Codice ID: 13877322 Radical Radon

Indoor radon entry rates in areas of Piedmont (North-Western Italy) with high natural radioactivity content

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Introduction

- This work shows how to obtain the **radon entry rates** and **ventilation rates,** analyzing the radon temporal variations. These parameters are useful
  - to have a first characterization of the monitored local,
  - to understand the mechanisms that can determine the radon accumulation.

- This work deals with the results of measurement campaign of radon levels in a well-known **radon prone area** in the North-Western Italy.

- Data presented here were collected by means of **Radim5B**, sampling the concentration hourly.

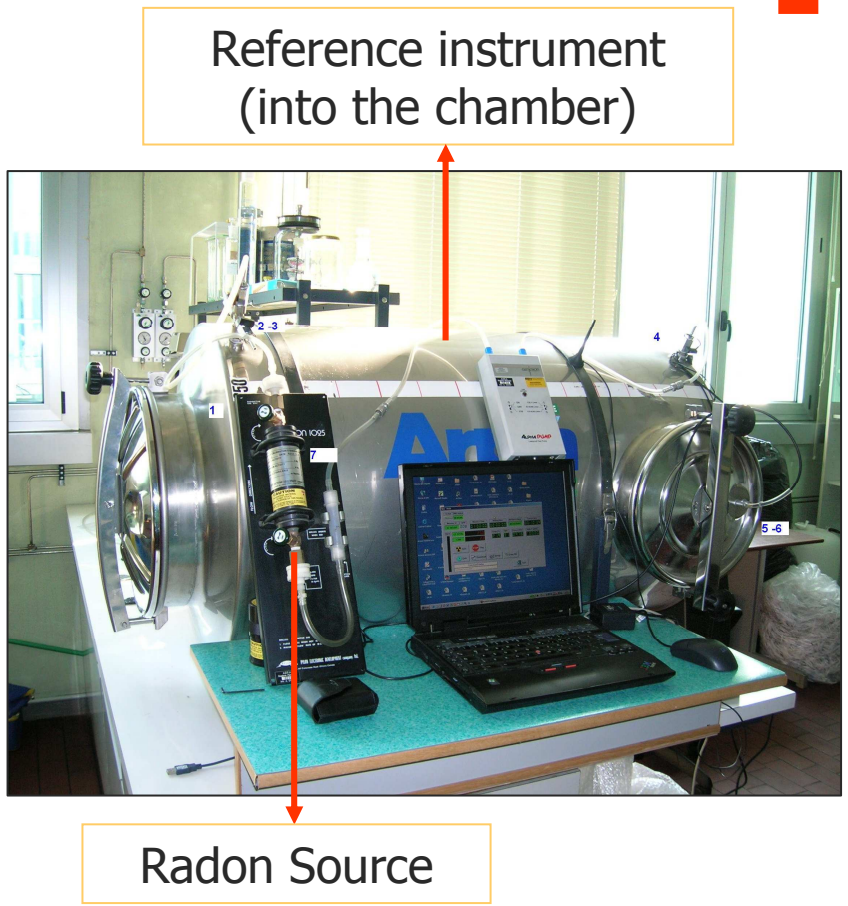
The Radim

- The Radim is a continuos monitor.
- It provides hourly concentration of Rn-222 in Bqm^{-3}, measuring the activity of alpha-emitted daughters (Po-218 and Po-214) by means of a Silicon detector.
- An electric field collects the daughters to the detector.
- Some advantageous aspects:
  - Low cost
  - High sensitivity (0.3 counts/h)(Bq/m^3)
  - Limited humidity dependence
  - Large memory capacity ($6*10^4$ sampling = 7 years)
  - Low power consumption → Long life battery (>360 days)

Instruments of the Radim family are produced by Jiří Plch M.Eng – SMM company (Prague)

