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A BRE guide to radon remedial measures in existing dwellings

Radon sump systems

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Contents

Introduction

This guide is one of a series giving practical advice on methods of reducing radon levels in existing dwellings. It is intended to help surveyors, builders and householders who are trying to reduce indoor radon levels by means of a radon sump system.

The guide is based on a large body of remedial work carried out to advice given by BRE, and on discussions with others working in the field. The measures it describes are applicable, in principle, to all dwellings and similar buildings. However, the success of an individual system will be significantly influenced by the characteristics of the dwelling and consideration of the various points discussed in this guide.

This guide should be read in conjunction with *Radon: a householder's guide* and *Radon: a guide to reducing levels in your home,* obtainable from local Environmental Health Officers or from the Department of the Environment, Transport and the Regions. The Government recommends that, if the average radon concentration in a dwelling exceeds 200 Bq/m^3 (the 'action' level), measures should be taken to reduce it. This guide assumes that radon measurements have been made in the building and that the annual average indoor radon level was shown to exceed the action level.

If it is difficult to decide which is the most appropriate remedial measure for a specific dwelling, additional guidance is available in BRE Report *Surveying dwellings with high indoor radon levels.* Further advice can also be obtained by contacting the BRE Radon Hotline (telephone 01923 664707).

What is radon?

Radon is a colourless, odourless radioactive gas. It comes from the radioactive decay of radium, which in turn comes from the radioactive decay of uranium. Uranium acts as a permanent source of radon and is found in small quantities in all soils and rocks, although the amount varies from place to place. It is particularly prevalent in granite areas but not exclusively so. Radon levels vary not only between different parts of the country but even between neighbouring buildings.

Radon in the soil and rocks mixes with air and rises to the surface where it is quickly diluted in the atmosphere. Concentrations in the open air are very low. However, radon that enters enclosed spaces, such as buildings, can reach relatively high concentrations in some circumstances.

When radon decays it forms tiny radioactive particles which may be breathed into the lungs. Radiation from these particles can cause lung cancer which may take many years to develop. In addition, smoking and exposure to radon are known to work together to increase greatly the risk of developing lung cancer.

The floors and walls of dwellings contain many small cracks and gaps formed during and after construction. Radon from the ground is drawn into the building through these cracks and gaps (see Figure 1) because the atmospheric pressure inside the building is usually slightly lower than the pressure in the underlying soil. This small pressure difference is caused by the stack (or

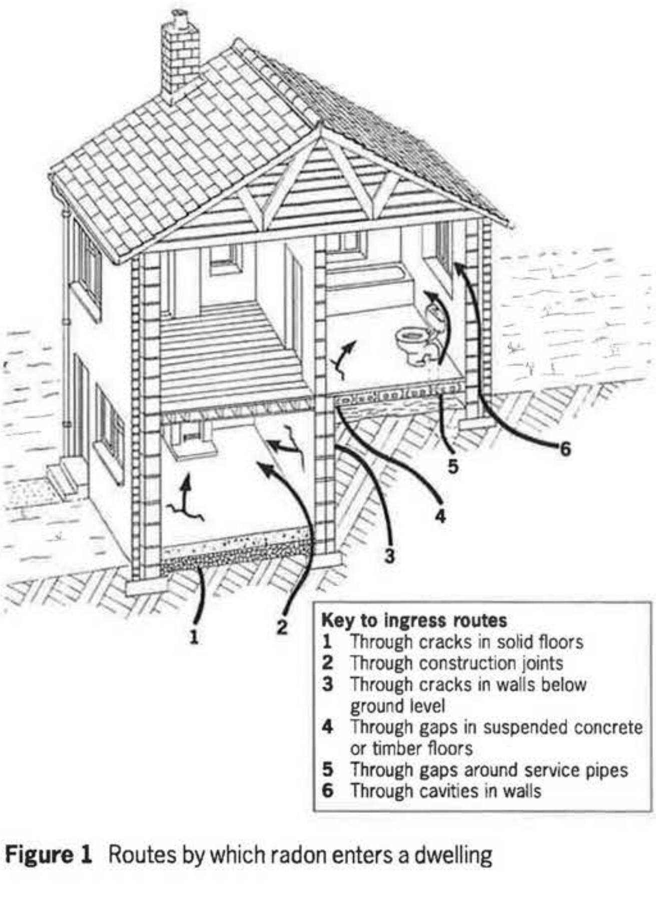

Figure 1 Routes by which radon enters a dwelling

chimney) effect of heat in the building and by the effects of wind. The solutions described in this report are designed to reverse this pressure difference to reduce significantly the flow of radon into the dwelling.

What is a radon sump?

A radon sump is essentially a hole in the ground with a fan connected to it sucking from the hole and thus producing a negative pressure in the hole. This negative pressure spreads through the pore spaces in the material immediately under the floor. The purpose of the radon sump is to reverse the air pressure between the soil and the dwelling and to stop the radon-laden air from entering the dwelling. Generally speaking the more permeable this material, the more effective the sump. The effect of a radon sump is shown in Figure 2. Owing to their depressurising effect, sump systems are sometimes referred to as subslab depressurisation systems.

The standard sump is shown in Figure 3. It consists of a 600 mm × 600 mm paving slab with a few rows of bricks below, with air gaps left between the bricks. The purpose of this open brick box is to prevent the suction pipe from getting blocked and also to spread the pressure field. An alternative to the standard sump is the prefabricated sump (Figure 4). Several companies manufacture and supply prefabricated sumps. Such sumps usually comprise a plastic box-like structure with holes in it, so that it behaves like the standard sump. In many cases however, particularly for a small family dwelling with a concrete floor and permeable layer of hard-core underneath, it may be sufficient to make a hole for the extract pipe by clearing out a space of about 200 mm radius around it to form the sump. This is often known as a mini-sump (Figure 5).

