good building guide

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Buildings and radon

GBG 25

1 Passive radon sump systems
2 Communal radon sump systems
3 Spillage of combustion products
4 Protecting new extensions and conservatories

This guide is divided into four sections, which draw together different areas of BRE radon-related research. It supplements existing guidance.

Sump systems are usually very effective at reducing indoor radon levels. The first part of the guide describes the benefits of passive sump systems, ie systems that are not fan-assisted. The second part shows how a single fan-assisted system can be used to treat several adjoining houses. Compared to installing several separate systems, a communal system of this type is quicker and cheaper to install and causes less disruption. Other sections tell you how to safeguard against the spillage of combustion products when using a radon remedial system, and how to protect new extensions and conservatories against the entry of radon.

1 Passive radon sump systems

Sump systems are the most effective way to reduce high radon levels in dwellings. Sumps can be used in any building where the ground is directly covered with concrete. This includes the various types of in-situ concrete floors and suspended floors where the soil is covered with a concrete oversite.

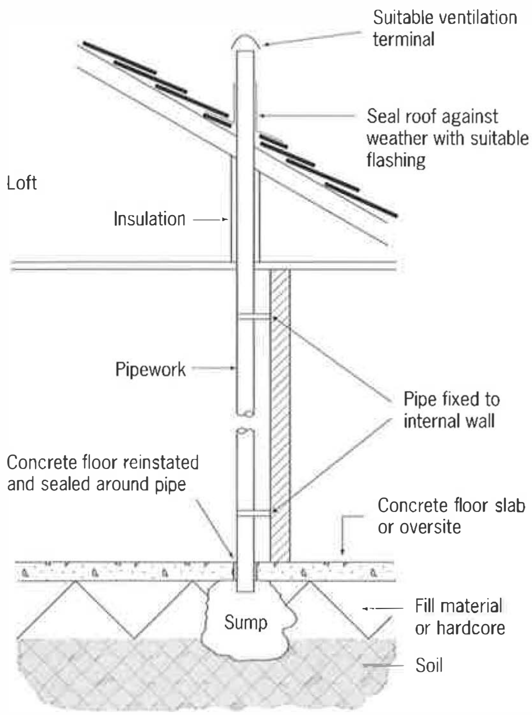
Active sump systems (as they are often called) use a fan to move air through the system. *Passive* sumps do not have a fan – they rely entirely on natural forces to drive air through the system – but, in the right circumstances, they can be very effective. A typical passive sump system is shown opposite.

Passive sumps use two natural forces to extract radon from the ground: the 'stack effect' and the 'wind effect'.

The stack effect
This describes the natural upwards movement of warm, buoyant air. The stack effect relies on the air inside the house being warmer than the air outside, so ensure the pipework for a passive system runs through heated spaces inside the house. As the air in the pipe is warmed up, it will rise and cause radon-laden air to flow from the soil, through the pipe, to the outside air.

For more information about radon sumps

Refer to *Radon sumps: a BRE guide to radon remedial measures in existing dwellings* (see page 12 of this guide for details of this and other BRE publications on radon).



A typical passive sump system

The wind effect

As the wind blows over the roof, it generates a negative pressure region on and above much of the roof surface. As it blows over the ventilation terminal of a passive system, the wind also generates negative pressure in the pipe. These negative pressures combine to cause an upwards flow of radon-laden air from the soil, through the pipe, to the outside air.

How effective is a passive system?

On average, passive sump systems produce a 50% reduction in radon levels. Active systems achieve relatively larger reductions — often more than 90%. However, as with any type of radon remedy, results do vary from house to house: during BRE research into passive systems, the best result was a reduction of 88%, with indoor levels falling from 770 Bq/m^3 to 94 Bq/m^3; and the worst result was no reduction at all.

On this showing, passive sumps should be able to treat successfully houses with indoor average radon levels of less than about 400 Bq/m^3. However, they also provide a good 'first-attempt' for dwellings with levels between 400 Bq/m^3 and 800 Bq/m^3.

The advantages of a passive system...

- If a passive system works it is always preferable to an active one. Without a fan the system is cheaper to install, run and maintain, and it is quieter.
- Because air flows in passive systems are small, there is no danger of spillage from open-flued combustion appliances (see pages 7–9 of this guide).

...and its drawbacks

- A passive system is not as effective as an active system (see opposite). This is because the natural forces that draw the radon from the ground are much smaller than those a fan can generate.
- Installation may be more disruptive because the work takes place indoors.

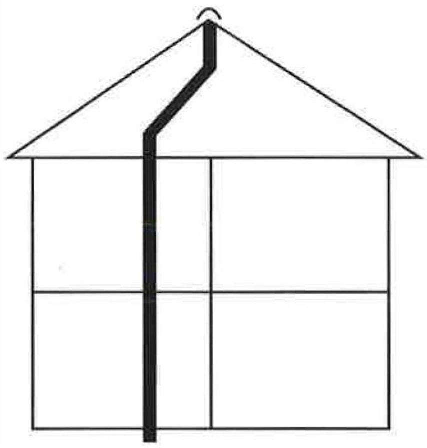
Despite this, the passive sump is an attractive solution in many cases. If it works the householder has all the benefits of a passive solution — if not, the system can be upgraded to an active type by simply fitting a fan (see page 4).

Designing the system

A typical passive sump system consists of a sump, linked to the atmosphere above roof level by continuous pipework (as shown on the front page of this guide). The pipework runs through the house, loft and roof, and the exhaust is fitted with a suitable ventilation terminal.

The sump is a void beneath a concrete layer from which air can be extracted. Make the sump by breaking a hole through the concrete slab and excavating a small amount of hardcore. (The sump's size is not critical; digging out about a bucket full of material is enough.)

There is a choice of two system layouts, each of which has advantages and disadvantages.

