GOOD REPAIR GUIDE GRG 37/1

RADON SOLUTIONS IN HOMES

Improving underfloor ventilation

Chris Scivyer

This Good Repair Guide offers guidance to builders and homeowners carrying out installation works to increase ventilation under suspended ground floors. It covers the installation of both natural and mechanical (fan-assisted) ventilation to underfloor spaces. Advice is also given on system maintenance and what to do if a system fails to adequately reduce radon levels.

This Good Repair Guide is Part 1 in a 3-Part set and replaces the guidance given in BRE Report BR 270. Parts 2 and 3 cover positive house ventilation and sump systems.

BACKGROUND

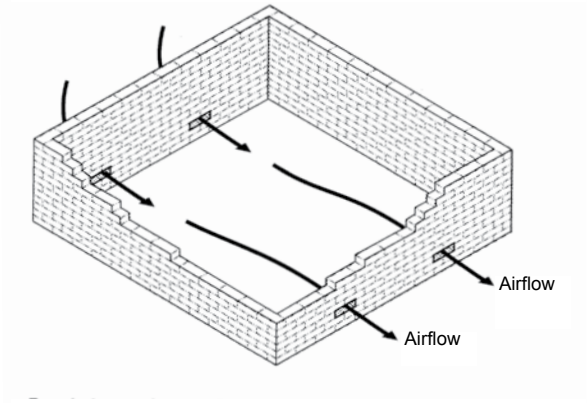
Radon

Radon is a naturally occurring radioactive gas that is present in all buildings. Prolonged exposure to high levels causes lung cancer The Health Protection Agency (HPA) recommends that householders with concentrations above the action level (200 Bq m^{-3}) should reduce their radon concentrations as far as they can and ideally to below the target level (100 Bq m^{-3}).

Improving underfloor ventilation

If part, or all, of the ground floor is of suspended timber construction, improving underfloor ventilation may be an appropriate method for reducing indoor radon levels. Suspended timber floors should be well ventilated to reduce the risk of timber rot and musty smells. Ideally, there should be vents in the walls on either side of the floor to encourage cross-ventilation and minimise dead areas beneath the floor (Figure 1). Improving underfloor ventilation to reduce radon levels therefore also benefits the floor in other ways.

Locating airbricks on the opposite sides of the underfloor space allows for complete cross ventilation



Poorly located airbricks cause areas of poor ventilation (dead areas)

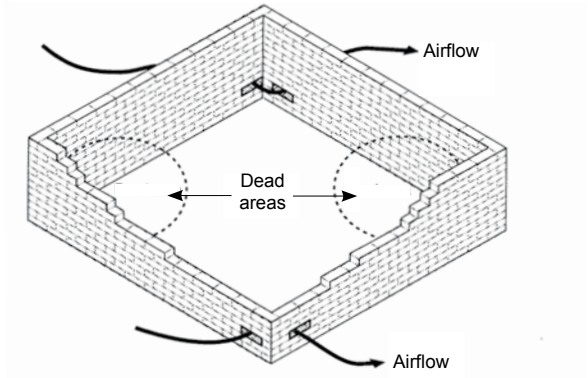


Figure 1: Examples of (a) good ventilation (b) poor ventilation

Improved natural underfloor ventilation is generally effective for radon levels up to 500 Bq m^{-3}. It may be effective with higher levels but if not an underfloor fan could be added later. Often with higher levels, mechanical underfloor ventilation (using a fan) or an alternative solution will be required.

Suspended timber floors

Suspended timber ground floors can be found in homes of all ages. There are two quick ways of finding out if a floor is suspended timber (or wood-based boarding such as chipboard or laminate flooring):

- roll back any floor coverings and see if the surface of the floor appears wooden and sounds hollow when tapped
- look outside for underfloor ventilation grilles or air bricks in the walls. They will be just above ground level in the external walls of the rooms with timber floors.

If underfloor grilles are not visible, the timber floor may be laid directly on a concrete slab in which case underfloor ventilation is not needed and the floor will need to be treated as a concrete floor when considering an appropriate radon solution.

