

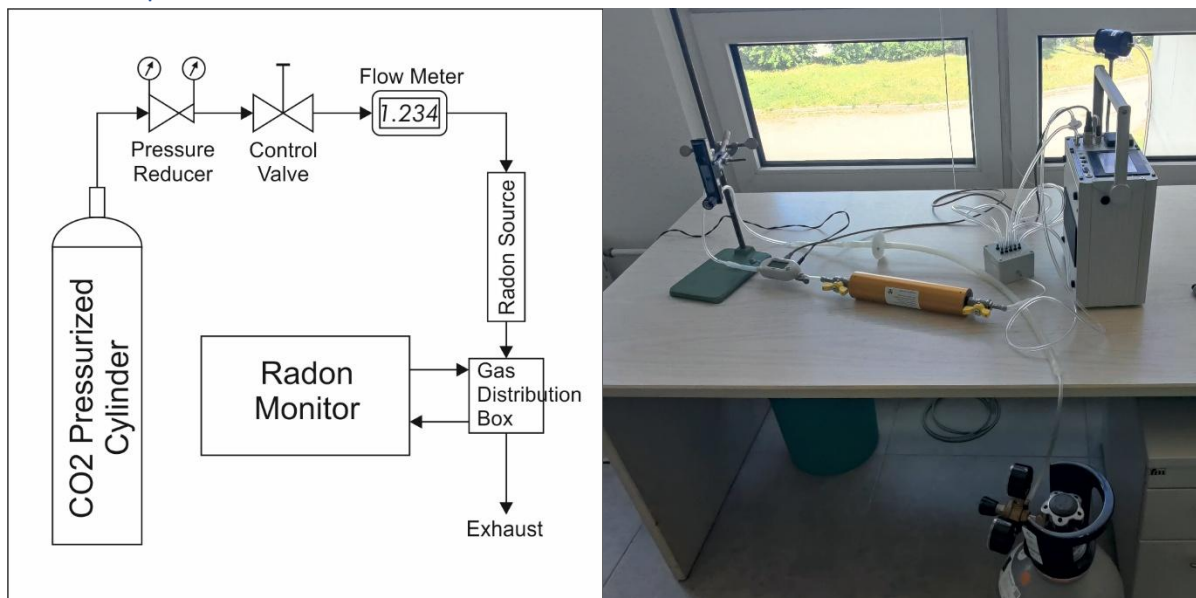
# Test report Radon detection in an 100% CO<sub>2</sub> Atmosphere

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This test was carried out to determine the possible effect of a 100% CO<sub>2</sub> atmosphere, rather than air, on the measurement of radon activity concentration using the RTM2300 and EQF33xx devices.

## Test setup



The CO<sub>2</sub> atmosphere was generated using a standard commercial CO<sub>2</sub> cylinder fitted with a pressure regulator. A manual control valve (float-type flow meter with needle valve) was used to maintain a constant flow rate throughout the test. Monitoring was carried out using a calibrated mass flow sensor from TSI (Model 4143) fitted downstream of the control valve. Radon was introduced into the air stream using a CMI radon source. The activity concentration is calculated as

$$C_{Rn} = \frac{E}{Q}$$

$C_{Rn}$  Radon activity concentration

$E$  Emanation rate of the Radon source

$Q$  Volume flow rate through the Radon source

A distribution box with a volume of approximately 200 ml was connected to the outlet of the radon source, from which the measurement gas is vented to the outside via a tube. Due to the continuous

flow, the distribution box contains a 100% CO<sub>2</sub> atmosphere with a defined and constant concentration of radon activity. The inlet and outlet of the radon monitor were connected to the distribution box via two further hose connections. The radon monitor thus operates in recirculation mode, measuring the atmosphere contained within the distribution box. Due to the high-volume flow rates relative to the internal volumes, the air still present in the system at the start of the test is replaced by CO<sub>2</sub> within a few minutes.

