Efficacy of Radon Remediation Methods – Factors Affecting Radon Reduction

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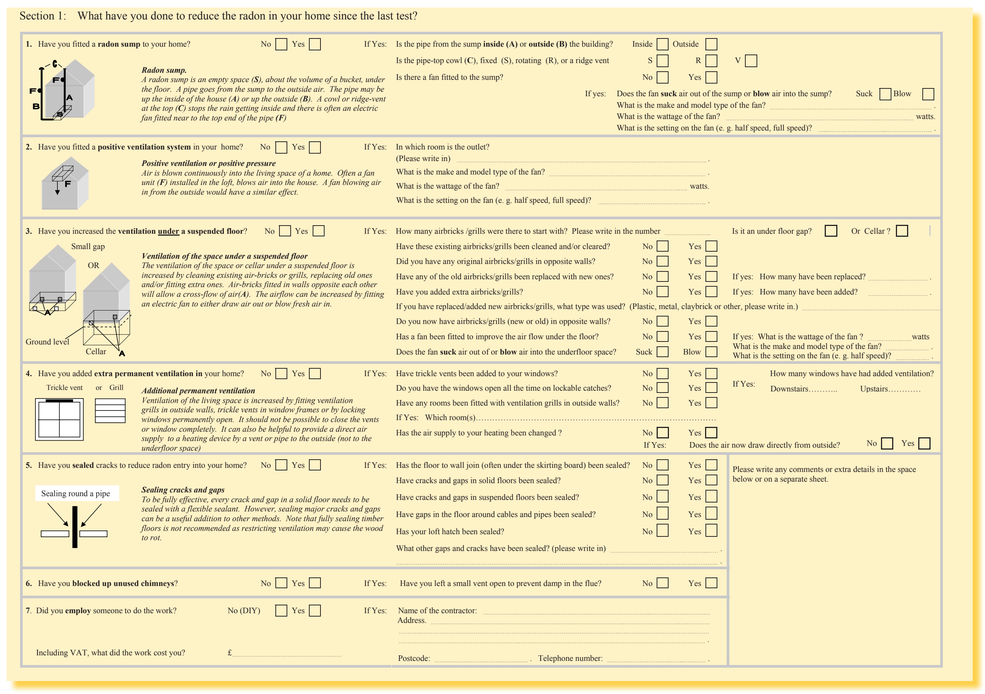
Introduction

Radon gas in the home is a major source of public radiation exposure and an established cause of lung cancer. The Health Protection Agency has an ongoing radon programme to 'find and fix' houses with radon concentrations at or above the Action Level (AL) of 200 Bq m^{-3}. The main aim of remedial work is to reduce radon levels to as low as reasonably achievable and to below the Target Level (TL) of 100 Bq m^{-3}. Householders with high radon levels receive free remedial advice.

Information is being routinely collected from householders who remedy and do a radon test after remediation. This information is stored in the UK national radon database. Analysis of the collected information has been done on around 2400 dwellings. The aims were to identify both the effectiveness of remediation measures and the factors that affect their performance including: the physical characteristics of the home, the radon level before remediation and who carried out the work.



Section 1: What have you done to reduce the radon in your home since the last test?

1. Have you fitted a **radon sump** to your home? No ☐ Yes ☐ If Yes: Is the pipe from the sump **inside (A)** or **outside (B)** the building? Inside ☐ Outside ☐
Is the pipe-top cowl (**C**), fixed (S), rotating (R), or a ridge vent S ☐ R ☐ V ☐
Is there a fan fitted to the sump? No ☐ Yes ☐
If yes: Does the fan **suck** air out of the sump or **blow** air into the sump? Suck ☐ Blow ☐
What is the make and model type of the fan? .....
What is the wattage of the fan? ..... watts.
What is the setting on the fan (e. g. half speed, full speed)? .....

Radon sump.
*A radon sump is an empty space (**S**), about the volume of a bucket, under the floor. A pipe goes from the sump to the outside air. The pipe may be up the inside of the house (**A**) or up the outside (**B**). A cowl or ridge-vent at the top (**C**) stops the rain getting inside and there is often an electric fan fitted near to the top end of the pipe (**F**)*

2. Have you fitted a **positive ventilation system** in your home? No ☐ Yes ☐ If Yes: In which room is the outlet? (Please write in) .....
What is the make and model type of the fan? .....
What is the wattage of the fan? ..... watts.
What is the setting on the fan (e. g. half speed, full speed)? .....