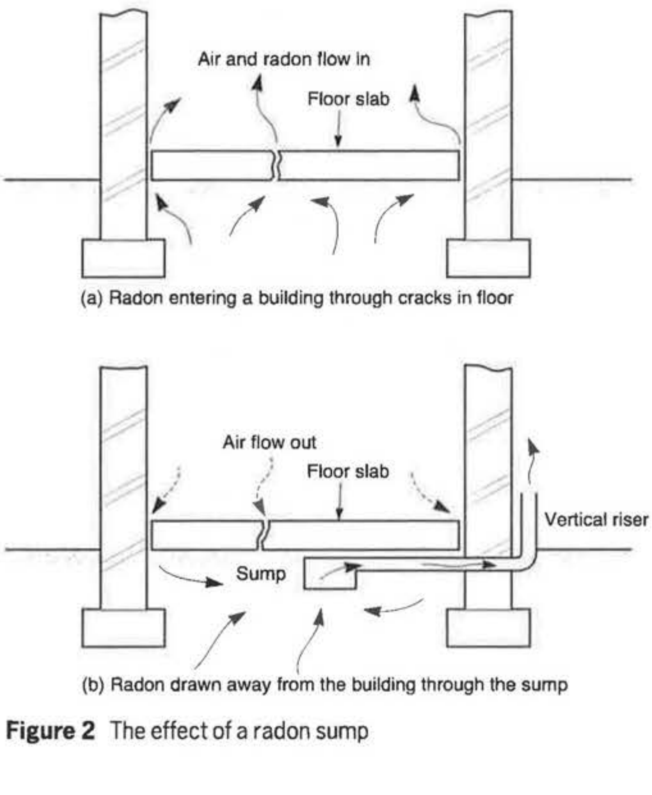

Figure 2 The effect of a radon sump

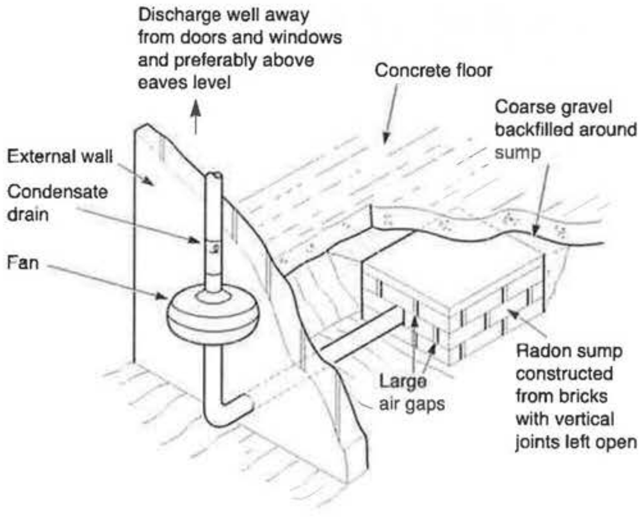

Figure 3 Construction of a standard sump

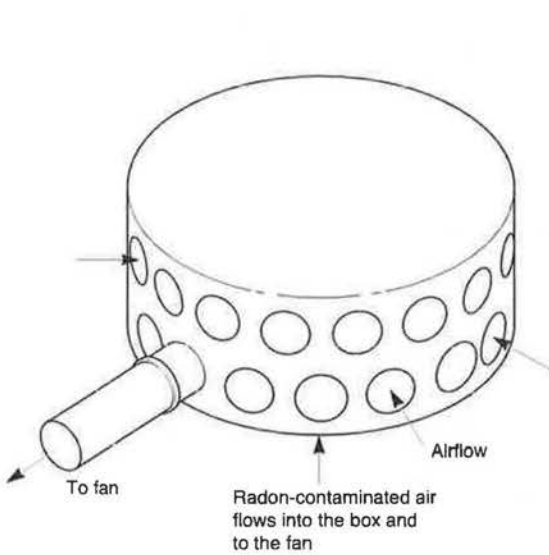

Figure 4 Prefabricated plastic sump

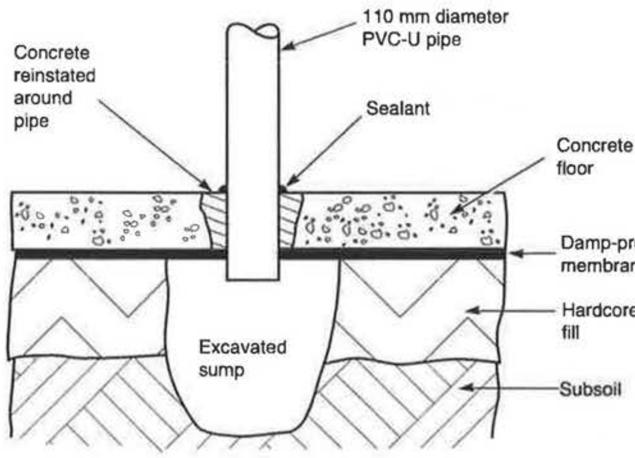

Figure 5 The mini-sump

Technical details and installation of sumps

This section gives detailed guidance to builders on the design and installation of a radon sump, including the choice of the most suitable type of sump, where best to locate the sump, problems likely to be encountered in breaking through floors, the routing of pipework, and the choice and positioning of fans. Guidance is also given on the likely effectiveness of a sump.

The choice of sump and where to place it

Sumps may be categorised as:

- Internal with internal pipework
- Internal with external pipework
- Externally excavated

They are illustrated in Figures 6 to 9.

In terms of effectiveness, an internal sump, located centrally within a dwelling, will generally be more effective than an externally excavated sump. But locating a system internally will prove more disruptive. Dust and dirt will be produced and it may often be difficult to find a suitable route for the pipe through the dwelling.

A sump placed centrally under the dwelling will give the greatest effective area of depressurisation but convenience, economics and aesthetics will determine the precise positioning of the sump and its associated pipework. For a typical dwelling a single sump will probably be sufficient. Where clean permeable fill has been used beneath the floor a single sump with a 50–70 watt fan is likely to have an influence over an area of approximately 250 m^2, or for a distance approximately 15 m from the sump. However, obstructions below the floor slab may reduce effectiveness, and more sumps or a larger fan may be required.

It is likely to prove impractical before excavation to determine whether the fill or soil immediately beneath the floor slab is permeable. However, unless the floor is located directly over bedrock or clay, both of which will restrict airflow beneath the floor, there is unlikely to be a problem.

If the underfloor area comprises several compartments the walls forming the compartments may restrict the flow of air beneath the floor slab. If this is the case then a sump may be required for each compartment (Figure 10(a) and

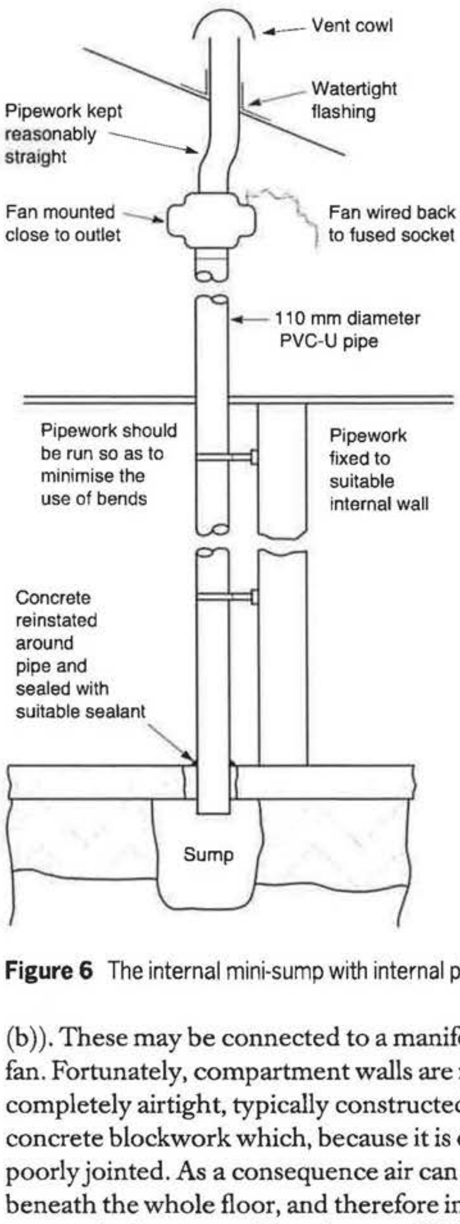

Figure 6 The internal mini-sump with internal pipework

(b)). These may be connected to a manifold and a single fan. Fortunately, compartment walls are rarely completely airtight, typically constructed in brickwork or concrete blockwork which, because it is out of sight, is poorly jointed. As a consequence air can still flow beneath the whole floor, and therefore in the majority of cases a single sump will be adequate. If there is concern regarding effectiveness, a single sump located against a separating wall with a few bricks removed to allow communication between compartments could be used (Figure 10(c)).

