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Domestic draughtproofing: ventilation considerations

Draughtproofing the windows and external doors of UK dwellings can be an effective and relatively inexpensive means of improving comfort and reducing heat loss by natural ventilation.

In most situations, draughtproofing is unlikely to cause any deterioration in the quality of indoor air. There are however a number of simple checks which should be made prior to installation to ensure that the ventilation requirements of the dwelling and its occupants are satisfied. These are summarised in this digest in the form of simple checklists, covering condensation, combustion appliances and other domestic appliances. The digest also presents the results of measurements of air leakage through windows and doors in a sample of typical UK dwellings.

Improved energy efficiency in dwellings is the most effective means of achieving higher standards of thermal comfort, without incurring cost penalties. Current attention is focussed on draughtproofing as a relatively inexpensive measure which can eliminate unwanted draughts and reduce heat loss by ventilation. Under the auspices of the Neighbourhood Energy Action movement alone, some 93,000 dwellings have been draughtproofed since mid-1981. Currently, the 170 Energy Action groups in the UK are installing simple draughtproofing measures in about 60,000 dwellings each year.

Simple advice is needed to ensure that draughtproofing does not lead to, or exacerbate, problems associated with poor indoor air quality. Consideration of the airborne domestic contaminants which can lead to problems if ventilation rates are inadequate has led to the development by BRE of a number of simple checks which should be made before draughtproofing is installed.

Of particular concern in relation to the provision of ventilation are the removal of water vapour from the dwelling and the provision of air to combustion appliances. Ventilation has also been identified as a possible way of solving short-term problems of formaldehyde vapour [1]. The guidelines presented in this digest are based on current knowledge of the mechanisms for controlling each of these contaminants.

Ventilation and infiltration

Natural ventilation is the exchange of inside and outside air through purpose-provided openings such as windows, ventilators and airbricks, and through adventitious openings such as cracks around windows, door frames, skirting boards and electrical and plumbing outlets. The level of ventilation in a dwelling depends largely on two factors: the pressure differences acting across the dwelling (determined by the wind speed, wind direction and difference between internal and external temperatures) and by the air leakage characteristics of the dwelling (ie the size and nature of the openings in the dwelling fabric).

In the context of draughtproofing, it is appropriate to consider the rate at which fresh air is likely to enter the dwelling when all controllable ventila-

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tion openings, such as windows and ventilators, are closed; this is usually referred to as the infiltration rate. Infiltration rates for an individual dwelling vary by as much as a factor of five with weather conditions and internal temperature levels over the course of a heating season.

The effect of draughtproofing any air leakage path is to reduce the dwelling's air infiltration rate, depending broadly on the proportion of total leakage via that path. In some dwellings, air infiltration alone may provide considerably more fresh air than is required for maintaining good indoor air quality; in such cases draughtproofing is likely to be a desirable and beneficial measure. Equally, in some dwellings, infiltration alone may be only just adequate or even inadequate for such purposes as removing moisture vapour from the dwelling or providing an air supply to combustion appliances.

It is for this reason that the application of draughtproofing measures cannot be covered by a few simple guidelines on installation. Dwellings must be assessed individually before draughtproofing. However, measurement of the air infiltration rate of a dwelling or its air leakage characteristics is not possible without specialised equipment and trained staff. In general, assessment of the dwelling will be restricted to visual inspection; this must be designed to ensure that the dwelling has adequate areas of permanent ventilation opening and that draughtproofing is indeed a desirable measure.

Air supply requirements for combustion appliances

One of the major factors in determining ventilation requirements is the need to supply fresh air to fuel-burning appliances. Air is required for two purposes: to ensure that combustion of the fuel is as complete as possible and to ensure the dilution and removal of the products of combustion. These are predominantly water vapour and carbon dioxide with small quantities of other gases, such as oxides of nitrogen, carbon monoxide, formaldehyde and sulphur dioxide depending on the type of fuel and burner.

If adequate combustion air is not provided or inadequate provision is made for the discharge of combustion products, circulation within the dwelling of carbon monoxide could occur at fatal concentrations. About 200 people die each year as a result of carbon monoxide poisoning; the number increases during severe winters. Most fatalities are caused by faulty appliances (generally those which have not been serviced for many years) and blocked flues or chimneys. Some deaths are, however, due to inadequate air supply to combustion appliances.

