Manual

RTM 2200 Soil Gas

Monitor for radon/thoron soil gas sampling

Version 04/2025

<u>Referenced documents:</u>
Software manual dVISION

SARAD GmbH
Wiesbadener Straße 10
01159 Dresden
www.sarad.de
info@sarad.de

Content

Further information about the device can be found in the manual of the DACM device family.

Applications

The new RTM 2200 Soil Gas is the ultimate tool for a quick, accurate and reliable in situ radon soil gas measurement (EN ISO 11665-11) operated by one single button.

Application examples:

- **Geological studies, volcanism and earthquake research**
- **Soil air measurements regarding the radon risk in construction projects, etc.**
- **Radon measurements in the air, in water probes, Rn emanation, exhalation, etc.**

Operational controls

A) Signal light
B) Bulkhead air inlet
C) Bulkhead air outlet
D) Water intake protection
1) Air inlet Radon monitor
2) Air outlet Radon monitor
3) Connector foe the level switch of the water intake protection
4) Connector for signal light on top of the case
5) Charge socket
6) RS232 serial interface
7) USB interface
8) Button
9) Charge indicator
10) Alert indicator

Measurement case

The RTM 2200 Soil Gas comes in a robust IP67 case for usage under field conditions. A signal light (A) is mounted on the top of the case indicating the state of operation even if the lid has been closed. The light is connected by a triple-pole connector (4) at the front panel of the instrument.

There are two bulkheads (B/C) at the left wall of the case with hose nozzles to connect flexible hoses with an inner diameter of 6 mm. The upper bulkhead (B) is the air inlet while the lower one works as air outlet.

The RTM 2200 Soil Gas is equipped with a water intake protection consisting of a hermetical sealed stainless steel can with a screw cap. A water level switch is fixed on the cap which stops the pump immediately in case of sucking water. Thus, no water can enter the internal air loop of the instrument. The can is fixed and positioned by a bracket installed on the left sidewall of the instrument. **The can must be used always in upright position.** The bulkheads of the water intake protection unit are connected by short pieces of hose with the air inlet bulkhead (B) and the air inlet of the instrument (1). The flow direction through the can is arbitrarily. The cable of the water level switch must be connected to the double-pole connector (3) at the front panel. **ATTENTION: After plugging in, turn the lock to the right and turn the lock to the left before pulling it off.**

In case of an unintended water intake all cables and hoses must be removed from the water intake protection. After that, the can be removed from the bracket and the water inside can be released after opening the cap. Make sure that the can has been dried completely before inserting the unit again.

If the water intake protection shall not be used, the dummy plug must be connected to the socket (3) instead the water level switch. Take care that no hose or cable becomes bended or jammed while closing the lid of the case.

Start-up

The fuse of the instrument was removed during shipping to ensure transportation safety. Take the instrument out of the case after disconnecting all hoses and cables. Now it is possible to access to the rear panel and to insert the fuse into the fuse holder. Place the instrument back to the case and connect all hoses and cables between instrument and water intake protection or case. Connect the charger to the connector (5) to charge the internal battery completely. The touch screen becomes active by pushing the button (8) below the display (possibly the battery has to be charged for a certain period prior to this). The desired measurement cycle must be chosen after removing and inserting the fuse even if a cycle name is shown on the main menu (see chapter “Operation”).

Power supply

The internal 12V NiMH battery allows an autonomous operation over several days. If the voltage drops below 11.2 V, the running measurement will be cancelled and the instrument enters the stand-by status. To protect the battery, it will be disconnected from the electronics if the voltage level falls below 10.8 V. This prevents the battery against deep discharging. It is possible to operate the instrument with connected charger. The LED “CHARGE” (9) lights during the charge process and will turn off if the battery is fully charged. The charging process will be interrupted if the ambient temperature exceeds about 40°C.

Operation

The touch screen becomes active by pushing the button (8). If no further action takes place the display returns back to stand by.

Carry out a measurement

After delivery, the following measurement cycles are available:

“Soil gas 0.4lpm”
“Soil gas 1.2lpm”
Cycle for soil gas sampling with integrated measurement of the soil permeability

“Permeability L”
“Permeability H”
Continuous permeability measurement (without Radon) using an one minute sampling interval

“Radon 5 min”, “Radon 15 min”, “Radon 30 min”, “Radon 60 min”
Continuous Radon measurement (without permeability) with the specified sampling interval

Additional measurement cycles can be programmed by the user.

