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Domestic draughtproofing: materials, costs and benefits

Draughtproofing the doors, windows and other sources of excessive air leakage of a dwelling can be an effective and relatively inexpensive means of improving comfort and reducing heat loss by natural ventilation.

The doors and windows considered in this digest are existing components not originally designed for draughtproofing. Products for general use on these components have to fill a wide range of gap sizes, be durable and retain the ease of opening and closing. This digest describes the requirements for such draughtstripping products, identifies kinds of products that are suitable for common types of component, and indicates situations where they can be cost effective. It also considers other sources of leakage and their treatment.

Draughtproofing is a relatively inexpensive measure that can improve the thermal comfort of dwellings by eliminating unwanted draughts and reducing the heat loss in ventilation. It can however be overdone; inadequate ventilation can lead to poor indoor air quality, a potentially dangerous lack of air to combustion appliances and problems from increased condensation — see Digest 306.

This digest concentrates on draughtproofing doors and windows because they are a main source of air leakage into building envelopes[1] and are likely to be the most frequent cause of noticeable draughts. It also considers other (background) sources of leakage, such as suspended timber floors, loft hatches and unused chimneys.

Existing doors and windows that were not originally designed for draughtproofing present a repetitive task of selecting a product of acceptable properties that can both fill the leakage gaps round a component and keep the opening and closing forces within the capacity of dwelling occupants. The task can largely be sidestepped by prior gap surveys and product tests. These have led to the guidance given on the use of various broad kinds of draughtstrip for the types of wood windows and doors and steel windows found in nearly all dwellings.

The guidance does not extent to details of installation, for which reference should be made to manufacturers' instructions or other publications[2], but the current costs of draughtproofing are indicated together with its effects and benefits.

Leakage gaps

The major air leakage gaps at doors and windows are usually found between the closed leaf or sash and its frame; that is, rather than between the outer frame and wall or at the glazing, which are anyway normally dealt with by sealants and not draughtstrips. A lot of doors and windows are old, up to 100 years. The variations in detail design and manufacture over such a period, combined with wear and tear in use, result in a much wider range of gap sizes that would be expected in new components. The range is relevant to both the varying potential for air leakage amongst different components and the selection of draughtproofing materials for general use on them. The important gaps are usually those between the face of an openable member and its frame stops; comparable spans of gap size can be expected between the edges of a member and its frame reveals.

Figure 1 shows the gaps in the commonest type of domestic window found in a national survey. Specimens with the largest gaps may need repair prior to being draughtstripped. Even so, a draughtstrip for general use on these windows should be able to close gaps which range from near zero to upwards of 6 mm. Most domestic casement sashes are of similar dimensions, and hence their effective air leakage areas are broadly proportional to the size of their average gaps. The typical leakage area round the perimeter of a sash of this kind is about 25 cm^2, and for an associated ventlight about 10 cm^2, but a range from three times down to one third of such levels can be expected.

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This kind of distribution, with relatively few cases at high values and a majority below the average, crops up quite frequently with housing and leads to large differences in the benefits of draughtproofing amongst comparable dwellings. For example, few dwellings are on highly exposed sites (and most are quite sheltered) or few use only expensive fuels, in addition to few which have components that fit badly; bad and good fit might be equated with values respectively of above double and below half the overall average for the type of component.

As shown in Table 1, the common types of domestic door and window have varying overall average and largest maximum gaps, but their distributions of gaps are comparable with those shown in Fig 1. Doors have larger perimeters than the usual window sash and relatively large gaps, so they are potentially more draughty, reflected by a typical effective leakage area for a single leaf door of about 75 cm^2; the same applies for large sliding and pivot windows.

Elsewhere in a dwelling, an unused and unblocked chimney of normal size has about five times the effective leakage area of the typical door. A suspended timber floor may seem to present more leakage area , at the gaps under skirting boards or between floor boards, than a chimney. But leakage usually has to pass through air bricks in the external walls as well, and the bricks are more likely than the floor to control the air flow. Most loft hatches are similar in construction to doors and windows, and are fairly small, hence the leakage area is likely to be of the same order as a window sash.

