Applied Radiation and Isotopes 67 (2009) 863–866

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

A radon facility at Naples University: Features and first tests

G. Venoso [a,b,1], M. Pugliese [a,b], V. Roca [a,b,*], C. Sabbarese [b,c]

[a] Dipartimento di Scienze Fisiche, Università degli Studi di Napoli Federico II, Italy
[b] Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, Italy
[c] Dipartimento di Scienze Ambientali, Seconda Università degli Studi di Napoli, Italy

ARTICLE INFO

Keywords:
Radon detectors
Calibration
Radon chamber
Controlled atmospheres

ABSTRACT

A radon calibration facility was developed at Naples University (Italy). It consists of an exposure chamber, a radon reference monitor and an apparatus suitable for radon circulation and air climatic control. The parameters that are possible to change and control are carrier gas, radon activity, gas pressure, temperature, and humidity. The characterization of the facility is actually underway to verify its reliability and stability with respect to various parameters of interest.

1. Introduction

A survey is carried out in the Campania Region since the early 1990s by the University Federico II of Naples (Roca et al., 1995) in the framework of the national survey promoted by the Italian National Agency for the New Technologies, Energy and the Environment (ENEA) and the Italian National Institute of Health (ISS) (Bochicchio et al., 1996) to measure the concentration of ^{222}Rn (hereafter radon) in the dwellings. This campaign confirmed the role that the climate plays in the prevention of radon accumulation by favoring natural ventilation. Nevertheless, in some cases the complex structure of the buildings and the compact configuration of the old urban centers may vanish or reduce the ventilation effect. This was proven by several measurements carried out during the past years in houses whose typology justified the forecast of high radon levels (Sabbarese et al., 2000). These measurements eventually showed the existence of true "hotspots", which are symptomatic of a situation that needs monitoring, thus revealing those instances where remedial actions have to be taken. It is therefore necessary to carry out a detailed survey of the territory in conformity with the national law.

Clearly, a correct approach to the issues concerning the effects of radon relies on the availability of data obtained by rigorously applying carefully studied protocols, which in turn are based on the correct choice of the detectors and on their accurate calibration and management.

In Italy, the Ionizing Radiation National Metrology Institute (INMRI) takes care of this responsibility. This institute developed a ^{222}Rn national standard, which is the reference for radon detector calibration. Such a standard and a complex traceability procedure allow producing operational sources of gaseous radon with activities known with a combined standard uncertainty of 1.3% (De Felice and Myteberi, 1996).

On the other side, the careful analysis of the large amount of data collected worldwide in the last twenty years demonstrated the dependence of the detection efficiency and of the other parameters used for the reading of the detectors, on several factors. These are e.g. the measured concentration, the detector batch and the effect of aging and fading. (Amrani and Belgaid, 2001; Siems et al., 2001; Colamosca and Penzo, 2008). Consequently, the calibration phase of a survey cannot be reduced to an *una tantum* calibration factor determination, but a more accurate and continuous control is needed that only the full availability of a calibration apparatus can guarantee.

For this reason a radon facility was built that is actually under test. In the following paragraphs the system will be described and the result of the first tests is reported.

2. Apparatus description

The calibration facility was developed according to the procedures of the INMRI (De Felice and Myteberi, 1996). The apparatus is able to perform the calibration of detectors using a radon source in a glass bulb with a well-defined geometry. A local radon transfer system allows the traceability of measurements with respect to the INMRI national radon standard by measuring the radon activity in the bulb with a high purity germanium detector (HPGe).

The scheme of the facility is shown in Fig. 1. As one can see, all components of the apparatus are disposed along a circuit where radon flows through and the gas carrier gains the desired

* Corresponding author at: Dipartimento di Scienze Fisiche, Università degli Studi di Napoli Federico II, Italy. Tel.: +39 081676162; fax: +39 081676346.
E-mail address: roca@na.infn.it (V. Roca).

[1] Since July 2008 at Istituto Superiore di Sanità, Roma, Italy.

0969-8043/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apradiso.2009.01.082