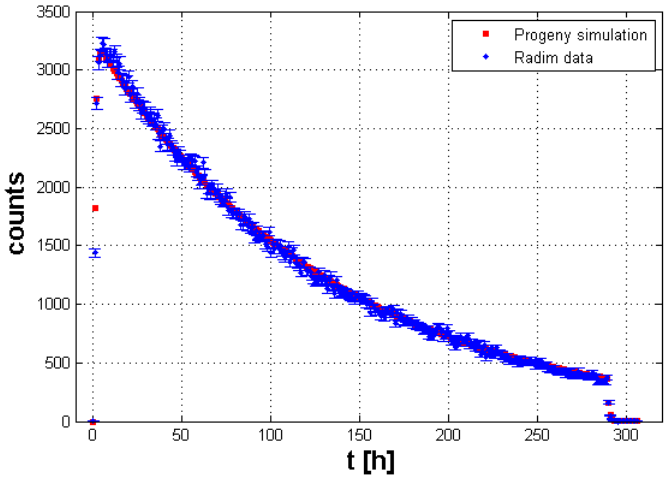
Radim tests in a radon chamber

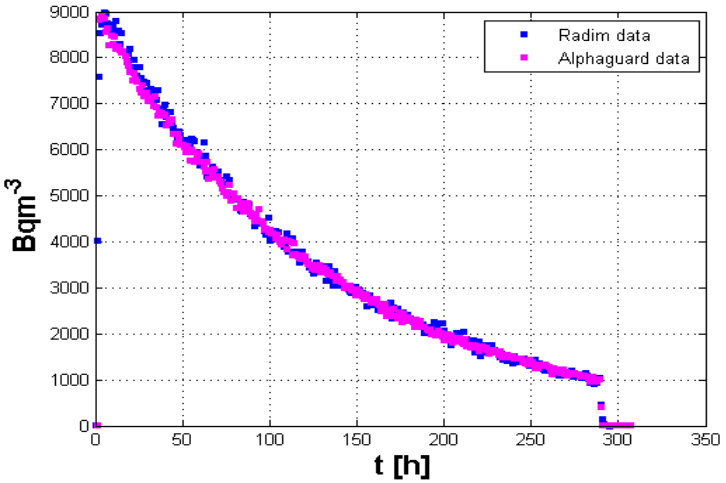
- Check of the Radim response.
- Radon injection of 9 kBqm^{-3} in a radon chamber.
- Exposure of about 300 hours.
- Reference instrument into the chamber.



A quick check of the instrument response

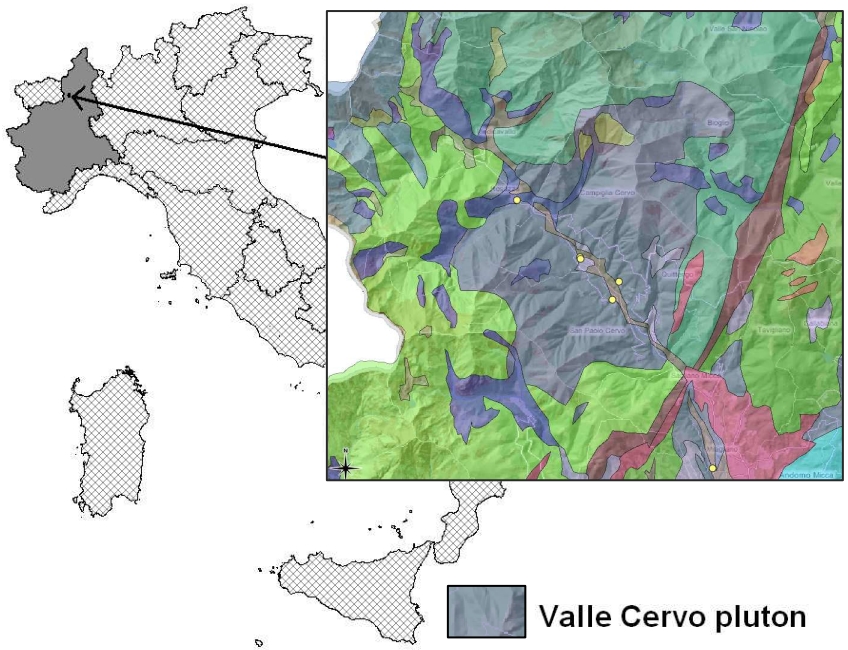
- The leading edge is compliant with the establishing of the saecular equilibrium between radon and its progeny.
- The radon half-life is estimated taking into account the leakage rate of the radon chamber (1.0 ± 0.2)*10^{-4} h^{-1}).
- There is agreement with the value estimated by the ALphaguard data and the reference value.