Positive ventilation or positive pressure
*Air is blown continuously into the living space of a home. Often a fan unit (**F**) installed in the loft, blows air into the house. A fan blowing air in from the outside would have a similar effect.*

3. Have you increased the **ventilation under a suspended floor**? No ☐ Yes ☐ If Yes: How many airbricks /grills were there to start with? Please write in the number ..... Is it an under floor gap? ☐ Or Cellar ? ☐
Have these existing airbricks/grills been cleaned and/or cleared? No ☐ Yes ☐
Did you have any original airbricks/grills in opposite walls? No ☐ Yes ☐
Have any of the old airbricks/grills been replaced with new ones? No ☐ Yes ☐ If yes: How many have been replaced? .....
Have you added extra airbricks/grills? No ☐ Yes ☐ If yes: How many have been added? .....
If you have replaced/added new airbricks/grills, what type was used? (Plastic, metal, claybrick or other, please write in.) .....
Do you now have airbricks/grills (new or old) in opposite walls? No ☐ Yes ☐
Has a fan been fitted to improve the air flow under the floor? No ☐ Yes ☐ If yes: What is the wattage of the fan ? ..... watts
What is the make and model type of the fan? .....
Does the fan **suck** air out of or **blow** air into the underfloor space? Suck ☐ Blow ☐ What is the setting on the fan (e. g. half speed)? .....

Small gap OR Ground level Cellar

Ventilation of the space under a suspended floor
*The ventilation of the space or cellar under a suspended floor is increased by cleaning existing air-bricks or grills, replacing old ones and/or fitting extra ones. Air-bricks fitted in walls opposite each other will allow a cross-flow of air(**A**). The airflow can be increased by fitting an electric fan to either draw air out or blow fresh air in.*

4. Have you added **extra permanent ventilation** in your home? No ☐ Yes ☐ If Yes: Have trickle vents been added to your windows? No ☐ Yes ☐
Do you have the windows open all the time on lockable catches? No ☐ Yes ☐
Have any rooms been fitted with ventilation grills in outside walls? No ☐ Yes ☐
If Yes: Which room(s).....
Has the air supply to your heating been changed ? No ☐ Yes ☐
If Yes: Does the air now draw directly from outside? No ☐ Yes ☐
If Yes: How many windows have had added ventilation?
Downstairs..... Upstairs.....

Trickle vent or Grill

Additional permanent ventilation
Ventilation of the living space is increased by fitting ventilation grills in outside walls, trickle vents in window frames or by locking windows permanently open. It should not be possible to close the vents or window completely. It can also be helpful to provide a direct air supply to a heating device by a vent or pipe to the outside (not to the underfloor space)

5. Have you **sealed** cracks to reduce radon entry into your home? No ☐ Yes ☐ If Yes: Has the floor to wall join (often under the skirting board) been sealed? No ☐ Yes ☐
Have cracks and gaps in solid floors been sealed? No ☐ Yes ☐
Have cracks and gaps in suspended floors been sealed? No ☐ Yes ☐
Have gaps in the floor around cables and pipes been sealed? No ☐ Yes ☐
Has your loft hatch been sealed? No ☐ Yes ☐
What other gaps and cracks have been sealed? (please write in) .....
Please write any comments or extra details in the space below or on a separate sheet.

Sealing round a pipe

Sealing cracks and gaps
To be fully effective, every crack and gap in a solid floor needs to be sealed with a flexible sealant. However, sealing major cracks and gaps can be a useful addition to other methods. Note that fully sealing timber floors is not recommended as restricting ventilation may cause the wood to rot.

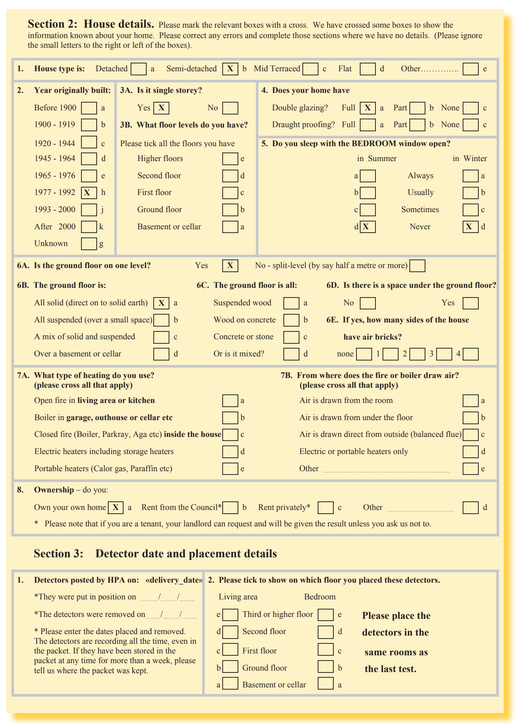
6. Have you **blocked up unused chimneys**? No ☐ Yes ☐ If Yes: Have you left a small vent open to prevent damp in the flue? No ☐ Yes ☐

7. Did you **employ** someone to do the work? No (DIY) ☐ Yes ☐ If Yes: Name of the contractor: .....
Address. .....
Including VAT, what did the work cost you? £..... Postcode: ..... Telephone number: .....

