DURRIDGE
RADON INSTRUMENTATION


*(ES) Equipements Scientifiques SA - Département Bio-tests & Industries - 127 rue de Buzenval BP 26 - 92380 Garches*
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# Radon

When the Earth was formed several billion years ago, it contained a huge amount of radioactive material. Since then almost all of this matter has decayed into more stable elements. All, that is, except for uranium and thorium, whose half-lives are billions of years. Much of the Earth's original radioactive uranium and thorium remains to this day.

## Where Radon Comes From

The uranium and thorium decay chains include a variety of radioactive elements. Most of these are metals, so they remain underground where they do little harm. But one of them is a gas: radon. Because radon has a half life of a few days, it often has enough time to seep up through the ground, through cracks in building foundations, and into homes and offices.

Radon and its daughters in the air can be inhaled. As they decay some emit high-energy alpha particles, as shown in Figure 1. These alpha particles are hazardous to living cells. Over time, continued

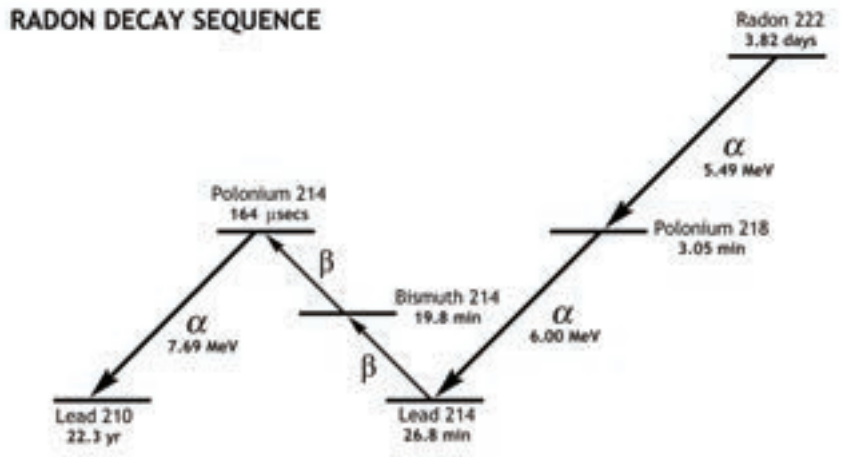


***Figure 1: Radon decay chain from Radon 222 to Lead 210.***



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## How Dangerous Is Radon?

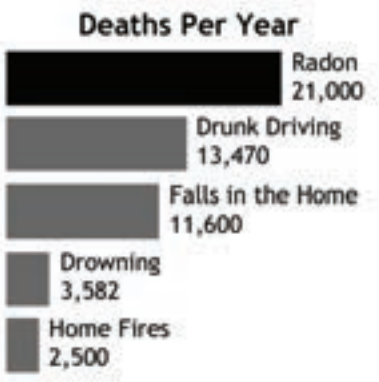


***Figure 2: Comparison of deaths from various causes. Source: U.S. EPA***

Radon is widely known to be the second leading cause of lung cancer, after cigarette smoking. While short term exposure to a high concentration of radon may not create an immediate health risk, continuous exposure over a period of time poses a significant danger.

Smokers are more susceptible to the effects of radon exposure, because their lungs are already damaged by smoking.

exposure can result in lung cancer. Modern, well insulated homes are especially effective at trapping high concentrations of radon.

Inexpensive and widely available home radon test kits can be used for screening tests to determine with reasonable accuracy whether a radon concentration exceeds the U.S. Environmental Protection Agency's recommended limit of 4.0 picocuries per liter (pCi/L). More precise radon measurements are possible with high-end instruments including the DURRIDGE RAD7, which is described in detail the next chapter.

## Radon Mitigation

When radon is allowed to collect in an enclosed space it poses a significant health risk. If dangerous levels of radon are detected in a building, it is necessary to install a mitigation system. Sub-slab depressurization is an effective mitigation method. Air beneath the basement slab is sucked out, causing a reduction in pressure, so that any air leakage goes out from the basement instead of in from the soil.



