Manual RTM 2200 Soil Gas

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Content

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

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 RTM2200 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 RTM2200 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.

In case of an unintended water intake all cables and hoses must be removed from the water intake protection. After that, the can 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:

> "10 min", "15 min", "30 min", "60 min"
> Continuous measurement with the specified sampling interval
>
> "Soil gas"
> Cycle for soil gas sampling with integrated measurement of the soil permeability

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]

Continuous measurement (10 min, 15 min, 30 min, 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:

<u>Radon fast:</u> 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.

<u>Radon slow:</u> 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".

Radon soil gas sampling (Soil gas)

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). 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.

The RTM2200 soil gas offers a special measurement cycle for soil gas sampling. The soil permeability will be simultaneously determined during that cycle. 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.

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
Diff. pressure	Differential pressure	Optional for blower door tests etc.

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.

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)
“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 RTM2200 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 RTM2200 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.

Permeability measurement

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-12	4E-13 … 4E-12	> 4E-13	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:

$$k = C \cdot \frac{Q}{\Delta p}$$

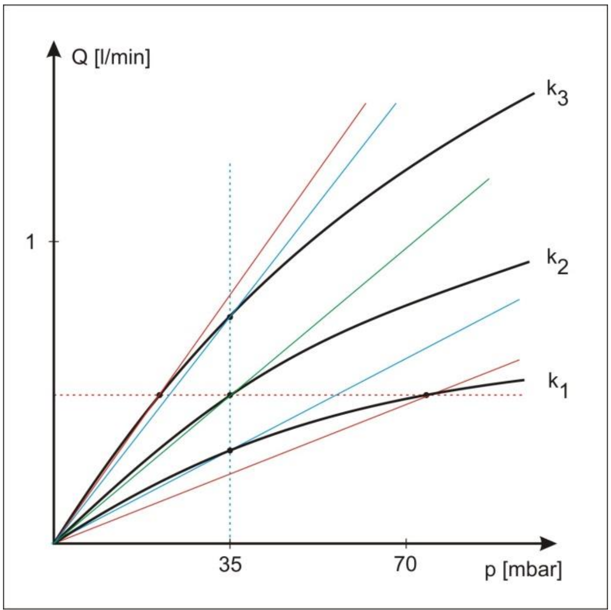
C device constant (contains technical parameters and natural constants)

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 RTM2200 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 RTM2200 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 RTM2200 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 m² or 4E-13 m²) 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 RTM2200 Soil Gas and the falling body permeability meter "Radon JOK" cited in [1] are present at a permeability of about 3E-14 m².

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 RTM2200 soil gas has a measuring range from approx. 2E-14 m² to 1E-11 m².

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 the impact probe supplied by SARAD or an identical impact probe. The probe must always be driven completely (825mm) into the ground and the lost tip driven out by 120mm. 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.

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

- RTM2200 Soil Gas: Instrument installed in a case (Bulkheads/signal light) with integrated water intake protection

- Charger
- Dummy plug for water intake protection
- Dust filter
- USB cable

RTM2200 – Technical Data

Radon chamber	
Detector	4 x 200 mm² ion-implanted silicon detector
Internal volume	300 ml (total volume of the internal air loop including water inlet protection)
Range	0…10 MBq/m³
Sensitivity	3 or 7 cpm/(kBq/m³) for fast or slow mode
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 0.5 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 (1 l/min)
Range	$8 * 10^{-12}$ m² … $8 * 10^{-14}$ m²
Sampling	Tube connection to soil gas probe
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
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 … 1200mbar, 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, AC/DC wall adapter
Dimensions/weight	235mm x 140 mm x 255 mm / 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	Instrument with caser 12V/60VA AC/DC adapter USB – cable
Options	TDR soil moisture probe Differential pressure sensor 0 … 25 Pa More sensors on request

References

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GAS PERMEABILITY CLASSIFICATION
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[2] Barnet, I., Pacherová, P., Neznal, M., Neznal, M., 2008, Special Papers No. 19. Czech Geological Survey. Praha.
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