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DURRIDGE SOIL GAS PROBE

CONTENTS

WARNING

The probe, drive rod amd pilot rod are heavy and long pieces of steel. They have sharp, induction hardened points. Take great care in handling them. Before or during use please make sure that the point does not pierce or damage any person, animal or object of value.

Please make sure that no gas, electric, telephone, water, sewage or other service lines or any objects of value lie in the path of pilot rod or probe before driving them into the ground.

1. Introduction

Designed to be simple and effective, the DURRIDGE soil gas probe consists of a hollow steel tube, ½" OD and ¼" ID, with a collar and NPT thread at the top. A ¼" drive rod that slides down the inside of the tube has a heavy cup at the top that clears the NPT thread and bears on the collar round the probe. Also supplied with the probe is a pilot solid steel rod ⅜" diameter to make a pilot hole for the probe.

2. Placement

Look for a location well above the water table where the soil is uniform and generally free of rocks. Hammer the pilot rod into the ground to the depth required for sampling. Should it become apparent that the rod has stopped against a rock, remove the rod and choose a new location at least ten inches (25cm) from the earlier spot. Once the rod has been successfully driven to the required depth, remove the pilot rod to leave a pilot hole in the ground for the probe to penetrate more easily.

With the drive rod positioned inside the probe, hammer the drive rod and probe together into the ground, down the pilot hole, to the depth required.

Remove the drive rod leaving the probe in the ground.

3. Connection

There are two alternative methods of connecting the probe to the RAD7. Either push the plug-in hose connector into the probe or screw on the NPT hose connector.

With the plug-in connector make sure the O-rings are clean and not damaged and that it is a tight, push fit into the probe. For the NPT connector, tightly wrap the NPT thread on the probe with two or three layers of teflon tape. Apply the tape clockwise looking from above - that is in the same direction as the adapter when it is screwed on. Screw on the hose adapter (or the water shut-off valve). Make sure it is good and tight. If there is a leak at this connection, ambient air will be sucked into the tubing to dilute the soil gas, thus reducing the radon concentration in the air sample delivered to the RAD7.

Tamp down the soil around the probe. Leakage of fresh air into the sample acquisition path or down the outside of the probe to the sampling point can be a major source of error in the measurement.

Attach the supplied plastic tubing to the hose connector. The other end of the tubing is then connected to the laboratory drying unit. (Note that this connection should go to the upstream connection on the drying unit. That is the one closest to the screw cap.) If a DRYSTIK is used, it should be inserted between the probe and the drying unit.

4 Measurement

Before starting any measurement, make sure the RAD7 memory and run number are not full. (Data, Free [ENTER]) and read the number of free cycles - should be more than 100, (Data, Read [ENTER]) and see the run number of the last run - should be less than 90. If the space or available run numbers are too few, use CAPTURE (may be downloaded free from <www.durridge.com>) to download the data from the RAD7 to a PC and erase the RAD7 memory.

There are three modes of measurement. One is by grab sample, another by continous monitoring in standard protocol and the third in THORON mode, with the pump running continuously.

4.1 GRAB Protocol

For GRAB protocol, it is necessary first to purge the RAD7 for ten minutes or more with dry, fresh air, before connecting the probe.

With the probe disconnected but the drying unit hooked up to the RAD7 start purging (Test, Purge, [ENTER]). After at least five minutes push 'Menu' (to stop the purge). With the printer switched off, put the RAD7 in SNIFF protocol (Setup, Protocol, Sniff [ENTER]) and start a reading (Test, Start). Go to the third status window (Menu, Enter, Enter, Rt. Arrow, Rt. Arrow) and observe the relative humidity in the top righthand corner. Let the RAD7 continue sniffing until the relative humidity drops below 6%.

If the RAD7 was previously used to measure a high radon concentration, it would be prudent also to measure the count rate in window A while the Sniff reading was continuing. Go to the fifth status window (from the third, just Rt. Arrow, Rt. Arrow). The lefthand number is the count rate. Typically, 0.25 cpm would be equivalent to a radon concentration of 1 pCi/L, or about 40 Bq/m3. Soil gas is seldom less than 100 pCi/L, so if the count rate in window A has dropped to below 0.5 cpm and the humidity to below 6%, the RAD7 is ready to make the next GRAB protocol reading.

Set the protocol to "Grab" (Setup, Protocol, Grab [ENTER]) then turn off the RAD7. Connect the tubing to the probe. Switch on the printer, switch on the RAD7 and let the printer print out a header for this measurement. Check the header to make sure the setup is what is required. Go to Test Start and push [ENTER] to start the measurement. The RAD7 pump will run for five minutes. The instrument will wait another five minutes and then count for four five-minute cycles. At the end of the half-hour period, the RAD7 will print out a summary of the measurement, including an average radon concentration in the soil gas from the four 5-minute cycle measurements. This method gives a quick (half-hour) reading and uses the least amount of soil gas. The accuracy will depend on the radon concentration, and would typically be better than +/- 10%.

After the five minutes pumping at the start of the GRAB protocol, the RAD7 may be disconnected from the probe and everything moved to a new site for the next measurement while the RAD7 continues to analyse the grab sample just taken, that is still in the measurement chamber. After completion of the analysis it is necessary to purge the RAD7 again in preparation for the next sample.

If necessary, the soil gas sample can be pumped out of the ground by a sampling pump, and fed to a Tedlar sample bag for later analysis by the RAD7. With that methodology, care should be taken to ensure that the sample is truly soil gas from the sampling point, and that there is at least 5 litres of soil gas sample in the bag. When analysis is made later, with the RAD7, care should be taken that the RAD7 is first purged thoroughly, so that the relative humidity inside the instrument drops below 6%. Then the bag is connected to the drying unit and a grab sample protocol measurement started. The result should be corrected for the decay of radon in the sample during the period from acquisition to analysis.