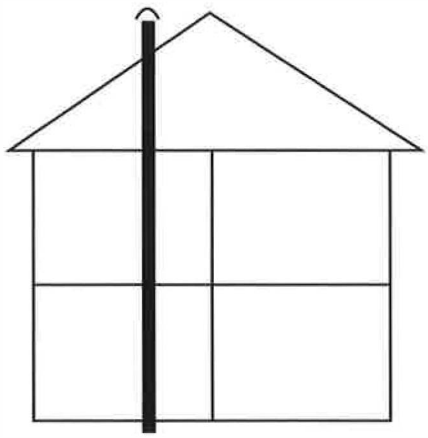


a) The roof ridge design

Roof ridge design — pipework leads from the sump to the ridge of the roof where it terminates with a roof ridge terminal

The system is almost invisible from outside **but**, to reach the roof ridge, you may have to use long pieces of pipework and bends. These increase the system's resistance to air flow, and so make it less efficient.

For outlet terminals, use roof ridge terminals with the appropriate adapters. The outlet terminal should have a free area not less than the pipe cross-sectional area, and should prevent birds or rain getting in. Gas flue ridge terminals are particularly suitable.



b) The straight design

Straight design — pipework from the sump runs straight up through the roof and a terminal is fitted to the exhaust

This scheme has straight pipework between the sump and the atmosphere, which minimises air flow resistance and so makes the system more efficient. The pipe should extend above the roof so the terminal is ideally at, or above, the height of the roof ridge. This ensures the exhaust is in the negative pressure region above the roof, which increases the airflow through the system, **but** it also means the duct and terminal are visible from outside.

For outlet terminals, use free-standing flue or soil pipe terminals. The outlet terminal should have a free area not less than the duct cross-sectional area, and should prevent birds or rain getting in. An 'H' pot terminal, or the multi-vaned revolving type, are both effective in using the wind to drive the air flow through the system. Read *BRE Information Paper* IP6/95 for further guidance. Do **not** use tile ventilators because these can be placed in regions where positive pressure occurs on the roof.

Swept bends and shallow angles are preferred

Sharp bends and angles reduce performance

Pipes, bends and accessories

Use rigid PVC-U pipes, bends and accessories. They are inexpensive and widely available 'off-the-shelf'. Pipework should have a diameter of about 100–150 mm.

Route the pipework as straight as possible because bends offer a resistance to air flow and therefore make the system less efficient – if bends are required, use no more than two. Swept bends are preferable to sharp ones: where possible, use shallow angles of less than 45°.

The precise route taken by the pipework depends on the layout of the house. It can be hidden by running it through cupboards, or boxed-in where it runs through the corner of a room.

Installing the system

General guidelines for installation

- Locate the sump as close as possible to the centre of the floor area. This gives the system the maximum area of influence.
- If possible, do not put the sump underneath a room with an open-flued combustion appliance in it. A passive sump will not cause spillage, but you may have to upgrade the system by fitting a fan, and spillage is a possibility with active extract systems (see pages 7–9 of this guide).
- Fully reinstate the floor above the sump. When reinstating the floor, make sure that concrete does not fall into the sump. After the concrete has set, the joint between the new concrete and the pipe should be sealed with a gun-applied sealant.
- Seal any joints in the pipe to prevent radon escaping.
- Keep the pipework as straight and as vertical as possible; limit the use of bends.
- Insulate the pipe where it runs through unheated areas, eg the loft and above roof level. This helps maintain the stack effect and increases system efficiency.
- Leave enough space to install a fan, just in case you have to upgrade the system (see page 4). The space for the fan should be located away from noise-sensitive areas.

either... ...or

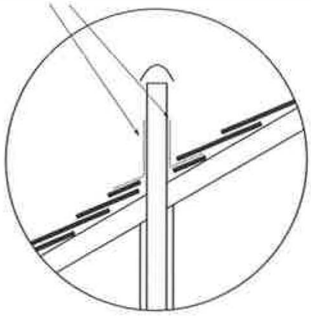
If you choose the straight design

- Measure the length of the pipe carefully. Ideally the terminal should be at, or above, the height of the roof ridge.
- Where the pipe penetrates the roof, seal with a traditional or prefabricated flashing (see opposite).
- Ensure the terminal is fitted securely to the pipe.

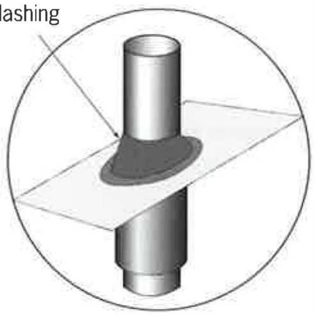
If you choose the roof ridge design

- Support the pipe so that it does not put undue strain on the joint with the ridge terminal.
- Make sure the roof structure is strong enough to allow for the installation of the ridge terminal. If the ridge-board is cut, ensure alternative bracing is provided.
- Ensure the terminal is fitted securely to the pipe and that the roof is sealed appropriately.

Traditional flashing

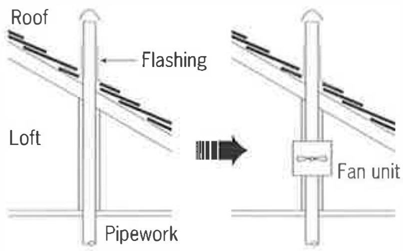


Prefabricated flexible flashing



Remonitor the radon levels

After installing a passive sump, remonitor radon levels in the building. This will show whether the system is successfully reducing indoor radon levels, or if a fan is required to activate the sump. For details on monitoring, contact the National Radiological Protection Board (NRPB) at the address given at the end of this guide.



Upgrading a passive sump by fitting a fan

Upgrading a passive system

If a passive system proves unsuccessful, it can be upgraded by fitting a fan. Suitable fans are of the centrifugal in-line type. A typical fan would be about 300–400 mm in diameter and 200–300 mm in length. Installation is straightforward: a short length of pipework is removed and the in-line fan is inserted and attached so it bridges the gap (see opposite). For further guidance, see *Radon sumps: a BRE guide to radon remedial measures in existing dwellings*.