	$t_{1/2}$ [h]	χ^2/DF
Radon half-life	91.752	
Radim	91.20 ± 0.33	1.18
Reference (Alphaguard)	91.42 ± 0.43	0.29

Measurement campaign in Valle Cervo



- Valle Cervo (North-Western Italy) is a radon prone area.
- Valle Cervo pluton is an intrusive rock formation with very high natural radioactivity content (^{238}U and ^{232}Th serie radionuclides).
  - ^{238}U = 346-764 Bq/kg
  - ^{232}Th = 202-478 Bq/kg
- Indoor avarage radon concentration is at the level of 1,000 - 2,000 Bqm^{-3}.

Measurement sites (springtime)

Village	Location			Mean (Bq/m^3)
Campiglia Cervo	primary school	▪ restaurant ▪ classroom	ground floor ground floor	**915** **744**
Campiglia Cervo	municipal building	▪ office	1st floor	**539**
Rosazza	municipal building	▪ office ▪ private house	1st floor 3rd floor	**209** **173**
Quittengo	municipal building	▪ main office ▪ Mayor's office	ground floor ground floor	**2277** **6848**
San Paolo Cervo	municipal building	▪ Mayor's office ▪ archive	1st floor 1st floor	**994** **4016**
Miagliano	nursery school	▪ red classroom ▪ theatre classroom ▪ bedroom ▪ corridor	ground floor ground floor ground floor ground floor	**533** **484** **472** **733**

500 Bq/m^3 (annual average) is the action level set by Italian law: DL n.241/2000. It refers to workplaces and schools.

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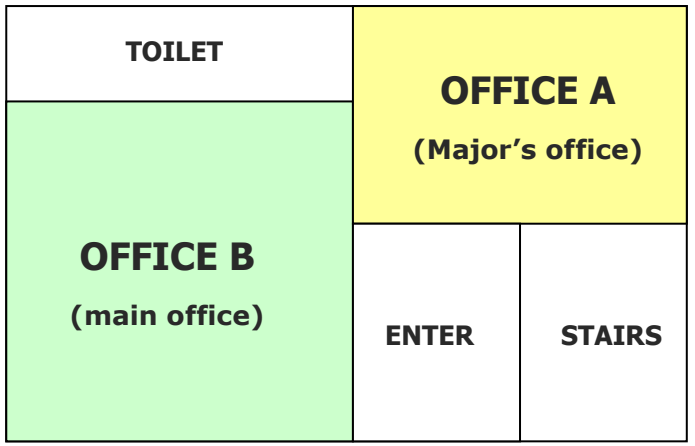
THE CASE STUDY

500 Bq/m^3 (annual average) is the action level set by Italian law: DL n.241/2000. It refers to workplaces and schools.

A case study - description

- The building has two offices (A and B), during springtime and winter.
- Most walls of the building are made by the local stone (Sienite della Balma).
- Some doors and windows are new, with double glazing.
- Being a mountain village, the temperature is quite cold and the workers, generally, do not have the habit of opening windows.
- The heating can still work during all the spring season.
- Office B is more used than the office A.



