Radon and buildings: 2. Minimising noise from fan-assisted radon sump systems

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Noise from fan-assisted radon sump systems can be a problem in the home. This leaflet describes how to design a sump system with a view to minimising noise disturbance. It also includes advice on reducing noise from unsatisfactory existing systems. The leaflet will be of interest to householders, builders and designers dealing with noise from fan-assisted radon sump systems.

INTRODUCTION

A common method of reducing radon levels in dwellings is to draw contaminated air from the ground into an underfloor sump[1]. This air is extracted from the sump by a fan and discharged into the atmosphere. However, operating fans create noise and vibration which can be unacceptable, particularly if the level of background noise is low.

SOURCES OF NOISE

There are three main sources of noise from a fan-assisted radon sump system (see Figure 1).

Fan noise

Noise from fans is mainly caused by turbulence in the air moving through the fan casing. This noise is broadband, ie it covers a wide frequency range, but in some instances it may have tonal components — noise at specific frequencies or over a narrow frequency range — which may be heard as a drone, hum or whistle. These tonal components can be particularly irritating. By comparison, mechanical noise from the motor bearings does not usually reach significant levels.

Regenerated noise

Regenerated noise is caused by the movement of air past an obstruction, ie where the velocity of the air changes or where the flow becomes turbulent. Regenerated noise often originates at the entry to the sump system and at bends and junctions, and the greater the speed of the air, the louder the noise. The frequency of the noise depends on the size of the obstruction: in general, the smaller the obstruction, the higher the frequency of the regenerated noise.

In sump extract systems, regenerated noise is often strongest at middle or high frequencies. Usually the noise has a constant level, but sometimes it may incorporate a periodic variation or audible buffeting. In extreme cases regenerated noise may be heard as a whistling sound.

Fan vibration and re-radiated noise

All fans vibrate to a greater or lesser extent. This vibration can be transmitted to the building through the fan or duct supports and travel through the structure, causing other fittings to vibrate in sympathy. Structure-borne vibration may be seen or felt, but it usually manifests itself as re-radiated noise: the building structure vibrates and these vibrations radiate noise into the building.

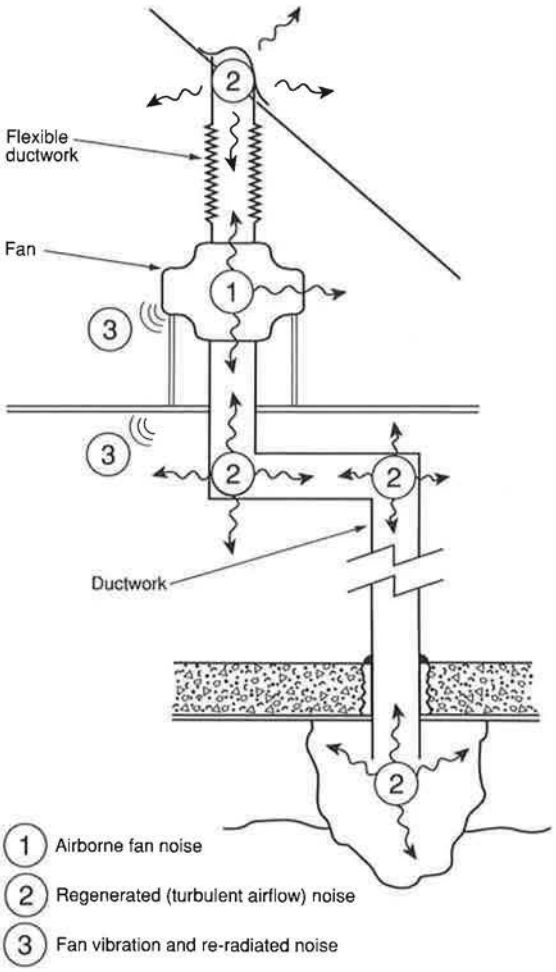

Figure 1 Main noise sources in radon sump extract systems

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The main frequency of any noise which comes directly from the fan is dependant on the fan's running speed. In most cases this noise is at a low frequency and is heard as a drone or hum. However, noise from fan vibration and re-radiated noise may have tonal components.

DESIGNING A SYSTEM TO MINIMISE NOISE

Choosing the right system

In general, the only fans suitable for radon sump extract systems are centrifugal fans because they do not stall[1]. It is therefore advisable to install the quietest centrifugal fan you can afford.

Circular ductwork (or pipework*) is preferable to flat-oval or rectangular ductwork because it is much better at reducing noise breakout, ie noise that passes through the duct wall. Lightweight flexible ductwork is generally poor at reducing noise breakout, and lengths should be kept to a minimum.

