



---

# VS472 Radon Sniffer User's Manual



**WARNING:** Never operate this device unless a Lucas cell or protective light tight cap is firmly in place over the PMT (Photomultiplier Tube). Doing so could damage the PMT!

# Contents

<b>1</b>	<b>Overview of Device</b>	<b>3</b>
1.1	Introduction . . . . .	3
1.2	Components and Equipment . . . . .	4
1.3	Controls . . . . .	6
1.4	Display Overview . . . . .	8
1.5	Batteries . . . . .	10
1.6	Filter and Desiccant . . . . .	10
<b>2</b>	<b>Operating Modes</b>	<b>11</b>
2.1	Radon Sniffer Mode . . . . .	11
2.2	Grab Sampling Setup . . . . .	13
2.3	Timed Sniff Modes . . . . .	16
2.4	Timer Mode . . . . .	16
2.5	Pump Mode . . . . .	18
2.6	Purging Lucas Cells . . . . .	19
<b>3</b>	<b>Other Information</b>	<b>20</b>
3.1	Upper Detection Limits . . . . .	20
3.2	Summary of Buttons, Indicators, and Other Functions . . . . .	20
<b>4</b>	<b>Accessory Kit</b>	<b>22</b>
4.1	Kit Equipment . . . . .	22

# Chapter 1

## Overview of Device

### 1.1 Introduction

The VS472 is a radon sniffer that utilizes a zinc sulfide coated Lucas cell coupled to a PMT (Photomultiplier Tube) along with a small air pump to detect radon levels. Air is taken in and passed through a filter and desiccant to remove radon progeny and moisture. This air then circulates through a Lucas cell where alpha particles are detected.

When sniffer mode is entered, the VS472 assumes that a clean Lucas cell (i.e. no radioactive contamination in the cell) has been attached. As air is sampled, radon progeny will accumulate in the cell. The VS472 calculates the expected levels of radon progeny in the cell and subtracts these values in order to obtain the radon levels. The VS472 also implements several other modes that allow gross counts to be displayed or the air pump to be operated independently.

## 1.2 Components and Equipment

A charger, Lucas cell, protective light tight cap, air hoses, various desiccants and filters, a retainer bracket, and reset key are included with the VS472.