To put these sources of air leakage into perspective, the typical effective leakage area of a normal-sized dwelling totals about 1000 cm^2 ('normal' = three bedrooms and having an internal volume of around 200 m^3 excluding roof voids, with doors and windows closed). Measure ments of air leakage rate under internal pressure[1] suggest that differences would be threefold or more between the leakiest and tightest dwellings of this kind. It is unlikely that any one component or source will account for more than 20 per cent of total leakage area[1][3].

Seasonal changes in gap size

Draughtstrips should be able to follow seasonal changes in gap size, as well as close existing gaps. Seasonal changes occur widely but not exclusively in timber constructions. The gaps around wood doors may change from summer to winter: the largest maximum changes on doors found in the survey were 10 mm, as either an increase or decrease in gap size, although that is exceptional; 90 per cent of doors showed maxima of ±3 mm or less. Less pronounced changes have been observed in wood windows of normal size and construction, and they might also occur in suspended timber floors, for example at the gap under a skirting board.

Variation in gap size round a component

Figure 1 shows how sashes are distributed by maximum or minimum gaps, but not how the gap sizes round any one sash perimeter tend to vary. There is a marked trend in such variations, although individual sashes may show considerable departures from it, and it is also found amongst the other kinds of component in Table 1. This trend is shown in Fig 2.

Because of this variation in gap size, there are two implicatons for the types of draughtstrip which operate by being deformed to fit *within* the leakage gaps. First, if a product is just too small to fill the maximum gap, this will usually be confined to a small proportion of the perimeter length and the effectiveness of the product on the component will not be markedly impaired. Second, if a product does fill the maximum gap, it will frequently be heavily deformed over major parts of the perimeter, with a possible high resistance to component closure if the product is too stiff. Resistance can be reduced by using different sizes at appropriate portions of the perimeter, but this may be unsightly.

Draughtstrips — size and deformability

The different aspects of leakage gap variation can be related to the primary requirements of size and deformability in draughtstrips, including the physical

Table 1 Doors and windows without draughtproofing — survey findings about air leakage gaps

Gap measure *mm*	Windows				Ext doors
	Steel casement	Wood casement	Wood sliding	Wood pivot	Wood hinged
Largest maximum*	7	10	10	10	20
Overall average	0.8	1.3	1.7	2.0	2.0

* 90 per cent of components have much lower maxima, ranging from 0.4 × largest maximum or less for external doors up to 0.7 × or less for sliding and pivot windows