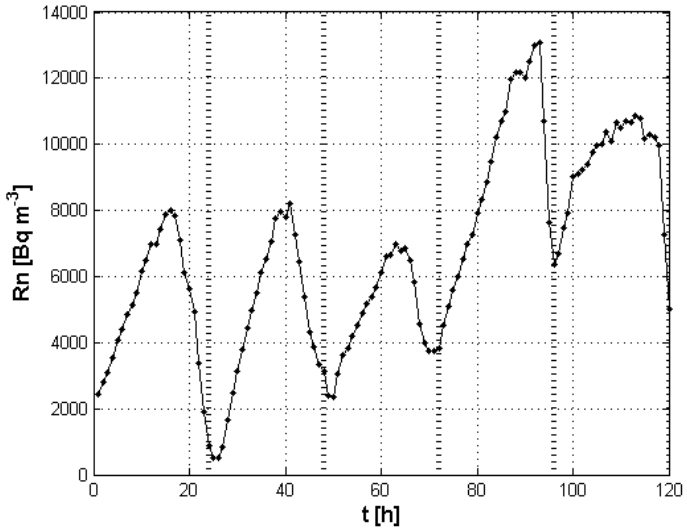
The radon entry rate and the ventilation rate

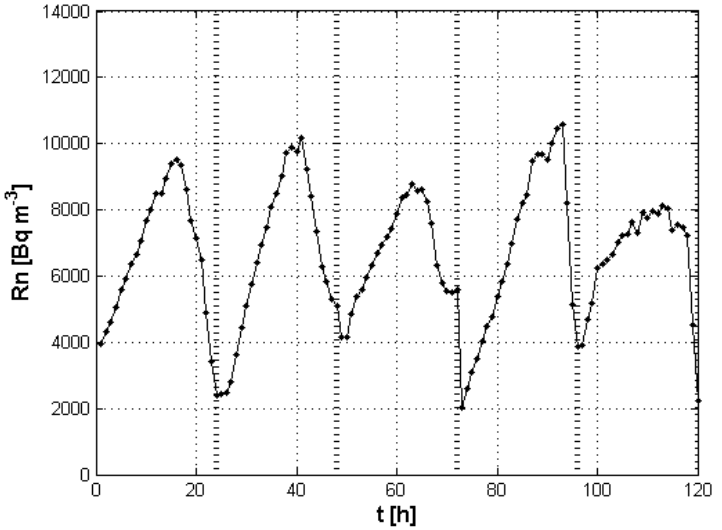
$$\frac{dc(t)}{dt} = -(\lambda_{Rn} + \lambda_v)c(t) + \frac{K}{V}$$

- c(t) = ^{222}Rn activity concentration
- λ_{Rn} = ^{222}Rn decay constant
- λ_v = natural ventilation rate
- K = ^{222}Rn entry rate
- V = room volume

Selection of the working days and alignment

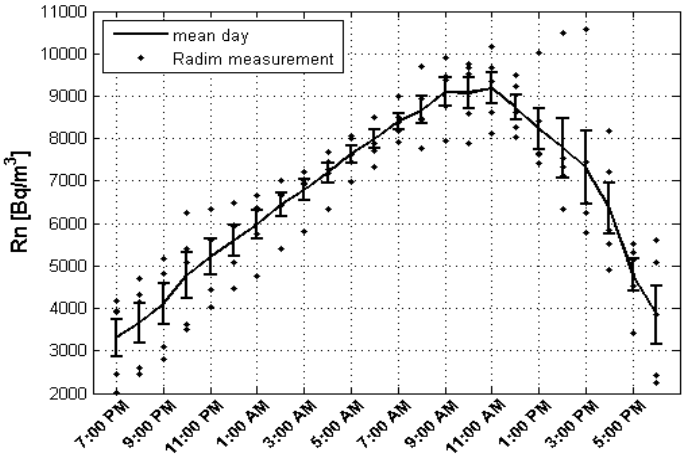
- Working day data (from Monday to Friday): the recursive daily variations are evident.
- The data were aligned to the mean value of each day.