Putting the system in the right place

When a system is being designed, the location of noise sources is critical, but it also can be the easiest aspect of noise to control. The best location for any radon sump extract system is away from noise-sensitive areas. In general terms, the system should be located (in order of preference):

- Outside, away from a dwelling
- Outside, near a dwelling
- Inside, near hallways, kitchens or bathrooms
- Inside, near living rooms
- Inside, near bedrooms

Obviously, local circumstances or individual preferences will influence the exact location of the system. It is also very important to avoid noise nuisance to neighbours.

Putting the fan in the right place

The noise from a fan may be minimised by locating it on a part of the structure which is not responsive to vibration. From this point of view, the most appropriate places to mount a fan are (in order of preference):

- Away from dwellings or other noise-sensitive areas
- At low level, on a concrete floor slab
- On a heavy concrete, blockwork or brickwork wall
- On a roof truss, beam or rafter
- On a lightweight internal partition or ceiling

There are, of course, other factors which affect the final location of the fan. For example, it is important to avoid carrying high concentrations of radon down a long pressurised pipe, because a leak in the pipe could significantly increase radon levels in the building. This type of consideration will sometimes conflict with, and should take precedence over, the attempt to reduce fan-related noise.

*In this leaflet, 'duct' and 'ductwork' are synonymous with 'pipe' and 'pipework'

Controlling airborne fan noise at source

Fans can be significantly noisier if there is an uneven flow of air into or away from the fan. The best way to encourage an even flow of air is to have a straight run of duct leading to and from the fan. Ideally this duct should be as long as possible, but a straight length of duct that is at least 4–5 times as long as it is wide is usually sufficient to provide a relatively even airflow. There should be no abrupt changes in section or obstructions in the duct close to the fan. Good and poor airflow conditions are shown in Figures 2 and 3.

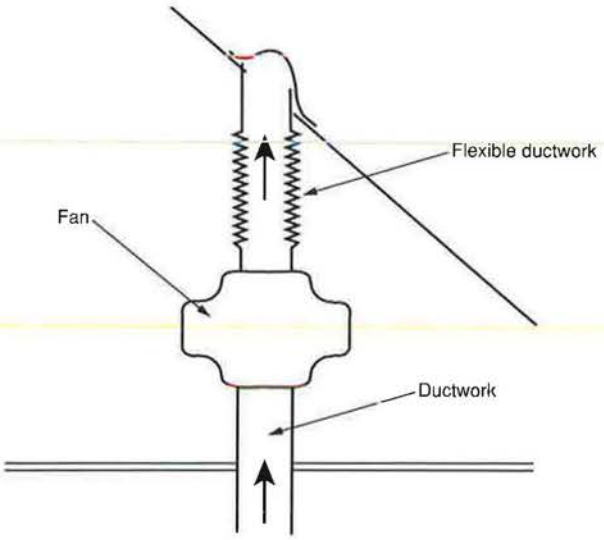

Figure 2 Good airflow conditions to and from a fan

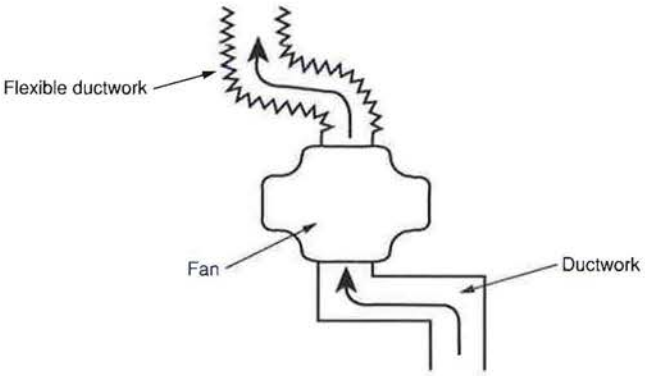

Figure 3 Poor airflow conditions to and from a fan

Controlling regenerated noise

Regenerated noise is the product of turbulence; noise levels are therefore largely determined by how quickly air moves through the system. For example, a doubling of the air speed can lead to a fourfold increase in loudness. Conversely, a relatively small reduction in the speed of air movement through the system can significantly reduce regenerated noise. Consequently, the most effective way to control noise levels is to minimise turbulence in the system by, for example:

- Ensuring that there are minimum velocities and pressure drops across fittings
- Avoiding bends and other fittings except where they are strictly necessary
- Locating fittings, branches or bends as far apart as possible: spacing them 3–4 duct widths apart will usually reduce turbulent interaction to a negligible level

Controlling noise breakout through ductwork

In general, noise breakout through ductwork can be controlled by boxing in the ductwork (see Figure 4). This type of noise is loudest near bends and intrusions into the duct. Therefore, if possible, avoid bends and intrusions into the duct where it runs close to noise-sensitive areas.