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# Detecting Radon with the DURRIDGE RAD7

The DURRIDGE RAD7 is a versatile radon detector. It is widely used not only in home radon testing, but also in laboratories and field sites around the globe. It is easy to set up and use: common measurement tasks can be completed using pre-programmed set-ups, and up to 1000 radon measurements may be recorded before being transferred to a Windows or Macintosh computer for further analysis.

The RAD7 comes complete with a built-in pump, rechargeable batteries, and a wireless infrared printer. It is built to withstand demanding use in the field, with a rugged, protective case and long battery life.


***Figure 3: The DURRIDGE RAD7 Electronic Radon Detector***



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## RAD7 Specifications

| | |
|---|---|
| Modes of Operation: | • Continuous Radon Gas Monitor<br>• Long-term/Short-term screener<br>• SNIFF mode, to search for radon entry points<br>• GRAB mode for batch sample analysis<br>• Continuous radon-in-water, with RAD AQUA<br>* Thoron mode logs radon and thoron simultaneously |
| Nominal Sensitivity: | • Monitor: 0.5 cpm/(pCi/L)<br>• Sniffer: 0.25 cpm/(pCi/L) |
| Operating Range: | 0.1 to 20,000 pCi/L (4 to 750,000 Bq/m3) |
| Internal Memory: | 1000 radon concentration records w/ associated data |
| Operation Principle: | Electrostatic collection with real-time high-resolution spectral analysis. Passivated Ion-implanted Planar Silicon detector. |
| Built-In Air Pump: | Nominal 1 liter/minute flow rate |
| Power Supply: | AC, external 12v DC, or battery powered - 5 AH 6V batteries. Battery life is 24 to 72 hours. |
| Connectivity: | RS-232 port with supplied USB Adaptor |
| Operating Range: | 30°-105° F (0° - 40° C). 0% - 100% humidity |
| Weight: | 11 pounds (5 kg) |
| Dimensions: | 9.5” x 7.5” x 10.5” (24 cm x 19 cm x 27 cm) |

***Additional specifications are available at www.durridge.com.***

Key RAD7 advantages include:

- Fast response: detects EPA action level of 4 pCi/L in just one hour.
- Vanishingly small intrinsic background for life of instrument.
- Independently and simultaneously measures radon and thorn.
- Complete, compact, and portable unit with rugged carrying case.
- Includes wireless infrared printer for on-the-spot feedback.
- USB and Serial connections for use with any computer.



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## Where Are RAD7s Used?

About 3,000 RAD7 radon monitors are in regular use around the world at locations ranging from elementary schools to universities and from underground uranium mines to oceanographic research institutes. RAD7s have been successfully deployed in deserts and volcanoes, at extreme temperatures and humidities. One university professor wrote:

***"I have four RAD7s and am about to purchase a fifth for some Greenland work. I have never had any major troubles with the instruments and found them to be EXTREMELY robust. I have repelled into craters with them on my back and hauled them out. Probably a better testament of their robustness is that I have masters students take them into the field and they still work!"***

## Technical Note: How the RAD7 Gathers Data

The RAD7 has a measurement chamber containing an electrostatic field. When radon atoms enter the RAD7 and decay, polonium 218 ($^{218}$Po) atoms are deposited onto the surface of the RAD7's *Canberra Passivated Ion-implanted Planar Silicon Alpha Detector*. Alpha particles from subsequent steps along the decay chain are counted and their energy recorded to memory. By identifying individual isotopes, the RAD7 achieves unsurpassed capability and functionality.

$^{218}$Po, the first daughter of radon, has a half-life of just 3.05 minutes. So when the RAD7 is set to count $^{218}$Po decays, it responds quickly and can be used to take multiple spot measurements within a short amount of time. After about 4.3 half lives or 13 minutes, the RAD7 count rate reaches 95% of its equilibrium value. This makes the RAD7 uniquely suited for radon testing when time is at a premium, or for following repid changes in radon concentration.

Among the other particles that the RAD7 can detect is that from the decay of $^{214}$Po, a later daughter of radon which takes about three hours to reach equilibrium with radon in the measurement chamber. Using the default settings the RAD7 will begin recording measurements with increased precision after three hours, by counting both $^{218}$Po and $^{214}$Po decays.



