Nuvap®

RADON GAS ACTIVE & CONTINUOUS MONITORING

WHITE PAPER

INDOOR POLLUTION

Understanding how to minimise health concerns and gain health benefits

People spend more than 90% of their time indoors. A good indoor environment is important, and therefore it is crucial to be aware of the health risks, how to prevent and if necessary, how to remediate them.

The exposure to pollutants has been proved to have an impact on people's health and increases considerably the risk and severity of respiratory diseases, cardiovascular and neurodegenerative diseases and cancer.

Many governmental programmes are being implemented in schools. Several programmes have been promoted to improve the quality of workplaces, with regard to impact on cognitive functions.

This white paper focuses on Radon Gas, which is by far the largest contributor to exposure to radiation.

The risk of lung cancer is related to long-term exposure, so it is important that estimates of radon levels in places where people spend several hours per day should be as close as possible to the long-term average.

Estimating long-term average figures is complicated by the fact that radon levels can vary widely from day to day. Several factors can influence the level of emissions. For instance, it has been observed that in some buildings the highest radon levels occurred when the wind was blowing in one particular direction.

OVERVIEW

RADON GAS

Definition: Radon is a naturally occurring radioactive gas. It comes from the natural (radioactive) breakdown of uranium in soil, rock and water and gets into the air

Sources: Radon can get into any type of building–homes, offices, and schools–which are close to radon sources and results in a high indoor radon level. Moreover, it is possible for any granite sample to contain varying concentrations of naturally occurring radioactive elements that can emit radiation and produce radon gas.

Risks: Overall, radon is the second leading cause of lung cancer. Radon gas decays into radioactive particles that can get trapped in people's lungs. As they break down further, these particles release small bursts of energy. This can damage lung tissue (or other tissues), and lead to cancer over the course of a lifetime.

RESPONSES

Governments have strategies for reducing the impact of radon on health and to raise public and political awareness regarding the consequences of long-term exposure to Radon.

Addressing radon levels is important both in the construction of new buildings (prevention), and in existing buildings (mitigation or remediation).

Radon exposure patterns in large buildings (schools, commercial buildings and multi-unit residential structures) may differ from exposure levels in detached houses, due to differences in building structure, occupancy and heating, ventilation and air conditioning (HVAC).

Radon measurements are relatively simple to carry out and are essential in order to assess Radon concentration

Radioactivity of a radionuclide, for instance radon, is reported in becquerels, Bq.
1 becquerel (1 Bq) = 1 disintegration of atom per second
Radon concentrations in the air are measured as the amount of radioactivity (Bq) in a cubic metre of air (Bq/m3). The average radon level outdoors is 5 Bq/m3 and in the homes of the United Kingdom, for instance, is 20 Bq/m3 of air.

(Source: WHO, Radon and Health)

RADON MEASUREMENT TECHNIQUES

PASSIVE METHODS

Passive Instruments are single-use passive detectors, to be left indoors for a certain amount of time, and then returned to a laboratory for analysis.

Basically, passive detectors are small pieces of materials which are able to absorb Radon. The sampling of the Radon is obtained by the natural diffusion of the gas in the room. After the exposure, the analysis of the detector provides an estimation of the average Radon concentration over the exposure time. Results usually require months.

There are different types of passive detectors. They do not need electrical power.

These types of measurements do not capture the fluctuations in Radon over time.

ACTIVE INSTRUMENTS

Active Instruments are electronic devices which are able to count the alpha particles emitted by the decay radon produces.

The analysis is carried out on Radon samples obtained by forcing a known volume of air into a small diffusion chamber. Active devices provide easy access to the data.

Active Radon detectors require electricity to operate. The expected lifetime of an active Radon detector varies depending on the device.

Examples of active radon detectors include Continuous Radon Monitors, which use different types of sensors and are able to provide continuous access to integrated data and punctual information. They enable an accurate analysis of the exposure.

Radon gas measurement devices and their characteristics

Detector Type (Abbreviation)	Passive/Active	Typical Uncertainty [%]	Typical Sampling Period	Cost
Alpha-track Detector (ATD)	Passive	10 - 25	1 - 12 months	low
Activated Charcoal Detector (ACD)	Passive	10 - 30	2 - 7 days	low
Electret Ion Chamber (EIC)	Passive	8 - 15	5 days - 1 year	medium
Electronic Integrating Device (EID)	Active	~ 25	2 days - year(s)	medium
Continuous Radon Monitor (CRM)	Active	~ 10	1 hour - year(s)	high

Source: WHO Handbook on Indoor Radon: A Public Health Perspective, Geneva: World Health Organisation; 2009

MEASUREMENT VERSUS MONITORING

CONTINUOUS MONITORING: WHY?