For a small, single, family dwelling an externally excavated sump under the dwelling may be the best

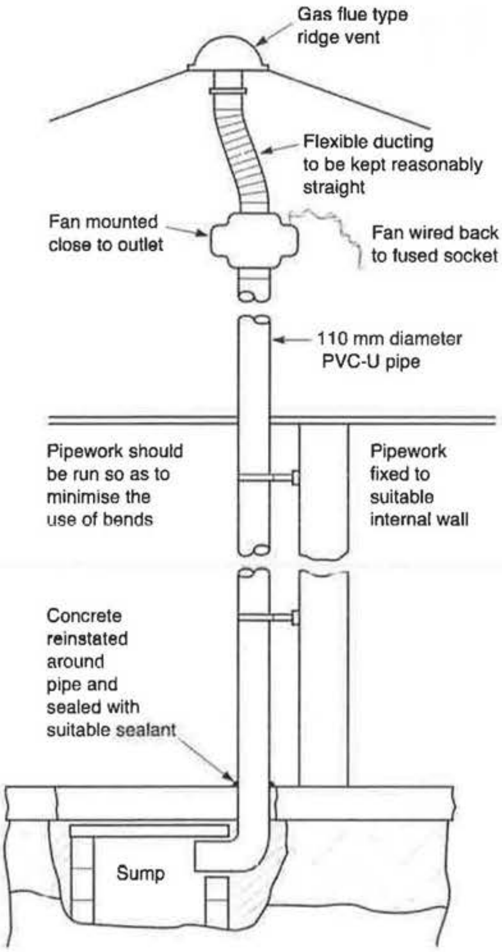

Figure 7 The internal standard sump with internal pipework

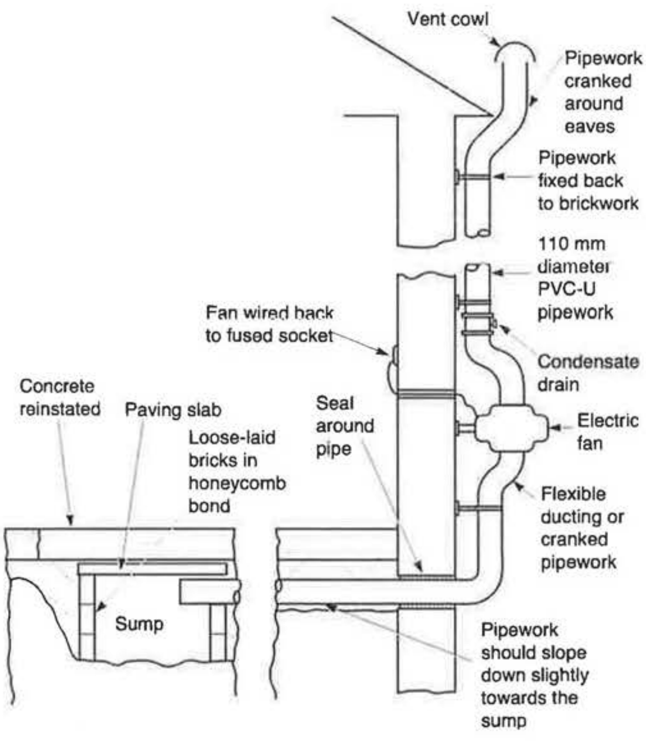

Figure 8 The internal standard sump with external pipework

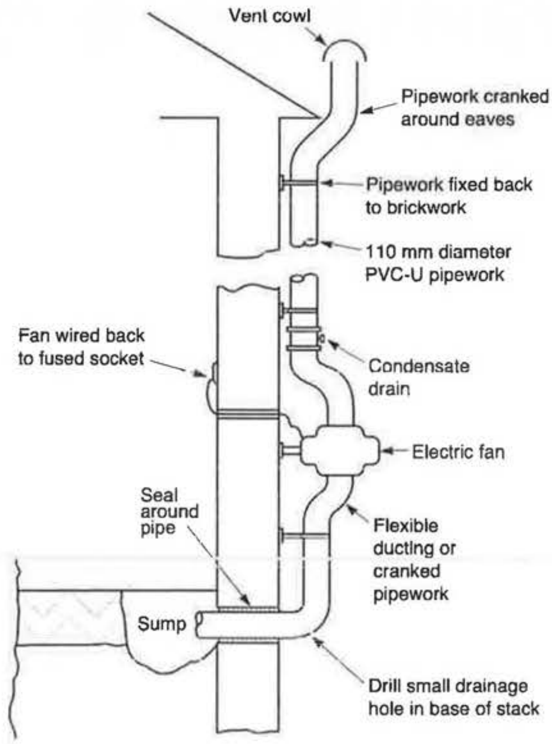

Figure 9 The externally excavated sump

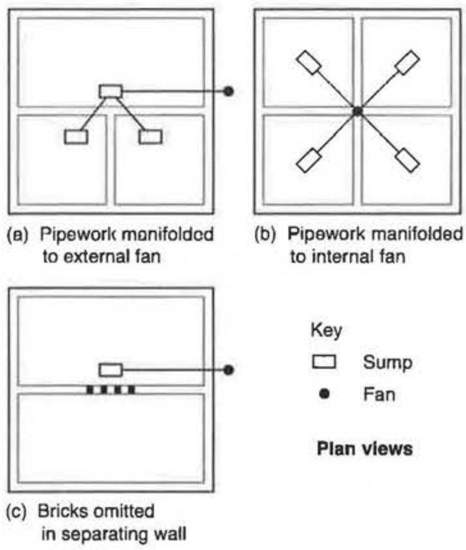

Figure 10 Location of sumps within multi-compartment subfloor areas

solution (see Figure 9), the whole dwelling being comfortably within the 250 m^2 area or 15 m direct run limits.

With all types of sump it is important to prevent air being drawn down directly from the atmosphere or elsewhere (eg the wall cavity or room above) into the sump rather than coming from under the dwelling. Short circuiting in this way will reduce the effectiveness of the solution. With an internally located standard or mini-sump system it is important to ensure that there is adequate sealing around the point where pipework exits the sump. With an externally excavated sump this is done by sealing around the point where the pipework exits the