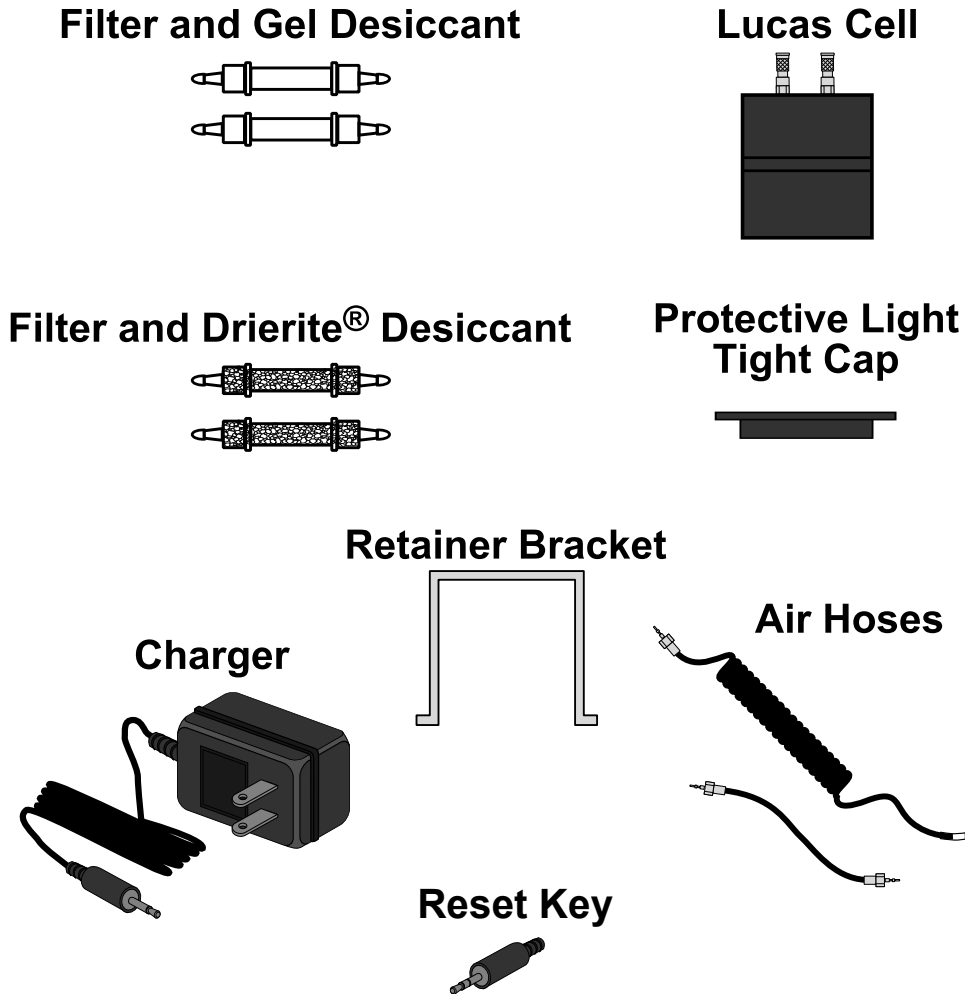


Figure 1.1: Equipment Included With The VS472

**Charger:** The charger is used to recharge the internal batteries.

**Reset Key:** The reset key is used to turn off the VS472 either during or after a timed sniff test.

**Lucas Cell:** Zinc sulfide coated cell where alpha particles are detected. A Lucas cell or protective light tight cap must be firmly in place over the PMT before the device is turned on; failure to do so could result in damage to the PMT. One side of the Lucas cell is labeled *Exhaust*, which connects to the VS472.

The other side is labeled *Intake*, which is connected to the filter and desiccant with the black coiled air hose.

**Protective Light Tight Cap:** This cap is used to protect the PMT when the Lucas cell is not in place. Also, by placing a scintillator and a filter under the cap, grab samples of radon progeny may be counted. See section 2.4 for details.

**Air Hoses:** Air hoses are used to connect the filter and desiccant, Lucas cell, and internal air pump together. Only the supplied black air hoses should be used with this device and the air hose that is connected to the *Intake* side of the Lucas cell should have no fewer than five coils. These measures prevent stray light from entering the PMT. When sampling the general area, the filter/desiccant tube may be tucked between the VS472 and the leather carrying case. For probing into air ducts and other difficult to access sources of radon, remove the filter/desiccant tube from the leather carrying case and hold it near the location to be tested.

**Desiccants and Filters:** Cylindrical tubes contain the desiccants and filters. The filter is used to remove radon progeny and other particulates from the air. The desiccant is used to remove moisture from the air, ensuring consistent plate out of radon progeny inside the Lucas cell. See section 1.6 for details.

**Retainer Bracket:** This bracket is used to hold the Lucas cell in place over the PMT. It is attached to the face plate with two screws.

A diagram showing the basic system components is given as Figure 1.2.

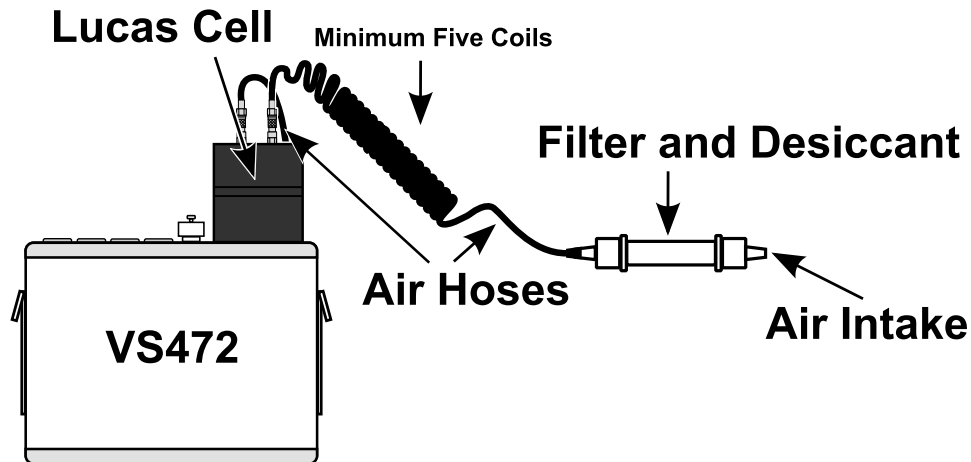


Figure 1.2: Overall System Schematic

## 1.3 Controls

An overview of the front face plate controls is given in Figure 1.3.

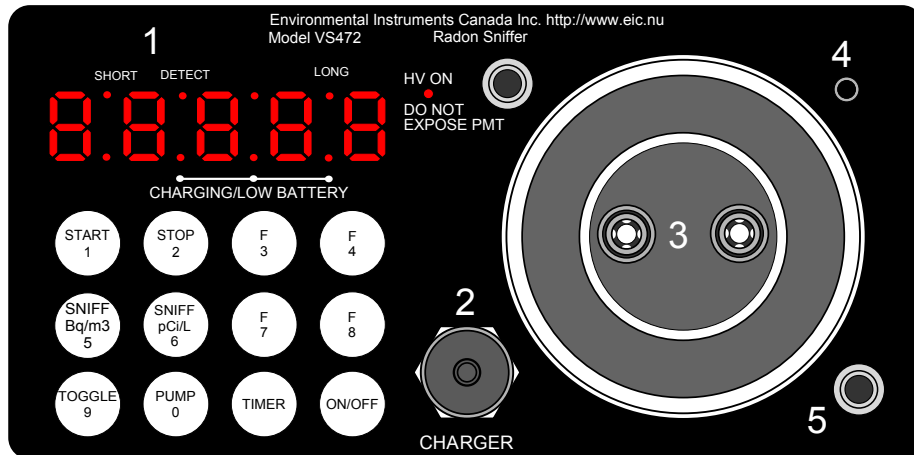


Figure 1.3: Front Plate Controls

1. Main Display
2. Charger Jack and Cover
3. Lucas Cell or Protective Light Tight Cap
4. Pump Connector
5. Threaded Holes for Retainer Bracket
6. Start Button
7. Stop Button
8. F4 Timed Sniff Button
9. F5 Sniff  $Bq/m^3$  Button
10. F6 Sniff pCi/L Button
11. F7 Total Average Button
12. Toggle Button
13. Pump Button
14. Timer Button
15. On/Off Button