Press the soft-key [CYCLE] in the main menu and select a desired measurement cycle from the list. Start the cycle with [START]

Radon soil gas sampling (Soil gas 0.4lpm, Soil gas 1.2lpm)

The instrument must not be used for “Radon in water” measurements or for soil gas sampling without the water intake protection unit (D). If water has been sucked accidentally, an alert is generated (display, signal light). In case of water entry, remove at first cable and hose between instrument and water intake protection. After that, pull out the stainless steel can, open the cap and remove the water completely (also from hoses and fittings).

Before starting a new measurement campaign all hoses as well as the can itself should be proved for tightness. You can do that by blocking the air inlet (B) with a finger. After a short time the flow rate shown on the display should be zero and the signal light (A) should turn on. In case of soil gas sampling then dust filter at air inlet (B) must be removed because the soil gas probe is connected to this terminal.

Use only the soil gas probe which has been configured in the RTM 2200 Soil Gas. The probe geometry is part of the result calculation and a wrong assignment results in false readings.

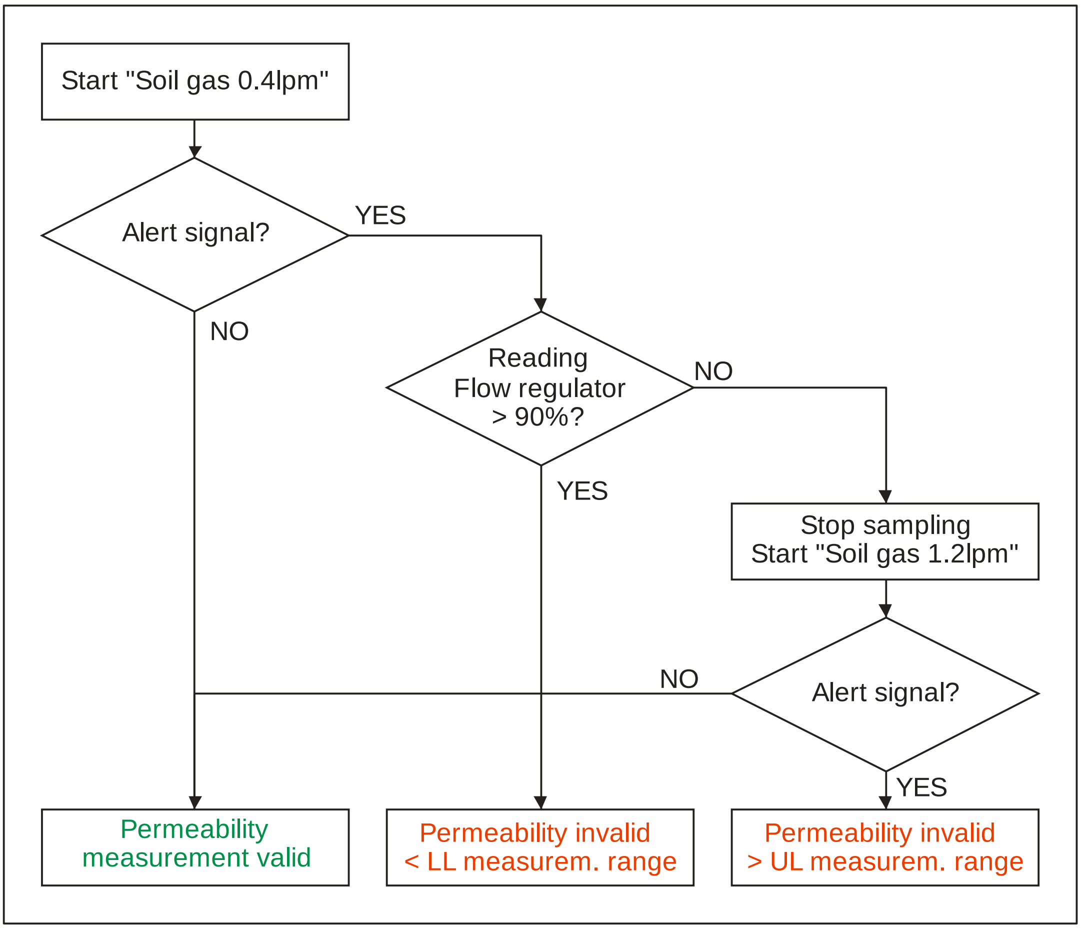
Connecting the Soil Air Probe

On the left front panel of the device, there are hose nipples for the inlet and outlet of the soil air sample, as well as a connection for the differential pressure sensor. A filter is located at the air inlet to trap dust particles, which can cause pump malfunctions, especially in dry and sandy soils. To ensure accurate differential pressure measurement regardless of the degree of filter contamination, the pressure sensor is connected using a T-piece in front of the filter and the water inlet guard. This connection is made inside the measuring case (figure below), so that only the connections for the sample air are connected to the outside via bulkhead fittings.

The filter should be replaced if there are signs of contamination, as higher pump power is required to suck in the air sample. This limits the permeability measurement range to low permeability.