Suspended concrete floors

Suspended concrete beam and block floors have only become common since the early 1980s before which they tended to only be used on sloping sites. These floors can be difficult to identify as the floor finish will be similar to a solid concrete floor. Since the early 1990s, however, most suspended concrete floors have included ventilation grilles or air bricks in the walls. If provided, these will be visible outside just above ground level in the walls alongside the rooms with suspended floors. If underfloor vents are not visible the concrete floor may be laid directly on the ground and will need to be treated as a concrete floor when considering an appropriate radon solution.

In either case, if you are still unsure, ask a builder to check for you.

SOLUTIONS FOR IMPROVING UNDERFLOOR VENTILATION

Underfloor ventilation can be improved by:

- increasing the *natural* ventilation
- providing *mechanical* ventilation.

Increasing natural underfloor ventilation

This involves clearing out or replacing existing underfloor ventilation grilles or air bricks, or adding additional vents. It is suitable for homes with indoor radon concentrations of up to 500 Bq m^{-3}.

How it works

Due to slight differences in indoor and outdoor pressures caused by wind and temperature differences, a building acts like a chimney drawing radon from the ground up into the building. By providing more open or additional underfloor ventilation grilles around the building the radon in the air beneath the ground floor can be diluted. Less radon is drawn into the building because the air contains less radon.

What to do

Check and clear existing ventilation grilles

It is common for underfloor vents to become blocked so that they no longer provide adequate ventilation to the

Figure 2: Examples of ventilation grilles that are blocked, covered or obstructed

underfloor space. They may have become blocked with dirt, obstructed by foliage, raised paving or driveways, or deliberately blocked by householders to reduce draughts or for some other reason (Figure 2). Sometimes, additional building works such as an extension, conservatory or garage or even pipework could block existing underfloor vents and therefore additional vents will be needed.

In the past, underfloor vents would usually be visible just above the ground. With homes built since the early 1990s, this is not always the case. Instead, vents are often set below ground within a well to maintain a level threshold for disabled access. These wells can quickly fill with debris which blocks the vents (Figure 3).

Check the vents in cavity walls

Vents in cavity walls should be sleeved through the wall so that air can flow freely from outdoors into the underfloor space (Figure 4). Unfortunately, the bricks or blocks used in each leaf of a cavity wall rarely align with each other making it difficult to install sleeves. Therefore, builders simply install vents in the external leaf and expect the air to find its way under the floor via open gaps in the masonry joints. Consequently, little ventilation reaches under the floor. To check whether a vent is open, push a knitting needle through it into the underfloor space.

Similarly, if the house has had cavity wall insulation injected, check that the vents were not blocked during installation. This solution is appropriate for houses with radon levels below 500 Bq m^{-3}. It is often possible to reduce the radon level to well below the action level by simply clearing major obstructions from existing air bricks.

How many vents should there be?

Guidance on specifying vents is as follows.

- Ideally, vents should be provided on at least two opposite walls to allow through-ventilation.
- The depth of the space beneath the floor can vary from virtually nothing to a more typical 450–600 mm. For floors with an underfloor space of this depth, vents should be large enough to give an actual opening of 1500 mm^2 for each metre run of wall.
- Typically, vents having the size of a house brick should be spaced every 1.5–2.0 m around the perimeter of the building.
- If the space beneath the floor is deeper as is common for a building located on a sloping site, even more vents will be needed to ventilate the larger space.

The layout of the building and location of suspended floors will limit where additional vents can be installed. It is rare for a house to have the entire ground floor constructed of suspended timber. Typically, the floor construction in wet areas such as kitchens, bathrooms, utility rooms and sometimes hallways is not suspended, preventing through-ventilation. In addition, access for installing vents may be obstructed by entrances or fireplaces. Terraced properties are often the most difficult to deal with as rear rooms and the hallway often have concrete floors, leaving just a short length of the front wall in which to install vents. Ideally, there should be at least two vents to facilitate circulation of air under the floor.