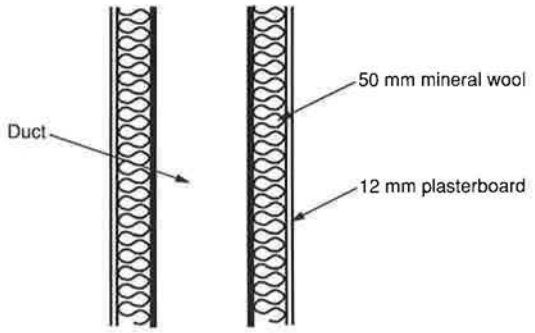

Figure 4 Section through a typical boxed-in duct

Controlling vibration

The level of fan vibration which enters the building structure can be reduced by:

- Disconnecting the fan and ductwork from the structure
- Resiliently isolating the fan from the ductwork and structure (see Figure 5), or connecting the fan to the ductwork but isolating the ductwork from the structure (see Figure 6)
- Mounting the fan and ductwork on a heavy, rigid support point which is not easily shaken (see Figure 7)

There can be a conflict between supporting the fan safely, and isolating the vibration from the structure. In these circumstances, it may be possible to support the fan resiliently on the ductwork, or to insert a neoprene or rubber coupling or bellows between the fan and the structure.

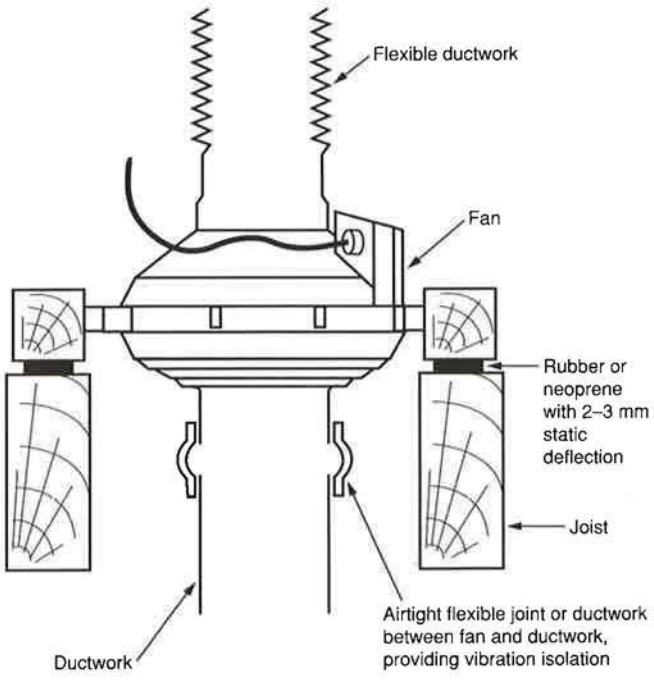

Figure 5 Side view of a fan which is resiliently isolated from the ductwork and the structure

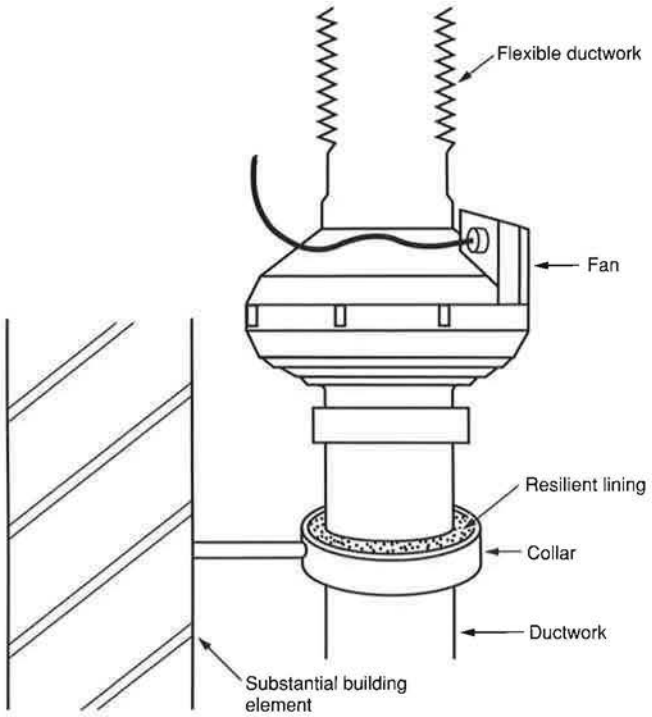

Figure 6 Side view of a fan connected to ductwork, where the ductwork is resiliently isolated from the structure