Measuring process

The RTM 2200 Soil Gas offers two special measurement cycles for soil gas sampling. The only difference is the flow rate used for the permeability measurement. The following flow chart shows the recommended usage of both cycles. Note: Please check the recent readings of the flow regulator (for 90% criteria) while the pump is running and the permeability measurement is in progress.



The upper and lower range limits (LL/UL) are determined by the used soil gas probe. Measurement results which have been obtained under invalid conditions are invalid.

Note: In case of soil permeability higher than the upper range limit the signal light becomes active just at begin of the permeability sampling period (after 13 minutes) within the soil gas measurement cycle.

Various sensors become activated at different periods during the soil gas measurement:

Minute 1 to 5

- First measurement of CO2/O2 sensors (if available) – CO2(1) and O2(1)

Minute 13 to 18

- Radon measurement
- Permeability measurement
- Second measurement of CO2/O2 sensors (if available) – CO2(2) and O2(2)

Minute 19 to 20

- Flushing the measurement chamber with fresh air

The pump runs at 0.4 lpm during the whole soil gas measurement cycle. The flow rate of 1.2 lpm is only applied between minute 13 an minute 18 if the cycle “Soil gas 1.2 lpm” was selected. 1.2 lpm are also applied for chamber flushing.

After the soil gas probe has been connected to the bulkhead (B) the measurement can be started by the soft-key [START]. No further operations are required. The entire internal air loop is flushed by fresh air at the end of the measurement cycle. During that period the signal light (A) indicates the end of the measurement and the instrument may be relocated and connected to the next place of measurement. After the flushing period, the instrument enters in stand by state. The results can be displayed by the [INTERVAL] menu.

For Radon soil gas sampling always the “Radon fast” value must be used as the result.

Continuous permeability measurement:
Permeability L (0.4lpm), Permeability H (1.2lpm)

These cycles can be used for a fast check of the permeability conditions. The measurement should be taken over few minutes until the permeability reading becomes stable. It takes a little time to reach the pressure/flow equilibrium in the soil.

Continuous measurement (Radon 5 min, Radon 15 min, Radon 30 min, Radon 60 min)

If ambient air measurements shall be carried out, the dust filter (included in delivery) must be connected to the air inlet (B). Take care for the right direction. The air must flow from the printed side of the filter to the blank side. In case of wrong connected filter the air inlet may become blocked completely. Replace the dust filter if pollution is visible.

The measurement of the Radon activity concentration requires always an integration interval. All detected disintegrations will be counted over that interval as a measure of the activity. Radioactivity is a statistical process resulting in statistical variations of the observed number of disintegrations. These variations can be minimized if the integration interval is set as large as possible for the application.

For any Radon measurement two results are presented:

Radon fast: Only the direct decay product Po-218 is used to determine the activity concentration. The response time is just 12 Minutes - however, the statistical fluctuation is higher compared with “Radon slow” due to the lower number of disintegrations included in the calculation.

Radon slow: Both short-living radon daughter products Po-218 and Po-214 are used to determine the Radon activity concentration. Thus, the statistical fluctuations are lower but the response time is prolonged to two hours due to the half–life times of the decay chain up to Po-214.

The response time is defined by the time span which the instrument needs to show the right value after a change of the activity concentration in the measured air. The response time is not a instrument specific parameter but results from the half-life times of the decay products. The “Radon fast” value should be used if fast concentration changes at medium and high Radon concentrations can be observed. Select a 10 or 15 Minutes integration interval for such measurement. At relative constant conditions, after two hours an equilibrium state is reached and both results should show a very similar value. More detailed information you will find in our application note “Measurement principals – Statistics – Test planning”.

Presentation of measurement results

Press the soft-key [INTERVAL] to show the results of already finished sampling intervals und use the navigation bars to select the desired result and the time of measurement.

To show the actual sensor/detector readings (updated each Second) use the soft-key [RECENT]. The result can be selected also by the navigation bar.

The table below shows the available measurement results

Result	Meaning	Notes
Radon fast Radon slow Thoron	Radon and Thoron activity concentration	For fast/slow calculation see chapter “Continuous measurement”. MIN/MAX is related to the 1-sigma error band. The [RECENT] page shows the number of detected disintegrations within the running interval. The [INTERVAL] page contains the alpha spectrum additionally. Use the [TOGGLE] button to switch between the results.
Permeability	Soil permeability	Only available for soil gas sampling cycle. The measurement starts one Minute after the start of the cycle and lasts four Minutes. All one-second readings are averaged for that period.
Flow control	Control factor for the pump regulation	Given as a percentage of the available regulation range.
Battery	Battery voltage	
Bar. pressure	Barometric pressure	
Temperature	Temperature	The result is a bit higher than the ambient air temperature due to the internal power dissipation