**Main Display:** This is the area where information such as the activity concentration of radon, the number of gross counts, and other information is displayed. The information displayed depends on the mode the device is in.

**Charger Jack and Cover:** The VS472 runs off of internal rechargeable batteries. The batteries may be recharged by connecting the supplied charger to this jack. The VS472 may be operated while the charger is plugged in.

The charger jack is also used with the reset key to turn the device off after a timed sniff. The reset key is inserted into the charger jack until the power turns off (5-10 seconds).

**Lucas Cell or Protective Light Tight Cap:** The PMT should be covered by either a Lucas cell or the protective light tight cap. The VS472 should never be operated without either one in place; doing so could damage the PMT.

**Pump Connector:** Connects to the air pump located inside of the VS472. Connect the *Exhaust* side of the Lucas cell to this connector with a short length of black air hose. The pump should not be run while there is nothing inserted in this connector.

**Start Button:** This button begins the count, starts the pump, or starts the uninterrupted sniffing test, depending on what mode is entered.

**Stop Button:** This button stops the count in Timer mode, stops the pump in Pump mode, and resets the running total counts in Sniff mode.

**F4 Timed Sniff Button:** After pressing this button, a time is entered for which the VS472 will sniff.

**F5 Sniff  $Bq/m^3$  Button:** This button is used to enter sniff mode, in which the VS472 can display either a 15 second radon activity concentration, a five minute average radon activity concentration, an average concentration over a time specified by the user, or an average concentration since entering Sniff mode. If Sniff mode is already entered, pressing this button will make the display show readings in  $Bq/m^3$ .

**F6 Sniff pCi/L Button:** Sniff mode can also be entered using this button. If Sniff mode is already entered, pressing this button will make the display show readings in pCi/L.

**F7 Total Average Button:** Pressing this button while in Sniff mode will show a reading of the average radon concentration since sniffing began, or since the stop button was last pressed.

**Toggle Button:** Used to toggle display between a 15 second radon activity concentration (Short) and a 5 minute average radon activity concentration (Long) when in one of the Sniff modes. While in Timer or Pump modes, this button will also briefly toggle the display to show either the pre-set time that the user has just entered or the time remaining for the count or pump.

**Pump Button:** Used to run the internal pump only.

**Timer Button:** Used to enter a time for which the VS472 will count.

**On/Off Button:** Used to turn the VS472 on and off. NOTE: This button must be held for two seconds in order to turn the power off.

**Threaded Holes for Retainer Bracket:** This is where the screws to hold the retainer bracket in place are inserted.

## 1.4 Display Overview

When in one of the Sniff modes, the main display gives a reading of the radon activity concentration in either  $Bq/m^3$  or  $pCi/L$ . When in Timer mode, the display gives a reading of the gross number of counts. When in Pump mode, a P is displayed in the center of the screen. In all modes of operation a time may be entered, in which case the display will show a time in either minutes and seconds (mmm:ss) for Pump and Timer modes, or hours and minutes (hhh:mm) for Sniff modes.

While counting, a value will be displayed using either five digits or three digits and an exponent. For numbers less than 100 000, five digits are used; see Figure 1.4. For numbers greater than 99 999, three digits and an exponent are used; see Figure 1.5.

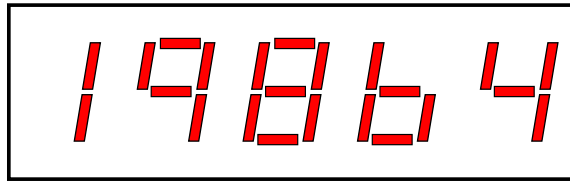


Figure 1.4: An example of the display reading 19864

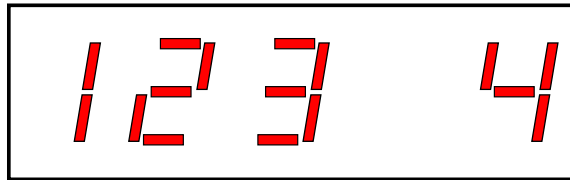


Figure 1.5: An example of the display reading  $123 \times 10^4$

When the device detects an alpha particle, an LED at the top of the display will briefly illuminate to show that it has registered a count, as shown in Figure 1.6.