Figure 3: Partially and fully obstructed vents set below ground level in newbuild homes

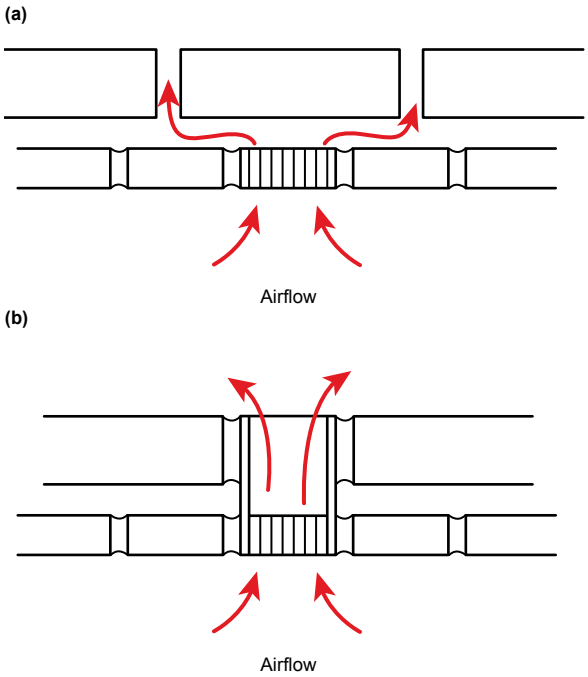


Figure 4: Airflow through (a) an unsleeved vent through cavity wall, (b) a sleeved vent through cavity wall

When constructed, separating walls between rooms should have been perforated below the floor to allow air flow between underfloor spaces. Lift a floor board or remove an airbrick to check. If the underfloor spaces are not interlinked then ventilation should be provided to each individual underfloor space.

Replace existing vents

Often the original vents have little open area. This is particularly so with some old-style terracotta air bricks and cast iron vents (Figure 5 a–c). Simply replace all existing terracotta vents with plastic louvred vents that allow a greater flow of air (Figure 5 d, e). Doubling the underfloor ventilation can often halve the radon level. Use more open vents but choose ones that are sufficiently screened to prevent entry by vermin.

Install additional vents

Where few or no vents have been provided additional vents should be installed. Using the *more open* plastic louvred vents rather than terracotta air bricks is recommended. Vents can be installed through brick or concrete block walls reasonably easily. Consider using a 110 mm diameter core drill when breaking through a thick stone wall. Circular grilles are available from builders' merchants and DIY stores.

Vents should be installed above ground level but located to provide ventilation beneath the floor. Where the ground level is high, periscopic ventilators will be required, although increased breaking out will be needed to fit this type of vent (Figure 6).

Install cowled vents

Draughts can be prevented in exposed locations by fitting cowled vents that are designed to allow free air entry but act as a baffle to gusts of wind (Figure 7).

Providing mechanical ventilation

How it works

Mechanical underfloor ventilation can be used with suspended floors where natural underfloor ventilation would be inadequate. This method has been used in homes with indoor radon concentrations at all levels.

Fans can be installed to blow air into the underfloor space (supply ventilation) or suck air from it (extract ventilation). Both extract and supply ventilation have been used successfully. Success depends on many factors, including soil permeability, floor leakiness, the number and position of air bricks, etc. The usual approach is to try one method, and if that does not work reverse the fan, ie use extract instead of supply ventilation or vice versa.

Mechanical underfloor ventilation works mainly by diluting radon in the air beneath the floor. However, extract ventilation also provides some extraction of radon and supply ventilation provides a slight pressurising effect which reduces radon entry into the underfloor space.

What to do

In most cases, an existing airbrick is removed and replaced by a short length of 110 mm diameter plastic drainage pipe. The pipe needs to be held firmly in