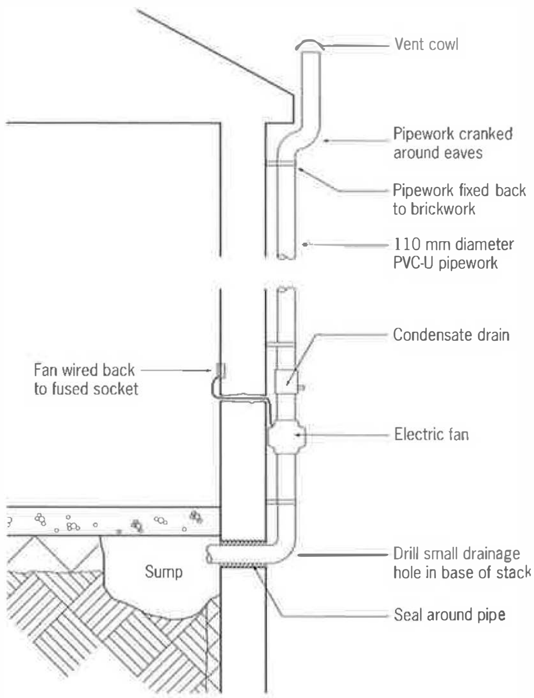
2 Communal radon sump systems

The most effective way to reduce high radon levels in dwellings with solid ground floors (or oversites beneath suspended floors) is to use a fan-assisted sump system. Usually a sump system draws radon-laden air from the ground and discharges it into the atmosphere where it disperses. However, a sump system can also work by blowing air into the sump.

Local authorities and housing associations can save time, money and disruption to tenants by using one communal system to treat a number of adjoining dwellings. BRE has used one sump system to treat groups of up to five terraced dwellings: it may be possible to treat more than this. The dwellings had solid concrete floors or suspended timber floors with oversites.

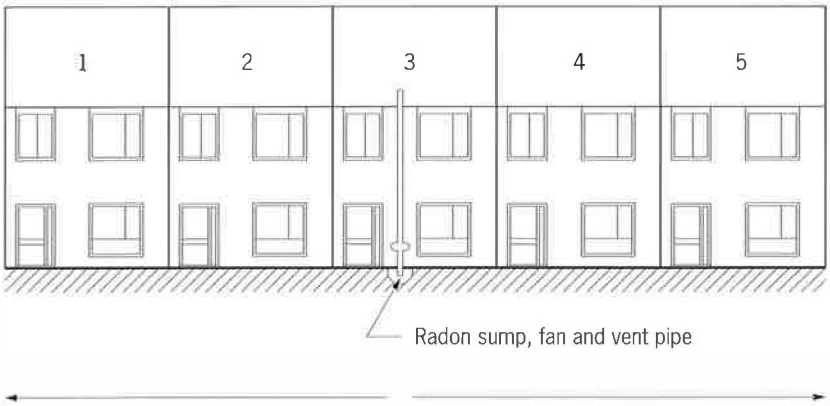
How an active sump system works

The sump is essentially a small hole under the floor slab, linked to the outside by a length of pipe, with a suitable fan connected (an example is shown opposite). Usually a fan is used to extract radon-laden air from the ground, although in some cases blowing air into the ground may prove equally effective. This creates a pressure change through the pore spaces in the hardcore/fill beneath the floor slab, sufficient to lower the indoor radon level.



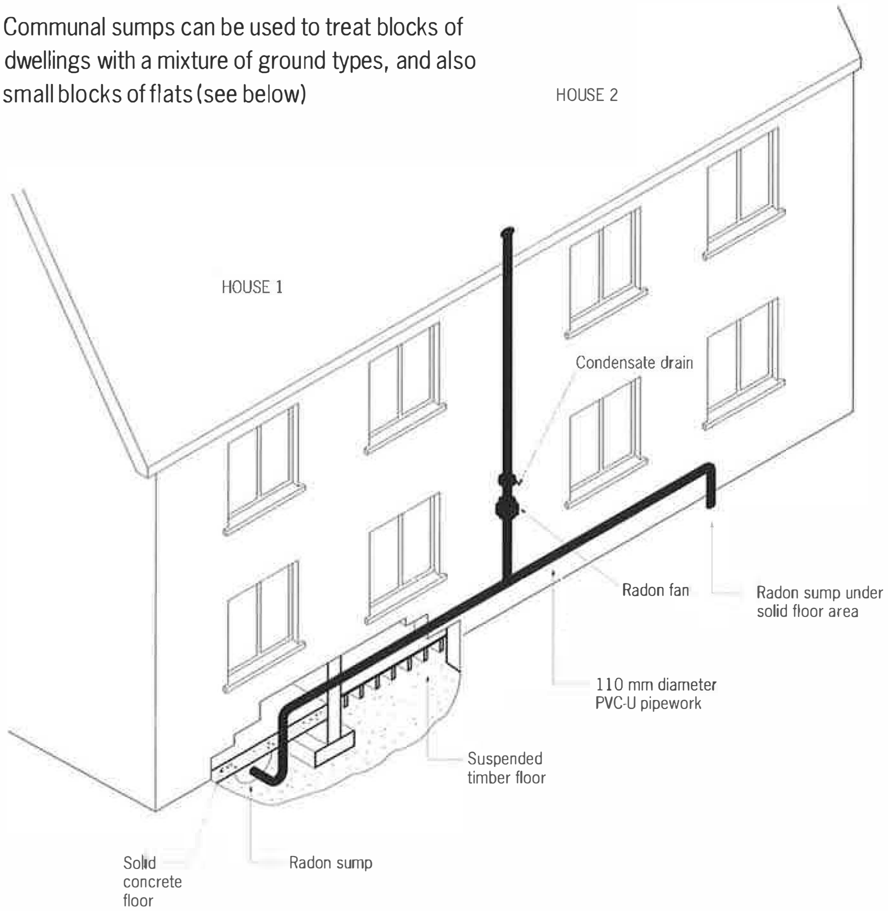
An active sump system works by using a fan to reduce the flow of radon into a dwelling