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## Thoron: A Clue to the Source of Radon Leaks

In addition to measuring radon concentrations, the RAD7 provides an independant assessment of thoron ($^{220}Rn$). This isotope of radon occurs in the thorium decay chain, and has a half-life of just 56 seconds. When a thoron atom decays inside the RAD7 the resulting $^{216}Po$ atom is precipitated onto the surface of the alpha detector. Here it immediately decays to $^{212}Pb$, emitting an alpha particle which is identified and counted by the RAD7.

If there is little air movement in a building, thoron will not diffuse far from its point of entry before it decays. The thoron concentration will be highest near the source. So the RAD7 may be used to "sniff" for thoron in order to locate radon entry points.

Since the $^{216}Po$ daughter of thoron has such a short half life (150 mS) the RAD7's response to thoron is practically instantaneous. Sniffing for thoron is therefore a fast and effective way to find out where soil gas is entering a building.

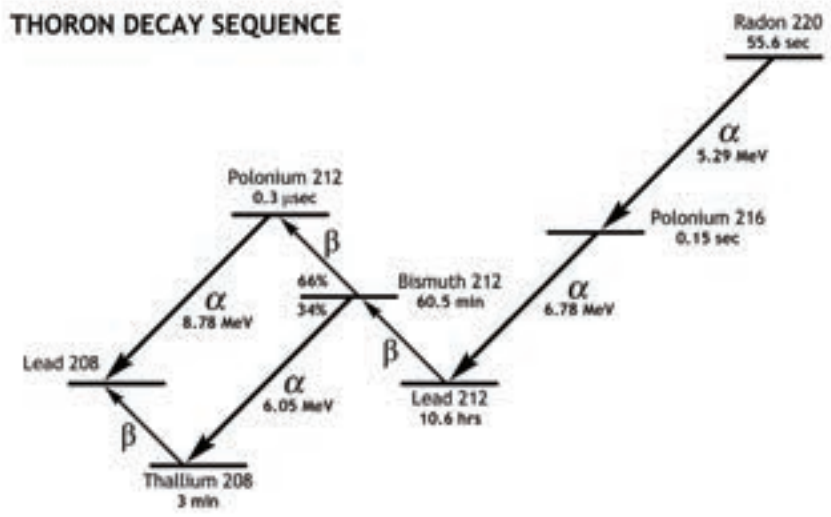


***Figure 4: Thoron decay chain from Radon 220 to Lead 208.***



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# Radon Data Acquisition and Analysis

Once radon data has been recorded to the RAD7's memory, it may be printed on the included portable infrared printer, or downloaded to a computer using a USB or serial connection, or a remote modem. DURRIDGE offers a dedicated RAD7 communications software package called CAPTURE, which transfers RAD7 data to disk, displays radon graphs, and produces a variety of supplementary information about each RAD7 record based on additional inputs such as temperature data and device calibration profiles.

## CAPTURE: RAD7 Data Retrieval and More

CAPTURE's ability to communicate with the RAD7 extends beyond downloading and graphing data: it is also possible to control testing runs, obtain data summaries, configure the RAD7's numerous settings, and obtain the RAD7's serial number and calibration date. In fact, any command available on the RAD7's physical keypad may be issued from within CAPTURE, whether the machine is located across the room or across the continent.

