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good building guide

Minimising noise from domestic fan systems

and fan-assisted radon mitigation systems

GBG 26

Noise from domestic fan systems can be a problem. This Guide describes how to design a system to minimise noise disturbance. The Guide also includes advice on how to reduce noise from existing unsatisfactory systems.

The Guide will be of interest to householders, and to builders and designers dealing with noise from household fan systems used for ventilation, condensation control or radon reduction.

Most of this Guide applies equally to domestic fan systems and to fan-assisted radon mitigation systems.
Where it applies ONLY to radon systems, it is printed in blue.

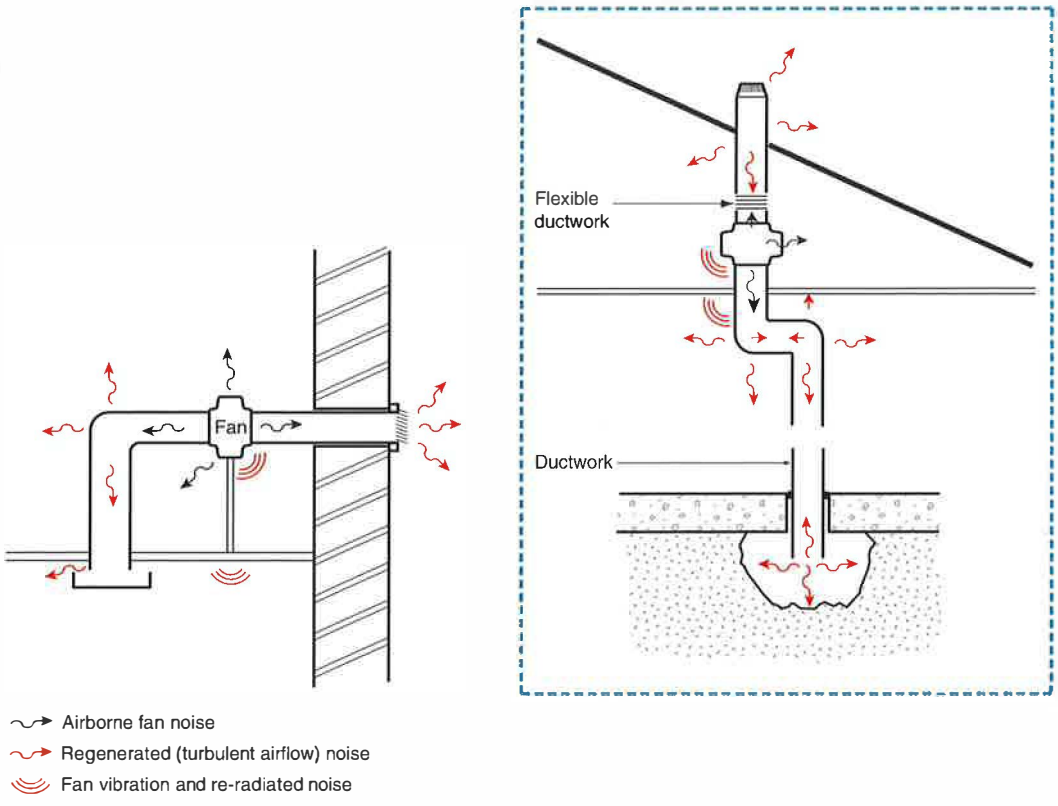

Figure 1 Main noise sources in (left) a fan system and (right) a radon extract system

Noise and domestic fans

A common method of reducing condensation and odours in dwellings is to draw air from inside using a fan and discharge it to the outside.

To reduce radon levels, fans can be used to induce pressure differences between the house, underfloor space and the ground.

A fan can create unacceptable noise and vibration during operation, particularly if the level of background noise is low. Some fans are difficult to treat; these include 'through-the-wall' devices and those located in the affected room, such as cooker hoods and ceiling-mounted fans. In other cases, it may be difficult to make noise from the fan completely inaudible. However, noise from domestic fans need not necessarily be inaudible to be acceptable.