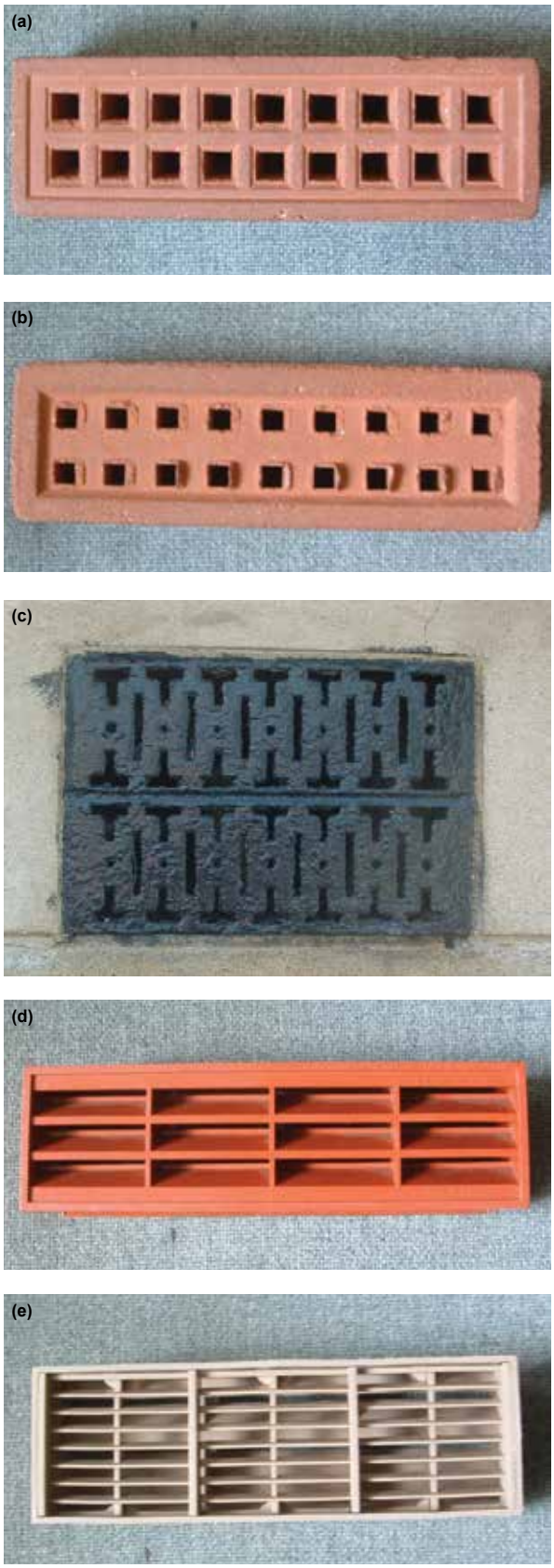


Figure 5: (a) front and (b) rear of a terracotta air brick showing actual open area is less than half what it appears from the front, (c) typical cast iron vent, (d) and (e) modern plastic ventilators offering more open area than a similar-sized terracotta air brick

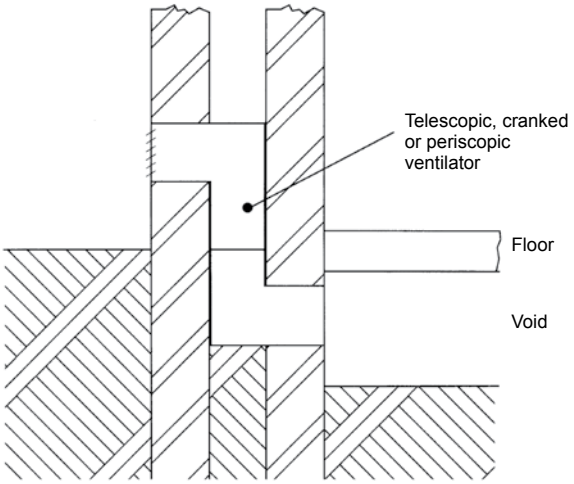


Figure 6: Section through a telescopic vent

Figure 7: Plastic vent cowl used to reduce draughts from an exterior ventilation grille in windy weather

place so that a fan can be attached to it. The fan can be located outside or beneath the floor of the building. If it is being installed outside then the fan itself will need to be a weather-resistant type, or the fan will need to be mounted within a weathertight box. The 'box' can be made of any material that is suitably weathertight and can be decorated to blend in with the building (Figures 8–10).

Alternatively, the fan can be located beneath the floor. The main advantage of this is that it will be hidden from view, though it is likely to increase the noise levels in the rooms above. *Avoid locating inlets or exhausts close to doors or windows*.