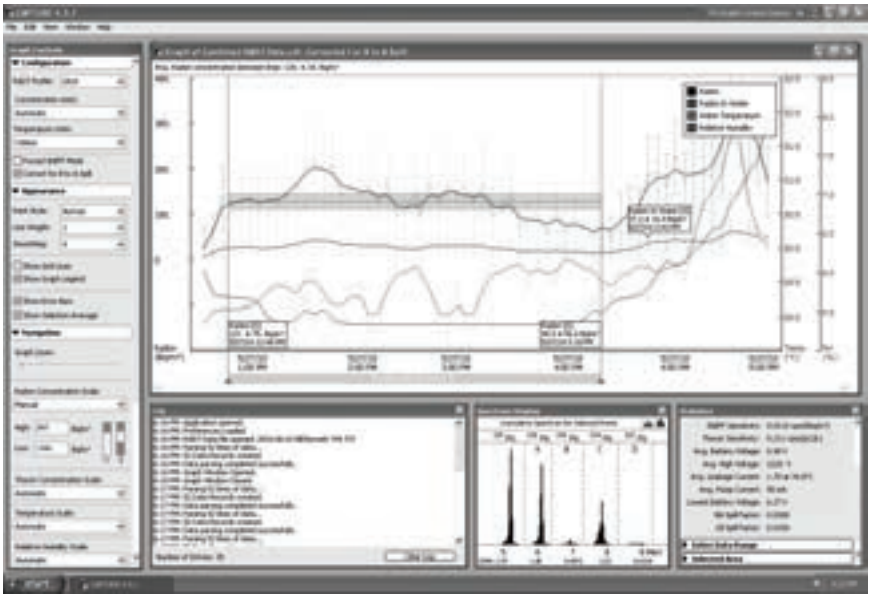

***Figure 5: A radon data graph generated with*** DURRIDGE CAPTURE.



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The CAPTURE Graph Window displays radon, thoron, air temperature, and humidity across a scrollable, zoomable time line. Under certain conditions it is also possible to graph radon in water, thoron in water, and water temperature. Each data point's uncertainty is represented visually, as is the average concentration and uncertainty of the current selection.

Auxiliary floating windows provide data navigation controls and a wealth of statistics on the RAD7 hardware, the full data set, the selected RAD7 records, and the point closest to the cursor.

In addition, a Spectrum Window displays a synthetic representation of the alpha energy spectrum printed out by the RAD7, indicating the presence of radon and thoron daughter particles.

CAPTURE's graph data may be cropped, combined, printed, and exported. Several data formats are supported, permitting further analysis with spreadsheets and other software.

## CAPTURE Software Key Features

Through continuous and ongoing development, DURRIDGE's CAPTURE software has come to include many features that improve the RAD7 workflow:

- Automatic detection of all connected RAD7s.
- Remote data downloading, without having to touch the RAD7.
- Automatic correction for humidity and other variables.
- Communication with RAD7s over phone lines and the internet.
- Easy access to frequently used configuration options.
- Synthesis of radon in water data.
- Support for damaged and incomplete RAD7 data files.
- Acquisition of supplementary RAD7 data for increased accuracy.

***Praise for the RAD7 from a radon professional:***
***"I want to let you know how much I have liked working with the RAD7 radon detector. I enjoy the ease of operation, and my customers appreciate the ability to see the print-out of results within 48 hours."***



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# DURRIDGE RAD7 Accessories

DURRIDGE offers a broad selection of accessories that make it possible to measure radon underwater, underground, and emissions from various types of natural and artificial surfaces. In addition, accessories are provided for measuring unusually high concentrations of radon and for controlling the equipment duty cycle as required by the needs of the user.

## Accessories Overview

**RAD H20**: This portable accessory kit is used to measure radon concentrations in samples of water collected from any source.

**RAD AQUA:** This accessory makes possible fast-response continuous monitoring of radon and thoron concentrations in water.

**Water Probe:** The Water Probe uses a permeable membrane tube for slow-response continuous monitoring of radon in water.

**Soil Gas Probe:** Measure radon in soil gas with a RAD7 and this selection of steel probes.

**DRYSTIK:** Remove moisture from the air entering the RAD7, reducing or eliminating the need for dessicant.

**Duty Cycle Controller:** This accessory regulates the DRYSTIK pump to avoid diluting underground soil gas with outside air.

**Range Extender:** The Range Extender makes it possible for a RAD7 to measure radon in concentrations up to ten times the normal limit.

**Emission Chambers:** DURRIDGE offers emission chambers for measuring the amount of radon being emitted from hard and soft ground surfaces.

**In-Line CO2 Sensor:** Monitor CO2 concentrations in real time and record the collected data to disk.

Read on for detailed descriptions of each DURRIDGE accessory.



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## RAD $H_2O$

### Radon In Water Accessory for the RAD7

For over ten years radon testers and laboratories worldwide have relied on the RAD $H_20$ to test radon in water. This versatile RAD7 accessory is capable of measuring radon concentrations ranging from less than 10 pCi/L to 500,000 pCi/L (20,000 Bq/L).