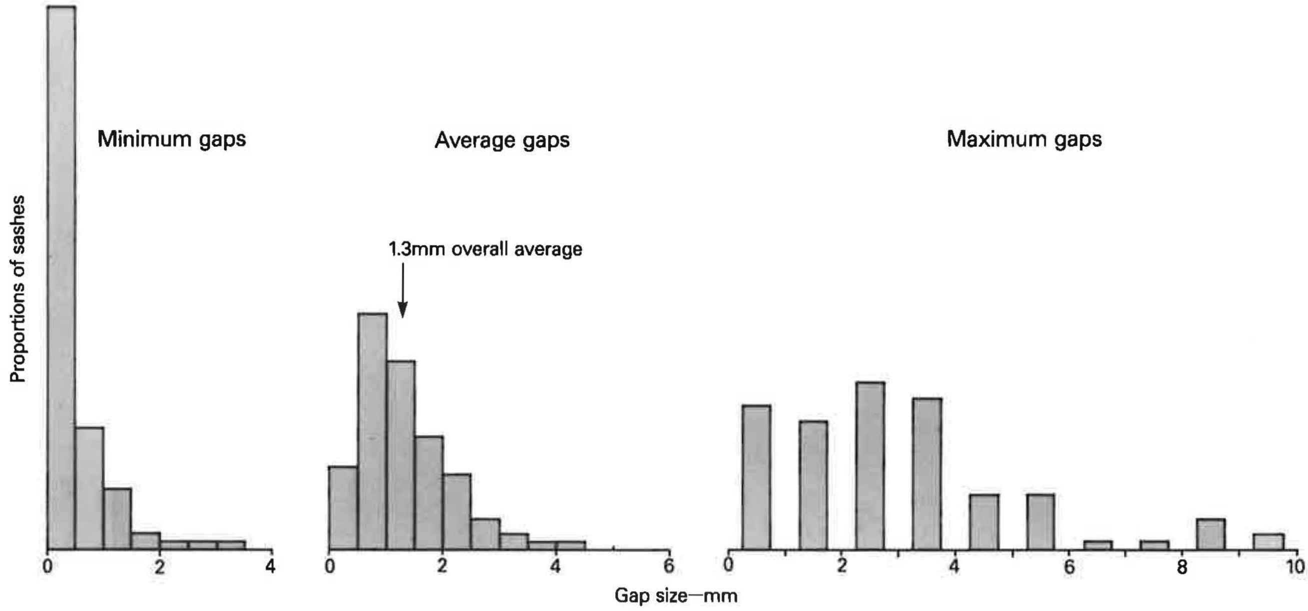


Fig 1 Wood casement windows — distributions of sashes by size of air leakage gap around perimeter

capabilities of occupants in the case of openable components like doors and windows. The requirements vary with the way a draughtstrip works;

(A) with no adjustment, except perhaps for different cross-sectional sizes - fit obtained by compression or sideways (wiping) deflection within the leakage gaps, both to close existing gaps and follow seasonal changes in them;

(B) positioned during fitting to close the existing gaps, or positioned by permanent setting after installation — need then only to follow the seasonal change;

(C) by acting as a gap filler, applied like a sealant — little capacity to follow seasonal changes in components like doors and windows.

With method (C) the required size is formed in-situ; the low subsequent deformability and a rather untidy appearance limit its usefulness for doors. (B) allows such draughtstrips to have a greater resistance per unit of deflection than with (A).

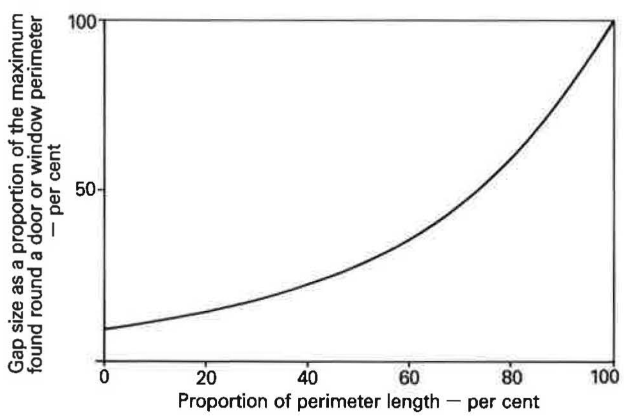


Fig 2 Doors and window sashes — typical variation in leakage gap size around perimeter

Suggested size requirements

The ideal product for general use on one type of existing component would provide a complete seal for all specimens, at least throughout the heating season. But that is unrealistic, and a target of some 90 per cent of specimens is more appropriate.

Even so, this can pose a difficult task for method (A) draughtstrips. On wood doors, for example, a single-sized draughtstrip would need to span gaps of between 1 mm and 10 mm, even after allowing for some 'give' in components. This large operating range can be halved by using (B), on which many door products are based.

On windows, the target is somewhat less difficult for (A) products, with largest gaps to be spanned of around 8 and 6 mm for wood and steel windows respectively. But there is usually the same need to get down to 1 mm or so, and these reduced operating ranges (compared with doors) are still beyond some kinds of draughtstrip construction. The range required with (B) is again much smaller, around 3 mm.

Resistance to deformation

Gap filler products apart, a seal is obtained by deflecting the draughtstrip, and on openable components this should normally be achieved by operating forces that are within the capacity of occupants. The critical force is usually that needed to close a component, and recommendations, based on ergonomic studies[4], might be summarised for Table 1 components as a general maximum of 60 N at the catch or handle; this level could be halved for high-set ventlights.

A 60 N closing force can be converted into allowable resistance per unit length of draughtstrip to attain the required deformation. For strips closing on to the face of typical components, the allowable maximum for casement and pivot windows, including ventlights, is around double that for doors and sliding windows. In either case, the maximum can be doubled for closure with a wiping action, provided the coefficient of sliding friction is low enough. Coefficient values of less than 0.33 are suitable; this tends to exclude special rubbers because their coefficients are often high.