Please note it is impossible to measure thoron concentration with a grab sample because all the thoron will decay away before the measurement is completed.

4.2 Continuous Monitoring

Continuous monitoring is a simple method of measuring the soil gas radon concentration and provides time resolution in the event that the weather or barometric pressure is changing. The setup is as above, but the RAD7 preset protocol may be set to “Weeks”. It is still desirable to purge the RAD7 before starting the measurement, but the continuous monitoring process will itself serve to purge the instrument and dry it out. In this protocol, once the relative humidity drops below 10%, the RAD7 will pump for the first five minutes of every two-hour cycle, and then for only one minute in every five.

There will be a reading after every two-hour cycle, though the first reading will be slightly (5%) low because the 218-Po decay rate in the detector takes more than 10 minutes to reach equilibrium with the radon concentration in the measurement chamber. There will be a reading printed out and stored in the RAD7 memory every two hours. The accuracy of the readings will be +/-5% for the typical high radon concentrations found in soil gas.

This method will draw from the sampling point a volume of soil gas equal to the flow rate of the pump (L/min) times 28 minutes, in every two-hour cycle. (Five minutes at the start and then one minute in every five for the rest of the cycle.) In a typical, porous soil the pump flow rate may be around 0.5 L/min. So the soil gas extraction rate will be around 14 litres every two hours. Depending on the soil porosity, this would come from a sphere around the sampling point of around 8" (20 cm) radius. For this protocol, therefore, it is necessary that the penetration depth be much more than the 20cm radius of the first sample volume. With the aid of an Active DRYSTIK and Duty Cycle Controller, a Soil Probe placed at a sufficient depth can be used to take continuous readings without diluting the sample with ambient air. This configuration is described and illustrated in the Duty Cycle Controller manual, which can be found at <www.durridge.com>.

4.3 Thoron Protocol

Thoron protocol uses 5-minute cycles and prints out both the radon and thoron concentrations at the end of every cycle. However, thoron has a short half-life (one minute) so that the pump has to run continuously. For radon the first two cycles should be ignored, while the radon reading reaches equilibrium. Thereafter, there will be a reading every five minutes. The print format should be set to SHORT to save paper. The thoron reading will be good for all except the first cycle.

Because of the short thoron half life, some estimate of sample acquisition time is needed if the thoron readings are to be properly interpreted. During acquisition, a flow meter may be connected to the RAD7 outlet. This will show how fast the air is flowing from the sampling point. An estimate of the sample acquisition volume will then allow a calculation of the time delay between sampling and measuring. Call the RAD7 one litre, and the laboratory drying unit one litre. The soil gas probe has a volume of around 150 ml while about 10ft of 3/16" tubing has another 50ml for a total of 200ml. The total acquisition delay, then, will be 2.2 litres divided by the flow rate. If that is 0.5 L/min, the delay will be 4.4 minutes. The thoron sensitivity stored in the RAD7 anticipates an acquisition delay of about 1.4 minutes, so the extra delay in this application will be about 3 minutes. During that time, the thoron will decay to about 0.125 of its original concentration, so the thoron reading should be multiplied by 8 to give the thoron concentration at the sampling point.

The final value of the thoron concentration has large uncertainties and the absolute accuracy is probably no better than +100/-50 %. For a soil gas radon concentration of 200 pCi/L (8,000 Bq/m3) the 5-min radon readings however, after the second 5-minute cycle, will have a precision of +/-10 % (95% confidence interval). Higher radon concentrations in the soil will improve the accuracy of the short term readings. Averaging several readings over a longer period than five minutes will also give a more precise measurement.

One disadvantage of the thoron and sniff protocols is that the pump runs continuously, so that much soil gas is drawn from the sampling point. Compared with 'Weeks' protocol, sniff protocol will draw nearly five times as much gas per hour. This means that the sphere of gas taken from the sampling point will be 1.7 times the radius of the sampling sphere for 'Weeks' protocol in the same total time. So, after a while, ambient air may filter down through the soil to the sampling point before its radon can reach equilibrium with the surrounding radium 226. This may thus dilute the radon concentration. On the other hand, thoron has such a short half life (less than 1 minute) that if the sampling point is deeper than 2ft (25cm) the thoron in any air filtering down from the surface will have more than sufficient time to reach equilibrium with the radium 224 in the soil. So, with a sampling point 2ft or more below the surface, thoron concentration can be monitored continuously forever, but in this protocol, the radon readings may start to drop after an hour or two because of dilution with fresh air from the surface.

5. Continuous Long-term Operation

It has been proposed that continuous monitoring of soil gas for radon may be a useful technique for predicting earthquakes. For this purpose, an array of soil gas probes covering half a square kilometer, say, may be more informative than a single sampling point. Such an array can be monitored with a single RAD7. Fine bore plastic tubes may be run for hundreds of metres from each probe to a centrally located DURRIDGE valve manifold system. The RAD7 may be connected to the manifold and switched from one tube to another under the control of the manifold system microcontroller. Each tube is purged prior to the RAD7 hook-up, so that the soil gas sampled is fresh. One measurement can be made every hour. If each sampling point had to be read six times a day, say, there could be four sampling points monitored by one RAD7.

A wireless modem may be connected to the RAD7. This would permit remote control of the RAD7 and simultaneous remote collection of the data.

6. Care and Maintenance

To ensure the longevity of the soil gas probe, avoid hitting rocks with excessive force. Remove all dirt and contaniments from the probe after each use and store the probe components in a dry place. Keeping the probe properly oiled will help to prevent rust from forming.

Contact DURRIDGE Company, info@durridge.com, for technical assistance.