Householders are requested to complete questionnaires providing information on the type of remedial method used and details about the home.

To provide a reliable indicator of the effectiveness of the remedy, measurements over a three month period were done before and after remediation.

Multiple regression analysis (5% statistical significance level) was used to assess the relative effectiveness of different radon reduction measures and the influence of house characteristics (STATA 7.0 and Minitab statistical packages).



Section 2: House details. Please mark the relevant boxes with a cross. We have crossed some boxes to show the information known about your home. Please correct any errors and complete those sections where we have no details. (Please ignore the small letters to the right or left of the boxes).

1. House type is: Detached ☐ a Semi-detached ☒ b Mid Terraced ☐ c Flat ☐ d Other..... ☐ e

2. Year originally built:
Before 1900 ☐ a
1900 - 1919 ☐ b
1920 - 1944 ☐ c
1945 - 1964 ☐ d
1965 - 1976 ☐ e
1977 - 1992 ☒ h
1993 - 2000 ☐ j
After 2000 ☐ k
Unknown ☐ g

3A. Is it single storey? Yes ☒ No ☐
3B. What floor levels do you have?
Please tick all the floors you have
Higher floors ☐ e
Second floor ☐ d
First floor ☐ c
Ground floor ☐ b
Basement or cellar ☐ a

4. Does your home have
Double glazing? Full ☒ a Part ☐ b None ☐ c
Draught proofing? Full ☐ a Part ☐ b None ☐ c

5. Do you sleep with the BEDROOM window open?

	in Summer		in Winter
a	☐	Always	☐ a
b	☐	Usually	☐ b
c	☐	Sometimes	☐ c
d	☒	Never	☒ d

6A. Is the ground floor on one level? Yes ☒ No - split-level (by say half a metre or more) ☐

6B. The ground floor is:
All solid (direct on to solid earth) ☒ a
All suspended (over a small space) ☐ b
A mix of solid and suspended ☐ c
Over a basement or cellar ☐ d

6C. The ground floor is all:
Suspended wood ☐ a
Wood on concrete ☐ b
Concrete or stone ☐ c
Or is it mixed? ☐ d

6D. Is there a space under the ground floor? No ☐ Yes ☐

6E. If yes, how many sides of the house have air bricks? none ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

7A. What type of heating do you use? (please cross all that apply)
Open fire in **living area or kitchen** ☐ a
Boiler in **garage, outhouse or cellar etc** ☐ b
Closed fire (Boiler, Parkray, Aga etc) **inside the house** ☐ c
Electric heaters including storage heaters ☐ d
Portable heaters (Calor gas, Paraffin etc) ☐ e

7B. From where does the fire or boiler draw air? (please cross all that apply)
Air is drawn from the room ☐ a
Air is drawn from under the floor ☐ b
Air is drawn direct from outside (balanced flue) ☐ c
Electric or portable heaters only ☐ d
Other ..... ☐ e

8. Ownership – do you:
Own your own home ☒ a Rent from the Council* ☐ b Rent privately* ☐ c Other ..... ☐ d
* Please note that if you are a tenant, your landlord can request and will be given the result unless you ask us not to.