The softness of draughtstrip can be considered in terms of its deflection (mm) per unit of loading (N per metre length of strip). The degree of softness required in products for general use on different types of component varies more widely than allowable resistance, due to the differences in operating range. Under a given force, an (A) product which closes on to the face of a door should yield about 10 times as much as a (B) product which wipes on to the side of a casement or pivot window; the door strip should deflect at an average rate of about 0.2 mm per N/m increment of loading. It is characteristic that all draughtstrips tend to feel soft under finger pressure, due to the localised loading, and laboratory measurements are necessary to establish the true differences between products.

Softness is usually of low importance in dealing with leakage gaps at fixed building elements such as timber floors, although the capacity to fill varying gaps is still required. The only constraint might be whether the fixings of an element are adequate to withstand any pressures from the draughtstrip or filler that arise from its initial deformation and possible seasonal changes.

Draughtstrips - other requirements

There is more to a good draughtstrip than just reducing air leakage: it should also be sufficiently durable, resistant to damage and be of acceptable appearance. Further, if it fails, it should not undermine the basic qualities of the component to which it is fitted. Considerations like these lead to the range of desirable properties listed in Table 2. Amongst them, (b) and (c) cover the detailed attention already given to leakage gap closure.

There has been an upward trend in product life expectancies, but even so it currently seems unwise to rely on a life of more than 10 years. An existing component may, however, have an expected life of 20 years or more, so it could be imprudent to fit a product which demands irreversible modifications to the component or which cannot be removed without considerable damage. Product life can be undermined by deficiences in the fixings. Nail and screw attachment might be preferred on these grounds, if feasible, because both are less dependent than adhesives on adequate surface preparation and freshness of product. Shortcomings in these can be exacerbated with some self-adhesive draughtstrip constructions, due to an inherent tendency to roll up from their ends. But self-adhesive products are also convenient to fit, and have been found satisfactory where these installation conditions were met.