The RAD $H_20$ equipment is portable, and basic radon measurements can be completed in under an hour of taking the sample. In fact, after 30 minutes the RAD $H_20$ gives results with accuracy matching or exceeding that of liquid scintillation methods. With a more complex procedure, it is also possible to detect radium in water.

***Figure 6: The RAD $H_20$ accessory connected to a RAD7.***



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## RAD AQUA

### Fast Response Monitoring of Radon in Water

The RAD AQUA is an accessory for the DURRIDGE RAD7 that is used to bring the radon concentration in a closed air loop into equilibrium with the radon concentration in a flow-through water supply. In this manner the reported radon concentration in the air entering the RAD7 can be used to determine the level of radon in the water passing through the RAD AQUA.

The RAD AQUA consists of a spray chamber, called an "exchanger", which is responsible for bringing the air and water into equilibrium. The radon in the air is monitored continuously by the RAD7, with a temperature probe operating simultaneously. DURRIDGE's CAPTURE software can be used to process the RAD7 data and the corresponding temperature probe data, to generate graphs displaying radon and thoron concentrations in water.

***Figure 7: The RAD AQUA provides continuous fast-response measurement of radon and thoron in a water supply.***

It takes time for the water passing through the RAD AQUA to deliver radon to the air loop, and for the RAD7 to respond to the changed radon concentration. With optimum configuration, the response time of the system may be reduced to less than half an hour.



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## Water Probe

### Slow Response Monitoring of Radon in Water

The DURRIDGE Water Probe consists of a semi-permeable membrane tube mounted on an open wire frame. The tube is placed in a closed loop with the RAD7.

When the probe is lowered into water, radon passes through the membrane until the radon concentration in the air loop is in equilibrium with the water. As with the RAD AQUA, the equilibrium ratio of radon in the air to radon in the water is determined by the temperature.

***Figure 8: The Water Probe, for slow response monitoring of radon.***

***Praise for the RAD7 from a university professor:***
***"The RAD7 is the best commercially available instrument for measuring Rn that I have ever seen. We originally bought one - we now own 12 and may purchase more."***



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## Soil Gas Probe

### In-Ground Radon Detection

When measuring radon underground, it is essential to collect samples without exposing them to the outside air. DURRIDGE offers three heavy-duty soil probes for this purpose: the durable and easy to use Stainless Steel Soil Gas Probe, the regular Steel Soil Gas Probe, and a third party soil gas probe provided by AMS, Inc.

Designed to be simple and effective, DURRIDGE's Soil Gas Probes consist of a hollow steel tube with a collar and NPT thread at the top. An included drive rod slides down inside the tube and penetrates the ground. Also supplied with the probe is a pilot solid steel rod 3/8" diameter to make a pilot hole for the probe.

The only necessary equipment, besides the RAD7 itself, is a self-grip wrench, a 5/8" open or adjustable wrench, hammer and teflon tape.

DURRIDGE's Soil Gas Probes operate anywhere above the water table, preferably in soil containing few stones. The pilot rod is hammered most of the way to the depth required, then removed and replaced with the drive rod inside the probe. Once it has been hammered down to the required depth, the drive rod is removed, creating a channel through which soil gas may flow upward.