When extracting air, do not install an extract fan within 1.5 m of an airbrick as it may simply draw outside air through the airbrick instead of drawing air from the underfloor space.

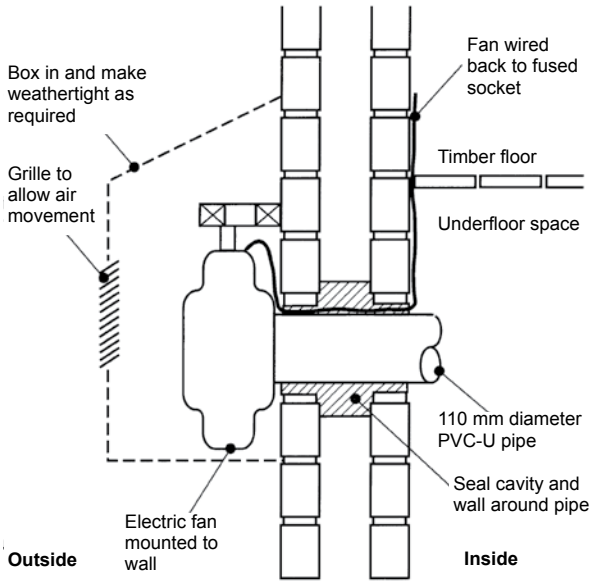


Figure 8: In-line duct fan with pipe fixed to a cavity wall

Figure 9: Boxed-in fan fitted in place of an underfloor vent

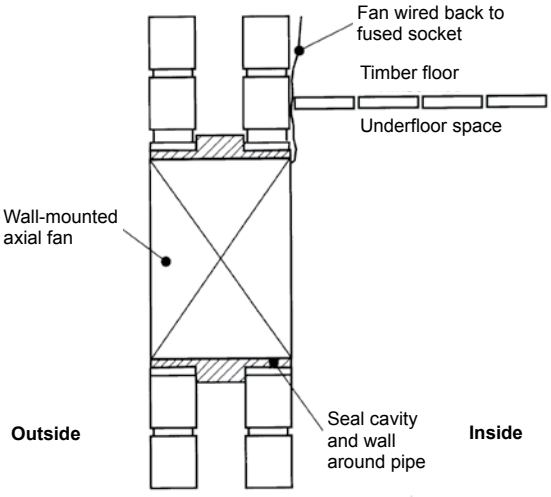


Figure 10: Axial flow fan located within the thickness of a cavity wall

Selecting the fan

For average-sized dwellings, a single fan should be adequate. The fan should have a flow rate that can exchange the volume of air in the underfloor space between three and ten times an hour and be able to run continuously throughout the year. A fan supplier will be able to provide a suitable fan based on the estimated volume of the underfloor space and the exchange rate (3–10 air changes per hour).

Typical fans will be either axial flow fans or centrifugal in-line duct fans. Either can be used although an in-line duct fan has the advantage of being able to be coupled to pipework and where necessary a silencer.

A fan that will be exposed to weather should be suitably protected to level IP54 as classified in BS EN 60529:1992[1]. If the fan does not have this level of protection it will need to be located in a waterproof housing.

Fans should be wired in accordance with BS 7671:2008+A1:2011, Requirements for electrical installations, the IET Wiring Regulations[2].

Noise reduction

In most cases, underfloor fans run relatively quietly but occasionally noise can be a problem. More often than not, noise is due to air movement not the running of the fan. The following advice should be considered in order to minimise noise nuisance.

- Position the exhaust outlet away from doors or windows, particularly ground-floor bedroom windows which may be left open at night.
- Consider packing insulation material around a fan that is mounted in a weathertight box.
- Ensure that fans installed beneath a timber floor are supported off the ground rather than fixed to the underside of the floor.
- Where a fan is to blow air beneath a floor, consider fitting a silencer to the system. This is particularly appropriate for manifolded systems (Figure 11). Fan manufacturers can advise on appropriate silencers.

For further advice see BRE *Good Building Guide* 26[3].