By following the installation procedures described in this Guide, the noise associated with fan systems will be minimised. If problems do occur, a range of diagnostic and remedial measures is available – see page 7.

Sources of noise

There are three main sources of noise from a fan system – see Figure 1:

- fan noise
- regenerated noise
- vibration and re-radiated noise.

Fan noise

Noise is caused mainly by turbulence in the air moving through the fan casing. This noise is broadband (it covers a wide frequency range), but in some cases 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 normally reach significant levels.

Regenerated noise

Regenerated noise is caused by the movement of air past an obstruction: where the velocity of the air changes or where the flow becomes turbulent. Regenerated noise often originates at the entry to the fan 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 fan extract systems, regenerated noise is often strongest at middle or high frequencies. The noise usually 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.

The main frequency of any noise which comes directly from the fan depends on the 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.

The level of noise

The level of noise from a fan can be described in two ways:

- the Sound Power
- the Sound Pressure.

Sound Power levels are independent of distance or fan location and are intrinsic to the fan.

Sound Pressure levels are dependent on distance away from the fan and how it is mounted. If a Sound Pressure level for a fan is given, a distance from the fan should also be stated.

In comparing levels, the same descriptions should be used, so compare Sound Power levels from one system with Sound Power levels from another. Sound Power levels cannot be directly compared with Sound Pressure levels.

Similarly, Sound Pressure levels from one system should be compared with Sound Pressure levels from another, but at the same distance.

Designing a system to minimise noise

Choosing the right system

Install the quietest fan you can afford.This is particularly important for fans in, or close to, noise-sensitive rooms, such as 'through-the-wall' fans; remedial options to reduce noise from these systems are limited. It is worth considering a fan with a ducted intake and outlet because there are more options for control.

Fans vary in noise level, and character. Manufacturers publish data on their fans which may be useful before making a choice. The noise from fans can be described either as a single figure dB(A) level, or in frequency bands such as octave bands (commonly these are given in 125, 250, 500, 1000 (or 1k), and 2000 (or 2k) Hertz bands).

In general, centrifugal fans with non-stalling characteristics are used for radon sump systems. Both 'through-the-wall' fans and those with ducted intake and outlet can be used to reduce radon levels in dwellings with suspended floors. House pressurising fans used to reduce radon levels (which are also sold as anti-condensation measure) are designed specifically for quiet operation.

Putting the system in the right place

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

- outside, near a dwelling
- inside, near hallways, kitchens or bathrooms
- inside, near living rooms
- inside, near bedrooms.

Remember that regenerated noise may be created at some distance from a fan, and a grille, louvre or other terminal unit may create noise. 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.

Mounting the fan

The noise from a fan can be minimised by locating it on a part of the structure which is not responsive to vibration. The most appropriate places to mount a fan are (in order of preference from best to worst):

- fixed 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.

Other factors which may affect the final location of the fan include space access arrangements and the area to be ventilated.

Ductwork

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

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. Where is is practicable, 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 four to five times as long as it is wide is usually sufficient to provide a relatively even airflow.

If the duct is on the outlet side of the fan in a radon system, ensure that the duct is airtight and does not leak radon into the building.

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 Figure 2. 'Attenuators' or 'silencers' are available but most suit only ducted systems. Most silencers take the form of of an oversize duct with a material on the inner surface which absorbs some of the sound as it passes down it.

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, doubling 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 wherever possible
- locating fittings, branches or bends as far apart as possible: spacing three to four duct widths apart will usually reduce turbulent interaction to a negligible level.