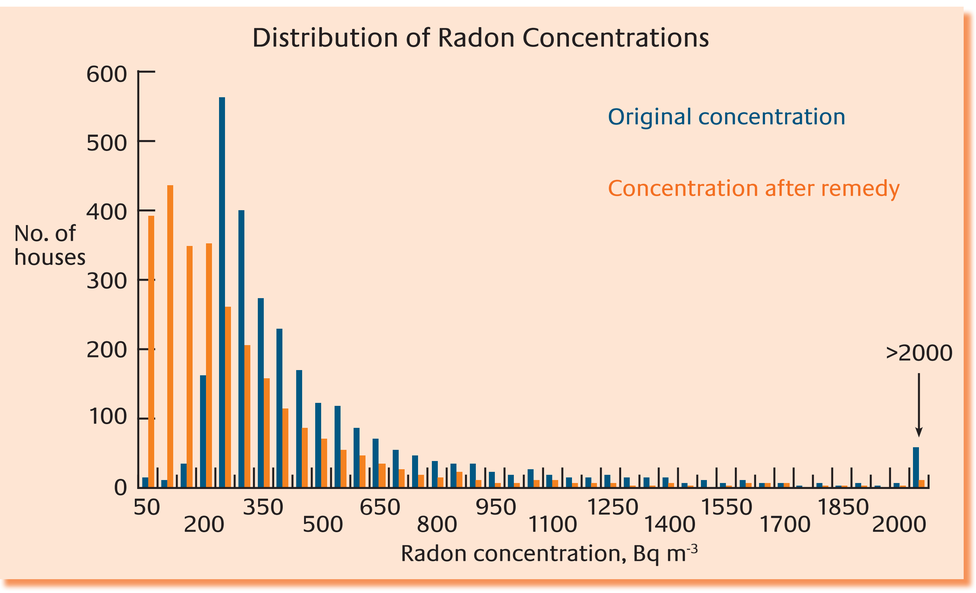
Section 3: Detector date and placement details

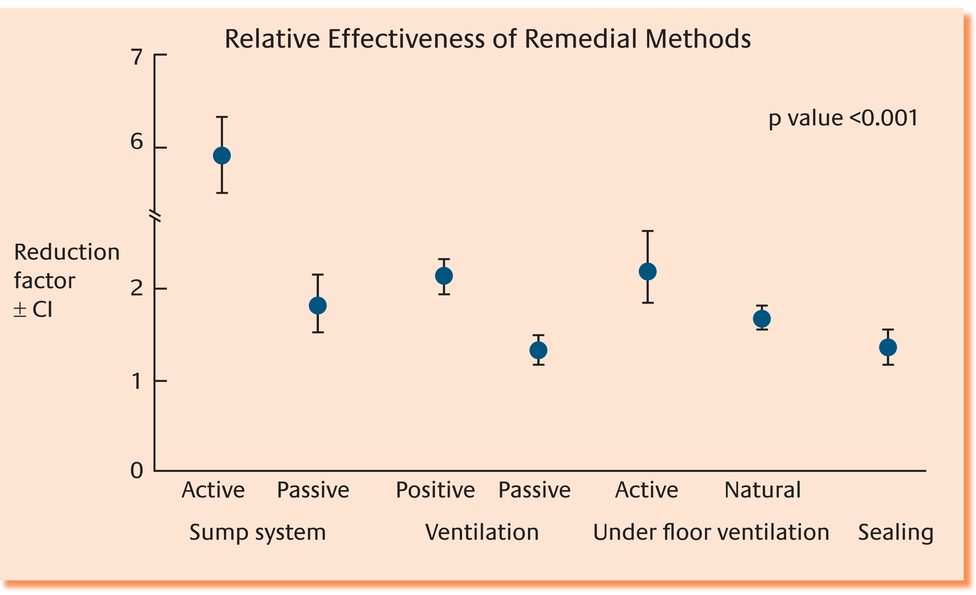
1. Detectors posted by HPA on: «delivery_date»
*They were put in position on ___/___/___
*The detectors were removed on ___/___/___
* Please enter the dates placed and removed. The detectors are recording all the time, even in the packet. If they have been stored in the packet at any time for more than a week, please tell us where the packet was kept.