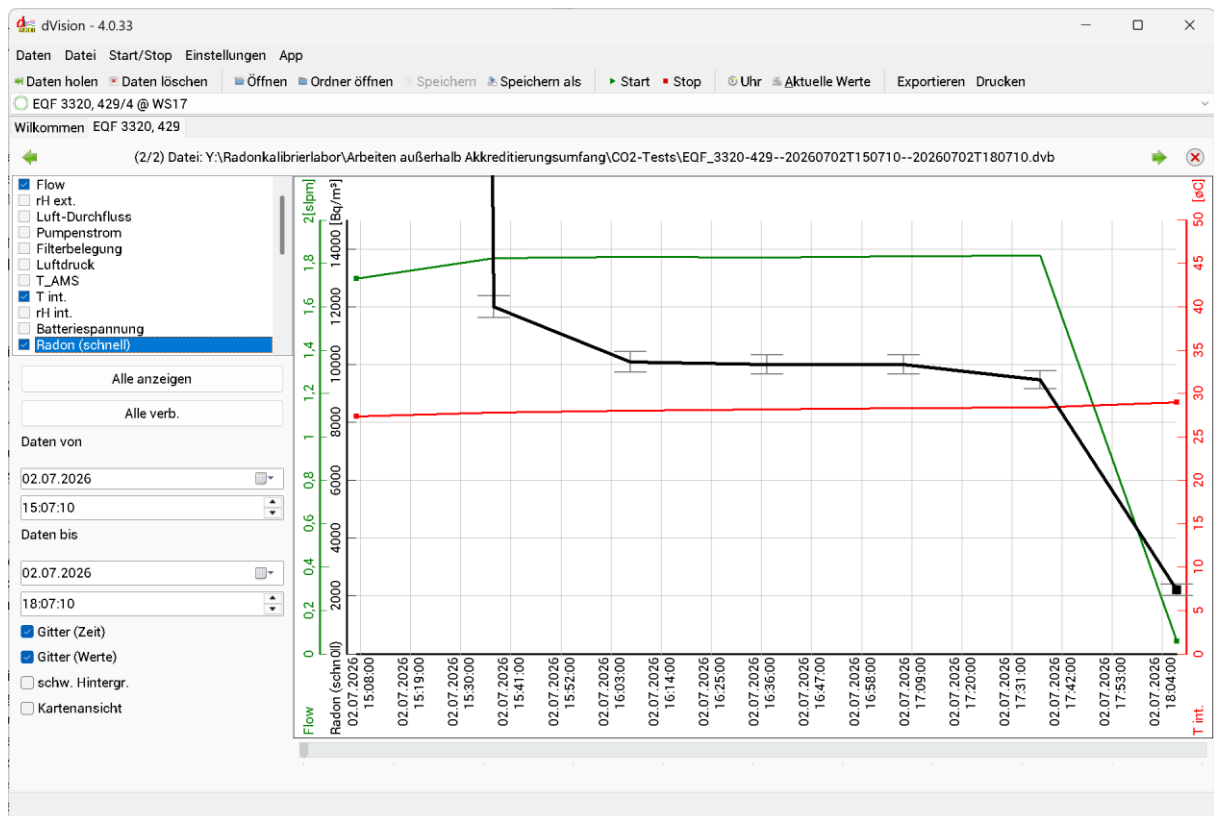
## Test procedure

First, the mass flow rate was set using the control valve. As the TSI sensor was calibrated for air, a correction factor for CO<sub>2</sub> is required. TSI does not specify a specific factor for this gas. Generally speaking, the typical correction factors for thermal mass flow sensors are around 0.74. A display value of 1.83 slpm was set, which, when the correction factor is applied, corresponds to a CO mass flow rate of 2.47 slpm. The standard conditions for the sensor are 21.1°C and 101.3 kPa, so the volumetric flow rate at 28°C (the temperature during the test) was approximately 2.53 l/min. The float-type flow meter fitted to the control valve (measuring the volumetric flow rate) confirmed this value with a reading of 2.6 l/min.



The nominal emission rate of the radon source is 0.4475 Bq/s. This results in a radon concentration of approximately 10,600 Bq/m<sup>3</sup> in the air flow.

The radon measurement was carried out with the EQF429 over a period of three hours at 30-minute intervals. The flow rate of the instrument was 1.35 slpm (related to air). The first two readings were discarded because the radon source had been sealed prior to the experiment and a very high concentration was released the moment it was opened. The results from “Fast Mode” were used. The following figure shows the readings acquired by the radon monitor.



## Measurement results

The measured average radon concentration for the four readings used was  $9,893 \text{ Bq/m}^3$ . This results in a deviation of  $-6.7\%$  relative to the calculated radon concentration of  $10,600 \text{ Bq/m}^3$ .

According to the certificate, the standard uncertainty of the radon source's emission rate is  $1.5\%$ . The manufacturer specifies the tolerance range of the mass flow sensor as  $1.75\%$ . In accordance with the GUM, this results in a standard uncertainty of  $2.35\%$  or an expanded uncertainty of  $4.7\%$  ( $k = 2$ ,  $95\%$  confidence interval) for the generated radon activity concentration.

The standard uncertainty of the radon measurement, derived from the counting statistics, is  $1.5\%$ . The standard uncertainty of the calibration factor, resulting from the traceability chain (BfS Berlin), is stated in the certificate as  $3\%$ . The total standard uncertainty is therefore  $3.35\%$  and the expanded uncertainty  $6.7\%$ .

Uncertainty intervals:

Calculated radon concentration:  $10102 \text{ Bq/m}^3 \dots 11098 \text{ Bq/m}^3$

Measured radon concentration:  $9,230 \text{ Bq/m}^3 \dots 10,556 \text{ Bq/m}^3$

Both uncertainty ranges overlap, meaning that a significant influence of the  $\text{CO}_2$  atmosphere cannot be demonstrated.

## Discussion

It is assumed that the emanation from the radon source occurs independently of the gas or gas mixture passed through it, so that the emanation rate is identical for air and  $\text{CO}_2$ . An assumption to the contrary is unlikely given the design of the source and the physical processes involved.

The measurement uncertainty is mainly determined by the calibration uncertainty, which is due to a long calibration chain. The instrument calibration and the source's emanation rate are traceable to two different national standards.

The correction factor for the mass flow sensor represents a significant, unquantifiable uncertainty factor. A reliable source is not available, and an AI query indicates a factor of 0.7 instead of 0.74. This would correspond to the reading on the float-type flow meter. The calculated activity concentration would then be 10,290 Bq/m<sup>3</sup>.

The intrinsic uncertainty of the radon monitor, which is stated as 2.5% in the data sheet, was also not taken into account.