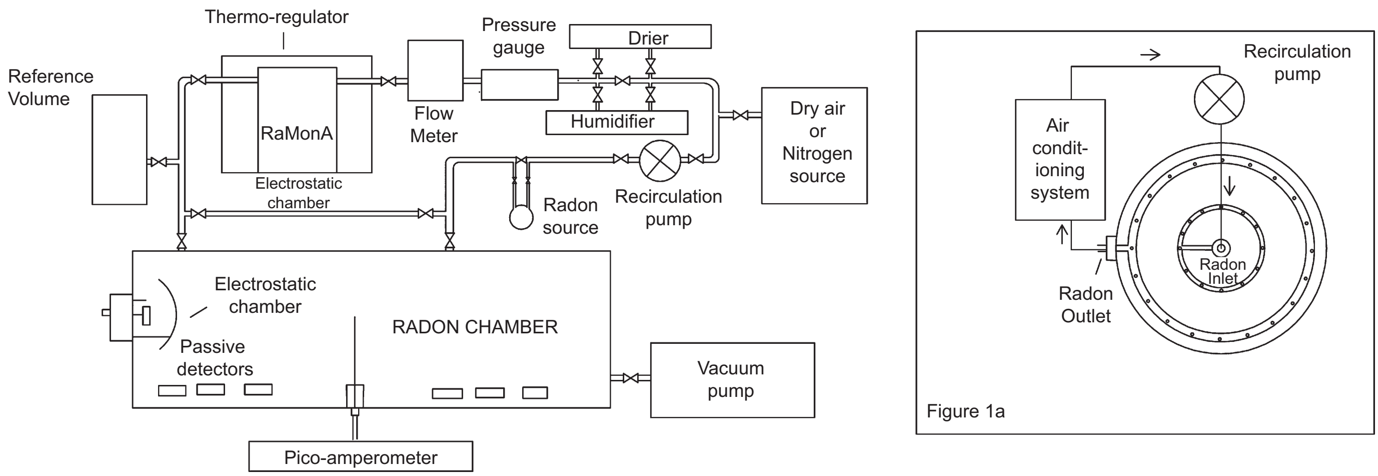

Fig. 1. The scheme of the radon facility. In the box (Fig. 1a), the inlet and outlet of radon in the chamber are shown.

characteristics in terms of kind of gas, radon activity, temperature, pressure, and humidity. An electrostatic cell coupled with a multiparametric acquisition system (Ramona) (Pugliese et al., 2000) is the reference monitor of the whole system, as well as the device used to study the behavior of active radon detectors under various air conditions (Roca et al., 2004). In fact, in the ordinary use of Ramona as reference monitor, a calibration factor measured under standard environmental conditions is adopted. Instead, putting in the circuit a known radon concentration, the response of the detector at various atmospheres can be studied, or a different active monitor can be calibrated. In these cases the thermostatic cell shown in Fig. 1 is used in order to control the temperature of the monitor. In the other cases, the temperature of the apparatus corresponds to that of the room, which is controlled. In the following the elements of the facility will be shortly described.

The exposure chamber consists of a 33 l stainless steel cylinder having a height of 15 cm and a diameter of 50 cm. It was chosen metallic instead of plastic material in order to avoid radon diffusion or adsorption on the wall surfaces. This chamber allows calibrating few detectors at a time and offers some useful characteristics for setting up the parameters of the radon atmospheres. In fact, the chamber walls present a series of flanges equipped with tube fittings for the inlet of radon and with passing connectors for mounting a variety of devices useful to control the air conditions and radon activity directly inside the chamber. A recirculation pump that assures the uniform gas distribution from a radon source provides the radon inlet. The radon flow comes from the upper wall through a circular tube with a series of regularly distributed holes from which radon can escape. The gas reaches a uniform steady state condition thanks to another coaxial tube, lying on the bottom of the chamber, providing for the radon outlet (Fig. 1a).

Ramona is used to monitor continuously the radon activity through alpha spectroscopy of the radon progeny. It allows monitoring the radon activity variations with a delay time of only 20 min.

The components of the facility are the following ones:

(a) a membrane pump (KNF model N 726 FTE) to carry the air or gas with a maximum flow rate of 15 l min^{-1}; the PTFE (Teflon®) garnitures guarantee a good radon sealing;
(b) a glass bulb-fitting channel, where it is possible to connect the glass bulbs containing radon source;
(c) a humidifier and a dryer that allow changing the moisture content in the air of the circuit in a controlled way. Both devices consist in a Nafion® tube, semi-permeable for the water molecules, housed within a flexible plastic tube shell (PermaPure MD/MH-110–24–F4). The possibility of the water vapor molecule permeation through the Nafion® is due to the difference of the water partial pressure between the internal and external shell of the tube. In the drying process, the sample gas can flow in the Nafion® tube while water vapor is absorbed by the walls of the membrane and is removed with a dry purging gas, which flows in the opposite direction. The humidification process follows the same principle. Hot water instead of a dry gas is flowing in the external Nafion® membrane . The moisture content can be absorbed within the internal tube, where the sampling gas is passing. Unlike the Drierite® salts, which are usually used as desiccant, these Nafion® devices are very reliable tools, because they allow varying the moisture content in an active way, within shorter times, and with higher precision;
(d) an electronic flux-meter with relative controller (MKS Mass Flow Controller 1179A) able to vary the air flux up to 2 l min^{-1} with uncertainty of less than 0.5%. It was placed at the entry of the chamber in order to set the inlet airflow rate;
(e) a pressure gauge (MKS Baratron 626A) for measuring the pressure in the circuit with good precision (uncertainty 0.1% in the 1–100 kPa range) and independently on the type of gas;
(f) a thermo regulator allows varying the temperature inside the electrostatic chamber. It consists of a 50 cm × 40 cm × 20 cm box where the monitor is placed. It is thermally isolated with respect to the external environment containing two Peltier cells that allow regulating the temperature. An electronic programmable device controls and sets temperature value with $\pm 0.2\,^{\circ}C$ tolerance in 0–60 °C temperature range, therefore the uncertainty is about 0.1% at room temperature;
(g) a reference volume, consisting of a stainless steel cylinder, is used to measure the effective volume of the circuit. Its value is determined by measuring the mass of distilled water that fills completely the cylinder. The combined standard uncertainty of this measurement is less than 0.5%;
(h) a vacuum pump that is used to clean the circuit and to prepare the system for the volume determination.

These components are connected with PTFE tubes with inner diameter of 6 mm (8 mm external diameter) and appropriate metallic radon and air tight connectors. All components are tightly sealed with respect to external air as it is shown in one of the tests presented in the next paragraph.