Radon and buildings: 1 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 mechanical ventilation or by the use of a radon sump. However, in some circumstances, these remedial measures may lower the air pressure inside the dwelling. In a small number of cases, this causes combustion gases from open-flued combustion appliances, such as open fires, to spill into the living spaces. Spillage of this type is potentially hazardous, and should always be avoided. This leaflet recommends ways to reduce the likelihood of spillage, and suggests solutions if spillage does occur. It will be of interest to anyone involved in reducing indoor radon levels.

BACKGROUND

Combustion appliances require adequate ventilation to aid combustion, dilute combustion gases and sometimes to cool the appliance itself. Most modern boilers are room-sealed gas-fired 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 (see box of definitions) and therefore lower the air pressure indoors to some extent. This makes them undesirable in a dwelling affected by radon because depressurising the dwelling can allow 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, eg radon sumps[1] or underfloor extract ventilation. 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 a small 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[2]. 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[2] in which tests are described for gas-fired, oil-fired and solid fuel appliances.

Figures 1 and 3 show combustion appliances and radon remedial systems working correctly. Figures 2 and 4, however, illustrate the problems which can

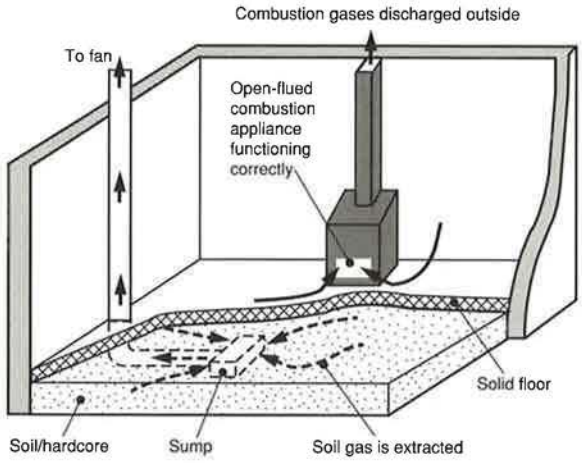
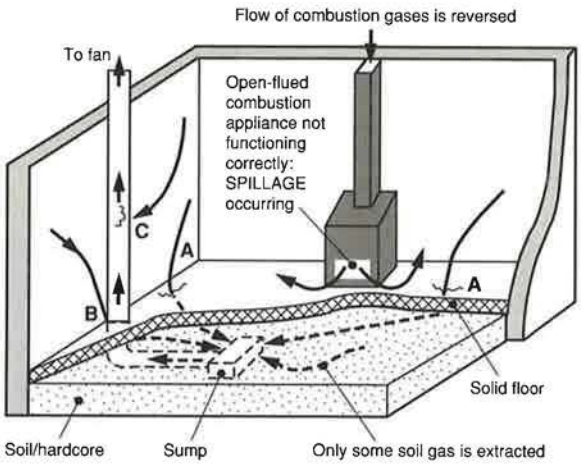


Figure 1 Sump and combustion appliance operating correctly



A Air enters sump from room through cracks in floor
B Air enters sump through gap where pipe penetrates floor
C Air enters system through crack in pipework

Figure 2 Sump causing spillage from combustion appliance

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arise with systems of this type. Figure 2 shows soil gas being extracted from underneath a concrete slab; Figure 4 shows it being drawn from the void under a suspended floor. In both cases, spillage is 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.

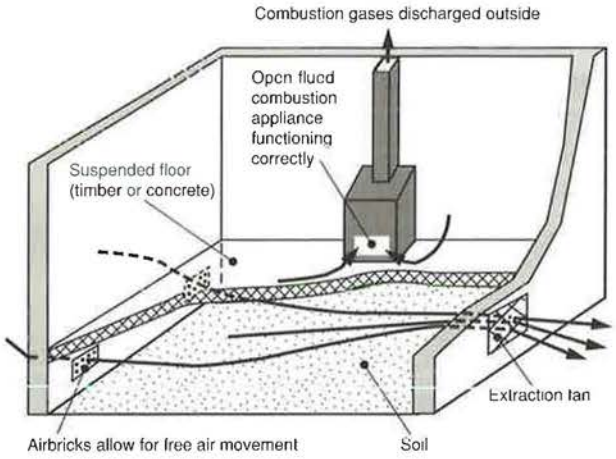

Figure 3 Underfloor extract ventilation and combustion appliance operating correctly