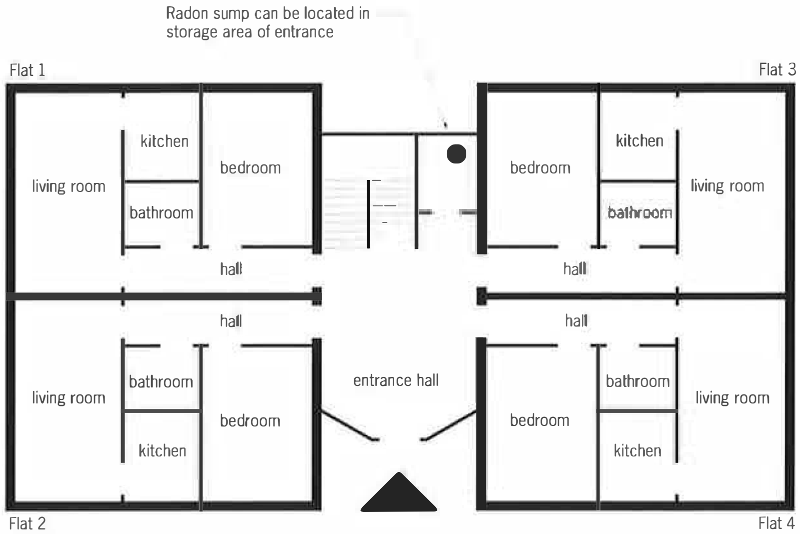
For sump systems to work effectively, they have to be used beneath a concrete or polythene layer which covers the ground. They are therefore suitable for dwellings which have solid concrete floors or suspended timber floors with a concrete or polythene oversite.



In long, narrow buildings, radon sumps can achieve an effective range of 15 m from the sump

Communal sumps can be used to treat blocks of dwellings with a mixture of ground types, and also small blocks of flats (see below)





Where clean, permeable hardcore or fill has been used beneath the floor slab, a sump can draw radon-laden air from an area of roughly 250 m^2. In long, narrow buildings, a sump system can influence air up to about 15 m away from the sump. This means that it is often possible to treat several adjoining dwellings using a single sump system.

To be most effective, a communal sump system needs clean, permeable hardcore or fill beneath the slab. In practice it is usually impossible to find out the condition of the hardcore/fill, but as a general rule-of-thumb any property built after 1960 is likely to have permeable hardcore/fill which will allow a communal sump system to work effectively.

To help provide a greater pressure difference in the hardcore/fill, the floor slab should be in good condition. Any large cracks or gaps should be filled with a flexible sealant. For further guidance, refer to *Sealing cracks in solid floors: a BRE guide to radon remedial measures in existing dwellings*.

Dwellings with mixed floor types

BRE research has shown that the communal sump approach works in blocks of dwellings with a mixture of ground floor types (as shown opposite). For example, in blocks with a mix of solid and suspended timber floors, several small sumps located under the solid floor areas, connected to one fan unit and ventilation pipe, can reduce the radon in all the dwellings. This approach should ensure that *all* floor areas are covered for the expense of supplying and running *one* fan unit.

Small blocks of flats

A communal sump can also be used to reduce radon levels in small blocks of flats. The sump should be located centrally in the block (as shown opposite). For blocks of flats covering a large floor area, more than one sump may be required. It is often possible to connect the sumps to one fan unit.

Where to locate the sump

In a communal system, the ideal place for the sump is at the central point of the group of dwellings (as shown in the picture at the top of page 5). This location optimises the sump's influence over the whole floor area.

However, radon levels sometimes vary greatly from one dwelling to another. Where this is the case, locate the sump closer to the area most affected. If remonitoring shows that radon levels are still above the recommended action level, either:

- create extra sumps beneath the slab in those areas where levels remain high and connect them to the existing fan, or
- install a second independent sump system for the area where radon levels are still too high.

For more information about fans

Refer to *Radon sumps: a BRE guide to radon remedial measures in existing dwellings* for specification guidance. Advice on how to minimise noise from fans is given in Good Building Guide 26.

What size of fan to use

It is very difficult to specify with any accuracy what size of fan is required to reduce radon levels successfully. As a rough guide, a centrifugal in-line duct fan with a power rating of 75 watts should be large enough to treat successfully most small blocks of dwellings. In some cases it may be necessary to fit a fan with a higher performance.

Planning and financing the scheme

In local authority and housing association properties, the building owners can agree with the tenants where to locate the sump, and ensure the running costs for the system are shared fairly (or perhaps included in the rent). Where the building owner has agreed to finance the running costs of the system, the reduction in the number of fan units required could lead to a large financial saving.

Where communal sumps are being considered for private housing, or where tenants of the properties are expected to pay for the running costs of the system, it is advisable to draw up a written agreement between the householders benefiting from the system. The aim is to ensure that the installation, running and maintenance costs are fairly divided, and that the system is kept in good running order, preferably by one nominated householder. Be aware that a possible problem with this approach is that, if one of the householders moves, the new occupant may be unwilling to comply with the agreement.

Likely cost savings

At 1995 prices, installing a sump system to deal with one dwelling costs £350–£1500, depending on the nature of the sump and the work involved. The sump system itself has an annual average running cost of approximately £50 (for a 75-watt fan).Where a single sump system is used to treat five dwellings, the costs could be reduced to £70–£300 per dwelling for installation, and £10 per annum per dwelling for power. The installation of one radon system to deal with several dwellings makes good economic sense and would reduce the cost of radon reduction work to more affordable levels.