Figure 1.6: Registering a Count

When the batteries are charging the three decimal points in the center of the display will be illuminated; see Figure 1.7. When the batteries are starting to run low the three decimal points in the center of the display will flash; see Figure 1.8.

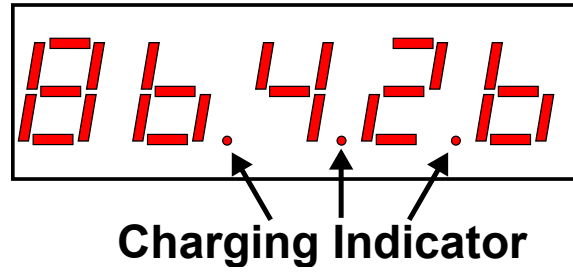


Figure 1.7: Charging Indicator

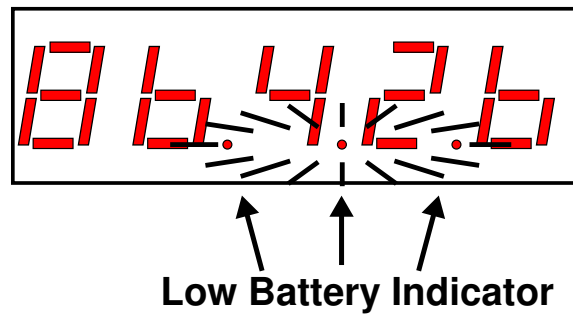


Figure 1.8: Low Battery Indicator

## 1.5 Batteries

The VS472 contains rechargeable batteries that are located inside the unit. These batteries should not need to be changed during normal operation. Battery life will vary depending on the mode the device is used in. When in radon sniffer mode, (with the air pump running) fully charged batteries should provide around 18-20 hours of operating time. After the low battery indicator is first displayed there is about 2-3 hours of operating time remaining (with the air pump running).

Once depleted, the batteries will need to be charged for 16 hours to restore full charge. To charge the batteries, plug the supplied charger into an electrical outlet (Only the charger supplied with the instrument should be used), remove the cover from the charger jack, and insert the end of the charger (see Figure 1.3 for the location of the charger jack). When the batteries are charging the three center decimal points should be illuminated; see Figure 1.7. If the charger is plugged in before the batteries become low, the device will not charge the batteries until they do become low. The batteries will automatically stop charging once 16 hours have elapsed.

The unit may still be operated while the batteries are charging.

## 1.6 Filter and Desiccant

The filter and desiccant are both contained inside a plastic tube. Air should pass through this tube before entering the Lucas cell. The filter removes radon progeny from the air before it enters the Lucas cell so that radon levels can be accurately calculated. The desiccant removes excess moisture from the air, ensuring consistent plate out of radon progeny inside the Lucas cell.

Two types of desiccants are provided, Drierite<sup>®</sup> and gel. When the Drierite<sup>®</sup> has become saturated it will turn pink. The Drierite<sup>®</sup> may be restored by removing it from the plastic tube and heating it at 200°C (400°F) for about 15 minutes (or until it turns blue). The gel will not become saturated as quickly. When the gel becomes saturated it clumps together and turns translucent. The gel cannot be restored. It must be replaced once it becomes saturated.

## Chapter 2

# Operating Modes

### 2.1 Radon Sniffer Mode

Radon sniffer mode is the standard mode of operation. To run the device in this mode, turn the power on by pressing the **ON/OFF** button and push either the **SNIFF  $Bq/m^3$**  button or the **SNIFF  $pCi/L$**  button.

In Sniff mode, the VS472 pumps air through the Lucas cell and calculates the radon activity concentration in the air. When using the device in this mode, the tube containing filter and desiccant should be connected to the *Intake* side of the Lucas cell and the *Exhaust* side of the Lucas cell should be connected to the pump connector on the VS472; see Figure 2.1. The PMT should be covered at all times when in this mode of operation. To exit radon sniffer mode and enter one of the other modes of operation, the power must first be turned off by pressing the **ON/OFF** button.

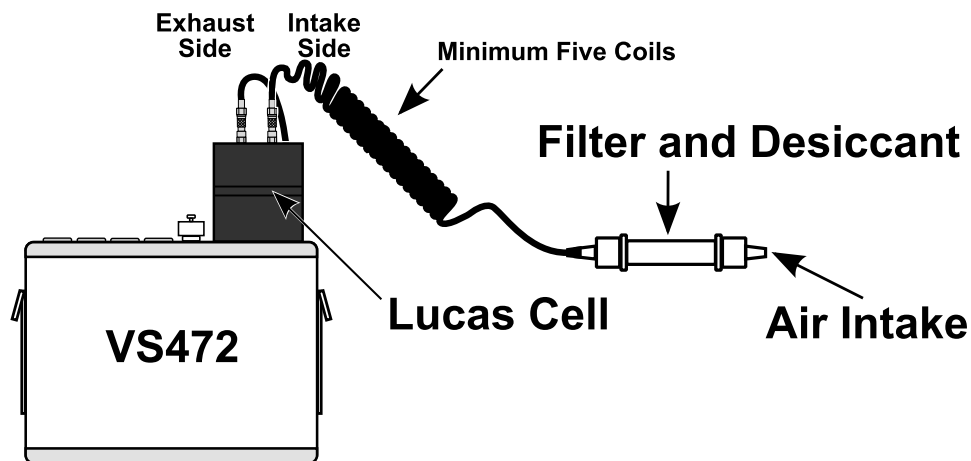


Figure 2.1: Radon Sniffer Setup

**Note:** Only the large Lucas cells should be used while in Sniff mode, otherwise an inaccurate result may be displayed.