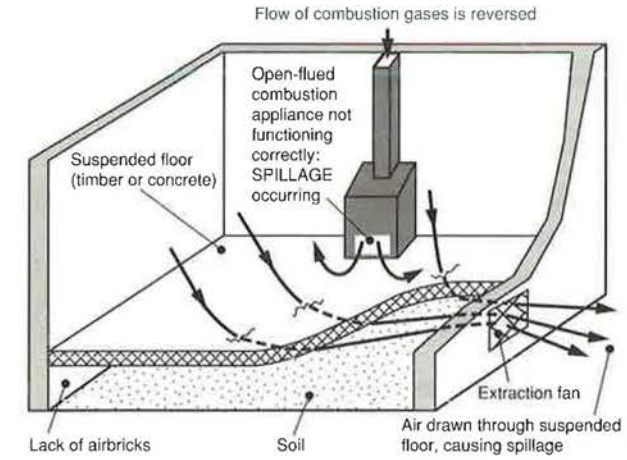

Figure 4 Underfloor extract ventilation causing spillage of combustion products

DEFINITIONS

Open-flued combustion appliance

Any combustion appliance, including an open fire, which takes air from the room in which it is installed and discharges the air, mixed with combustion gases, through a chimney or flue

Spillage

A reversal in the flow of combustion gases from an open-flued combustion appliance, ie the gases 'spill' into the room which contains the combustion appliance, instead of being discharged outside through a chimney or flue

Oversite

The concrete layer which covers the soil beneath a suspended floor

PLANNING AND INSTALLATION OF RADON REMEDIAL SYSTEMS

Sump systems

If a radon sump is being installed:

- Ensure that the sump is located away from open-flued combustion appliances, preferably beneath the floor of a different room
- Check that all pipework is free from cracks and gaps
- 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 floor, oversite and membrane directly above the sump[3]
- Check that the fan is not too powerful (see section on fan size)

Underfloor extract ventilation systems

In some circumstances, underfloor extract ventilation may not be the most appropriate form of protection against radon, eg in a dwelling with both a suspended floor and an open-flued combustion appliance. Research has shown that blowing air into a void is also an effective way of reducing radon levels. If spillage is a possibility, the blowing method is preferable because it will not depressurise the house, and therefore will not cause spillage.

Underfloor extract ventilation has similar disadvantages in dwellings with timber floors. Timber floors, especially old ones, often have large gaps between the floorboards which allow air to move freely between the inside of the dwelling and the void under the floor. An extraction system may depressurise the rooms, and increase the likelihood of spillage, by drawing air down through the gaps in the floor. It is not even advisable to seal the floor by covering it with a membrane, because the membrane traps moisture and may cause the timber to rot.

If underfloor extract ventilation is to be used as a radon remedial method, the following precautions are essential:

- Ensure that airbricks surrounding the property are open so that air can enter the void from outside, and check that the airbricks are adequately sized. As an approximate guide, there should be a free, open 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, ie fans and airbricks are best located on opposite sides of the dwelling to each other (see Figure 3)
- Check that, where the wall cavity is breached by a fan or pipe, the wall is sealed to prevent air being drawn out of the cavity
- Ensure that obvious cracks and gaps in suspended solid floors are sealed[3]. Sealing is not recommended for timber floors: moisture can not 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
- Specify a fan which is not too powerful (see section on fan size)

Beware! 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 reverse the air flow through the vent, thereby limiting the air supply to the appliance (see Figure 5). Vents in the floor should therefore be sealed and replaced with vents in an external wall above floor level (see Figure 6).

Fan size

It is difficult, if not impossible, to specify what size of fan is required to reduce radon levels successfully. As a rough guide, a fan with a power rating of 75 watts will be large enough to protect 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*[1].