The "mean working day"

- The "mean working day":
  - An accumulation branch (night)
  - A depletion branch (day)



- The initial slope of the radon growth curve is a good estimate of the **radon entry rate** K [Jonassen, 1983] :

$$(\lambda_{Rn} + \lambda_v)c(0) \approx 0 \Rightarrow \frac{dc(0)}{dt} = \frac{K}{V}$$

The **natural ventilation rate** λ can be measured fitting the accumulation/depletion branches of the curve, assuming K constant.

Jonassen,N.,The determination of the radon exhalation rates, Health Physics 45 (1983), 369-376

A case study - results

Location	Volume [m^3]	Season	Rn mean [Bqm^{-3}]	Entry rate [Bqh^{-1}]	Natural ventilation rate (night) [h^{-1}]	Natural ventilation rate (day) [h^{-1}]
Office A	55	Spring	6668	$(2.6 \pm 0.4)*10^4$	0.016 ± 0.001	0.150 ± 0.015
		Winter	11136	$(4.0 \pm 0.3)*10^4$	0.089 ± 0.007	0.115 ± 0.008
Office B	90	Spring	1399	$(2.0 \pm 0.2)*10^4$	0.059 ± 0.004	0.319 ± 0.015
		Winter	7127	$(3.4 \pm 0.8)*10^4$	0.062 ± 0.003	0.099 ± 0.004

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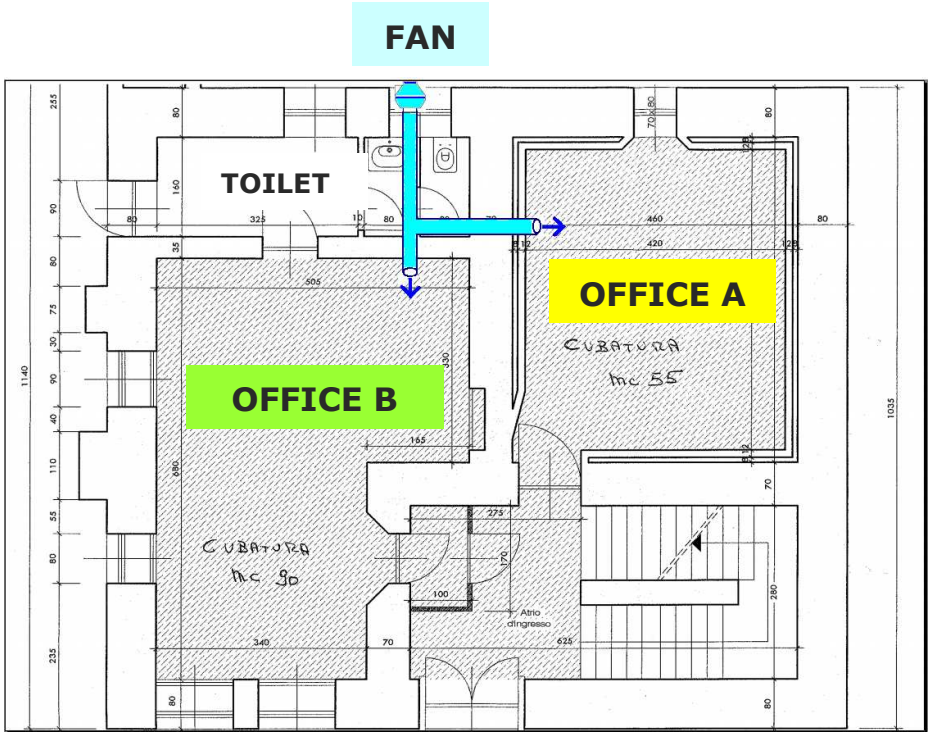
A case study - remedial actions

- Installation of a ventilation system with only one fan
- The fan injects external air into the offices (the air can be heated)