It is likely that a component will be redecorated at least

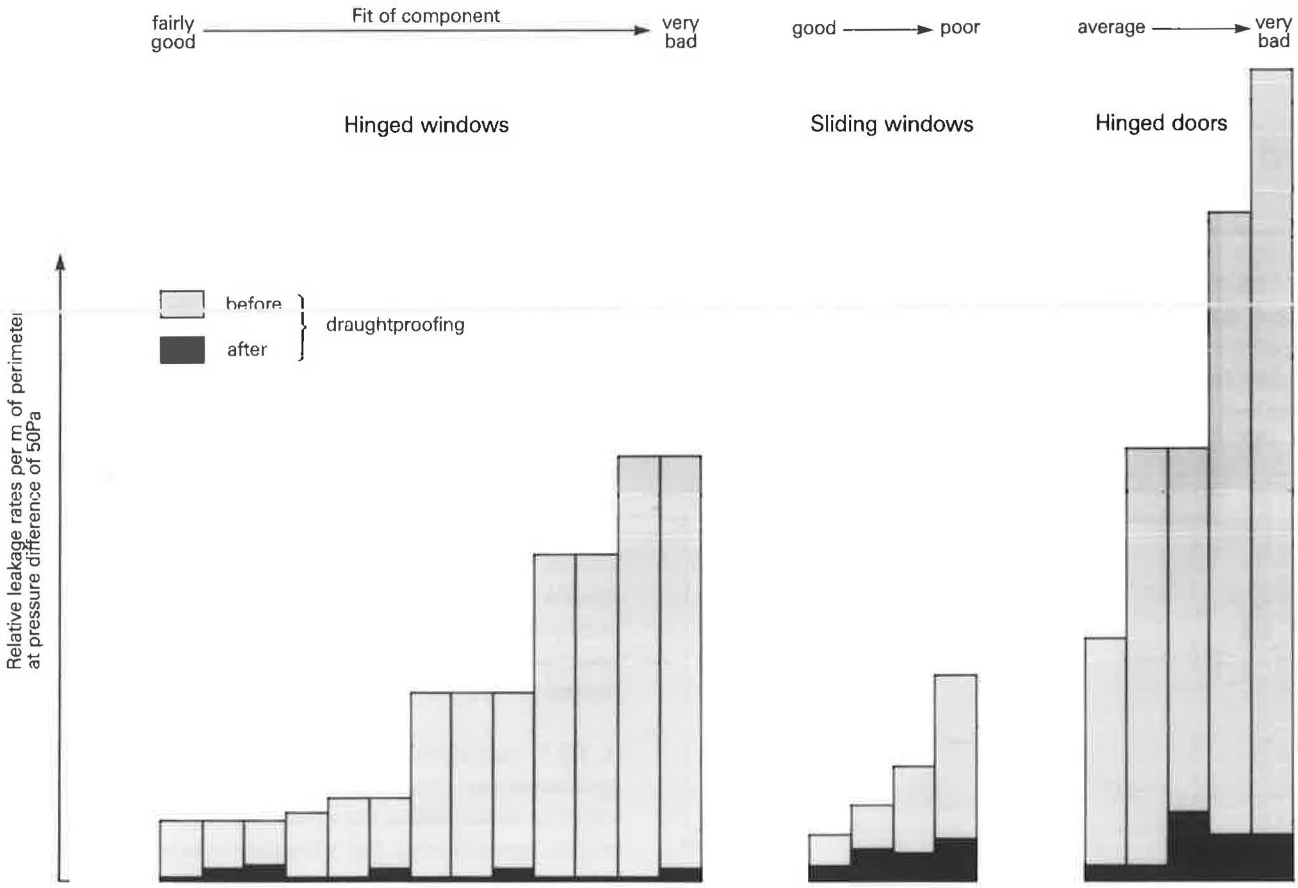


Fig 3 Effects on air leakage of well-fitting draughtstrips

once during the ten-year life of a draughtstrip and wet paint does sometimes get on to in-situ draughtstrips, either accidentally or unwittingly. If paint gets into brush and open foam strips, it can take a long time to dry as well as affecting the product, and damage will be caused if the component is closed too soon. On other, non-porous strips and materials, wet paint may dry normally and often with little effect on their operation. However, there might be incompatibility between the paint and material; for example, alkyd paint can take several months to dry on EDPM rubber strips. A test should be carried out if there is any doubt about suitability.

Table 2 Desirable properties in draughtstrips for existing doors and windows

(a)	Fit without irreversible alterations to door or window
(b)	Sufficient deflection, with low enough resistance
(c)	Slide easily enough (where needed)
(d)	Stand up to repeated opening and closing of component
(e)	Resist adventitious painting
(f)	Remain in place during working life
(g)	Materials that age slowly enough
(h)	Acceptable appearance (or hidden)
(i)	Sufficient reduction in air leakage through component
(j)	Removable without marked damage at end of its life

Air leakage reduction

Draughtstrip products which can close the range of gaps, and are not in themselves permeable, reduce the leakage characteristics of different specimens of a component to much the same level, whatever their initial variations in fit. This is shown in Fig 3, which covers the five types of component in Table 1 and eight kinds of draughtstrip. The descriptions of fit are based on the findings from components in service.

Figure 3 shows that draughtstripped doors and sliding windows are unlikely to be as airtight as hinged windows. It also shows that, although test results for different products may vary considerably, the variations can be relatively unimportant compared with the leakage reductions effected by any of them. A further implication is that the benefits from stripping a badly-fitting component can be very much greater than from one of initially good fit.

Evaluation of products

There is no one product that is ideal for all existing doors and windows. The selection of products depends on evaluating and weighing strengths and weaknesses, largely against the kinds of component and particular applications on which they are to be used.

Some properties may be quantified and measured by test, as suggested here for gap closing capacity and resistance to deformation. The evaluation of others involves subjective judgement, supported by tests and experience from service. An evaluation need not be confined to the items listed in Table 2, given a product which has individual characteristics that might be of concern to dwelling occupants, for example noisiness in use.

This approach can be used to appraise the suitability of broad types of draughtstrip for different kinds of component.

Draughtstrip types and suitability

There are only about a dozen generic types of draughtstrip but if variants by way of materials, fixing and different brands and models are included the total is of the order of 100; even this excludes further variations in finishes and details of housings. A complete appraisal of available products against the different kinds of component would not be up to date for long.