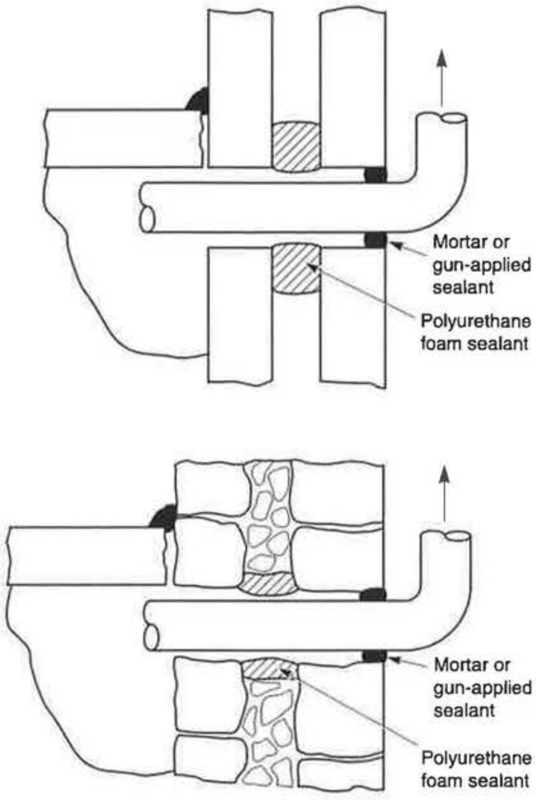

Figure 11 Sealing around an externally excavated sump

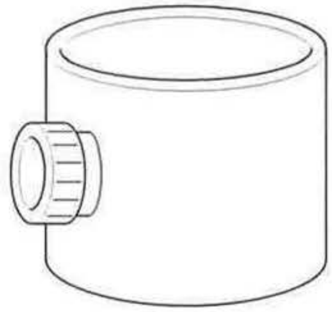

Figure 12 Condensate drain

sump through the foundation or cavity wall. In addition there may be a need to seal the joint between the floor and wall immediately above the sump (Figure 11).

Condensation within the pipework, particularly external pipework, may adversely affect the operation of the fan. The fitting of a drain, such as that shown in Figure 12, is recommended in order to make it possible to drain off condensate continuously. When draining off condensate from an internal system the drain must be led to the outdoors.

Sumps and solid concrete floor construction

Before any radon sump is specified or built, the type of floor construction must be identified. The basic element found in most post-war dwellings will be a concrete slab of at least 100 mm thickness. This will commonly, but not always, be covered by a cement/sand screed. The usual thickness of the screed will be between 35 and 60 mm. Usually there will be a damp-proof membrane (dpm) either beneath the concrete, in which case it will almost certainly be polyethylene, or between the concrete and screed (sandwich construction), when it may be a hot-applied bitumen, a bitumen solution, a tar/rubber emulsion or occasionally polyethylene. Sometimes the base concrete or screed will be covered directly by other floorings like ceramic tiles, magnesite, wood blocks, mastic asphalt and, in recent construction, chipboard floating on expanded polystyrene insulation.

In dwellings with good solid floors where the base concrete is at least 75 mm thick the mini-sump may be used (Figure 5). There may be a few problems removing or cutting through floorings before breaking open the concrete base to form a hole. Ceramic tiles and wood blocks should be removed, and mastic asphalt should be warmed before breaking open, otherwise substantial cracking may occur. Care should be taken when breaking through concrete floors in case steel reinforcement is present. Where the floor is laid directly on the ground, cutting through reinforcement is not likely to be detrimental. Where floors are suspended, cutting the reinforcement should be avoided particularly in beams, where it should never be cut.

If the concrete floor is in reasonable condition and a mini-sump is to be installed, it may be possible to use a core-drill to break through the slab. Fill from beneath the slab can then be scooped out through the drilled hole. This will minimise the amount of disruption caused during breaking out and reduce the amount of making good necessary when the pipework is installed.

If the concrete floor is suspended there is no need to construct a sump because the subfloor void is, in effect, a single large sump. Instead a fan can be installed to extract air directly from the underfloor void. Experience has shown that in some cases blowing air into the subfloor void can prove more effective than sucking. This is discussed later in this guide.

With older properties a variety of 'solid' floor constructions may be met. Where concrete bases of reasonable quality and at least 75 mm thickness are encountered then mini-sumps can be installed. The mini-sump should not be used if the base is less than 75 mm thick or of poor quality, in case the floor collapses into the sump void; the standard or prefabricated sump should be used instead.

Floors may be found where wood blocks are stuck with hot pitch to a thin mortar layer directly overlying hard-core and, of course, there are many examples of stone slab or flag floorings laid directly on earth. With such floors it is better to make a large hole in the floor, construct a standard sump with bricks and paving slab or install a prefabricated sump and reinstate the floor with concrete 100 mm thick before re-laying the wood blocks or stone flags.

Care should be taken when breaking the concrete floor to avoid damaging any concealed services, eg electricity cables, water mains, central heating pipes, and gas and oil supply pipes. The hole in the floor should be just large enough for the extract pipe from a mini-sump to fit (normally 110 mm diameter) or to allow installation of a brick-built or prefabricated sump (normally 600 mm square) as appropriate. In the latter case the reinstatement should include some kind of damp-proof protection.

When reinstating the concrete floor take care to make a good joint between the old and new concrete and between the new concrete and the extract pipe. If a large excavation is made, some form of shuttering may be required to prevent the new concrete filling the sump and blocking the pipe inlet. It is difficult to prevent wet concrete mixes by-passing the shuttering. The use of a semi-dry concrete mix containing screeding sand is preferred. Where a dpm has been broken through it should be reinstated. If it is not reinstated then it is effectively by-passed. In the case of a mini-sump where the dpm is below the slab it is not necessary to repair the dpm because the dpm is not by-passed by moisture. Finally, after the concrete has set, the joint between the new concrete and the pipe can be sealed with a gun-applied sealant to prevent air leakage should shrinkage and thermal movement of the pipe form a crack at this position.

Sumps and suspended timber floor construction

In most dwellings with suspended timber ground floors, radon entry can be remedied by increasing the natural underfloor ventilation, by installing additional air vents or by using mechanical underfloor ventilation. However, where this is not possible or increased underfloor ventilation proves inadequate, a sump system might be considered.

It is only possible to install a sump system beneath a suspended timber floor where depressurisation of the soil can be achieved. Depressurisation will only be possible where the soil is capped in some way. Fortunately many dwellings built since the Second World War and particularly those built recently have such a capping. This is because of the need to protect suspended timber floors from moisture from the ground. As a consequence most modern timber floors are underlain with either a layer of concrete or polyethylene sheeting covered with sand. Where this is the case it is a relatively simple task to install a sump system (Figure 13). With older dwellings it will be necessary to consider providing a capping to the soil before a sump can be installed. This is likely to prove both difficult and disruptive as access will be needed to the whole underfloor area.