In this mode, one of two quantities is normally displayed: a 15 second average radon activity concentration or a 5 minute average radon activity concentration. The 15 second average concentration is based on the last 15 seconds of sampling and is updated every 3 seconds. The 5 minute average radon concentration is averaged over the last 5 minutes and is updated every 15 seconds. This average is more useful in areas with low radon concentrations, as the 15 second value may tend to vary when the concentration is low.

Each quantity also has its own indicator point located at the top of the display. The 15 second average concentration is labeled *SHORT* and the 5 minute concentration is labeled *LONG*. Press the **TOGGLE** button to change the display between the two quantities.

**Note:** The 5 minute average radon concentration is only accurate if the device has been running in Sniff mode for 5 minutes or more.

**Note:** If the device is turned off while in Sniff mode, a clean Lucas cell must be used if using Sniff mode again within 4 hours.

To change the display to show the concentration in either  $Bq/m^3$  or  $pCi/L$ , press the corresponding **SNIFF** button (F5 or F6). When displaying  $pCi/L$ , the value will be displayed with one decimal place, as shown in Figure 2.2.

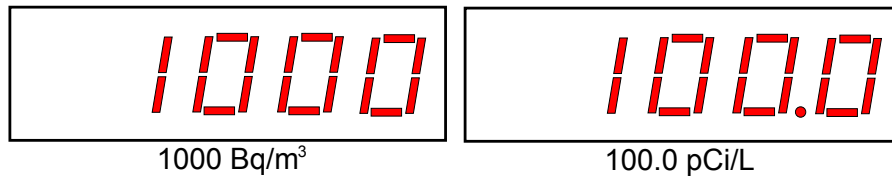


Figure 2.2: Difference in display between  $Bq/m^3$  and  $pCi/L$  Sniff modes

If you wish to obtain an average reading over a specific amount of time, press the **TIMER** button, enter the time (in hhh:mm format), and press the **TIMER** button again. Neither radon activity concentration indicator will be illuminated, meaning that the device is giving an average radon activity concentration over the user defined interval of time. A maximum time of 999 hours and 99 minutes may be entered, but if the time entered is greater than 12 hours and the device has been sniffing longer than this, it will only display an average over the previous 12 hours. If the time entered is longer than the time that the device has been running, it will display an average for the amount of time that it has been running.

To display an average radon concentration since sniffing began, press **F7**. Pressing the **STOP** button will reset the starting point of this average so that future presses of the **F7** button will display an average over the time since pressing **STOP**. To resume displaying the 15 second average radon concentration, press the **TOGGLE** button. Figure 2.3 shows the various display options when in one of the Sniffer modes.

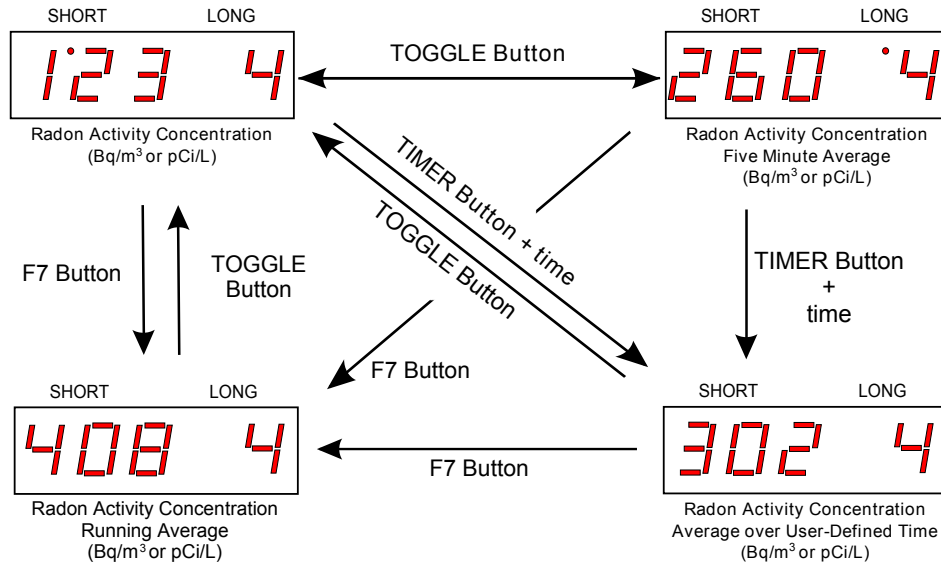


Figure 2.3: Radon Sniffer Modes

After sampling in an area of high radon concentration, the lower limit of detection will be temporarily increased due to radon progeny inside the Lucas cell. If you immediately move to an area of low radon concentration, the error in the reading will temporarily increase. If the VS472 has not been turned off, it should recover to about 5% of its peak value within 5 minutes.

