

# MEASUREMENT PROTOCOL FOR RADON MEASUREMENTS IN WORKPLACES ABOVE GROUND

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## ABSTRACT

The Swedish Radiation Protection Authority, SSI, has established a measurement protocol for measurements of radon in workplaces. The result from a measurement according to the protocol can be compared to the limit for indoor radon at workplaces, 400 Bq/m<sup>3</sup> issued by the Swedish Work Environment Authority and also to the action level for homes and public premises, such as schools and pre-schools, 200 Bq/m<sup>3</sup>, issued by the National Board of Health and Welfare.

The protocol recommends measurements to be done in two steps. The first measurement, the screening measurement, will be done with an integrating measurement method over a period of at least two months. Track etch detectors or electret devices can be used. Since the screening measurements often overestimates the radon levels the workers are actually exposed to during working hours, a follow-up measurement has to be done if the screening measurement gives a result that exceeds 200 Bq/m<sup>3</sup>. In case there is need for an annual mean for comparison to the action level for public premises a long-term measurement has to be done. Otherwise a method for follow-up measurements can be used at once. The follow-up measurement has to show the radon level during working hours. Two measurement strategies can be used depending on the function of the ventilation system.

Measurements have to be performed during the heating season, i.e. when the 24-hour average temperature is below +10°C, usually between October 1 and April 31. Most important, the difference between interior and exterior temperatures must be big enough to allow natural draught ventilation system to activate. The result from a measurement made during the warmer part of the year is likely to show radon levels that are not representative for the whole year.

Measurements have to cover at least 20 % of the rooms used for work places situated on the ground floor, in upper floors one measurement per floor has to be made and at least one per 500 m<sup>2</sup>. More measurements are recommended for buildings constructed from material with enhanced uranium and radium levels, such as blue lightweight concrete. The detectors should not be moved during the measurement period and they should be placed so that the result is representative for the work place.

Measurement devices must be calibrated every 12 months. This can be done at SSI or another laboratory recommended by SSI. Laboratories, consulting firms etc responsible for radon measurements have to guarantee that the results are correct. A quality system is required in order to perform measurements. The measurement protocol describes every method that can be used for radon measurements in detail as far as calibration and control systems are concerned.

## REGULATIONS ON RADON

The Swedish Radiation Protection Act covers activities involving radiation, i.e. not naturally occurring radioactivity or radon. Several authorities are involved in radon and radon regulations are found in different legislations; the Environmental Code, the Building and Planning Act and in the Work Environment Act. SSI cannot issue regulations on radon but is, according to

agreements between radon authorities and the government, responsible for observing the development of measurement techniques and risk estimations.

The Environmental Code is applicable on homes and public premises, such as schools and pre-schools. The National Board of Health and Welfare is responsible for supervision according to the Environmental Code and issues general advice on radon in indoor air (SOSFS 2004:6). This is where the action level for homes and public premises is found, 200 Bq/m<sup>3</sup>. It says that measurements should be made according to the SSI measurement protocol in order to get an annual mean value that can be compared to the action level.

The Work Environment Authority issues regulations on radon in workplaces. An action level for workplaces above ground, as an exposure limit value, is found at 400 Bq/m<sup>3</sup> (AFS 200:3). This limit, as it is expressed, cannot be exceeded ever during working hours. Anyhow, a note explains that it also can be used as an annual mean value.

## RADON MEASUREMENTS IN WORKPLACES

The measurement protocol that was established in January 2004 describes how to measure radon in workplaces above ground in order to get an overview of the radon situation in the building. It only allows radon gas measurements, three measurement techniques are recommended, alpha track detectors, electret ion chambers and continuous radon gas monitors. The measurement protocol consists of a general part with information on calibrations, control systems and the measurement performance and a second part that describes each recommended measurement method in more detail.