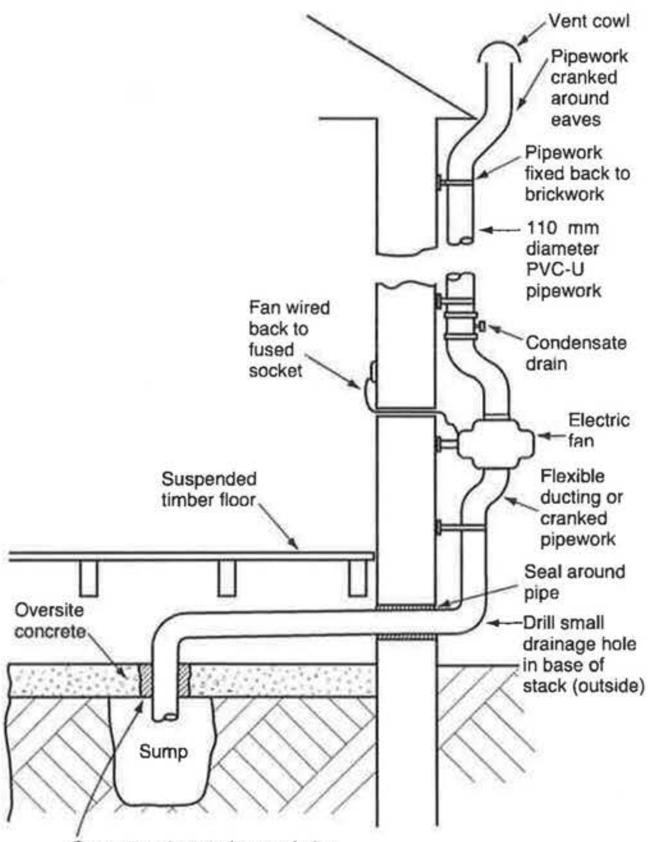

Figure 13 Sump installation beneath suspended timber floor

Routing of the pipework

Typically, the pipework can be 110 mm diameter PVC-U (unplasticised polyvinyl chloride) pipe as used for domestic soil and vent pipes. For a system with an externally mounted fan, it would be best to locate the pipework at the rear of the dwelling or at a re-entrant corner where subsequent installation of a boxed-in fan and pipework will be least obtrusive.

Where the system is such that the fan and pipework are located inside the dwelling, the pipework will need to

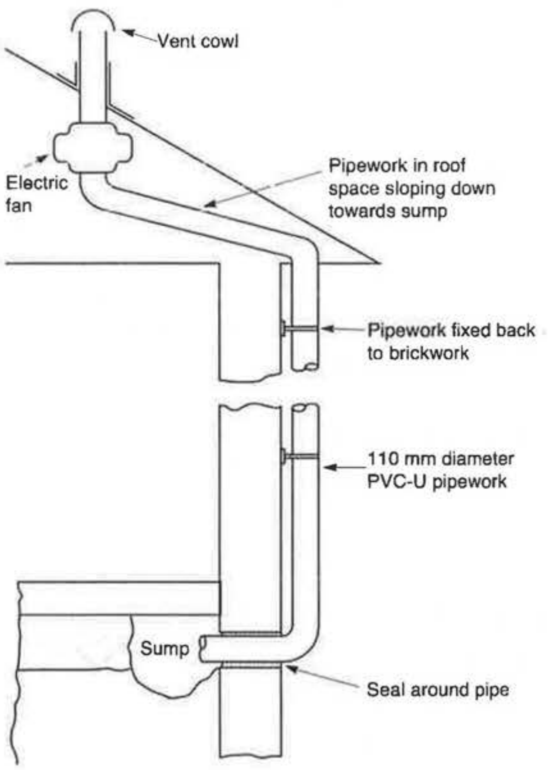

Figure 14 Externally excavated sump with fan unobtrusively located within roof space

be routed so that it can be supported on a wall. Consideration will also need to be given to putting pipework where it will be least obtrusive, eg inside a storey-height cupboard, or boxed-in in the corner of a room. Care will be needed in positioning the pipe to avoid ceiling joists and any services such as water storage tanks in the roof space.

In some cases it may be possible to take pipework up the outside of the dwelling, re-entering at eaves level in order to locate the fan unobtrusively within the roof space (Figure 14).

Horizontal pipework should always slope down towards the sump to provide drainage should any condensation form within the pipework. Low points such as U-bends must also be avoided.

Positioning the fan and outlet

The fan should be positioned with the outlet well away from windows, doors and ventilation grilles, ideally discharging through a vent cowl just above eaves level or through a gable wall, or through a ridge-mounted terminal. The system **must never** discharge into a roof space. With internal systems the fan should always be placed as close to the outlet as practical so that the pipework is always under suction. This is of particular importance when routing pipework inside the dwelling as even slight leaks could increase indoor radon levels. Where pipework is routed entirely outside the dwelling, it is not necessary to site the fan near the terminal. Fans should be adequately supported.

Experience has shown that provided that there are no doors, windows or ventilation grilles close by, systems can discharge at low level. This can prove useful where aesthetics are important. As a rule of thumb it is usually only appropriate where the exhaust is two or three metres from the nearest opening, there are no other buildings or regularly used spaces (such as patios) immediately adjacent, and the exhaust can be directed to discharge away from the building.

Minimising noise from sump systems

It is important to ensure that sump systems are installed in such a way as to minimise noise both to occupants within the building and to their immediate neighbours. Sump fans are generally quiet running, so in most cases noise does not pose a problem. Nevertheless problems can arise if care is not taken during installation.

Fans should not be supported on lightweight walls or components that might transfer vibration to the rest of the property. One option is to support the fan on vibration mounts fixed to brick or blockwork. Also avoid locating fans above or adjacent to living rooms, bedrooms or other quiet areas. Pipework should be routed away from quiet areas, and should be kept as straight as possible to minimise noise from air movement. More detailed guidance is available in BRE Good Building Guide 26 *Minimising noise from domestic fan systems*.

Choice of fans

The most commonly used type of fan for radon sump systems is known as a 'centrifugal in-line duct fan'. These are compact, quiet, widely available and are easily fitted in straight pipe runs. However, there is no technical reason why other types of fan with similar airflow performance should not be used (eg one type, developed specifically for radon applications, has inlet and outlet spigots at an angle of 90° to each other). For most radon sump applications the following fan specification is recommended.

The fan should have a non-stalling pressure/flow rate characteristic, ie the pressure difference across the fan should always rise as airflow rate through the fan is reduced. Thus only centrifugal-type fans are normally suitable (note that 'in-line duct fans' have centrifugal impellers but the casing can make them look like axial fans). The fan may be required to operate almost anywhere on the fan performance characteristic curve and so should have a non-overloading characteristic, ie the fan motor should be capable of operating the fan continuously at any point on the characteristic curve from zero flow to free delivery.

Successful sump systems used in dwellings and small school buildings have mostly used a fan with a similar characteristic to that given below.

Flow rate (m^3/h)	400	350	300	225	175	100	0
Pressure difference (Pa; static)	0	50	100	150	200	250	300

A fan with this performance may be expected to have a power consumption of about 70 watts. This may be regarded as a minimum performance but routine use of much higher performance is not recommended because of consequent increases in noise and running costs.

However, sump systems in large or difficult buildings may require a higher fan performance than that recommended here and that is usually achieved by using the 'next fan size up' in a manufacturer's range (typically having a power consumption of about 140 watts). Fans larger than this cannot be recommended without specialist advice.

To prevent the escape of radon-bearing air into the building (including a garage, cupboard or roof space) the fan should have an airtight casing. Casings assembled using sliding/push fits alone are unlikely to be airtight unless sealed or taped. The pipe connecting spigots/flanges should be so designed that the pipe connection can be made airtight with ease.

The fan should be suitable for operation with air temperatures between –5 °C and +30 °C and with relative humidity up to 95%. The fan must be designed in such a way that condensation run-off from the pipework cannot collect in the fan casing in sufficient quantity to affect the fan performance or safety (including perforation of the fan casing due to corrosion). Note that fans are not normally fitted in horizontal pipe runs.

The fan should be of 'maintenance free' design. This would normally mean that the fan motor and impeller bearings are of the 'sealed for life' type. Fan manufacturers are reluctant to give an expected service life for small fans because they have no control over the operating conditions and environment. However, the fan should clearly be of good-quality design and manufacture and should be expected to run continuously without attention for many years.