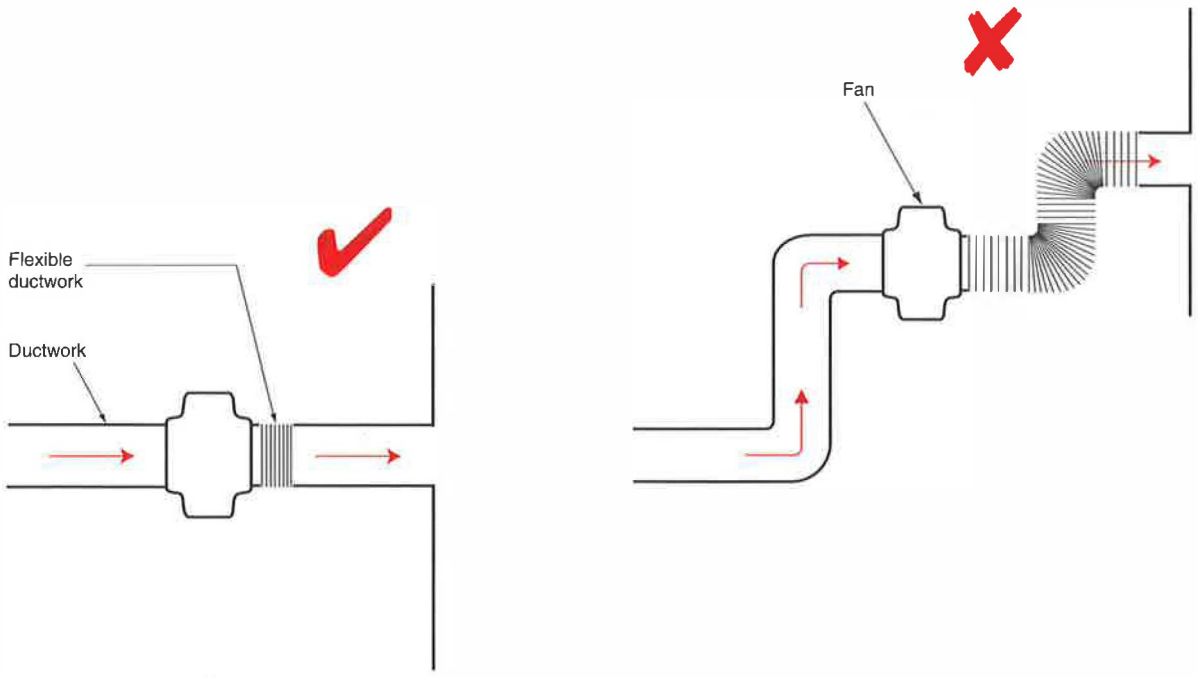

Figure 2 Good (left) and poor (right) airflow conditions to and from a fan

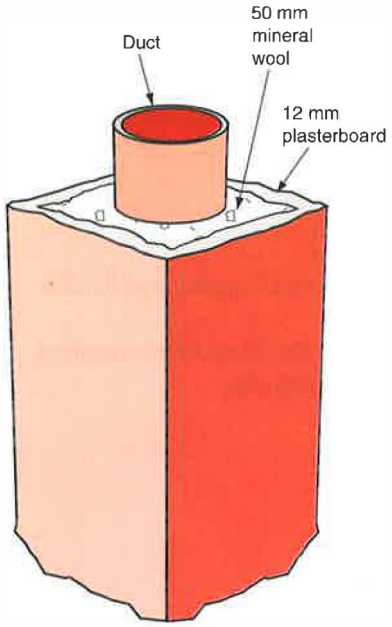

Figure 3 A typical boxed-in duct

Controlling noise breakout through ductwork

In general, noise breakout through ductwork can be controlled by boxing in the ductwork (see Figure 3). 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.

Controlling vibration

The level of fan vibration causing the noise which radiates from 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 4), or connecting the fan to the ductwork but isolating the ductwork from the structure (see Figure 5)
- mounting the fan and ductwork on a heavy, rigid support point which is not easily shaken (see Figure 6)
- stiffening or adding mass to any lightweight element to which the fan or duct is fixed, such as a plasterboard wall or ceiling.

If there is a conflict between supporting the fan safely and isolating the vibration from the structure, 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.

Ductwork mounting

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.