Rel. humidity	Relative humidity	The result is a bit lower than the ambient air moisture due to the internal power dissipation. The water vapour concentration is the same.
Flow rate	Air flow rate	Defined by the set-point of the pump regulator.
Soil moisture	Soil moisture	Only for optional soil gas probe
Soil temperature	Soil temperature	Only for optional soil gas probe
CO2(1), CO2(2)	CO2 gas concentration	Only for optional CO2 sensor; readings at the begin (1) and end (2) of the measurement
O2(1), O2(2)	O2 gas concentration	Only for optional O2 sensor; readings at the begin (1) and end (2) of the measurement

Note: A result will be only presented in the [RECENT] menu if the sensor/detector is really used with the running measurement cycle. For example, the soil permeability is present not before one minute after starting the cycle.

Data download

The communication is realized either through a RS232 (6) or an USB (7) interface. The RS232 interface becomes inactive as soon as the USB cable will be connected. The communication is controlled by the software “dVISION”. It is possible to load data during a running measurement. The transmission speed can be significantly increased if the measurement is stopped. Press the soft-key [CARD READER] to enter in high speed transmission mode. The “CARD READER” option must be also selected in the dVISION software. It is also possible to download the data just for a selected time period.

Gas sensors for quality assurance

The RTM 2200 Soil Gas is optionally equipped with sensors for CO2 and O2. These are primarily used for quality assurance of a soil gas measurement. The gas measurement takes place over an interval of five minutes at the beginning and end of the soil gas measurement cycle. Minimum, maximum and average values are stored in the device. During a soil gas measurement, the gas concentrations should rise (CO2) or fall (O2) from typical ambient air values to soil gas concentrations and remain at these values. The absolute values of the soil gas concentrations play a subordinate role, since these are strongly dependent on the investigated soil. A differing behaviour indicates fresh air suction probably by an insufficiently sealed probe.

Testing:

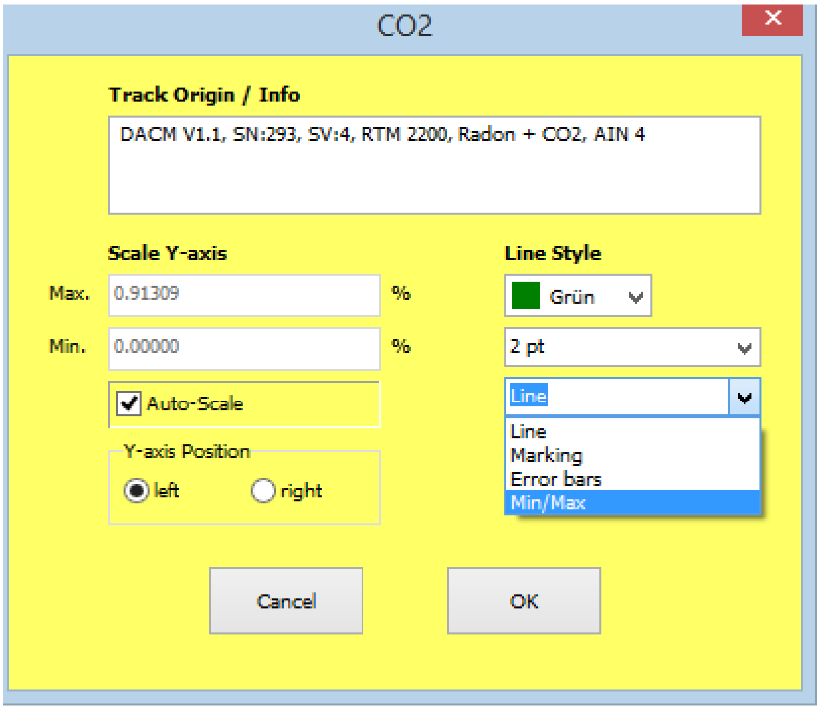
- The minimum value of CO2(1) should be in the range of 0.04...0.06 % ppm

- Maximum value of CO2(1) as well as minimum value, maximum value and average value of CO2 (2) should be identical within the measurement uncertainty and should be above the minimum value of CO2(1).

- The maximum value of O2(1) should be in the range of 20...21 %.

- Minimum value of O2(1) as well as minimum value, maximum value and mean value of O2(2) should be identical within the measurement uncertainty and should be below the maximum value of O2(1).

Note: To get minima and maxima of a measurement result in the exported text file (dVISION software), this option must be activated for the selected measurement result. After doubleclicking on the desired measurement result in the list on the left side of the graphic the following dialog window appears:



Select Min/Max from the list box as shown before exporting the data.