Fan connections to pipework

It should be remembered that the fan will require airtight connection to a pipe system. The most commonly used pipe materials are 110 mm and 160 mm diameter plastic soil/drain pipes, but other pipes/ducts can be used. Conversions from the pipe size and shape to the fan inlet and outlet spigot size may be required. Because of the variety of pipe materials which can be used, the fan inlet and outlet dimensions do not form part of the above specification, but large differences in pipe and fan spigot size should be avoided if possible.

Manufacturers and suppliers of fans

A list of potential fan manufacturers and suppliers is provided in the Appendix.

To suck or blow?

Throughout this guide, sump systems are described as being fitted with electric fans to depressurise the adjacent soil (to extract, or suck, radon-laden air). In most cases extraction adequately reduces the radon level. But BRE is aware of a few cases where suction has proven ineffective. Usually the solution is to try a larger fan. However this is not always the case. Experience has shown that in cases where the soil or fill beneath the building is highly permeable it is better to reverse the fan to blow into the sump and pressurise the area beneath the building with fresh air.

So when installing a fan should you suck or blow? The answer really depends upon the permeability of the soil beneath the building but usually the installer will not know what this is, and it would probably prove expensive to carry out a diagnosis to find out. BRE therefore generally recommends installing fans in suction. If subsequently it is found that radon levels have not been adequately lowered, it is a simple task to turn the fan around to blow (see also the later section on checking system performance).

Passive sump systems

The sump systems so far referred to in this guide are all *active* systems – they rely upon the use of an electric fan to move air through them. Experience has shown that in cases where the indoor radon level is relatively low, ie just above the action level, it is possible, in the right circumstances, to operate a system *passively* – without the need for an electric fan.

If it works, a passive sump system is always preferable to an active one. Without a fan the system is cheaper to install, run and maintain, and is quieter. However, is it not as effective as an active sump system and will be more disruptive to install as it has to be installed inside the building.

A passive sump system uses two natural forces to extract radon from the ground: the stack effect and the wind effect.

- **The stack (or chimney) effect**
  This term describes the natural upwards movement of warm, buoyant, air. It relies on the air inside the house being warmer than the air outside. 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. Therefore pipework for a passive system needs to run through heated spaces inside a building.
- **The wind effect**
  As wind blows over the roof, it generates a negative pressure region on and above much of the roof surface. As it blows over the outlet 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.

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 building to building: during BRE research into passive systems, the best result was a reduction of 88%, with indoor radon 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 sump systems should be able to treat successfully houses with indoor radon levels of less than 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 as it is a simple task to add an electric fan later if the radon level is not adequately reduced.

A passive sump system is essentially an active sump system without the fan. However, to maximise the system's effectiveness it is important to consider the following points:

- Route pipework inside the building
- Keep pipework as straight as possible because bends offer a resistance to airflow and therefore make the system less efficient.
- Use rigid pipework, bends and accessories.
- Position the exhaust exit at roof ridge level through a ridge ventilator, or through the slope of the roof with a vent cowl. 'H'-pot terminals or multi-vaned rotating cowls are both effective in using the wind to drive the airflow through the system, and can be used in place of a vent cowl. Do **not** use tile ventilators as these can be placed in areas of the roof where positive pressure occurs.
- Leave enough room for a fan just in case one has to be fitted later.

Avoiding spillage of combustion products

In some circumstances a sump system operating in suction (depressurisation) may lower the air pressure inside the dwelling. This, 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 prevented.**

So, how does a radon sump system cause spillage? All combustion appliances need a sufficient air supply for efficient combustion, to dilute combustion gases and sometimes to cool the appliance itself. Many 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 depressurising effect can encourage radon to seep in. Installing a sump system to depressurise the area beneath the dwelling will usually counter the depressurisation effect of the combustion appliance and result in reduced indoor radon levels. Unfortunately in a few rare cases the effect of the sump could be severe enough to result in combustion gases or smoke being drawn into the living space.

It is important to avoid spillage of combustion gases by taking the following precautions:

- Ensure that the sump is located away from open-flued combustion appliances, preferably beneath the floor of a different room.
- With an internally excavated sump, ensure there is a good seal around the pipe where it penetrates the floor.
- Seal obvious cracks and gaps in the concrete floor above or adjacent to the sump. Pay particular attention to the join where the floor meets the wall.
- 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.
- If the appliance requires an air supply vent (eg an airbrick), make sure it is present in the room and is not blocked. (Most radiant gas fires do not need a vent but most open-flued boilers do require one.)

Additional protection for methane

In some very rare instances, the building being treated is located on or next to a landfill site or old coalfield, in which case additional precautions will be needed to deal with methane. It is therefore advisable to contact the local authority environmental health department before starting work to establish whether the property is near a landfill site. If there is a problem, further advice can be otained from the BRE Radon Hotline (telephone 01923 664707).

Dwellings with integral or attached garages

Where a dwelling has an integral or attached garage it may be possible to install the sump system from within the garage. Excavation work carried out in the garage would require less making good than inside the dwelling. Pipework would be less obtrusive and easier to install than if routed through the dwelling (Figure 15).

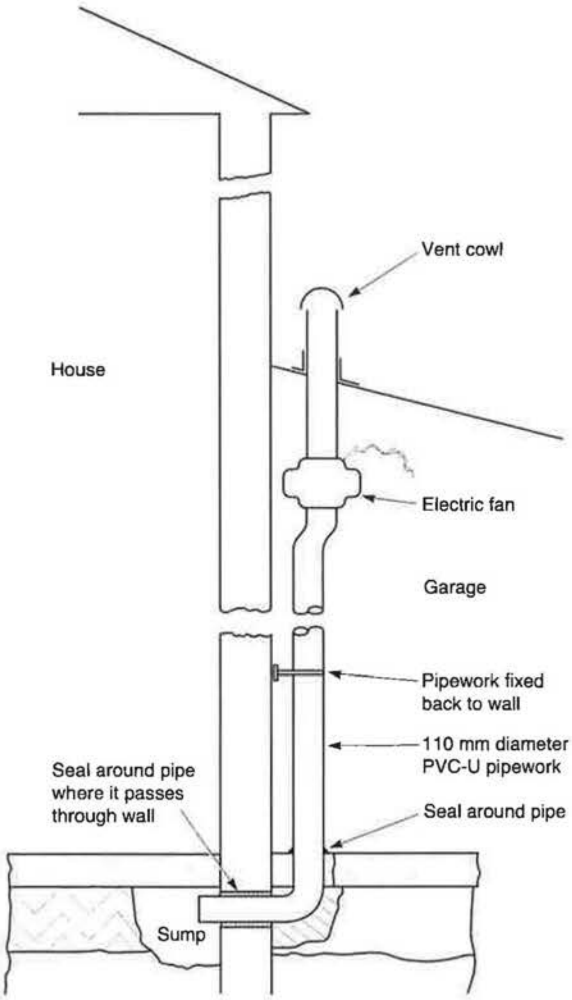

Figure 15 Sump system located within integral garage

Communal radon sump systems

As mentioned earlier a single sump is likely to have an influence over an area of some 250 m^2. Bearing in mind that the average semi-detached house has a ground floor area of around 40 m^2 then it can be seen that the influence of the sump is likely to extend beyond the dwelling. What this means is that where dwellings are joined together, as with semi-detached houses or bungalows, a terrace of properties or a block of flats, it may be possible to install a single system to resolve the radon problem in more than one property. BRE is aware of blocks of four and five dwellings having been successfully remedied using a single sump system. Such systems are described as 'communal sump systems' (Figure 16).