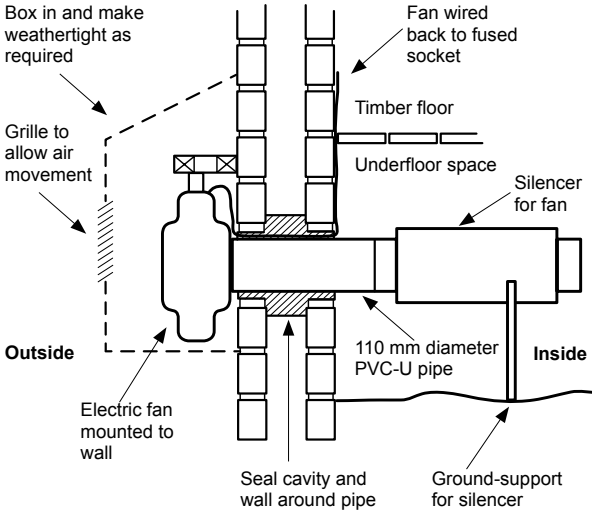


Figure 11: System fitted with silencer

ADDITIONAL POINTS TO CONSIDER WHEN IMPROVING UNDERFLOOR VENTILATION

Underfloor services

The impact of increasing underfloor ventilation means that the underfloor space will be colder in winter. It is advisable to seal any obvious openings through the floor, or even cover the floor with hardboard. Do not use polyethylene sheet as the timber must be able to breathe to prevent timber rot.

Services routed under the floor, particularly central heating or water pipes, should be insulated to avoid the risk of freezing.

Vents cut through timber floors

It is common to find that vents have been cut through a suspended timber floor to provide air to a combustion appliance such as an open fire or gas appliance. Where this occurs, the vent should be sealed and an alternative vent provided through a wall above the floor or the vent should be ducted directly to the outside.

Combustion appliances

Avoid locating an extraction fan adjacent to an open-flued combustion appliance such as an open fire, gas fire or gas boiler which draws air from the room for combustion. *There is a potential risk of spillage of harmful gases.* If it cannot be avoided use supply ventilation (fan blowing air into the floor void), rather than extract ventilation.

Multiple fans

This sheet describes using a single fan to reduce radon levels. Experience has shown that using two smaller fans, one on each side of the building, can also work. Smaller fans can be easier to install, less visually obtrusive and quieter.

Manifolded system

In cases where there are no obvious openings between individual underfloor spaces, pipework can be connected to the fan to extend the range of ventilation under several rooms (Figure 12).

CHECKING THAT THE IMPROVED VENTILATION WORKS AND CONTINUES TO WORK

The HPA recommends that householders who have installed remedial measures to reduce radon concentrations should do a long-term (3 month) validated measurement of radon levels to ensure effectiveness. Shorter measurements (7–14 days) are not normally used and may lead to false indications because of the large 'day-to-day' fluctuations of radon concentrations. Radon measurements should be repeated at intervals of five to ten years and after any substantial changes to the building, the way it is used or a change of occupants. Improvements such as adding an extension or conservatory, installing new double-glazed windows

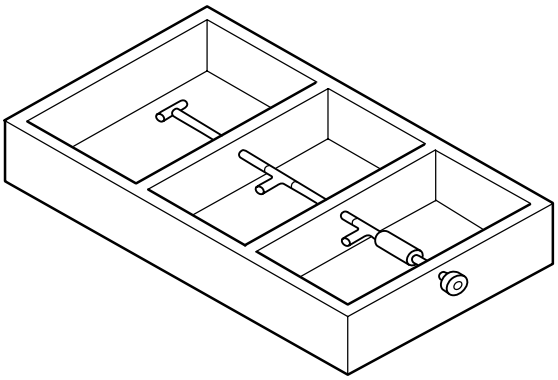


Figure 12: A manifolded system beneath three rooms fitted with a silencer close to the fan

or upgrading the insulation can alter the ventilation and/or heating patterns which could affect the indoor radon concentration.