Operation with CH4 sensor:

If the device is equipped with a CH4 (methane) sensor, it requires regular zero calibration with a methane-free air sample. A special measurement cycle called "CH4 zero" is available for this purpose. The zero calibration should be performed before each use of the device. After the end of the measurement cycle, the device can be used for calibration. Fresh air, for example, can be supplied via the additional hose connection on the left front panel.

The sensor requires a warm-up period of 15 minutes after the operating voltage is switched on at the start of a measurement cycle. During this period, the sensor's full-scale value is output instead of the measured value. Therefore, for continuous measurements, measured values that include this time period in whole or in part must be discarded (for measurement intervals longer than 15 minutes, the first measured value). For single measurements, the measurement cycles are designed so that the CH4 concentration is only measured from the sixteenth minute onwards.

Alert messages and surveillance functions

A number of warnings can be generated during operation. Warnings will appear as text message on the screen but also indicated by the signal lights at the front panel and on top of the case. A warning remains present until the user confirms the warning by a soft-key on the touch screen. If the reason of the warning is still present the warning appears again immediately.

Message	Reason	Solution
"High humidity"	Danger of condensation in the measurement chamber by high humidity	Flushing the chamber with dry air
"Low permeability"	It is impossible to achieve the desired flow rate at maximum pressure drop - very low soil permeability - blocked hose - dust filter very polluted	Check dust filter and hoses. Cancel soil gas sampling (Radon results are not representative in case of very low permeability)
"High permeability"	The pressure difference generated by the air stream in the soil is too small for reliable measurement	Try soil gas cycle with 1.2 lpm flow rate to increase the measurement range. The result is invalid
"Water protection"	Pump stopped by the water intake protection	Remove water from water intake protection can. Connect dummy plug with connector (3) if no water intake protection is used.

The measurement cycle will be stopped immediately if:

- the battery voltage drops below 11,2 V
- the power consumption of the pump is unexpected high (>300 mA)

Avoiding condensation and verification of results

Moisture must not be deposited on surfaces by condensation inside the measurement chamber. Otherwise leakage currents driven by the internal high voltage may overlay the detector signal. In that case a reliable measurement cannot be guaranteed. Condensation takes place if warm air saturated with vapour touches a cold surface. This could be the case if a soil gas sampling is carried out in wet warm soil while the ambient air is very cold (e.g. temperature-drop after rain). The instrument warns if the relative Humidity exceeds 90 %rH. Then, the user should observe the sensor readings and stop the measurement in case of further increase. If condensation still took place, the unit should be dried immediately by sucking less humid air.

If a measurement was taken under probably condensing conditions, the results should be verified by a visual assessment of the acquired alpha spectrum. The measurement is definitely valid if all peaks show a clear shape and if they are placed at the correct position.

GPS receiver

The RTM 2200 Soil Gas is equipped with a professional GPS receiver. The receiver uses satellite signals of the navigation systems NAVSTAR (GPS) GLONASS and Galileo in parallel to achieve the best accuracy. The antenna placed at the front panel must not be covered by RF absorbing materials (like metal). Do not operate devices with strong RF emission (like mobile phones) in the direct surrounding of the antenna. The lid of the case does not affect the signal and can be closed.

The geographical position is obtained by the geometrical mean of all position fixes (one fix per Second) over the entire measurement cycle. The accuracy of the coordinates depends on various environmental parameters. For a 20 Minute soil gas sampling an uncertainty of about 5 to 6 m can be assumed.

Maintenance

Battery

The battery and the charge circuit design are optimized for cyclic operation. Continuous operation at mains power without periodical discharge results in a premature capacity lost. SARAD offers optionally a setup for permanent operation from a power supply.

The battery should be recharged directly after usage of the instrument. If the instrument is not used over longer periods the fuse should be removed because of small power consumption even in standby mode. The storage of a discharged battery results in an irreversible destruction of the chemical structure.

Filter

The dust filter must be replaced if a strong pollution can be observed or if the warning "Low permeability" appears even if no soil gas probe is connected.

Calibration and Check

Because of the principal of operation no long term contamination by Po-210 and therefore no Radon background level can occur. A calibration and check of the instrument should be carried out periodically with respect to the statutory regulations (e.g. every two years).

Flexible tube connections

Flexible tubes age over the years resulting in loss of elasticity and porosity. Replace the hoses if you have doubt with respect to tightness and reliability.

Sampling with the impact probe

Impact probes have been established as the standard method for in-situ Radon in soil measurements. Correctly applied, they allow the quick and reliable extraction of soil air.