Checklist for installing and maintaining a communal sump system

- Position the sump system at the central point of a group of affected dwellings **or** nearer to the area with the highest radon levels.
- Make sure that the furthest floor area from the sump is no more than 15 m away and the combined floor area of the dwellings is not more than 250 m^2 (it may be possible to treat larger areas, or greater distances, depending on the permeability of the hardcore).
- Check the ground slab is in good condition, ie there are no large, visible cracks in it.
- **Safety warning!** Ensure the sump is located away from any open-flued combustion appliances, otherwise there is a danger of combustion products 'spilling' into the dwelling (see pages 7–9 of this guide).
- Draw up a written agreement between householders to ensure all installation and running costs are shared fairly between those benefitting from the system.
- Nominate a householder to take responsibility for the upkeep and maintenance of the system.

3 Spillage of combustion products

An effective way of reducing the level of radon in dwellings is to extract air from beneath the ground floor. This is usually achieved by underfloor extract ventilation or by the use of a depressurising sump. In some circumstances, these remedial measures may lower the air pressure inside the dwelling which, in a small number of cases, can cause combustion gases from open-flued combustion appliances, such as open fires, to spill into living spaces. **Spillage of this type is hazardous, and should always be avoided!**

How radon extract systems cause spillage

An open-flued appliance takes air for combustion from the room in which it is installed. It discharges the air, mixed with combustion gases, through a chimney or flue.

All combustion appliances need a sufficient air supply to aid combustion, dilute combustion gases and sometimes to cool the appliance itself. Most modern boilers are room-sealed gas or oil-fired boilers, which take their air supply from outside the dwelling. Open-flued combustion appliances, on the other hand, draw air from the space around them and lower the air pressure indoors to some extent. This makes them undesirable in a dwelling affected by radon because depressurising the dwelling can encourage radon to seep in.

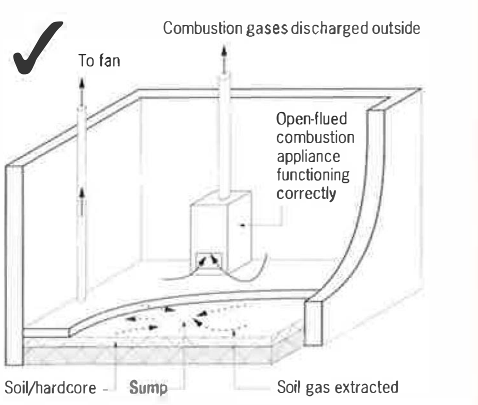
It is also undesirable to use open-flued combustion appliances in conjunction with radon remedial systems which extract air from beneath the floor, such as depressurising sumps or underfloor extract ventilation. Radon remedial systems of this type can cause a slight pressure reduction in the rooms above. If there is an open-flued appliance in one of the rooms, there is the risk that this pressure reduction will encourage combustion gases to spill out of the appliance and into the living spaces.

Spillage occurs when pressure in the space around the appliance is lowered to a critical value relative to the pressure outside. This critical value cannot be easily defined because it is determined by a number of variables, including the specific appliance in use, wind conditions, temperature differences, etc. It may therefore be prudent to carry out one of the spillage tests given in *BRE Information Paper* IP21/92 in which tests are described for gas-fired, oil-fired and solid fuel appliances respectively.

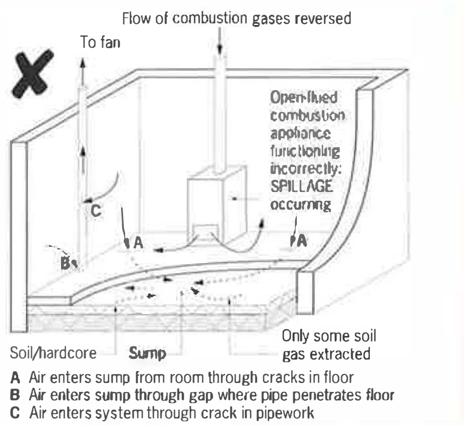
The illustrations on this page and opposite show spillage occurring because, as the radon remedial system extracts air from the dwelling, it causes pressure in all or part of the dwelling to fall below the critical level.

The great majority of gas-fired and oil-fired boilers now being installed have balanced flues and take their air supply from outside the dwelling. These appliances do not draw air from the space around them, and therefore do not suffer from spillage or cause radon levels to rise.

Circumstances in which depressurising radon sumps can cause spillage

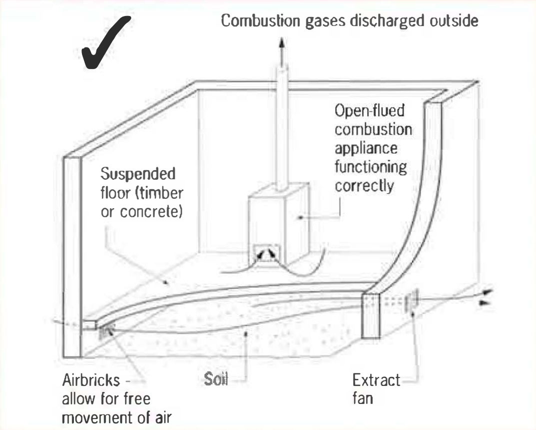


Sump and combustion appliance operating correctly

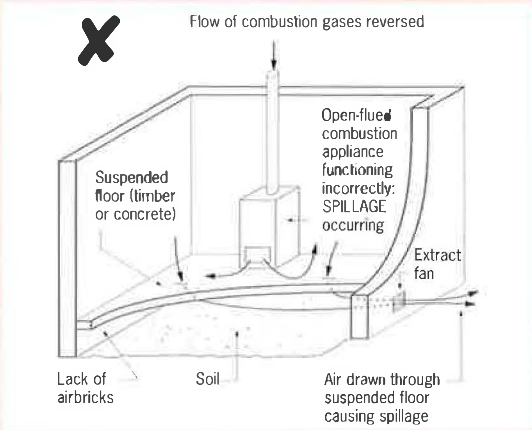


Sump causing spillage

Circumstances in which underfloor extract ventilation can cause spillage



Underfloor extract ventilation and combustion appliance operating correctly



Underfloor extract ventilation causing spillage

Only underfloor extract systems cause spillage

Pressurised sumps and underfloor supply ventilation are two techniques that can successfully treat dwellings affected by radon. Both systems use a fan to blow air beneath the floor – they do not extract air, like depressurised sumps and underfloor extract ventilation. **Blowing air under the floor cannot cause spillage, so choose this method if spillage is a concern.**