Ideally the sump system should be located at the central point of the group of affected dwellings or nearer

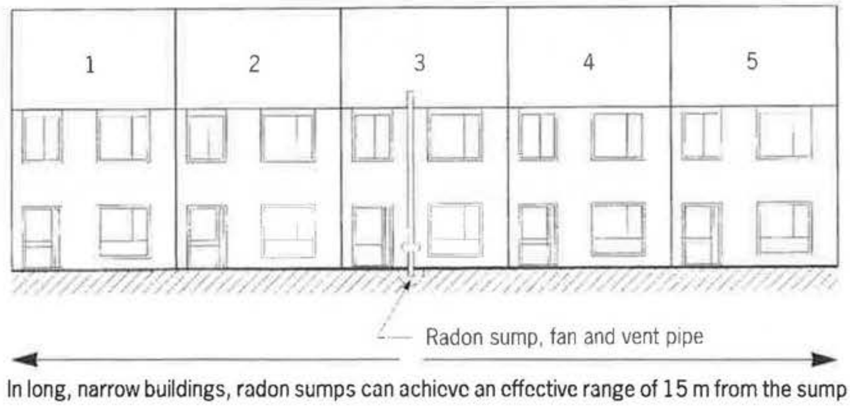

Figure 16 Communal sump system for a terrace of five houses

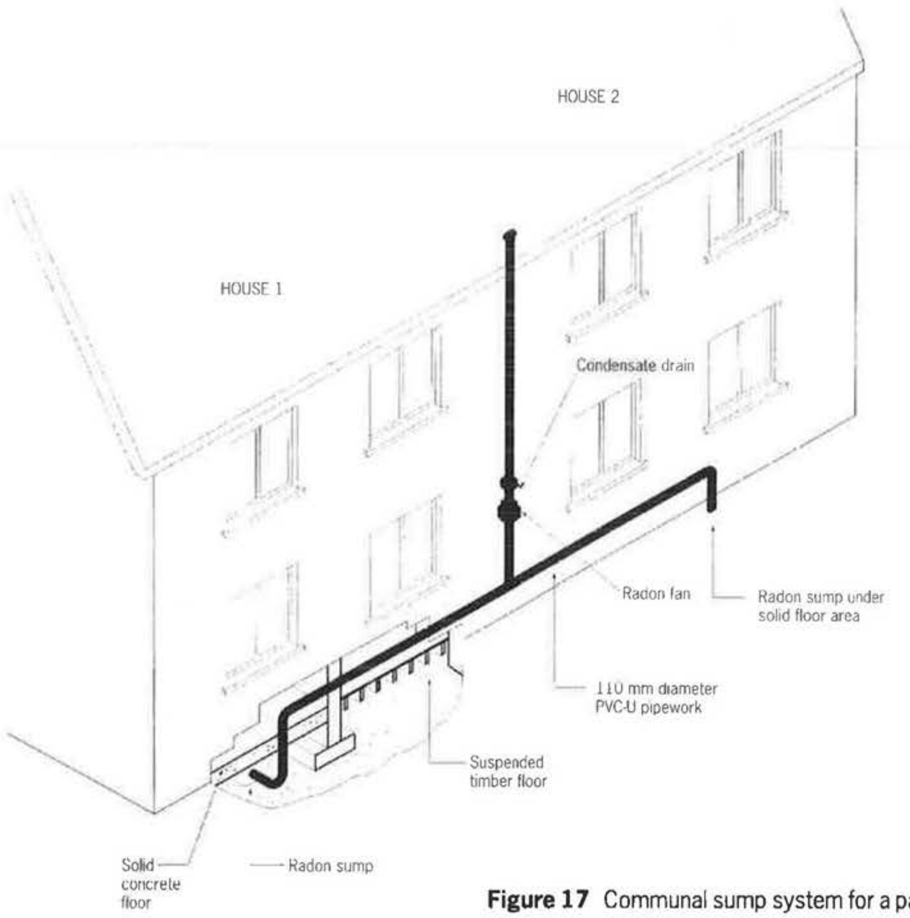

Figure 17 Communal sump system for a pair of houses with mixed floor construction

to the area with the highest radon levels. As a rule of thumb the total floor area should not be greater than 250 m^2 and the furthest floor area should probably be no more than 15 m away from the sump. (It may be possible to treat larger areas, or greater distances, depending on the permeability of the fill or soil beneath the building.) Communal systems can be applied to buildings of mixed floor construction (Figure 17).

The main advantage of installing a communal sump system is that installation, running and maintenance costs can be shared between the occupiers of more than one property. For this communal approach to be successful, a written agreement should be drawn up between householders to ensure that installation and running costs are shared fairly between those benefiting from the system. One householder or perhaps a landlord should be nominated to take responsibility for the upkeep and maintenance of the system.

Checking system performance

After a sump system has been installed, the building should be retested to see whether the works have been effective in lowering the indoor radon level. Ideally retesting should be carried out for a further three months using detectors as supplied by the National Radiological Protection Board or other NRPB validated laboratory. Short-term measurements are sometimes used to get a quick indication of success, but should be followed up with long-term testing. To ensure consistency, detectors used for retesting should be placed in the same locations as the original detectors were.

In most cases simply installing the system, running it and remeasuring the radon level is adequate to establish whether a system is working satisfactorily. However, if the system is found not to be adequately lowering the radon level then additional diagnosis may be needed.

Householders and general builders may need specialist help with this since it generally requires the use of a sensitive manometer instrument to measure very small pressure differences down to about 5 pascals (1 lb/square inch ≈ 6895 pascals). Whilst these instruments are widely used in the heating and ventilating industry, householders and general builders may have difficulty obtaining them. However, the additional diagnosis can be very helpful in resolving problems.

As discussed earlier the permeability of the soil or fill beneath the floor slab is important in the operation of the sump. If the soil or fill has too low a permeability then the area of operation will be restricted and the system may not have any influence at the extremities of the building.

To establish whether the system is working effectively across the whole building, pressure readings below the floor can be taken. This will necessitate drilling small pressure tapping holes through the slab at distances away from the sump and measuring the pressure difference above and below the floor slab using a sensitive manometer. A subfloor pressure reading of more than 5 pascals suction measured under the floor at a point most distant from the sump will generally indicate that the sump is operating satisfactorily. The test holes must be resealed afterwards.

Measuring the pressure difference between the sump and the room above (or outside) can also be useful in diagnosing problems. Most successful sumps operate with a pressure difference of about 50–200 pascals or more. If the pressure difference is less than, say, about 20 pascals then that may be an indication of short circuiting due to leakage around the extract pipe, as discussed below. If short circuiting has been eliminated then there is probably another easy route for airflow into the sump, such as extremely permeable ground, large cracks or voids leading to the outside air (or even to old mine workings), or other hidden reasons. If this is the case it is worth turning the fan round to blow into the sump (instead of sucking from it) and testing for radon again. This does not increase the sump pressure but can result in a satisfactory reduction in radon level. If the radon level remains high after this you should seek specialist advice.