An impact probe consists of a one-metre long tube, on the lower end of which a so-called "lost tip" is placed. By means of a hammer, the tube is driven into the soil with the tip first. To protect the end of the tube, an impact sleeve is placed on top of it during the driving process. The probe has reached the correct position when the upper end still protrudes approx. 15cm from the ground. In order to achieve maximum sealing of the probe against the surrounding soil, the pipe must be driven in straight and without pendulum motion. Then the drive rod is inserted into the pipe and the lost tip is driven out of the pipe with a few hammer blows (use also the sleeve). The process is completed when the top end of the drive rod still protrudes from the tube by approx. 1cm. This creates a sample volume with a defined geometry in the soil as a prerequisite for the permeability measurement. The driving rod can now be pulled out and the connecting hose to the RTM 2200 Soil Gas can be attached to the upper end of the tube. The hose connection must be checked for leaks before each measurement. A silicone hose with an inner diameter of 8mm should always be used as the connection to the probe. Always use the water inlet protection between the probe and the air inlet of the instrument. Now start soil air measurement cycle on the instrument to measure radon concentration and permeability simultaneously.

Sampling with packer probe

Follow the manufacturer's instructions for use. Make sure that the configuration of the RTM 2200 Soil Gas is adapted to the probe used.

Permeability measurement

Important! If you purchased and received both probes from SARAD, you also received the device configurations required for using of the two soil gas probes from SARAD. Depending on which soil gas probe is used, you should then load the corresponding device configuration for the soil gas probe into the device using the dCONFIG software before the measurement. If you do not have any further device configuration for the second supplied soil gas probe or if you have any questions, please contact SARAD.

Permeability and Radon Potential

Radon potential is the product of soil permeability and radon soil air concentration. The higher the two values, the greater the probability that a large amount of radon is available in the area of the ground contacting parts of a structure. The uncertainty of a permeability measurement is mainly determined by the inhomogeneity of the soil and deviations from the defined geometry of the sample volume. In the case of an in-situ method, the user has no information about these factors. An in-situ measurement of permeability can therefore only serve to estimate the actual conditions. For the radon measurement, relatively large uncertainties result from sampling and different environmental conditions during the measurement too.

Extensive investigations in this field were carried out by Martin and Matěj Neznal [1][2], who introduced a so-called Radon Index taking into account the above mentioned uncertainties. The Radon Index can only assume the values "low, medium and high", which relatively reliably assess the Radon risk for a planned structure.

For this purpose, three defined permeability ranges are assigned to three radon concentration ranges each in a table. To determine the radon index, the permeability measurement is used to select the corresponding column and search for the row whose radon concentration range contains the measured radon concentration. The Radon Index can now be read in the last column of the obtained row.

Permeability k [m²]	< 4E-13 (low)	4E-13 … 4E-12 (medium)	> 4E-12 (high)	Radon Index
Radon concentration [kBq/m³]	< 30	< 20	< 10	Low
	30 … 100	20 … 70	10 … 30	Medium
	> 100	> 70	> 30	High

Measurement methods, accuracy and comparability with other equipment

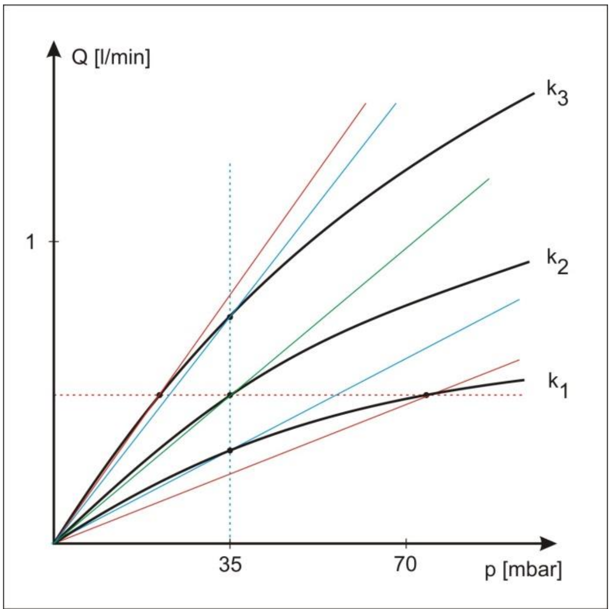
An in-situ measurement of soil permeability k is performed by measuring the pressure drop in the soil and the air volume flow through the soil according to Darcy's law. If all equipment-specific parameters and natural constants are combined, the equation can be written as follows: $$k = C \cdot \frac{Q}{\Delta p}$$

C device constant (contains technical parameters and natural constants)

Q volume flow generated in the soil

Δp pressure drop in the ground between probe and ambient air

Darcy's law applies to laminar flows, since only in this case a linear relationship between volume flow and pressure difference is given. However, a laminar flow can only be assumed if volume flow and pressure difference are close to zero. This cannot be implemented in practice, since a volume flow or differential pressure must be generated for all types of equipment. The selection of one of these parameters determines the operating point of the equipment. With the RTM 2200 Soil Gas, a constant volume flow (0.4 l/min) is applied and the resulting pressure drop in the soil is measured. For equipment with falling bodies, however, a constant pressure (20...100 mbar) is generated and the volume flow is determined by measuring the fall time.