The easiest way to cure a spillage problem caused by an extract system is to adjust the fan so it blows air beneath the floor. However, given that the direction of air flow has been changed, it does mean that the indoor radon levels will need to be monitored again to ensure radon levels are kept low.

For some houses, extract systems provide the **only** practicable solution to the radon problem – which is why this section of the guide has been written.

Avoiding spillage when installing and using radon extract systems

Checklist of precautions for depressurised sump systems

- If installing a new system, ensure that the sump is located away from open-flued combustion appliances, preferably beneath the floor of a different room.
- Ensure that all pipework is free from cracks and gaps. Seal any that you find with an appropriate sealant.
- Ensure that there is a good seal around the pipe where it penetrates the floor, oversite and membrane.
- Seal obvious cracks and gaps in the concrete floor above the sump (or oversite/membrane if using a sump under a suspended floor). Pay particular attention to the join where the floor meets the wall. For further guidance, refer to *Sealing cracks in solid floors: a BRE guide to radon remedial measures in existing dwellings*.
- Check that the fan is not too powerful. If the fan is too powerful, it may be possible to solve a spillage problem, without significantly increasing the radon levels, by turning the fan speed down or by installing a smaller fan. As a rough guide, a 75–watt fan will be large enough to treat most dwellings. However, in large dwellings it may be necessary to use fans with a higher performance. A more detailed description of the specification requirements is given in *Radon sumps: a BRE guide to radon remedial measures in existing dwellings*.

Checklist of precautions for underfloor extract ventilation

- Ensure that airbricks surrounding the property are open so that air can enter the void from outside.
- Check that the airbricks are adequately sized. As a guide, there should be a free area of 1500 mm^2 per metre run of exterior wall, or of 500 mm^2 per square metre of floor area: use whichever criteria give the largest open area. Ideally air should move across the void from one side to the other, so fans and airbricks are best located on opposite sides of the dwelling to each other.
- Where a wall cavity is breached by a fan or pipe, check that the wall is sealed to prevent air being drawn out of the cavity.
- Ensure that obvious cracks and gaps in suspended concrete floors are sealed. Complete sealing is not recommended for timber floors: moisture cannot escape and may cause the timber to rot. However, large gaps in a timber floor can be sealed, eg where the floor is penetrated by services. For further guidance, refer to *Sealing cracks in solid floors: a BRE guide to radon remedial measures in existing dwellings.*
- Check that the fan is not too powerful. If the fan is too powerful, it may be possible to solve a spillage problem, without significantly increasing the radon levels, by turning the fan speed down or by installing a smaller fan. As a rough guide, a 75 watt–fan will be large enough to treat most dwellings. In large dwellings it may be necessary to use fans with a higher performance. A more detailed description of the specification requirements is given in *Radon sumps: a BRE guide to radon remedial measures in existing dwellings.*
- Seal any vents in the floor and replace them with wall vents if necessary (see below)

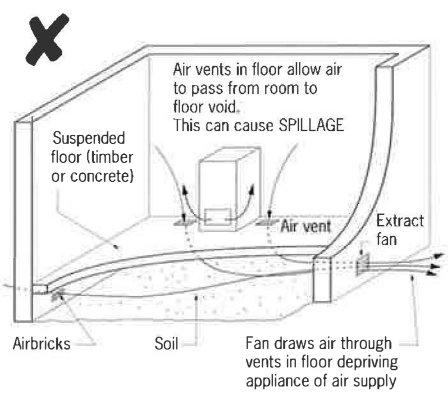
Options if spillage continues after taking the precautions on page 8 and above

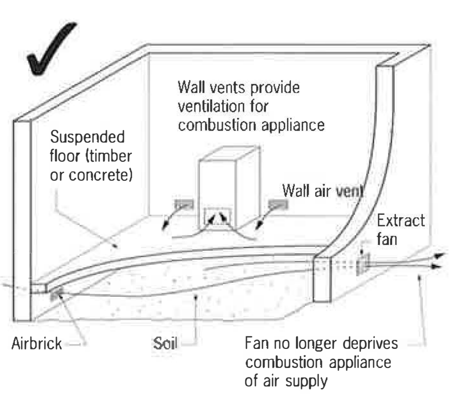
- Increase direct air supply to the appliance by installing a suitable underfloor ventilation duct or by increasing the ventilation to the room by installing an extra wall vent or fitting trickle ventilators in windows. Such vents should be **permanently open** — they should **not** be controllable.
- Remove the open-flued combustion appliance and install an alternative heating method. This guarantees success.

Safety warning! Increasing the ventilation to the room where the spillage occurs, eg by the use of a controllable air vent in the wall or controllable trickle ventilators in the windows, or by opening doors and windows is **not** recommended: the occupants have control over the ventilation, and they may inadvertently cause spillage by closing a vent or shutting a door. Other possible drawbacks are uncomfortable through-draughts, and larger heating bills because the dwelling is less energy-efficient.

Safety warning!

Some open-flued combustion appliances are vented from the underfloor space by means of a vent in the floor near the appliance. Air extraction from the void will almost certainly affect the air flow through the vent, thereby limiting the air supply to the appliance (see illustration on the left). Therefore seal vents in the floor and replace them with permanently open vents in an external wall above floor level (as shown on the right).