Mass measurements of indoor radon concentration have been conducted for about 30 years. However, until now, there is no single and generally accepted international protocol for determining the AAIR (Annual Average Indoor Radon) level with a known confidence interval, based on measurements during different duration periods. Obviously, as the duration of measurements increases, the uncertainty of the AAIR estimate decreases. The lack of information regarding the confidence interval of the determined AAIR level does not allow a fair comparison with the radon reference level. This greatly complicates the development of an effective indoor radon measurement protocol and strategy.
Based on the simple criteria widely used in metrology, a general principle of indoor radon regulation can be applied, introducing a new parameter – the coefficient of temporal radon variation KV(t) – that depends on the measurement duration and determines the uncertainty of the AAIR.

Source: *Indoor radon regulation using tabulated values of temporal radon variation (Andrey Tsapalov, Konstantin Kovler,),*
Journal of Environmental Radioactivity,
Volume 183, 2018, Pages 59-72,
ISSN 0265-931X,
(http://www.sciencedirect.com/science/article/pii/S0265931X17308287)

By monitoring radiation levels with concurrent passive and active measurements, in a study conducted in historical buildings, it has been possible to compare measurement techniques for the evaluation of Radon concentration levels. (222Rn).
The comparison shows that the active monitoring system permits the detection of punctual variations in Radon concentration, and then understanding if the variations are due to the behaviour of the occupants, to climate change, or other random error sources. This kind of analysis is not possible with passive monitoring systems.
This study has highlighted that for historical heritage buildings, as with all public buildings, the normative requirement to perform passive and long-term monitoring of Radon gas is not sufficient owing to the behaviour of the occupants that can mis-state the measurement results. Active monitoring, permits the detection of such error sources.

Source: *Passive and active methods for Radon pollution measurements in historical heritage buildings* (V. Nastro, D.L. Carnì, A. Vitale, F. Lamonaca, M. Vasile),
Measurement, Volume 114, 2018, Pages 526-533,
ISSN 0263-2241,
(http://www.sciencedirect.com/science/article/pii/S0263224116305024)

ACTIVE MONITORING

ADVANTAGES

Connected monitoring devices can be managed remotely and data can be visualised at a distance.

By adopting continuous Radon monitoring it is possible to automatically collect and store the measurement data. Some monitoring solutions provide data export.

Cloud-based monitoring solutions can be integrated into third-party applications.

Buildings that have high average Radon concentrations, but are only occupied for part of the day, need to be measured during periods of occupation to determine if there is significant daytime Radon variation.

When a high level of Radon is detected, continuous active measurements are very helpful in identifying the cause of the problem.

Some continuous Radon monitors are equipped with other environmental sensors to simultaneously measure several parameters and allow the analysis of the correlation between different factors and events.

QUALITY ASSURANCE

The duration of the measurement minimises the uncertainty of the measurement.

Active Systems have to be calibrated and maintained. Calibration and maintenance have to be duly documented.

Connected monitoring solutions can be validated real-time: sensors functioning can be continuously monitored and predictive maintenance can be easily scheduled.

Continuous monitoring active solutions minimise random errors and eliminate human errors in the measurement.

The quality of the data is related to the sensitivity and the accuracy of the sensors, plus the thresholds and the average values calculation methods. The supplier of the monitoring system has to state this information.

Sensors have to be certified.

RADIATION PROTECTION IN EU

EURATOM

European legislation obliges Member States to establish a radon action plan to reduce long-term risks of Radon exposure in dwellings, buildings with public access and workplaces

Euratom (European Atomic Energy Community) was created in 1957 to tackle energy shortages by utilising nuclear energy.

Council Directive 2013/59/Euratom of 5 December 2013 lays down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

Its main objectives are the modernisation of the European Radiation Protection Legislation as follows:

- To integrate, as far as possible, numerical values with international standards

- To cover all radiation sources and all exposure situations

DIRECTIVE 59/13

Better protection of **workers**, in particular medical staff, emergency workers and workers in workplaces with natural radiation sources (indoor radon; activities processing naturally occurring radioactive material (NORM));

Better protection of the **public**, in particular from radon in dwellings, from exposure resulting from NORM activities and building materials and from deliberate exposure for non- medical purposes;

Better protection of **patients**, in particular with regard to the avoidance of incidents and accidents in radio-diagnosis and radio-therapy;

Establishment of a data system to register and record occupational exposures

Establishment of a national reference level for indoor radon concentration in workplaces ≤ 300 Bq/m3

Sources

EPA (United States Environmental Protection Agency) - Online resources
EEA (European Environment Agency) - Online Resources
WHO (World Health Organisation) - Handbook on Indoor Radon: A Public Health Perspective.

Nuvap is a pioneer in the management of indoor pollution and promotes people’s health and the healthiness of built environment.

Nuvap solutions enable the monitoring, assessment and communication of indoor environmental quality in a simple and in-depth way, considering up to 26 environmental parameters, including many chemical and physical pollutants.

Nuvap's R&D efforts are focused on the detection and analysis of environmental data. The intellectual property is protected by international patents.

In 2017, Nuvap won the Edison 'Best Smart Home Technology' Pulse award and in 2019 it won the eHealth4all award, as the best prevention technology.

The company has an engineering lab in Pisa and offices in Milan.

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