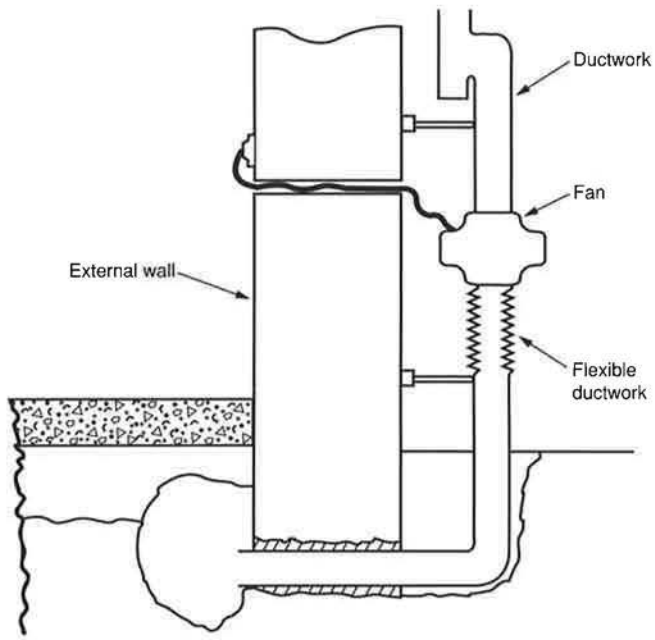

Figure 7 Section through wall showing fan and ductwork mounted on a heavy, rigid support point

Ductwork mounting

Ductwork at floor level must be sealed and fixed so that air is drawn into the sump from the ground under the building and not from the building itself. Ideally, ductwork at higher levels in the building should not be fixed. If this is not possible, the ductwork should be fixed to heavyweight constructions, and only as a last resort mounted on lightweight constructions such as drylined walls or ceilings.

Anticipating the need for remedial work

In some cases the normal good practice described in this leaflet may not succeed in keeping noise down to acceptable levels. Remedial measures can be expensive and difficult to install unless space and

Table 1 Possible solutions to noise from fan-assisted radon sump systems

Problem/symptom	Possible cause	Possible solution
Perceptible vibration or an audible low-frequency tone	The fan is vibrating excessively	Replace or mend fan
	The fan or ductwork is mounted on a lightweight part of the structure	Isolate the fan or ductwork from the structure or fix to heavyweight structure
	Anti-vibration mounts have not been fitted, or have been fitted incorrectly	Fit anti-vibration mounts correctly
Whistling noise	Holes, gaps or cracks in the ductwork or fan casing	Securely repair leaks
	Small obstructions in the airflow, or the air is being channelled through a small hole	Remove obstruction, or widen the air passage
Middle to high frequency broadband noise	Fan noise from the fan casing	Enclose the fan in a box lined with a sound-absorbent quilt
	Fan noise transmitted down the duct, and subsequent noise breakout through the duct or noise radiation from the end of the duct	Install a silencer between the fan and duct. If noise breakout is the problem, box in the duct
	Regenerated noise from the ductwork or from the inlet or discharge	Modify the ductwork to reduce the speed of the airflow, or install a silencer between the source of regenerated noise and the noise-sensitive area. If noise breakout is the problem, box in the duct
	Residual fan vibration	See solutions to perceptible vibration or an audible low-frequency tone

access are available. Where practicable, it is therefore wise to allow:

- Access to the fan and its mounting arrangements
- Access to ductwork and supports, and space to install lagging and flexible support if they are required in future
- Access for silencers to be installed, and space for the silencers themselves, preferably a minimum of 700 mm on either side of the fan
- Space to enclose the fan

CONTROLLING NOISE FROM EXISTING SYSTEMS

If an existing system causes disturbance, it may be possible to reduce the noise to a level where it is no longer annoying. Table 1 describes a range of simple diagnostic measures and possible solutions. However, more detailed advice may be necessary in those cases where the noise is not readily identifiable or easily treated.

CONCLUSION

It may, in some cases, be difficult to make noise from domestic fans completely inaudible. However, the noise need not necessarily be inaudible to be acceptable. By following the installation procedures described in this leaflet, it is possible to minimise the noise associated with radon sump extract systems. If problems do occur, a range of diagnostic and remedial measures are available.

FURTHER INFORMATION

Help with radon-related problems of all kinds is available from the Building Research Establishment (BRE) Radon Hotline (telephone: 0923 664707): questions about the subject of this leaflet will be referred to its author, Nick Antonio. Details of radon sumps and their installation are given in a BRE Report[1]; additional literature on radon protective methods is available from the BRE Bookshop (address at the foot of this page).

For further advice regarding building matters, contact:

BRE Advisory Service
Building Research Establishment
Garston
Watford
WD2 7JR

Telephone: 0923 664664

REFERENCE

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

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).

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