What to do if it does not work

There should be a reduction in radon level in the majority of cases if the guidance given in this *Good Repair Guide* is followed. Occasionally, the radon concentration may not change, or it may be only slightly reduced. Table 1 indicates why this may happen and suggests solutions to the problems.

MAINTENANCE

Underfloor ventilation grilles should be checked at least annually, preferably in the Spring, to ensure that they have not become blocked in any way. Debris should be swept away from grilles with a hand brush. Where a fan is used for ventilation, check that it is still running, and that the air inlet or outlet has not become blocked. If it has become blocked, switch off the fan and remove the obstruction before switching the fan back on. If the fan sounds noisier than previously it may be an indication that it is wearing out. Fan manufacturers tend to advise that the life expectancy of a fan is about 5–7 years. In practice, however, fans can run for much longer. In-line duct fans have been known to run continuously for over 20 years.

FURTHER INFORMATION

Further advice on radon risk and testing is available from the Health Protection Agency, Chilton, Didcot, Oxfordshire OX11 0RQ.
Telephone 01235 822622
Website www.ukradon.org

***Table 1:* Troubleshooting for underfloor ventilation**

Problem	Observation	Solution
Natural underfloor ventilation		
No change in radon level or only a small reduction	The vents appear to be clear	Check that there is sufficient open ventilation as described in this *Good Repair Guide*. If not, consider adding additional vents. Alternatively, consider installing a fan in place of one of the vents.
		In cases where only part of a ground floor has suspended construction the effectiveness of increased underfloor ventilation may not be that great and an alternative solution such as a sump system or a positive ventilation system that targets other areas in the house should be considered (see *Part 2* of this Good Repair Guide).
Mechanical underfloor ventilation		
No change in radon level or only a small reduction	The fan is not working	Check that the fan is switched on! If it is, check that the fuse has not blown. If the fuse is not at fault and the fan is still not working consult an electrician or the manufacturer.
	The fan is working	Consider reversing the flow of the fan, ie if the fan is extracting air from the underfloor space, turn it around to blow air under the floor. Also, check that the fan is not close to an open air vent as the fan may be drawing fresh air from outside rather than radon-laden air from under the floor. If this appears to be the case consider blocking up the air vent.
		If there is a slight reduction in radon concentration it suggests that some dilution or change in pressure is occurring. Check that the fan size and speed setting are appropriate. Consider increasing the fan speed or fitting a more powerful fan.
Radon level increases	The fan is working	Occasionally, radon concentrations increase when a fan is fitted. While initially disappointing, it does at least indicate that the fan is affecting the pressure balance under the floor. Consider reversing the flow of the fan (ie if the fan is extracting air from the underfloor space, turn it around to blow air under the floor).

Note: After completing work to reduce radon concentrations, a 3-month validated measurement of radon levels should be conducted to ensure effectiveness.

REFERENCES

[1] BSI. Specification for degrees of protection provided by enclosures (IP code). BS EN 60529:1992. London, BSI, 1992.

[2] BSI. Requirements for electrical installations. IET Wiring Regulations. 17th edition. BS 7671:2008+A1:2011. London, BSI, 2008, 2011.

[3] BRE. Minimising noise from domestic fan systems and fan-assisted radon mitigation systems. GG 26. Bracknell, IHS BRE Press, 1996.

Acknowledgements

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This *Good Repair Guide* has been prepared by BRE and HPA. It should be noted that BRE and HPA cannot guarantee that the measures described in this leaflet will reduce the radon level in a home. However, similar measures have frequently proved successful in a range of UK locations.

Other radon publications from BRE

Radon: Guidance on protective measures for new buildings

BRE Report BR 211, 2007 edition

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Good Building Guide 74

Find out how to install radon-protectiion measures in new dwellings successfully. This *Good Building Guide* will help designers, site managers, building control authorities and site operatives to ensure that radon-protection measures work.

Radon protection for new large buildings

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Find out how to install radon-protection measures within large buildings successfully, eg laying a radon-proof barrier across a large floor area, how many sumps to install and how to construct the sump and pipework. In addition to the requirements of building regulations, a building used as a workplace has to meet the requirements of the Ionising Radiations Regulations 1999.

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