Combustion appliances can be grouped into three broad categories:

	Balanced flue (room sealed)	Open-flued	Flueless
Combustion air:	Directly from outside	From room	From room
Discharge of combustion products:	Directly to outside	To outside via flue	Into room
See table for provision of combustion air	1	1	1 and 2

For most appliances, permanent openings in the form of airbricks or fixed vents are required; for others, adventitious openings in the dwelling fabric are relied upon to provide an adequate supply of fresh air. If the required permanent openings to outside air are not provided, the dwelling should NOT be draughtproofed and occupants must be advised to consult the appropriate fuel supply organisation.

Table 1 Air supply requirements for fuel burning space heating appliances

Type of appliance	Requirements for permanent opening to the outside air in the room or space containing the appliance as specified in British Standards	Guidance on draughtproofing
Balanced-flue heating appliance	None – air supply provided directly from outside	Check from outside that the terminal is not blocked or covered.
Open-flued gas appliance, including gas fire with back boiler but excluding room gas fire	Permanent opening required: (i) for a decorative (solid fuel effect) appliance, an area of 1800 mm² for each kW of rated input over 2 kW (ii) for any other appliance, an area of 450 mm² for every kW of input rating over 7 kW.	Check that opening is provided and that it is not blocked or covered.
Room gas fire, open-flued	No requirement for permanent opening; it is assumed that there is a minimum adventitious area of 3500 mm².	Unless room containing appliance has clear, permanent ventilation opening, leave at least 2.5 m of window perimeter without draughtproofing.
Flueless gas space heater (fixed)	Permanent opening of at least 9500 mm² and an openable window required. Appliance must NOT be fixed in a bedroom or bathroom.	Check that required opening is provided and that it is not blocked or covered.
Open solid-fuel fire	Permanent opening of at least 5500 mm² or 50% of the throat opening, whichever is the greater.	Check that opening is not blocked or covered.
Other solid fuel flued appliance	Permanent opening with total area equal to at least the combined areas of the primary and secondary air inlets to the appliance.	Check that opening is not blocked or covered.
Oil burning flued appliance	Permanent opening of at least 550 mm² per kW of appliance rated output.	Check that opening is not blocked or covered.
Flueless space heating appliances (LPG, paraffin)	No requirement for permanent opening but adequate ventilation air is essential.	Unless room(s) in which appliance is likely to be used have clear, permanent ventilation openings of at least 9500 mm², they must not be draughtproofed.

Notes:
1. For more detailed guidance on precise areas of openings to the outside air, and dimensions of air vents required to achieve these areas, references 2, 3, 4, 5 and 6 should be consulted.
2. Flueless space heaters should not be used in closed rooms for more than a few hours.

Table 2 Air supply requirements for flueless domestic gas appliances

Type of appliance	Room volume m^3	Requirements for permanent opening to the outside air	Guidance on draughtproofing
Gas cooker	6-9	Opening of 6500 mm² or external door	Room containing gas cooker must not be draughtproofed
	9-11	Opening of 3500 mm² or external door	
	11 and above	No permanent opening required	
Instantaneous water heater	6-11	Opening of 3500 mm²	Room containing appliance must not be draughtproofed
	11 and above	No permanent opening required	
Storage water heater	6-11	Opening of 9500 mm²	Room containing appliance must not be draughtproofed
	11-21	Opening of 3500 mm²	
	21 and above	No permanent opening required	

Notes:
1 Installation of these appliances is not permitted in rooms with volume less than 6 m³
2 Rooms containing these appliances must have an openable window
3 Water heaters in bathrooms must have balanced flues

The guidance given for gas fires, which do not usually require a fixed permanent air-opening, according to standards and regulations, is designed to ensure a minimum adventitious opening of 3500 mm^2: this is based on an assumed average gap width of 1.5 mm around the window. If draughtproofing is deliberately omitted, occupants must be made aware of the reasons and of the importance of maintaining these gaps.

Although appliances in kitchens and bathrooms must be checked for a suitable air supply, it is recommended that the windows of kitchens and bathrooms should not be draughtproofed in any dwelling, even if there are no fuel burning appliances. This is to aid water vapour removal, which is discussed later.

Ventilation and condensation

About 2.5 million dwellings in the UK are believed to suffer from problems of serious surface condensation and mould, resulting in damage to decorations, floors, carpets and furniture. Other causes of dampness which should be identified and remedied include rising damp, penetrating damp and plumbing defects.

Four factors combine to cause condensation: inadequate ventilation, inadequate heating, poor standards of thermal insulation and excessive moisture generation. Inadequate ventilation alone can, however, lead to condensation problems, as has been demonstrated in highly insulated, well heated but airtight dwellings. It is therefore important to ensure, as far as possible, that draughtproofing does not reduce ventilation to such an extent that indoor relative humidity levels rise above 70% for prolonged periods. Above this level, conditions are conducive to the germination of mould fungi, with resultant growth of mould on surfaces.

