α-spectroscopy increases due to the progressive long-term contamination.

OTHER FACTORS TO CONSIDER

IS THORON AN ISSUE THAT AFFECTS ME TOO?

Thoron is the radon isotope Radon-220. It has a very short half-life and therefore rarely occurs in rooms. However, it is almost always found in the soil air and in a similarly high concentration as radon.

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Thoron is the radon isotope Radon-220. It has a very short half-life and therefore rarely occurs in rooms. However, it is almost always found in the soil air and in a similarly high concentration as radon. It can also be exhaled by building materials containing thorium. If Thoron gets into the measuring chamber of a non-spectroscopic device, this indicates that the radon concentration is too high. The device remains contaminated by the Thoron progeny for a few days. Devices with α-spectroscopy can differentiate between radon and Thoron decays. This means that the correct measured value for both isotopes is always displayed. This property also enables so-called "sniffing" after entry paths into buildings.

There are two approaches:

1. SPECTROSCOPIC

Spectroscopic devices can distinguish the decays of radon, Thoron and their decay products. This means that the concentrations of radon and Thoron can be determined very quickly and correctly even with continuous measurement. The reaction of a spectroscopic measuring device to changes in the Thoron concentration takes place very quickly. Short Thoron measurements (three or four minutes) in or on cracks and crevices therefore provide information about potential radon entry points. This is known as "sniffing".

2. NON-SPECTROSCOPIC

One non-spectroscopic device uses a special measurement cycle in which the measurement air is pumped into the chamber for a certain time and the decays of both isotopes are detected. After the pump has been switched off, the system waits until the Thoron has decayed in order to determine the radon value from the remaining activity. The measurement uncertainty for the isotope present in lower concentrations is significantly increased. Continuous measurement is not possible with this method, and repeated measurement also leads to contamination by Lead-212.

EQUIPMENT MANAGEMENT

WHAT ABOUT LONG-TERM CONTAMINATION?

Long-term contamination by Polonium-210 occurs in all devices with ionisation and scintillation chambers and other devices without real spectroscopy. These result either in measured values being too high or increased detection limits and measurement uncertainties.

The more radon that has been measured in the past, the greater the number of Polonium-210 decays. This is known as long-term contamination.

LONG-TERM CONTAMINATION

Long-term contamination by Polonium-210 occurs in all devices with ionisation and scintillation chambers and other devices without real spectroscopy. These result either in measured values being too high or increased detection limits and measurement uncertainties. Long-term contamination is irrelevant for measuring devices with semiconductor detectors and spectroscopy.

The decay chain of radon only ends with the stable lead isotope Lead-206. The polonium isotope Polonium-210 occurs within the chain with a half-life of more than twenty years. After a very long time, each decayed radon atom generates another decay in the measuring chamber, which is not related to the current radon concentration. The more radon has been measured in the past, the greater the number of Polonium-210 decays. This is known as long-term contamination.

CONTACT

Discover the wide range of personal and area monitoring for radon, thoron and its daughter products, for all levels of detection.

Contact us at sales@nuscientific.com.au.