## CALIBRATION AND CONTROL

All measurement systems must be calibrated before being used. Calibration must be performed before new equipment is used and after repairs or modifications that could alter the system's properties. Calibration must be performed at least annually at SSI or another laboratory notified by SSI. Above calibrations must all laboratories, consulting firms and others that perform radon measurements take steps to assure that the measurement has the highest possible precision and accuracy. This means checking the equipment, laboratory procedures, calculation methods as well as procedures handling possible measurement variations. All measurement and control data must be kept in a log book or equivalent in order to assure repeatable and controlled results. A voluntary accreditation is available at the Swedish Board for Accreditation and Conformity Assessment, SWEDAC. Calibration and control procedures are described in more detail under each measurement method in the measurement protocol.

## MEASUREMENT PERFORMANCE

Measurements have to be performed during heating season, i.e. when the 24-hour average temperature is below +10°C, usually between October and April. Most important, the difference between interior and exterior temperatures must be big enough to allow natural draught ventilation system to activate. The result from a measurement made during the warmer part of the year is likely to show radon levels that are not representative for the whole year. Although most work places have forced ventilation the natural draught in the building is a force that cannot be neglected.

The measurement equipment must be placed in order to get a result that is representative for the radon concentration in the workplace. Rooms that are used more than temporarily should be chosen for measurement and the devices should not be placed closer than 25 centimeters from a wall, not closer than 1,5 meters from an air inlet or 0,5 meters from air outlets.

## SCREENING MEASUREMENT

The first measurement step is to do a screening measurement in the workplace. This measurement should be made with a method where the uncertainty is less than 10 % at 200 Bq/m<sup>3</sup>, a long-term measurement. Alpha track detectors or electret ion chambers are recommended. A minimum of 20 % of all rooms in the ground floor, must be measured and at least one measurement per upper floor or one measurement per 500 m<sup>2</sup>. More measurements are recommended where higher radon concentrations might be expected or when gamma radiation exceeds 0,3 µSv/h as that indicates that the building is made out of blue lightweight concrete. Rooms in upper floors with vertical piping or other vertical openings through the building or rooms adjacent to rooms with piping should be measured. This measurement is likely to show a higher result compared to the actual radon concentration the workers are exposed to because of the ventilation system that usually is closed down during night time.

## FOLLOW-UP MEASUREMENT

If the screening measurements show radon levels exceeding the action level a follow-up measurement is necessary. This measurement will show the radon concentration during working hours. The measurement can be done with a method where the uncertainty is less than 20 % at 200 Bq/m<sup>3</sup>. Depending on the ventilation system different methods can be used. If the ventilation system can run constantly during day and night, alpha track detectors or electret ion chambers can be used. If the ventilation system must be closed at night (or outside working hours) electret devices can be used if they are closed when no one is working in the building. The other option is to use a continuous radon gas monitor. The measurement period varies between 2 days and 10 days depending on the measurement method.

Table 1. Measurement methods and minimum measurement periods.

| Measurement | Measurement method            | Measurement period   | Ventilation             |
|-------------|-------------------------------|--|-------------------------|
| Screening   | Alpha track detectors         | Minimum 2 months   | Normal, including timer |
|             | Electret ion chamber          | Minimum 2 months   | Normal, including timer |
| Follow-up   | Alpha track detectors         | Minimum 10 days<br>8 working days  | Constant                |
|             | Electret ion chamber          | Minimum 5 working days   | Constant                |
|             | Electret ion chamber          | Minimum 5 working days if the chamber is closed during hours when no-one works in the building | Normal, including timer |
|             | Continuous radon gas monitors | 2 days   | Normal, including timer |

## THE RESULT

The screening measurement gives an annual mean value for the specific room that was measured. This is necessary if the result needs to be compared to the action level for public premises. For other workplaces only covered by the Work Environment Act the screening

measurement is not compulsory, a method for follow-up measurement can be used immediately, as the legislation does not demand an annual mean value. You never get an annual mean value or mean value for the whole building, only for the rooms you have measured.

## THE MEASUREMENT REPORT

The report, established by the laboratory or measurement company, must contain certain information: name and address to the measurement company, the name of the workplace and workplace number, type of workplace and ventilation system, measurement period, measurement methodology, information about measurement equipment, annual mean value/mean value and uncertainty in the result, result of gamma radiation measurement (if done) and an evaluation of the result.