If the power is turned off while in Sniff mode, a clean Lucas cell must be used the next time that this mode is entered. This is because when Sniff mode begins, the VS472 assumes that there is no radon progeny inside the cell. In order to clean a Lucas cell after sampling in Sniff mode, move to a location with very low radon gas concentrations and run the pump in either Sniff mode or Pump mode for 20 minutes using the configuration shown in Figure 2.1.

The VS472 also has the ability to send its radon concentration readings to a Bluetooth enabled device. When the VS472 receives the proper request, it will send any new readings since the last transmission to the Bluetooth device. Because the VS472 records up to 12 hours of readings in sniff mode, a maximum of 12 hours of data can be sent this way.

## 2.2 Grab Sampling Setup

If an area of low radon concentration must be sampled directly after sampling in an area of high radon concentration and a very accurate result is required, a second Lucas cell can be temporarily attached to the VS472, as shown in Figure 2.4. (To ensure no stray light enters the Lucas cell attached to the VS472 the secondary Lucas cell should have its window covered.)

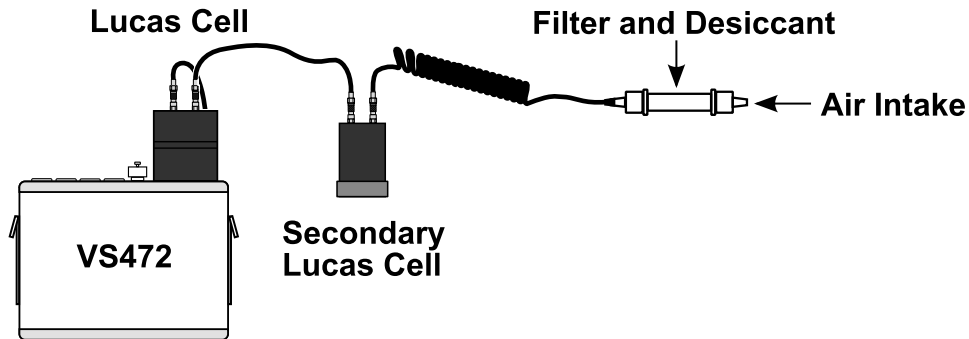


Figure 2.4: Radon Sniffer Setup With Dual Lucas Cells

The air is sampled in this configuration for two minutes. The second Lucas cell is then removed. This cell can be counted at a later time following the procedure in section 2.4. A Lucas cell can also be filled with air by using the Pump mode, as described in section 2.5. Additional Lucas cells are available as part of an optional accessory kit. See chapter 4 for details.

To measure the activity inside a Lucas cell by the delayed count method, begin by filling a cell with air as described in section 2.1. To count the activity in the Lucas cell, first ensure that the HV indicator LED is not illuminated. Remove anything that is attached to the PMT, place the Lucas cell directly over the PMT, and press down firmly to ensure a tight fit. Secure the cell using the retainer bracket, then start the count; see Figure 2.5.

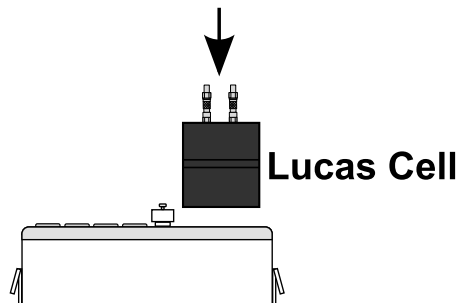


Figure 2.5: Lucas Cell Count Setup

When using a small Lucas cell, follow the same procedure described above, but place the small Lucas cell retainer over the cell before securing it in place with the bracket; see Figure 2.6.