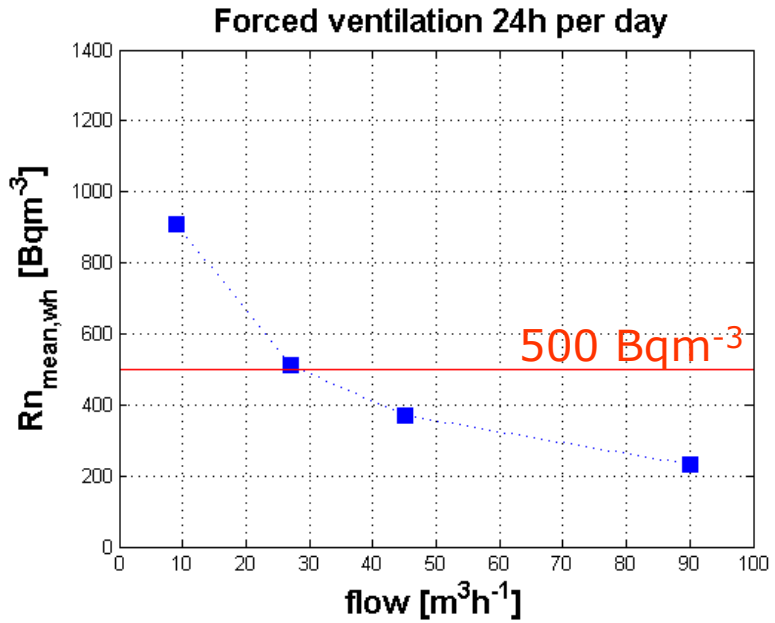
Regulation of the ventilation parameters

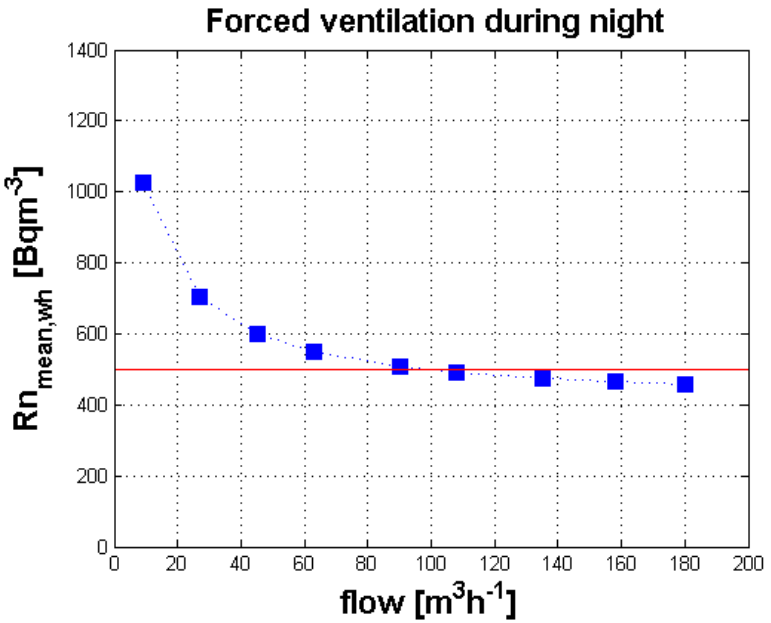
- To regulate :
  - Flow of the ventilation system
  - Start and stop of the fan

- To check:
  - $Rn_{wh,after}$ = mean radon concentration during working hours (9:00 AM – 18:00 PM), after mitigations (*estimated values)*
  - Some investigations are carried out to choose the right compromise between consumption and mitigation.