Average ventilation rates of between 0.5 and 1.5 air changes per hour, with increased ventilation in kitchens and bathrooms during or immediately after periods of moisture generation, will in general ensure the satisfactory removal of moisture. However, direct measurement of ventilation rates in dwellings relies on techniques which are not widely available and for the purposes of draughtproofing, guidance must be based on a subjective assessment of the severity of the dwelling's existing condensation problems.

If the dwelling does not suffer from any problems of condensation or mould, routine draughtproofing of doors, windows (except kitchens and bathrooms) and loft hatches will usually be an effective measure and should not produce problems. Guidelines on the extent to which draughtproofing should be applied in dwellings already affected by condensation are given in Table 3.

As a general rule for the avoidance of condensation, the following recommendations apply:

Moisture should be removed at source if possible. Transfer of moisture from the 'wet' rooms to the living and bedrooms can be limited if kitchen and bathroom doors are kept closed and fitted with draughtproofing; the windows of these rooms should not be draughtproofed.

Extract fans (preferably with humidistat control) can be effective in removing moisture from kitchens and bathrooms but guidance should be sought from the appropriate fuel advisory body if these fans are to be installed in rooms containing open-flued, fuel burning appliances. (Provision for additional permanent ventilation may be necessary to prevent combustion products being drawn back into the room).

All rooms should have provision for introducing limited controllable ventilation, without creating draughts or a security risk.

Table 3 Condensation and draughtproofing

Severity of problem *(See Digest 297)*	Guidance on draughtproofing
1 Severe condensation/ mould in living room or bedrooms	Dwelling should not be draught-proofed
2 Condensation/mould (severe or light) in kitchen or bathroom only.	Living rooms and bedrooms may be draughtproofed. Occupants should be advised of the need to remove moisture at source.
3 Small areas in living rooms or bedrooms affected by condensation/light mould; easily easily removed with damp cloth and no stain remaining.	If affected rooms have permanent ventilation opening, use draughtproofing. If no permanent ventilation, leave at least 2 m of window perimeter without draughtproofing.

Formaldehyde

Formaldehyde vapour is found in most dwellings; in a few isolated cases, it can cause irritation to the eyes, nose and throat. Sources of formaldehyde include adhesives in particle boards, furnishing materials, urea-formaldehyde (UF) foam insulation, tobacco smoke and the combustion products of natural gas.

Particle boards and UF foam have been the subject of much publicity in recent years; as a result, British Standards now exist to govern the manufacture and testing of board products and the manufacture and installation of UF foam insulation. In these two cases, emission of formaldehyde vapour is usually a temporary problem and can be overcome by increased ventilation to all rooms of the house. There is no evidence available to suggest that draughtproofing can lead to formaldehyde related problems and it is therefore reasonable to assume that the ventilation rates required to control moisture vapour will control formaldehyde levels. However, as a precautionary measure, it is recommended that draughtproofing should not be installed in a dwelling which has had UF foam cavity fill insulation installed within the last twelve months, unless permanent ventilation openings are provided.

Air leakage in dwellings

The guidance offered in this digest is based on a visual assessment of the dwelling, the only option likely to be available in the majority of cases. An assessment based on measurement is obviously to be preferred but the equipment and expertise required are currently available in only a few UK organisations. However, simple testing techniques are likely to become more widely available in the not too distant future.

Direct measurement of air infiltration rates relies on the use of tracer gases and is an expensive and time-consuming operation. The techniques are complex and require measurements to be made over a two or three-week period; this approach is likely therefore to be limited to research organisations.

Fan pressurisation is a much simpler technique that can be used to improve understanding of the air leakage characteristics of a dwelling. A portable fan assembly is sealed into a doorway or window opening and the air flow rates required to maintain a series of pressure differences in the range 10 to 60 Pa are measured. (The pressures acting on a dwelling as a result of the natural effects of wind and internal-external temperature difference are usually, on average, no more than about 8 Pa). The test usually takes less than two hours to complete. It should not be done on windy days because it would be difficult to maintain an even and constant pressure distribution over the dwelling.

Measurements of air leakage rates from over 100 dwellings have been studied by BRE. The leakage rates (expressed in air changes per hour (ach) at an applied pressure difference of 50 Pa and with windows, doors and extract fans closed and flues sealed) are shown in Fig 1.