Any flow resistance (as the soil is too) shows a non-linear behaviour, i.e. the differential pressure increases disproportionately with increasing flow. For this reason, too low a permeability is always determined for Δp and Q greater than zero. The lower the actual permeability, the higher is the deviation. A type of equipment measures more accurately the lower the pressure drop and flow rate are chosen. If you compare equipment with falling bodies (constant pressure) and the RTM 2200 Soil Gas (constant volume flow), there exist a permeability value from which a constant volume flow results in a lower pressure drop. In the direction of higher permeability, the RTM 2200 Soil Gas provides the more accurate values, while for lower permeability, the equipment with falling bodies has an advantage. The figure left illustrates the situation.

The black curves show the non-linear flow characteristics of three soils with different permeability (k3 > k2 > k1). The working points of the equipment are derived from the intersection points of the curves with the provided flow (RTM, red dotted line) or inlet pressure (falling bodies, blue dotted line). The measured permeability corresponds to the slope of the straight lines through the respective working points. The actual permeability would correspond to the slope of the curves at zero-point. For the permeability k2 the working points are identical (green line), both equipment show the same measured value. For k3, the permeability is underestimated by the system with drop body, for k1 by the system with constant flow.

Therefore, any equipment should be adapted to the permeability range of interest. According to the section "Permeability and Radon Potential", the boundaries between the three indicated permeability classes (4E-12 m^2 or 4E-13 m^2) are of particular interest for estimating the radon potential. A further criterion for field measurements is the measuring time. In case of low permeability, the volume flow of equipment with fall bodies become very small, which results in sampling times up to the hour range.

The same operating points for the RTM 2200 Soil Gas and the falling body permeability meter "Radon JOK" cited in [1] are present at a permeability of about 3E-14 m^2.

Measuring range and operating conditions

The lower measuring range limit for permeability is determined by the maximum negative pressure provided by the pump, while the upper limit is determined by the minimum measurable pressure difference. The permeability measuring range of the RTM 2200 Soil Gas depends on the used soil gas probe. Above the upper limit, the measured value runs towards infinity, since the differential pressure is in the denominator of the Darcy equation. Pulsating air flow can cause strong jumps in the display or negative values in the surrounding of the upper range limit. These fluctuations are compensated by averaging over the measuring period. If the measuring range limits are exceeded, the alarm light is activated. The measurement must always be carried out with probe type configured at the RTM2200. If a different probe shall be used, the parameters must be changed in the configuration space of the instrument. The user is responsible to keep the right sampling geometry on site (size and depth of the suction point). Deviations from the requested geometry result in wrong readings. Any change in the measurement geometry will result in an invalid measurement. Do not insert long or small diameter tubes between the instrument and the soil probe. The standard hose supplied (l = 1m, di = 8mm) must be used. The pressure sensor (especially its zero point) must be periodically checked and calibrated. This can be done by a defined flow resistance. In case of a well-adjusted zero point, the displayed results varying between positive and negative values significant higher than the upper limit of the measurement range. Fore zero point checking the probe should be connected but placed on fresh air.

Disposal instructions

Do not dispose the instrument in the household waste. The instrument contains valuable and easy recyclable components which must be saved for re-use. Send back the instrument to the manufacturer after its lifetime or take it to a certified collection station.

Scope of delivery

article no.	name	qty
22040021	RTM 2200 soil gas	1
	Power supply adapter	1
	Water inlet protection (built-in)	1
	GPS receiver (built-in)	1

	Dust filter(40µm)	2
	Fuse	2
	PVC tube (6,35 x 3,18) mm PVC tube (10x6mm)	1,5 m 1,5m
	USB cable	1
	RS232 cable	1
	Case for field use, IP65	1
	dVision/dConfig (SARAD) (Win), manual	1 CD*
	Calibration certificate	1
	Warranty certificate	1

*also available on Homepage https://sarad.de

Optional accessories:

Nr.	article no.	name	Qty.	remark
1	10010003	Aqua Kit incl. 1x tube 1m (6x3mm) 2x adapter 5/10mm 2x tubes 15cm (10x6mm)	1	For Rn meas. in water
2	10010004	Gas transfer membrane	1	For Rn meas. in water
3	10010007	Soil gas probes Incl..2x adapter 10/13mm 2x adapter 5/10mm, 1x tube 1,5m (6x3mm) 1x tube 1,5m (10x6mm) 1x tube 15cm (14x10mm	1, Set	
4	10010017	Sharp tips for soil gas probes	100 pcs	
5	80020005	Simple retractor for soil gas probes	1 pc	
6	10010010	Special retractor for soil gas probes	1	
7	20040003	Monopak Borehole packer probe + Pump	1	
8	10010009	Exhalation unit 430 mm x 430 mm incl. 1x tube 1,5m (6x3mm) 2x adapter 5/10mm 2x tubes 15cm (10x6mm)	1	
9	80020002	Dust filter	10	
10	78800001	4G VPN-Router incl. Mains adapter	1	
11	50011012	5l barrel	1	for Radon-emmanation for bulk materials
12		TDR soil moisture probe		
13		Differential pressure sensor 0 … 25 Pa		
14		More sensors on request		

RTM 2200 – Technical Data

Radon chamber	
Detector	4 x 200 mm² Si-detector with HV chambers
Internal volume	300 ml (total volume of the internal air loop including water inlet protection)
Range	1…10 MBq/m³
Sensitivity	3 or 6,5 cpm/(kBq/m³) for fast or slow mode
Accuracy	<=5%
Response time	12 or 120 min for fast or slow mode
Analysis/Results	Alpha spectroscopy with separate calculation of Radon and Thoron concentration. Storage of the alpha spectrum for each data record
Pump	High quality membrane pump; Flow rate 0.4 or 1.2 l/min controlled by processor
Fresh air flushing	Automatic switch over between fresh air and sample air inlet
Soil permeability	
Principle	Measurement of the pressure difference at regulated flow rate (0.4 or 1.2 l/min)
Range	$8*10^{-12}$ m² … $8*10^{-14}$ m²
Sampling	Tube connection to soil gas probe; flow rate for permeability measurement selectable (0.4 l/min or 1.2 l/min)
Protection functions	
Battery voltage	Measurement will be stopped in case of discharged battery; hardware protection against deep discharge
Flow rate	Alert signal if flow rate cannot be maintained by the regulator (e.g. permeability too low)
Pump power consumption	Measurement will be stopped in case of damaged or worn pump
Water inlet protection	Pump will be stopped as soon as water is sucked. Stainless steel can may be removed to drain the water
Internal sensors	
Rel. humidity	0 …100%, accuracy ± 2%
Temperature	-20 … 40°C, accuracy ± 0.5°C
Bar. pressure	800 … 1200 mbar, accuracy 0.5% MW
Flow rate	0 … 2 l/min, accuracy ± 5% @ 1 l/min

	Humidity/temperature sensor are integrated in the air internal air loop
Common	
GPS receiver	High accuracy by simultaneous reception of GPS, Galileo and GLONASS
Sampling programs	Continuous sampling (1, 5, 15, 30 and 60 minutes) Soil gas cycle (20 minutes) Additional cycles may be programmed by the user
Memory	SD card, 2 GB (approx.. 1 million data records)
Control/Display	Touch screen 6 x 9 cm wide, visible in direct sunlight Interfaces: USB and RS232
Power supply	Internal 12V NiMH rechargeable battery (>100h), AC/DC mains adapter 100-240 V ~50/60Hz, 1,8A
ATEX category	no
Environmental conditions	0 ... 40°C 0 ... 95% rH, non-condensing 800...1100mbar
Dimensions	235 mm x 140 mm x 255 mm
Weight	approx. 6 kg (instrument only)
Case	Peli case 1430 with bulkhead fittings and signal light (W x D x H: 417 mm x 221 mm x 334 mm; weight 2.9 kg)
Software	dVISION/dCONFIG; server software for instrument access via internet
Included in delivery	USB- & RS232-cable, dust filter (x2), fuse (x2), PVC tubes 10x6mm (1,5 m), 6x4mm (1,5 m), incl. transition pieces, water intake protection (x1), charger/power supply adapter (x1), case for field applications, user manual & software (on CD), DAkkS-accredited calibration certificate
Options	on request / soil gas probes, AquaKit, exhalation bonnet, emanation barrel, packer probe, and other

References

[1] RELIABILITY OF THE NEW METHOD FOR ASSESSING THE RADON RISK –
GAS PERMEABILITY CLASSIFICATION
Matěj Neznal, Martin Neznal; Radon v.o.s. corp. Novákových 6, 180 00 Praha 8, Czech Republic
[2] Barnet, I., Pacherová, P., Neznal, M., Neznal, M., 2008, Special Papers No. 19. Czech Geological Survey. Praha.
ISBN 978-80-7075-707-