Regulation of the ventilation parameters

Example: Office B – Springtime

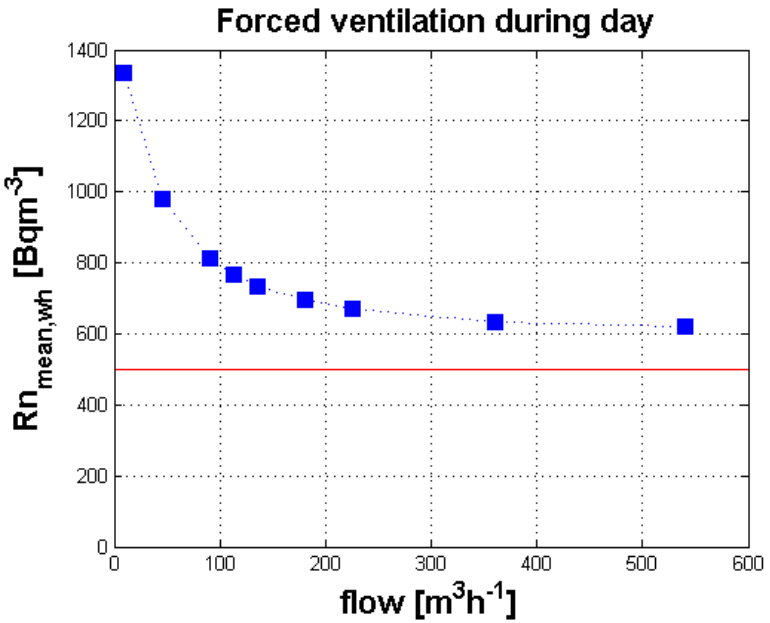




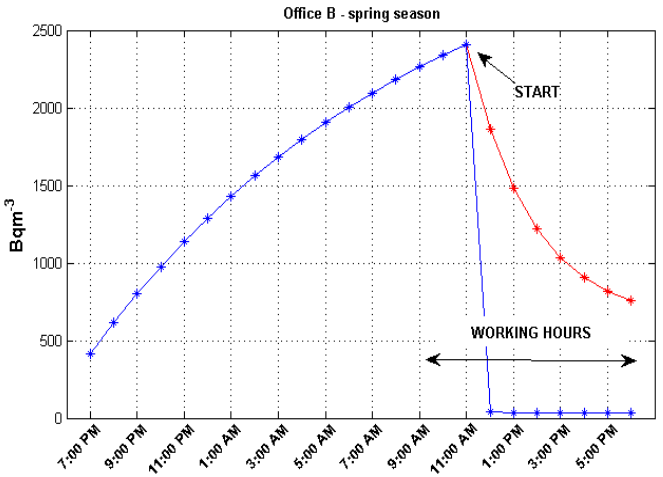
The mean concentration is low in the night but quickly drops during the day.

Regulation of the ventilation parameters

Example: Office B – Springtime



flow = 540 m^3h^{-1}
(λ_{forced} = 6 h^{-1})



The mean concentration during working hours is not low because the first and second radon value (9:00 - 10:00 AM) before starting fan are very high.

Before and after mitigations

Season	Flow [m^3h^{-1}]	Start	Stop	Location	λ_{forced} [h^{-1}]	$Rn_{wh,before}$ [Bqm^{-3}]	$Rn_{wh,after}$ [Bqm^{-3}]
Spring	90	08:00 AM	06:00 PM	Office A	1.63	6610	324
				Office B	1	1277	235
Winter	135	05:30 AM	07:30 PM	Office A	2.45	9334	313
				Office B	1.5	6108	265

- Flow of the ventilation system
- Start/Stop of the fan
- λ_{forced} = forced ventilation rate
- $Rn_{wh,before}$ = during working hours, before mitigations
- $Rn_{wh,after}$ = during working hours, after mitigations (*estimated values)*

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Season	Flow [m^3h^{-1}]	Start	Stop	Location	λ_{forced} [h^{-1}]	$Rn_{wh,before}$ [Bqm^{-3}]	$Rn_{wh,after}$(*) [Bqm^{-3}]
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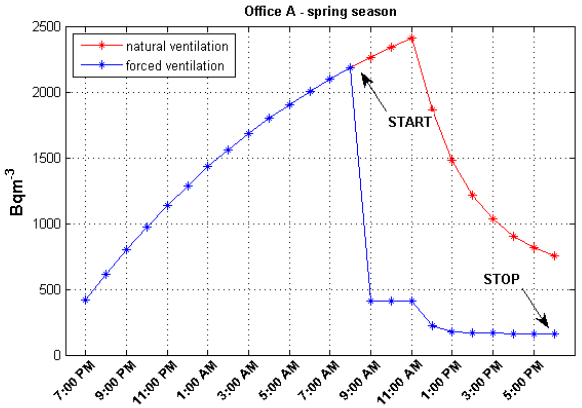