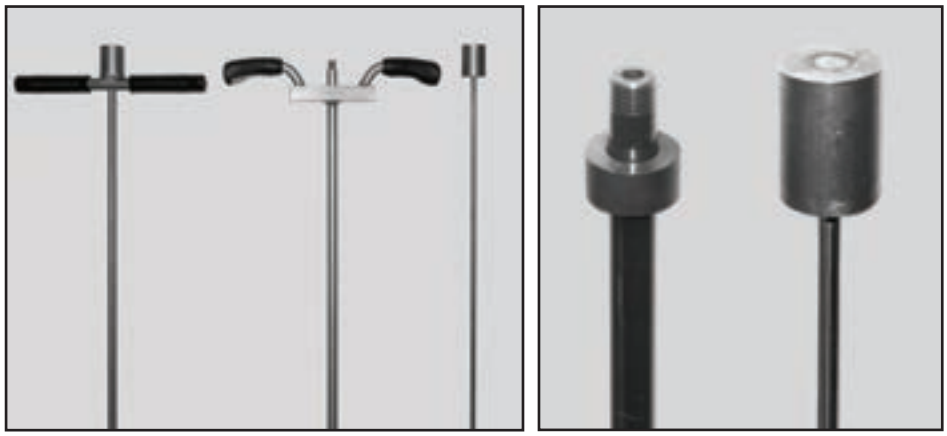

***Figure 9: Stainless Steel Soil Gas Probe (L) and Regular Steel Soil Gas Probe close-up (R)***



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## DRYSTIK

### Moisture Exchanger to Extend Desiccant Life Span

The RAD7 works best when the incoming air sample has a low relative humidity. The DURRIDGE DRYSTIK assists by transferring moisture from the incoming air to the air being pumped out of the RAD7. This means that any air being sent through a drying unit on its way to the RAD7 will have already lost most of its moisture, greatly extending the life of the desiccant in the drying unit.

The DURRIDGE DRYSTIK is available in two models: the Active DRYSTIK, which contains a built-in pump, and the Passive DRYSTIK, which relies on the RAD7's internal pump. Each model is available with three lengths of NAFION moisture-exchanging tubing, with the greater lengths providing higher efficiency.

In typical conditions, the 12" Passive DRYSTIK will preserve a container of desiccant for two months of continuous use, a significant improvement over its standard useful life span of 10 days. The 48" Active DRYSTIK, by comparison, will preserve the desiccant for over three months. DURRIDGE also offers a premium 144" option.


***Figure 10: 12-inch Passive DRYSTIK with NAFION Tube (L) and Active DRYSTIK enclosure with built-in pump (R)***



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## Duty Cycle Controller

### Accessory for Active DRYSTIK and Soil Gas Probe

Monitoring soil gas in the long term, for geotechnical and earthquake studies, is likely to dilute the soil gas sample with fresh air diffused down from the surface. The DURRIDGE Duty Cycle Controller can control the 12V supply to an Active DRYSTIK, with a duty cycle anywhere from 100% to less than 1%. This means that the average flow rate can be carefully controlled to eliminate dilution of the sample and enable soil gas sampling to continue indefinitely.

The Duty Cycle Controller has an ON time in each cycle of 3 seconds. The OFF time in the cycle may be varied from zero to 1,000 seconds or fully off.

Side benefits to reducing the flow rate include reducing wear on the Active DRYSTIK pump and increasing the life of the desiccant.

The Duty Cycle Controller can also control the power to any 12V device, such as a sampling pump, whose current draw is not more than 1A. Thus a sampling pump may be set, by the Duty Cycle Controller, to pump for three seconds once every minute.


*Figure 11: Duty Cycle Controller*



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## Range Extender

### Increase the range of the RAD7 in high radon areas

The Range Extender mixes fresh air with sample air to reduce the concentration of radon in the air fed to the RAD7 radon detector by an order of a magnitude, greatly increasing its effective range.

The extender consists of two parallel capillary tubes joined at one end to the outlet hose connector. Fresh air is fed to the input of one tube while the incident radon sample is fed to the other. A differential pressure sensor across the two tube inputs, with a needle valve for adjustment, is used to ensure that both capillary tubes have the same pressure drop across them.

The Range Extender can be used for the measurement of very high radon concentrations in air, in soil gas and in water. It can also be used with any other instrument that has its own pump, for any gas. If used to extend the range of thoron measurement care must be taken to assess and correct for the additional decay of the thoron due to sample acquisition delay.


***Figure 12: DURRIDGE Range Extender.*** **The radon concentration delivered to the RAD7 is reduced by a factor of 10. The pump can cycle on and off without affecting the reduction fac*tor*.**



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## Emission Chambers

### Soil and Hard surface emission detection

Two emission chamber accessories are offered for the RAD7 radon detector: one for soil surfaces and one for hard surfaces. The Soil Surface Emission Chamber has a stainless steel skirt around the circumference, to penetrate the soil. The Hard Surface Emission chamber has a flat base with sealant.

For soil emission measurements, the skirted chamber may be placed on the ground and stood upon, to push the steel skirt into the dirt. A closed loop measurement may be completed in approximately 30 minutes. Open loop monitoring may be performed continuously, showing diurnal variation of soil emission and allowing the user to obtain as high a precision as desired.