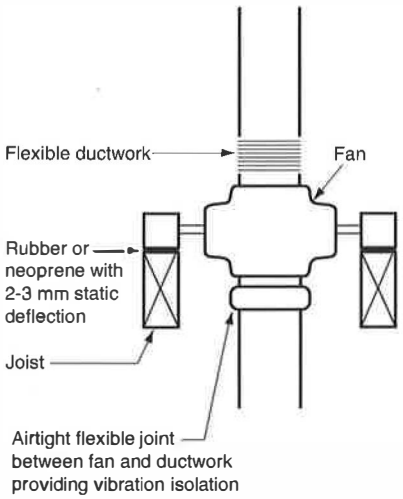

Figure 4 This fan is resiliently isolated from the ductwork and the structure

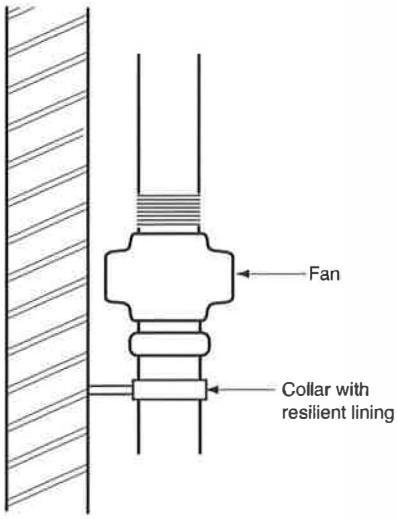

Figure 5 This fan is connected to ductwork which is resiliently isolated from the structure

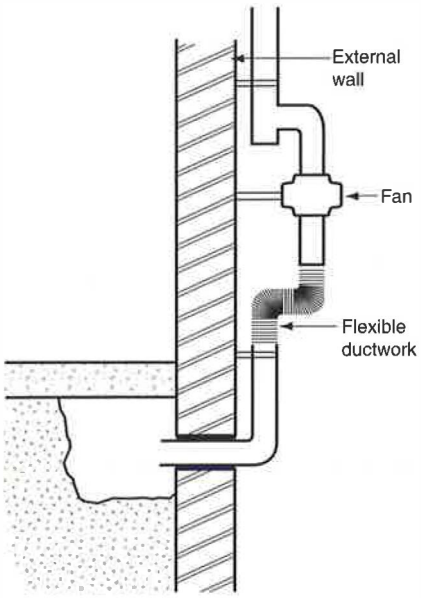

Figure 6 This radon sump extract fan is mounted on a heavy, rigid support point

Anticipating the need for remedial work

In some cases, normal good practice may not succeed in keeping noise down to acceptable levels. The scope for remedial treatment may be limited, for example in 'through-the wall' fans. Remedial measures can be expensive and difficult to install unless space and access are available.

Where practicable, therefore, 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 the future
- access for silencers to be installed, and space for the silencers themselves, preferably a minimum of 700 mm on each 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. For 'through-the-wall' fans, the options for control are limited so a new fan or system may have to be considered. Table 1 describes a range of simple diagnostic measures and possible solutions. More detailed advice may be necessary in those cases where the noise is not readily identifiable or easily treated.

Table 1
Diagnosis and possible solutions

Problem/symptom	Possible cause	Possible solution
Perceptible vibration or an audible low-frequency tone	The fan is vibrating excessively	Replace or repair 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; be careful the fan does not overheat.
	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*.

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Radon sumps: a BRE guide to radon remedial measures in existing dwellings.
BR 227. Garston, BRE, 1992.
Sound control for homes.
BR 238. Garston, BRE, 1993.
Major alterations and conversions: a BRE guide to radon remedial measures in existing dwellings.
BR 267. Garston, BRE, 1994.
Protecting buildings with suspended timber floors: a BRE guide to radon remedial measures in existing dwellings.
BR 270. Garston, BRE.
Positive pressurisation: a BRE guide to radon remedial measures in existing dwellings.
BR 281. Garston, BRE, 1995

More advice about radon

Help with radon-related problems of all kinds is available from the BRE Radon Hotline (tel: 01923 664707)

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