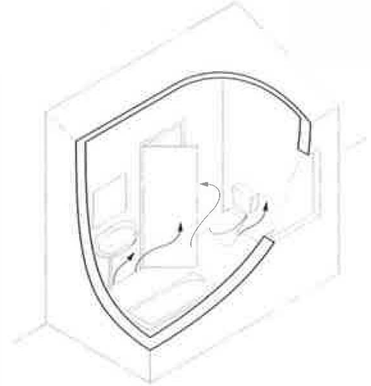
4 Protecting new extensions and conservatories

How radon gets in

Radon mainly gets into buildings through openings between the building and the underlying soil or rock, such as cracks in solid floors, gaps in suspended timber floors, and cracks and cavities in walls.

However, radon is unlikely to get into a new extension or conservatory by these particular routes, provided that the new building has a modern solid concrete floor incorporating a damp-proof membrane. In this case, radon is much more likely to enter through:

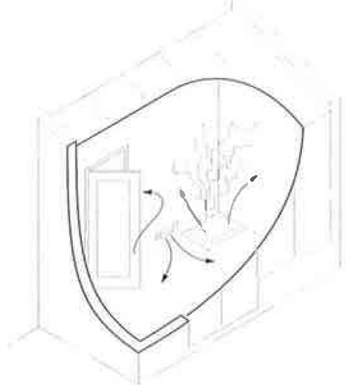
- construction joints
- gaps around service entries
- underfloor ventilation grilles
- openings in the floor of a conservatory for plant and flower beds.



Radon routes into an extension

Radon can get into the extension or conservatory and it can pass through the new building into the house itself.

There tends to be a greater risk of radon entering the house from an extension than from a conservatory. This is because an extension is likely to be used in the same way as the rest of the home, and its services will be connected to the main house. A conservatory, on the other hand, often has its own heating and ventilation, and is generally separate from the main house, ie it has its own distinct use, is not continuously occupied, and the door to the main house is often kept closed.

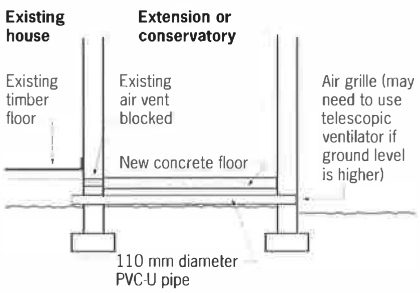


Radon routes into a conservatory

Underfloor vents

If the main house has suspended ground floors, ensure that the new building does not impair the underfloor ventilation of the existing floor. This is particularly important with suspended timber floors where adequate ventilation is necessary to reduce the risk of timber rot. In the past it has been common practice for existing underfloor vents to be either permanently blocked, or left so that they open directly into the new building. In areas known to be affected by radon, the correct practice is to:

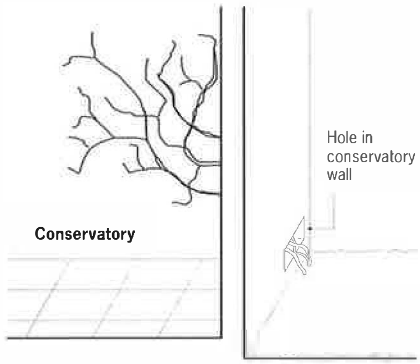
- block up the vents permanently and provide an alternative air supply to the void under the floor (as shown opposite), or
- where the vents are low enough, open them up and duct air under the floor of the new building.



Ventilating a suspended timber floor by ducting air under the floor

Plant and flower beds

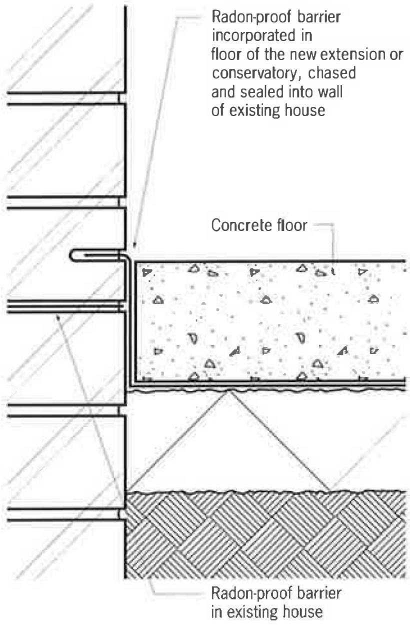
It is quite common for part of a conservatory floor to be omitted so that plants growing inside, eg vines, can be planted directly into the soil. Unfortunately, plant and flower beds can be major entry routes for radon, particularly where the adjacent outdoor area is paved. There are other ways to achieve the same effect which will not affect indoor radon levels, such as growing the plants outside the conservatory and training them through an opening in the wall (as shown opposite), or planting them inside in tubs.



Plants can be grown outside and trained through an opening in the wall

Suspended timber floors

In radon-affected areas it is not advisable to install suspended timber floors in conservatories and extensions. Floors of this type are commonly associated with high levels of indoor radon, even where the floor has good ventilation and the soil underneath is covered with a polyethylene damp-proof barrier and concrete.



Service penetrations

Routing services through the floor is not recommended in radon-affected areas. Where this cannot be avoided, seal around each penetration by either:

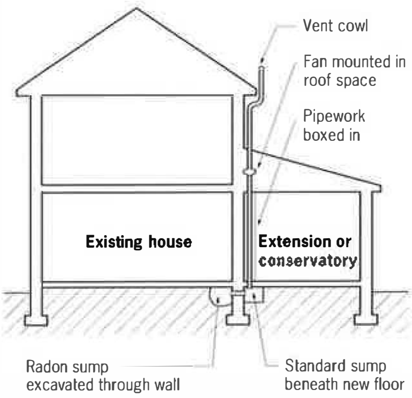
- Sealing the service pipe to the radon-proof or damp-proof barrier with a suitable adhesive tape or proprietary sealing collar, or
- Sealing the gaps in the floor after it has been installed. Fill large gaps with sand-cement mortar, and small gaps with a bathroom sealant or mastic. For further advice, refer to *Sealing cracks in solid floors: a BRE guide to radon remedial measures in existing dwellings.*

Construction joints

If possible, seal the construction joint between the new floor and the existing house. Where radon-proof barriers have been incorporated in both the new floor and the existing floor, the two barriers should be jointed where they meet within the wall of the house. It will be necessary to break out some mortar from the wall to gain access to the radon-proof barrier in the existing house: this can easily result in the barrier being damaged.