In some cases, as just mentioned, the sump system may fail to reduce the radon level due to short circuiting in the system. There are various ways in which short circuiting can occur. Examples include:

- leakage around the pipe at the point where it enters the sump,
- leakage at the joint between the edge of the floor slab and the wall above an edge-located sump, and
- leakage due to poorly jointed or damaged pipework.

These can be identified by using a smoke pencil or smoke tube. In each case simple sealing will usually resolve the problem. Short circuiting can also occur where pipework connecting to an externally excavated sump is not sealed where it passes through the wall. This is more difficult to identify and rectify without reopening the excavation to the wall. Occasionally short circuiting can occur because the exhaust from the sump system is incorrectly positioned so as to discharge back into the building.

If after final retesting the radon level remains high then further advice should be sought.

Sumps in new buildings

This guide is principally aimed at the installation of sump systems within existing buildings. However, they can also be used within new buildings. In some parts of the country sumps are required to be included within new dwellings (see BRE Report BR211 *Radon: guidance on protective measures for new dwellings*). Where this the case, all that is required when the building is built is to construct the sump and provide a length of pipe from the sump to a point just above ground level alongside the building (Figure 18). The sump is simply provided to make it easier to achieve subslab depressurisation should it prove necessary at a later date.

Although there is no requirement to install the fan and pipework during construction, it is nevertheless important to consider where the fan and pipework might need to be located in the future. For aesthetic reasons the pipework should be located on the least obtrusive facade of the building. Likewise pipework will need to avoid doors and windows. If such a sump needs to be activated, the fan and pipework can be added according to the advice in this guide.

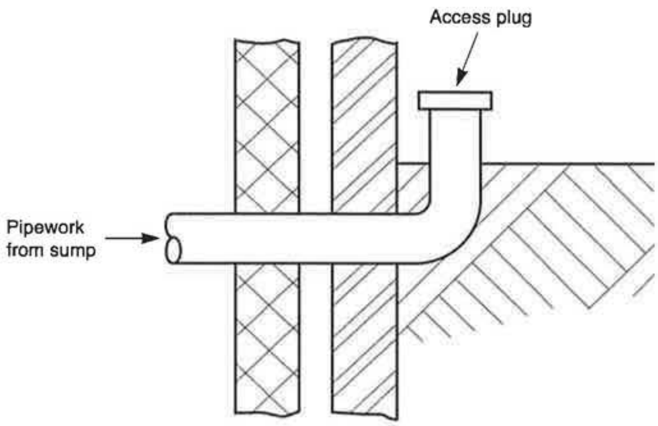

Figure 18 Detail of sump pipework capped-off alongside a new building

New extensions

If a dwelling to be extended is within an area affected by radon (as defined in BRE Report BR211), it is advisable that radon-protective measures be incorporated within the new work. For a dwelling which already has radon-protective measures the extension should include full protective measures. For an unprotected dwelling the extension should be constructed in such a way that will not cause an increase in radon concentrations in that dwelling. Consideration should be given to linking the radon-proof barrier in the new floor to the damp-proof course or radon-proof barrier within the existing building. To enable subsequent subfloor depressurisation should it prove necessary, a radon sump should be installed beneath the extension floor alongside the existing part of the dwelling. Further advice on providing protection to new extensions is contained in BRE Report BR211 and Good Building Guide 25.

Acknowledgements

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More information

Help and advice on building matters relating to radon is available from the BRE Radon Hotline (telephone 01923 664707). BRE publications on the subject of radon can be obtained from Construction Research Communications Ltd, 151 Rosebery Avenue, London, EC1R 4QX (telephone 0171 505 6622).

References and further reading

Department of the Environment, Transport and the Regions

Radon: a householder's guide. London: HMSO or DETR.
Radon: a guide to reducing levels in your home. London: HMSO or DETR.

Building Research Establishment
Reports

Radon: guidance on protective measures for new dwellings. BR211, being revised.
Scivyer C R and Gregory T J. *Radon in the workplace*. BR293, 1995.

BRE guides to radon remedial measures in existing dwellings

Pye P W. *Sealing cracks in solid floors*. BR239, 1993.
Scivyer C R. *Surveying dwellings with high indoor radon levels*. BR250, 1993.
Scivyer C R. *Major alterations and conversions*. BR267, 1994.
Scivyer CR and Jaggs M P R. *Dwellings with cellars and basements*. BR343, 1998.
Stephen R K. *Positive pressurisation*. BR281, 1995.
Welsh P A, Pye P W and Scivyer C R. *Protecting dwellings with suspended timber floors*. BR270, 1994.

Good Building Guides

GBG25 Buildings and radon
GBG26 Minimising noise from domestic fan systems and fan-assisted radon mitigation systems

Information Papers

IP21/92 Spillage of flue gases from open-flued combustion appliances
IP7/94 Spillage of flue gases from solid-fuel combustion appliances

Video

Radon, no problem. 1994.

Appendix
Potential suppliers of radon sump extract fans

The following companies are known to produce fans suitable for use with radon sump systems. The list is not exhaustive; it only contains those companies known to BRE; there are bound to be other companies which do not appear on the list. The companies listed must not be regarded as or referred to as recommended suppliers. BRE cannot accept responsibility for matters arising from the use of this list. Details given were correct at the time of going to press.

Air Control Environmental Services, No 6 Chapman Road, Canvey Island, Essex, SS8 7QS
Tel: 01268 510184

Airflow Developments Ltd, Cressex Industrial Estate, Lancaster Road, High Wycombe, Buckinghamshire, HP12 3QP
Tel: 01494 443821

Air Movement Group, Roof Units Group, Peartree House, Peartree Lane, Dudley, West Midlands
Tel: 01384 74062

Greenwood Air Management Ltd, Brookside Industrial Estate, Rustington, West Sussex
Tel: 01903 771021

Manrose Ltd, 8G Bedford Avenue, Slough, Berkshire, SL1 4RA
Tel: 01753 691399

Vectaire Ltd, Peterley Wood House, Peterley Lane, Prestwood, Great Missenden, Buckinghamshire, HP16 0HH
Tel: 01494 890072

Ventaxia Ltd, Fleming Way, Crawley, West Sussex, RH10 2NN
Tel: 01293 526062

Vortice Ltd, Milley Lane, Hare Hatch, Reading, Berkshire
Tel: 01734 404211

Xpelair Ltd, PO Box 220, Deakin Avenue, Witton, Birmingham
Tel: 0171 242 7634 or 0121 327 1984

There are many more fan manufacturers, as well as wholesalers and local distributors around the country – see business telephone directories, heating and ventilation guides, etc, for details of these.

In addition the Radon Council maintains a list of contractors, suppliers and consultants offering advice and services involving remedial works for radon gas, many of whom can supply fans. Details can be obtained from The Radon Council Limited, PO Box 39, Shepperton, Middlesex, TW17 8AD, Tel: 01932 221212, Fax: 01932 229779.

Trade associations may also be able to help – details of these can be often be found in main libraries.