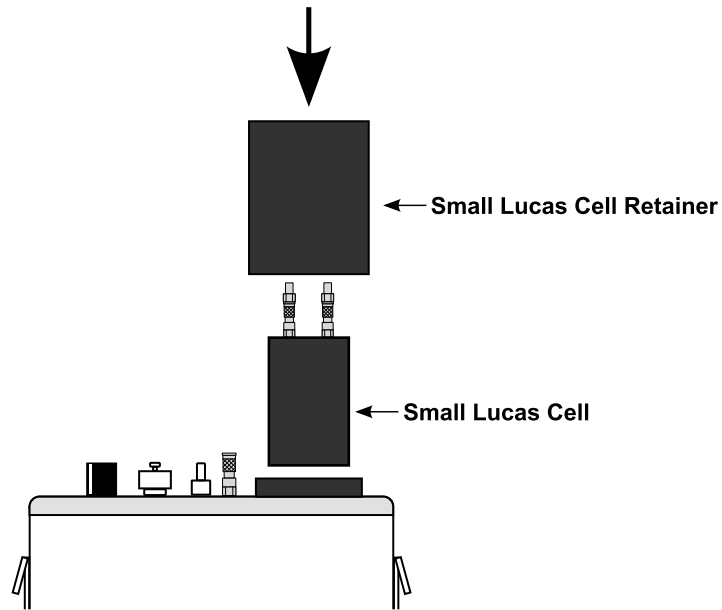


Figure 2.6: Small Lucas Cell Retainer

When a grab sample is taken using a filter, the activity can be measured by using the protective light tight cap. To measure the activity on a filter, first ensure that the HV indicator LED is off. Remove the Lucas Cell or protective cap and place a scintillator (ZnS coated side up) on the PMT. Place the filter to be measured on the scintillator, put the protective cap over the PMT, then start the count; see Figure 2.7.

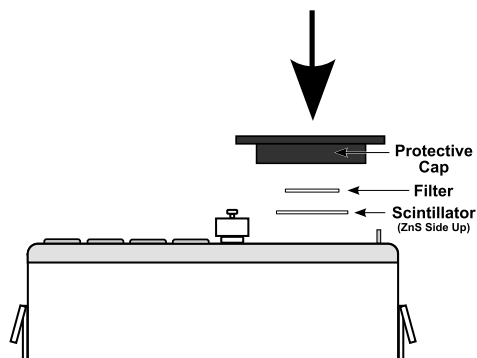


Figure 2.7: Filter Count Setup

## 2.3 Timed Sniff Modes

As well as being able to run indefinitely in Sniff mode, the VS472 can run for any preset time between 1 minute and 30 days. In order to enter a time for which to run the device in Sniff mode, the power must first be turned on using the **ON/OFF** button. Pressing the **F4** button will display 000:00. Enter a time (in hhh:mm format) that you would like to sniff for using the number pad and press **TIMER** button to accept this time. If you made a mistake, you may press the **TIMER** button to re-enter a time. A maximum time of 999 hours and 99 minutes may be entered, but if the time entered is greater than 720 hours, it will only sniff for 720 hours.

Once a time has been entered, pressing the **START** button will begin the test. During the test, the display will show - - - - and the keypad will be disabled to ensure an uninterrupted test. Once the sniffing has concluded, the total average radon concentration will be displayed in  $Bq/m^3$  and the results can be transmitted to a Bluetooth enabled device that is paired with the VS472.

Since the keypad is disabled, the device can only be turned off with the supplied reset key. Insert the key into the charger jack until the display turns black (5 - 10 seconds). Immediately remove the reset key after this happens.

## 2.4 Timer Mode

If you have been using the device in one of the other two modes of operation and wish to enter Timer mode, you will first need to turn off the power by pressing and holding the **ON/OFF** button for two seconds. After attaching a Lucas cell or a filter, ZnS screen, and light tight cap, turn on the power by pressing the **ON/OFF** button. To enter the time you would like to count for, press the **TIMER** button, enter the time (in mmm:ss format) using the number pad, then press the **TIMER** button again. If you made a mistake, you may repeat this same procedure to enter a new time. A maximum time of 999:59 may be entered.

To start the count, press the **START** button. The count will begin two seconds after the High Voltage indicator LED illuminates. The count stops when either the preset time has elapsed or the **STOP** button is pressed.

When in Timer mode, the gross counts are normally shown on the main display. To briefly display the time remaining, press the **TOGGLE** button. The display will change to show the time remaining in mmm:ss format for two seconds before automatically switching back to display the gross counts. This button may also be used before the count has started or after the count has finished to display the preset time that has been entered. An overview of the Timer mode display is shown in Figure 2.8.

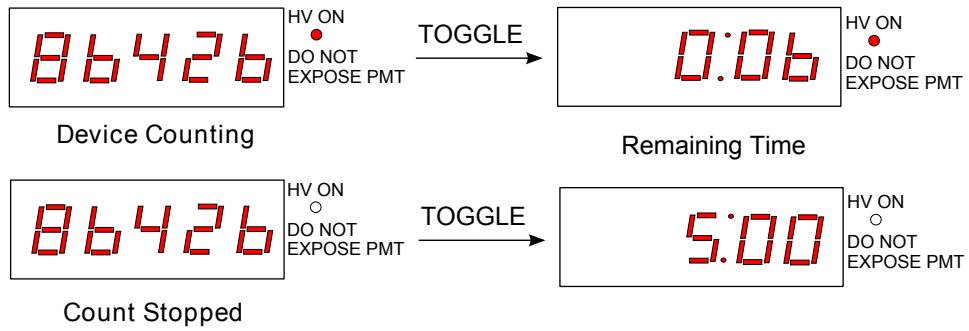


Figure 2.8: Counting Display Indicator

The Timer count mode has an upper display limit of  $167 \times 10^5$  counts. Once this limit has been reached the display will read  $167 \times 10^5$  and no further counts will be registered.