For hard surface emission measurements, the chamber with a soft seal may be applied to the surface. Closed and open loop measurements may be made.

Closed loop protocol provides a quick and sensitive reading, while open loop offers increased scope for investigating variations in emission due to changes in parameters such as barometric pressure, temperature, relative humidity, and ambient radon concentration.

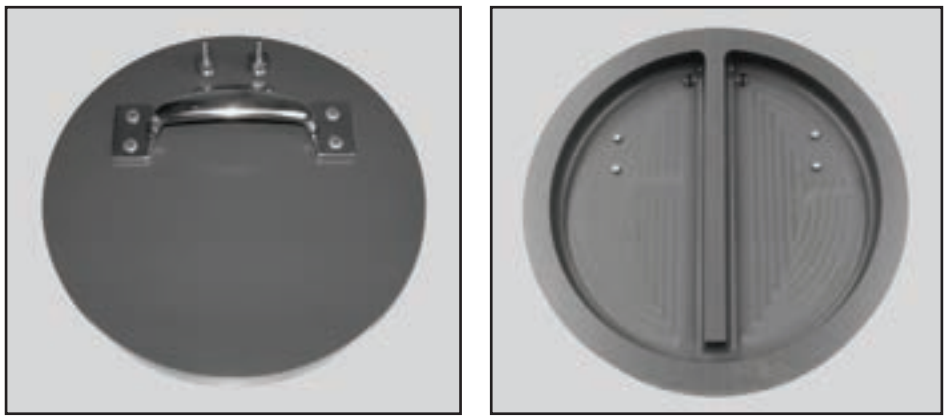

***Figure 13: Soil / Hard Surface Emission Chamber, top view (L) and Hard Surface Emission Chamber, bottom view (R).***



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## In-Line $CO_2$ Sensor

### Measures carbon dioxide in air samples

The DURRIDGE $CO_2$ Sensor measures the carbon dioxide in an air sample up to 10,000 parts per million by volume (ppmv). The air must be pumped into the $CO_2$ Sensor at a flow rate no greater then 1L/min. The $CO_2$ Sensor was designed to accompany the RAD7 Radon Detector, but can be used with any source of flowing air.

As soon as the CO2 Sensor is powered on, the LCD screen will begin to display the level of carbon dioxide measured in parts per million. Coupled with the EL-USB-3 data logger (or other 0-5V voltage logger), the DURRIDGE $CO_2$ Sensor can be used to record carbon dioxide levels at regular intervals.


***Figure 14: The DURRIDGE $CO_2$ Sensor***



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# Customer Testimonials

Praise for the RAD7 and other DURRIDGE products from industry and academic professionals.

***From a University Professor:***
"We have been measuring Rn for about 20 years - mostly in water but in air as well. The RAD7 is the best commercially available instrument for measuring Rn that I have ever seen. We originally bought one - we now own 12 and may purchase more. The RAD7 is a very nice little device with features that one would only expect in much more expensive instruments."

***From an Environmental Laboratory:***
"We find the RAD7 user-friendly. When side-by-side studies were run against our liquid scintillation unit we found the RAD $H_2O$ to be within +/- 5% of our Packard unit. We find the instrument to be more hassle-free than the Packard unit because we no longer have to fool around with the Optifluor liquid. Your unit's portability allows us to bring the "lab" to the customer. We are very pleased with the RAD H2O. It performs better than I expected and I will recommend your product to my colleagues."

***From a Radon Mitigator:***
"I have been using the RAD7 now for a few years, and I am very pleased with it. When searching for radon entry points I discovered that Thoron often shows in the spectrum printout, where radon enters the house. Measuring one half meter away from that point Thoron doesn't show. This is a very good help to find the entry points."

***From a University Graduate Student:***
"The RAD7 has been an excellent purchase. It significantly helped a research project I was working on and I see many new research opportunities in the future using the RAD7. The machine and add-ons (RAD AQUA and RAD $H_2O$) are all well documented and work very well and easily in the field. The greatest help and what really separates DURRIDGE from other companies is the unparalleled service I have been given. Answers and advice have always been quick, helpful and thorough."

***More customer testimonials are available at www.durridge.com.***



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