A simpler alternative is to cut a chase in the wall, slightly above or below the existing barrier. The new barrier, ie the one incorporated in the floor of the conservatory or extension, can then be tucked into the chase in the wall (see opposite).

Where the existing floor does not incorporate a radon-proof barrier, seal the joint between the floor of the new building and the wall of the existing house with a bathroom sealant or other flexible filler.



How to reduce radon levels in the whole dwelling

Measuring radon levels before building begins

Before building an extension or conservatory, measure the radon level inside the existing house. If the house is found to contain high levels of radon, you can build protective measures into the new building. These measures will help to reduce radon levels in the whole dwelling.

Indoor radon levels fluctuate from season to season, from day to day, and by the hour. Therefore, to obtain reliable results, monitor radon levels over as long a period as is practical. The ideal is to monitor for three months using etch-track (plastics) detectors. For further information on radon monitoring, contact the NRPB (their address is given at the end of this guide).

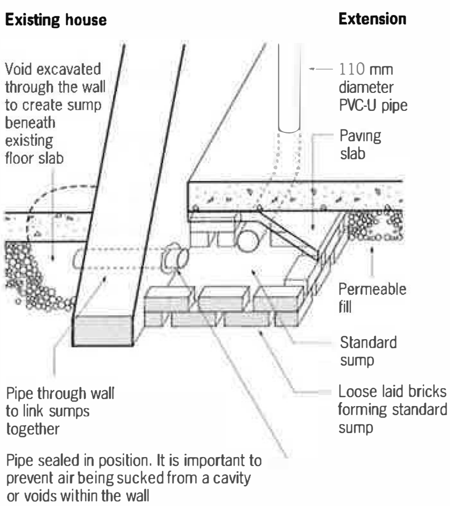
Installing radon-protective measures

Whether or not you have measured radon levels inside the existing house, it may still be worth installing radon-protective measures in the new building, with the aim of reducing radon levels in the whole dwelling.

If the existing house and the new building both have solid concrete floors, it may be appropriate to install a radon sump during the construction of the extension or conservatory. If the house is known to have a high indoor radon level, a complete sump system can be installed and activated. On the other hand, if the radon level inside the house has not yet been measured, it is possible simply to install the sump and pipework: if necessary, the system could be activated at a later date.

In either case the most appropriate location for the sump is beside the wall of the existing house. To maximise the effect of the sump on the main house, it should be connected through the wall to the fill beneath the house (see opposite).

More detailed information on radon sumps is given in *Radon sumps: a BRE guide to radon remedial measures in existing dwellings.*



Radon systems and fire safety

When designing a radon system, ensure that it does not prejudice the fire provisions for the given building. This is most likely to occur in flats and commercial buildings — for example, where a radon extract pipe passes through a compartment floor. For further information about fire safety, consult your local Building Control Officer.

Contact points

For additional information on measuring radon levels, contact:
National Radiological Protection Board
Chilton
Didcot
Oxon, OX11 0RQ
Freephone: 0800 614529

For further advice regarding building matters, contact:
BRE Advisory Service
Building Research Establishment
Garston
Watford, WD2 7JR
Telephone: 01923 664664

Help with radon-related problems of all kinds is available from the BRE Radon Hotline (telephone: 01923 664707). For specific advice on the subjects covered in this guide, contact the following at BRE:
Paul Welsh (passive sumps, spillage)
Michael Jaggs (communal systems)
Chris Scivyer (extensions, conservatories)

Remeasuring radon levels after construction

Even if you have taken the precautions against radon entry described in this guide, there is no guarantee that overall indoor radon levels will not rise when the new building has been completed. It is quite possible that radon which used to be harmlessly dispersed outside could now be diverted into the house by the new extension or conservatory. Consequently, when the new building is finished, remeasure radon levels in the whole dwelling.

Building Regulations

In certain areas of the United Kingdom, it is necessary to install radon-protective measures in extensions and conservatories to comply with the Building Regulations. You should contact your local authority building control department to find out whether protective measures are necessary in your area. Requirement C2 of Schedule 1 of the Building Regulations 1991 for England and Wales refers to guidance included in a BRE Report, *Radon: guidance on protective measures for new dwellings*. This guidance is as follows.

It is advisable when a house is extended that radon-protective measures be incorporated in the new work. For **a house with radon-protective measures** the extension should include protective measures equivalent to those in the existing house. Consideration should be given to linking the radon-proof barrier in the new floor to the radon-proof barrier in the existing house.

Within the [defined] areas..., an extension to **an unprotected house** only requires secondary protection [provision for future subfloor extraction, ie radon sump and extract pipe or ventilated subfloor void] when the ground-floor area of the extension is greater than 30 m^2.

Where the house is unprotected, there is no requirement for radon-protective measures to be incorporated in an extension or conservatory with a ground floor area of less than 30 m^2. However, even if the new building does meet these criteria, it might still be prudent to install protective measures for the reasons discussed in this guide.

For more detailed guidance on the construction of dwellings in radon-affected areas, refer to *Radon: guidance on protective measures for new dwellings.*

Further reading

Department of the Environment and the Welsh Office

The Building Regulations 1991. Statutory Instrument 1991 No 2768. London, HMSO, 1991.

Building Research Establishment

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