Although air leakage rates cannot be interpreted directly in terms of natural air infiltration rates, it is likely that, in the dwellings at the lower end of the range shown, natural infiltration would be inadequate for a high proportion of the time, unless occupants made regular use of controllable ventilation openings. At the upper end of the range, natural infiltration is likely, on average, to be in excess of requirements.

As fan pressurisation testing becomes a more widely available and accepted technique, it promises to have potential for identifying the extent to which dwellings should be draughtproofed, once the initial checks for provision of air to combustion appliances and condensation have been made. For most dwellings, an air leakage rate at 50 Pa of between 10 and 20 ach (with doors and windows closed and flues sealed) is likely to correspond to an acceptable average air infiltration rate.

For an individual dwelling, the relationship between air leakage rate and air infiltration rate depends on the dwelling's exposure, its situation with regard to adjacent buildings, its orientation and internal-external

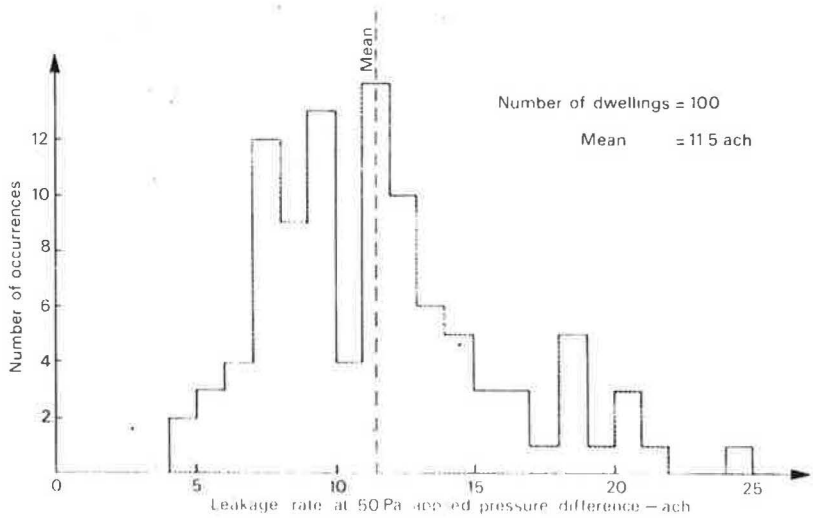

Fig 1 Distribution of whole house leakage rates at 50 Pa

temperature difference. A mathematical model developed at BRE[6] can be used to predict natural air infiltration rates under a range of weather conditions, from the results of a fan pressurisation test. Further development of this model will lead to valuable tools for predicting the ventilation performance of individual dwellings.

Fan pressurisation testing has been used to determine the relative importance of different air leakage paths in dwellings and thence to identify the most appropriate draughtproofing treatments. Measurements to date have found that windows can account for between 5% and 60% of total leakage (at 50 Pa), although 20% to 40% is a more representative range. So in many dwellings, less obvious leakage paths account for the major proportion of ventilation heat loss. Whilst this may help to ensure a safe minimum air infiltration rate, it should also be taken into consideration in assessing the cost effectiveness of routine draughtproofing treatments.

Recommendations

Before draughtproofing a dwelling, check:

there is an adequate air supply to combustion appliances — see Tables 1 and 2;

severity of condensation problems — see Table 3.

If the air supply requirements set out in Tables 1 and 2 are not met, because air vents have not been provided or have been blocked, the dwelling MUST NOT be draughtproofed. Air vents must be installed or unblocked as required, then draughtproofing may proceed, but occupants must be made aware of the importance of permanent ventilation openings and of the need for regular servicing of combustion appliances.

If Table 3 dictates against draughtproofing, measures should be taken to alleviate and prevent condensation. If these prove successful over a period of at least one year, draughtproofing may then be considered.

Do not draughtproof within one year of the installation of urea formaldehyde cavity foam insulation, unless the dwelling has permanent ventilation openings.

If all of the requirements of Tables 1, 2 and 3 have been met, draughtproofing may be fitted to external doors, windows (except in kitchens and bathrooms) and loft hatches.

The removal of moisture at source is important in draughtproofed dwellings: make occupants aware of the guidance available[7] on preventing condensation.

Some activities generate a lot of moisture: clothes washing and drying, tumble driers vented indoors, and cooking; draughtproofing internal doors of kitchens and bathrooms and the installation of extract fans can limit the transfer of moisture to other parts of the dwelling. Seek guidance from the appropriate fuel supply body before fixing an extract fan in a room containing a flued combustion appliance.

A number of domestic airborne contaminants can give cause for concern but, except in unusual circumstances, the levels of ventilation required to supply air to combustion appliances and control moisture vapour will adequately control all contaminants.

References and further reading

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