2. Please tick to show on which floor you placed these detectors.

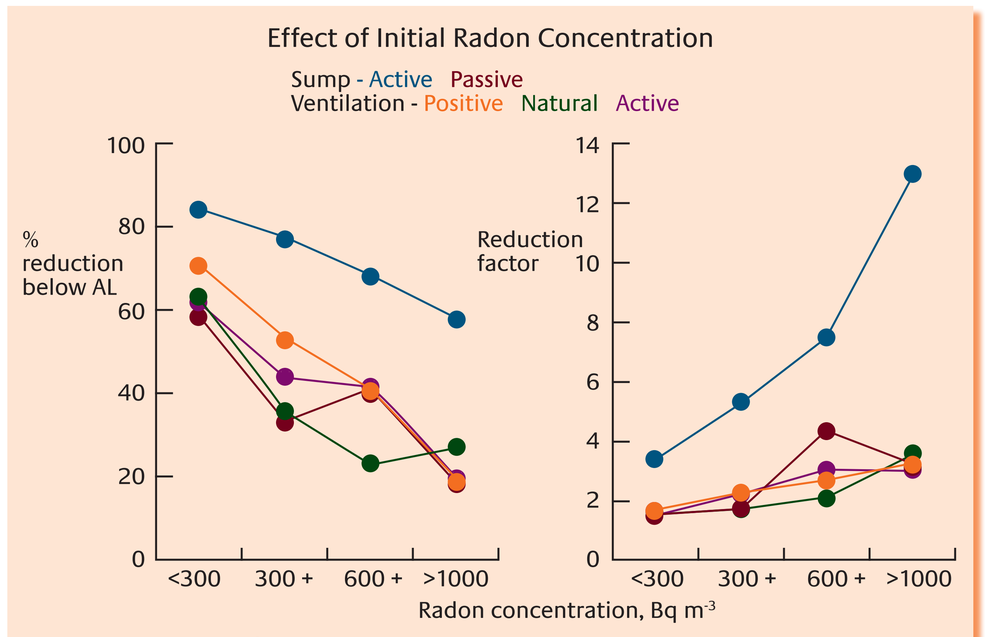
Living area		Bedroom
c ☐	Third or higher floor	☐ e
d ☐	Second floor	☐ d
c ☐	First floor	☐ c
b ☐	Ground floor	☐ b
a ☐	Basement or cellar	☐ a

Please place the detectors in the same rooms as the last test.





An active sump is clearly the most effective remedy indicating a reduction factor of around 6. Other techniques typically achieved reduction factors of around 2, sealing floors and passive ventilation of living space are least effective. Active measures generally perform better than passive measures.



Performance is measured in two ways
Success: the percentage reduced to below the Action Level

Reduction factor: $\frac{\text{Initial concentration}}{\text{Final concentration}}$

Each remediation method showed a trend in performance with respect to the initial radon concentration. The higher the initial concentration the better the reduction in exposure for most measures. Higher concentrations are less likely to reduce below the action level. Even if the success rate of achieving a reduction below the AL is low, the reduction factor could be high and thus the remedy still achieves a significant reduction in exposure. The effect was more pronounced for active sumps than for other methods.

Effect of House Characteristics on Performance of Remedial Measure

Method of reduction	Factors affecting performance: House type	Date built	Single storey	Basement	Double glazed	Ground floor	Heating type
Sump							
Active	ND	Strong[a]	Strong[b]	Strong[c]	Some[d]	ND	ND
Passive	ND	ND	Some[b]	ND	Some[d]	ID	ND
Ventilation							
Positive	ND	ND	Strong[b]	ND	Some[d]	ND	ND
Passive	ND	ND	ND	ID	Some[d]	Some[e]	ND
Underfloor							
Natural	ND	ND	ND	ND	Some[d]	ND	ND
Active	ND	ID	ID	ID	Some[d]	ID	ND
Sealing floors	ID	ND	ND	ID	Some[d]	ID	ND

[a] Newer the house, the better
[b] More effective in single storey homes
[c] More effective in homes without a basement
[d] Generally more effective with double glazing
[e] Slightly more effective for suspended floors

ND No difference ID Insufficient data

The table indicates the degree of influence of each housing characteristic on the performance of each remedial measure. Remediation performance is not significantly affected by the type of home or the heating method although double glazing generally improves remediation performance. Sump systems are not as effective in a house with a basement. The more recent the build date, the more effective active sumps tend to be. The performance of other measures are largely unaffected by the age of the home. In single storey homes, sumps and positive ventilation are more effective.

Effectiveness of Contractor Depending on Initial Radon Concentration

Bq m^{-3}		Contractor: Experienced	General	DIY
<500	No. of homes	470	377	347
	Reduction factor	3.0	1.8	1.7
	% reduced below Action Level	74.5	55.7	55.3
500 - 1000	No. of homes	205	115	65
	Reduction factor	5.4	3.1	2.9
	% reduced below Action Level	61.5	38.3	38.5
>1000	No. of homes	109	55	32
	Reduction factor	8.5	9.2	5.3
	% reduced below Action Level	45.0	49.1	40.6

Experienced - Those that have completed 10 or more works
General - Assumed less experience and not necessarily specialist radon contractor
DIY - Homeowners doing their own work

Performance of remediation may depend on several factors, the initial radon level, house characteristics, choices made by the customer and who does the work. The best reductions are achieved by experienced contractors, then general contractors, followed by DIY. It is not clear cut, further work is necessary to determine if better reduction factors are due to higher initial radon levels or the quality of work, or a mixture of both.

Improved guidance for householders, contractors and others will be prepared using information from this work. Guidance will be published as fact sheets and on HPA's dedicated radon website (www.ukradon.org) so that better informed decisions can be made.

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