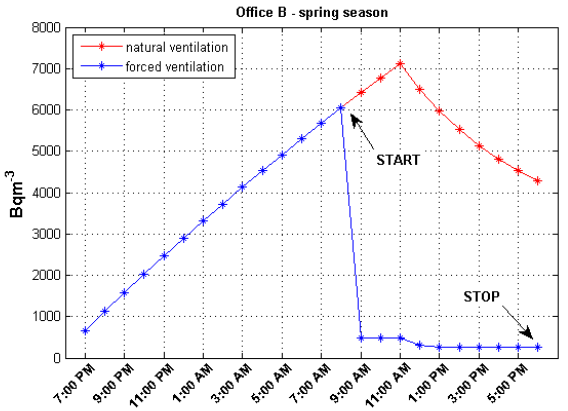

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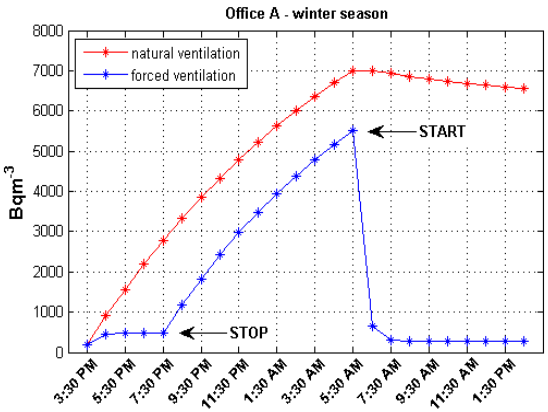

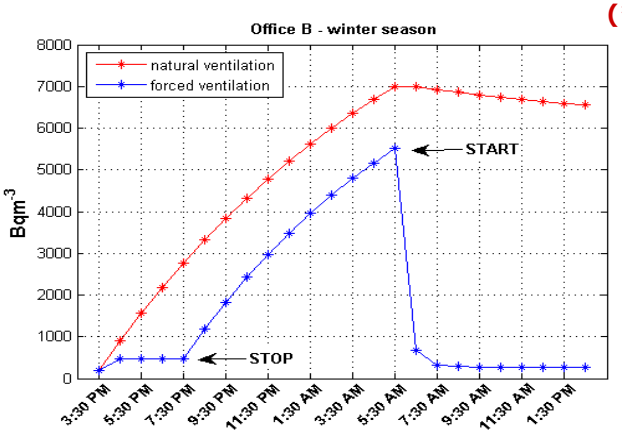

Mitigations by the 2012

- After carrying the mitigations out, a new monitoring will be scheduled to verify the real radon levels.

- The values obtained by the model could be an overestimate because the injection of the external air can decrease the radon entry rate from soil (pressurized room).

- This model was already tested with success in a workplace (*).

(*) E.M. Chiaberto, M. Magnoni, F. Righino and R. Costa Laia , *Reduction of Radon concentration in a basement workplace: study of the problem and characterization of the main parameters affecting the radon concentration,* Proceedings of European IRPA Congress 2002 "Towards harmonization of radiation protection in Europe", Florence, Italy, October 8th-11th 2002

Conclusions

- The Radim response was checked:
  - The agreement with the reference instrument is good.
  - The estimated radon half-life is in agreement with the reference value.
- The model allows estimating:
  - Radon entry rate
  - Natural ventilation rate
- When the remedial actions consist in installing of a ventilation system, it is possible to regulate the ventilation parameters by means of the model to get the radon concentration under the limit.

Aknowledgments

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RADICAL

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