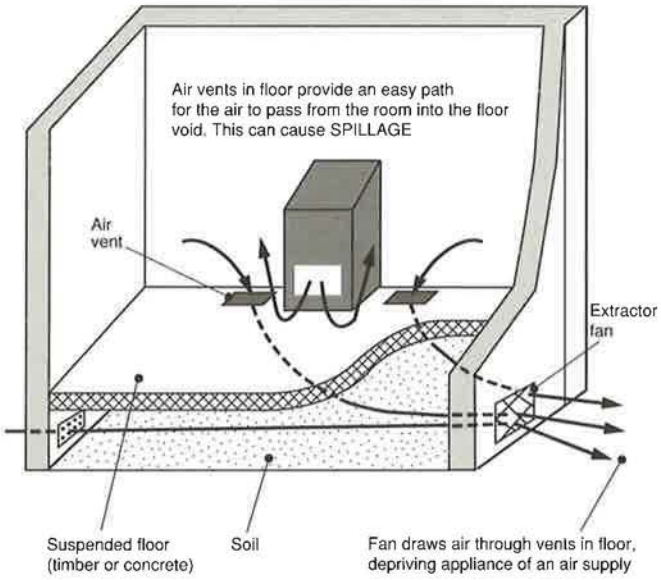

Figure 5 Spillage caused by air flowing through floor vents

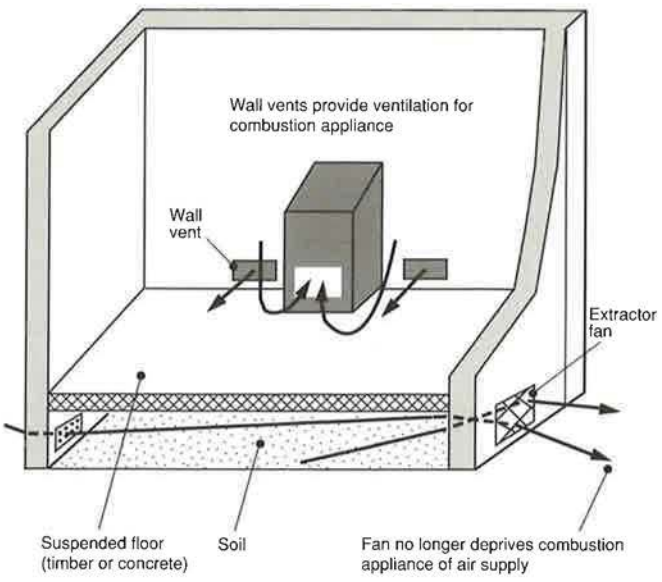

Figure 6 Wall vents ventilating combustion appliance

IF AN EXISTING SYSTEM CAUSES SPILLAGE

Sump system check-list

- Inspect the pipework and seal any cracks or gaps with an appropriate sealant
- Ensure that there is a good seal around the pipe where it penetrates the floor, oversite and membrane
- Inspect the solid floor, oversite and membrane directly above the sump and seal any obvious cracks or gaps. Pay particular attention to the gap around solid floors where the floor meets the walls
- If the fan is too powerful, it may be possible to solve the spillage problem without significantly increasing the indoor radon level by turning down the speed or installing a smaller fan (see section on fan size)

Underfloor extract ventilation system check-list

- Inspect the airbricks surrounding the property. Air should be able to enter the underfloor void, ideally through airbricks on the opposite side of the dwelling to the fan. As an approximate guide, there should be a free, open 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
- Check that, where the wall cavity is breached by a fan or pipe, the wall is sealed to prevent air being drawn out of the cavity
- Replace existing floor vents with wall vents (see Figure 6)
- Ensure that obvious cracks and gaps in suspended solid floors are sealed[3]. Sealing is not recommended for timber floors: moisture will be unable to 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
- If the fan is too powerful, it may be possible to solve the spillage problem without significantly increasing the indoor radon level by turning down the speed or installing a smaller fan (see section on fan size)

IF SPILLAGE CONTINUES TO OCCUR

Only a few options remain if, after checking the system as just described, spillage continues to occur. These include:

- Increasing the ventilation to the room where the spillage occurs, eg by the use of an air vent in the wall (see Figure 6) or trickle ventilators in the windows, or by opening doors and windows. However, this option 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
- Increasing the direct air supply to the appliance by installing a suitable underfloor ventilation duct, allowing outside air to enter the room
- Removing the open-flued combustion appliance and installing an alternative heating method. This guarantees success

FURTHER INFORMATION

For further advice regarding building matters, contact:

BRE Advisory Service
Building Research Establishment
Garston
Watford
WD2 7JR

Telephone: 0923 664664

Help with radon-related problems of all kinds is available from the BRE Radon Hotline (telephone: 0923 664707). For specific advice on the subject of this leaflet, contact its author, Paul Welsh, at BRE. Additional literature on radon and radon protective methods[1,3,4,5] is available from the BRE Bookshop (address below).

Further copies of this leaflet can be obtained, price £2 each, from the BRE Bookshop, Building Research Establishment, Garston, Watford, WD2 7JR (telephone 0923 664444; fax 0923 664400).

Building Research Establishment
XL8 February 1994

REFERENCES

1 **Building Research Establishment.** *Radon sumps: a BRE guide to radon remedial measures in existing dwellings.* BRE Report. Garston, BRE, 1992.

2 **Shepherd T A**. Spillage of flue gases from open-flued combustion appliances. *Building Research Establishment Information Paper* IP21/92. Garston, BRE, 1992.

3 **Pye P W.** *Sealing cracks in solid floors: a BRE guide to radon remedial measures in existing dwellings.* BRE Report. Garston, BRE, 1993.

4 **Building Research Establishment.** *Radon: guidance on protective measures for new dwellings.* BRE Report. Garston, BRE, 1991 (revised 1992).

5 **Building Research Establishment.** *Surveying dwellings with high indoor radon levels: a BRE guide to radon remedial measures in existing dwellings.* BRE Report. Garston, BRE, 1993.

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