Once a Lucas cell has been counted, the results can be converted into  $Bq/m^3$  or  $pCi/L$  using the Radon Gas Measurement by Delayed Count program in the On-Line Uranium Radiation Safety Toolkit v2.0 at [www.eic.nu](http://www.eic.nu).

## 2.5 Pump Mode

In pump mode the air pump is operated and no other operations are performed. This mode may be useful when you wish to take a grab sample with a Lucas cell and only the air pumping feature is required.



**WARNING:** A Lucas cell or protective light tight cap must be firmly attached to the PMT whenever the VS472 is on; even if a count is not being taken. Failure to do so could result in damage to the PMT.

If you have been using the device in one of the other two modes of operation and wish to enter Pump mode, you will first need to turn off the power by pressing the **ON/OFF** button for two seconds. Turn the power on again with the same button then press the **PUMP** button. A "P" will appear in the center of the display to indicate that the device is in Pump mode. To enter a time for which the pump will run, press the **TIMER** button, enter a time in mmm:ss format, and press the **TIMER** button again. If you made a mistake, follow this same procedure to enter a new time.

The pump is turned on by pressing the **START** button and the pump will run until either the pre-set time has elapsed or the **STOP** button is pressed. To briefly display the time remaining, press the **TOGGLE** button. The display will change to show the time remaining in mmm:ss format for a few seconds before automatically switching back to display a "P". This button may also be used before the count has started or after the count has finished to display the pre-set time that has been entered. While the pump is running the high voltage indicator will be illuminated, as shown in Figure 2.9.

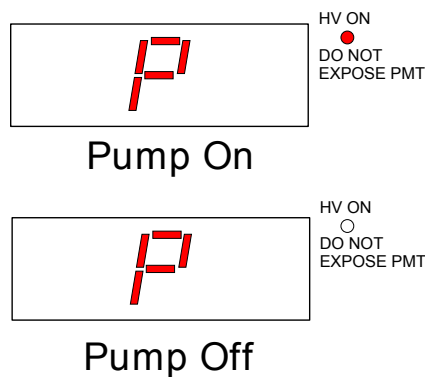


Figure 2.9: Pump Mode Display

## 2.6 Purging Lucas Cells

After a Lucas cell has been exposed to radon, it must be cleaned immediately to prevent large amounts of radon progeny from accumulating inside. Once you have finished sampling, place the device in a location with very little radon (eg. outside) and pump air through the cell for at least 15 minutes. To further reduce the background in the cell, wait for 3-4 hours and pump air through the cell again for at another 10 minutes.

## Chapter 3

# Other Information

### 3.1 Upper Detection Limits

The upper detection limits for each mode are given in Table 3.1. These limits are approximations based on various detector and device characteristics.

Mode	Limit
Radon Sniffer	$220 \times 10^5 \text{ Bq/m}^3$
Radon Sniffer Five Minute Average	$220 \times 10^5 \text{ Bq/m}^3$
Three Minute Gross Counts	$185 \times 10^4 \text{ count/(3min)}$
Five Minute Gross Counts	$309 \times 10^4 \text{ count/(5min)}$
Total Gross Counts	$167 \times 10^5 \text{ count}$

Table 3.1: Approximate Upper Detection Limits

### 3.2 Summary of Buttons, Indicators, and Other Functions

A summary of the button, indicator, and air pump functions in the different operating modes is give in Table 3.2.

	Radon Sniffer Mode	Count Mode	Air Pump Mode
<b>START Button</b>	No Function	Starts Count	Starts Air Pump
<b>STOP Button</b>	Resets Running Average	Stops Count	Stops Air Pump
<b>TOGGLE Button</b>	Toggles Displayed Values	Displays Time	Displays Time
<b>Air Pump</b>	On	Off	Pump Controlled by Buttons
<b>High Voltage LED</b>	On	On When Counting, Off When Not Counting	On When Pump On, Off When Pump Off

Table 3.2: Summary of Buttons, Indicators, and Other Functions

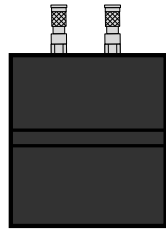
## Chapter 4

# Accessory Kit

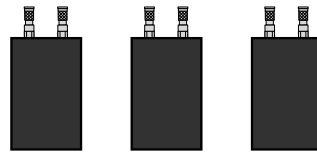
### 4.1 Kit Equipment

An accessory kit containing the following items may be purchased separately.

#### Large Lucas Cell



#### Small Lucas Cells



#### Air Hose



#### Small Lucas Cell Retainer



Figure 4.1: Accessory Kit

**Small Lucas Cells:** Three small Lucas cells, designed for taking grab samples.

**Large Lucas Cell:** One large Lucas cell.

**Air Hose:** A length of straight air hose, used for attaching an additional cell when sampling with dual Lucas cells.

**Small Lucas Cell Retainer:** The small Lucas cell retainer is used to hold the small Lucas cells in place over the PMT.