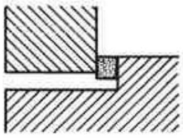
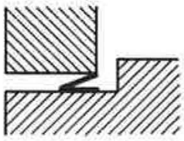
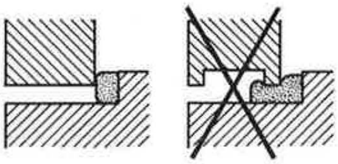
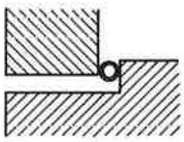
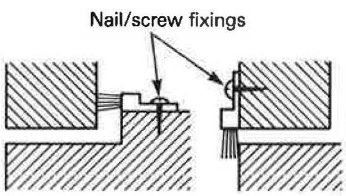
Table 3 gives a limited assessment for five current types of draughtstrip. Each is suitable for at least selective use on two or more of the common kinds of door and window. In this table a designation for general use implies that the gap closing and deformation requirements are met, despite possible limitations in other properties.

A restriction to selective use may be for a number of reasons. One is a limitation in gap closing, such as for PVC foam strips on casement windows; they could nevertheless fit a majority of specimens but not necessarily all the windows in one dwelling. Another could be the variety of designs amongst a particular kind of component, for some of which the draughtstrip is ill-suited, (eg silicone rubber tubing and some wood pivot windows).

Owing to their construction and use, doors normally need a different type of draughtstrip at the threshold than at the top and sides; for example from Table 3, a housed brush for the threshold and V-fin elsewhere. A smaller though sometimes marked source of draught is the letter box. An effective excluder is an airtight receptacle on the inside with a draughtstripped lid, but this is bulky. Neater products are available, such as a secondary flap or a housing with two facing brushes. But the former is ineffective if a package is left through the box, and the latter gives only limited leakage reduction unless the existing box flap is a bad fit; both need to be able to accept a thin letter as well as a substantial package.

Most of the draughtstrips in Table 3 could be used on loft hatches, provided they are positioned where damage is unlikely. Polypropylene brush strips have been found effective round skirting boards, although a neat and inconspicuous design could be needed. But they are unnecessary on floors with close-fitted carpets and underlays; these alone provide quite good draughtproofing for the whole floor if the carpet is tight into the skirtings. In any case, many of the background sources of air leakage are better and more cheaply dealt with by fillers and sealants.

Such fillers could be used round the edges of baffles to close the fireplaces of unused chimneys. Sufficient ventilation must be retained to keep the chimney dry; an air brick or grille should be included at the baffle for a normal chimney, and even with this the leakage area will be reduced twentyfold or more.

Type of draughtstrip *	Windows: Steel casement	Windows: Wood casement	Windows: Wood sliding	Windows: Wood pivot	External doors: Wood hinged	Remarks
Self adhesive foam strip (PVC) 						Relatively stiff; if heavily compressed possible high force needed to close the component, hence match size of strip to sizes of gap.
Self adhesive V fin (Polyester) 						Durability may not be high, but is cheap and easily replaced on doors; somewhat noisy when opening and closing the component, can hum in high winds.
Self adhesive gap filler (Silicone rubber) 						Untidy appearance, but hidden on outward opening windows; high friction; avoid undercuts in sash frame sections; cannot follow appreciable seasonal changes in gap size.
Glued-on tubing (Silicone rubber) 						Not very sightly; high friction; correct size of tubing relative to gap is important at points where sliding and compression occur together, otherwise possible high force needed to close the component.
Finned brush (Polypropylene) in housng (PVC, aluminium) 						Brushes without a central plastics fin are less effective, but may be needed at some door thresholds; short brushes cannot follow substantial seasonal changes in gap size.

Suitability

General use on type of component

Many specimens of type of component

Unsuitable, or of too limited usefulness

* The absence of other types of draughtstrip does not imply that they are unsuitable for any of these components, any more than the indications imply that all brands and models of a type are equally suitable for a component.

Table 3 Assessment of suitability — some draughtstrips for common types of doors and windows

A minor but quite common source of leakage is through clearance holes around pipes through the top of airing cupboards into the roof space; if these gaps are appreciable, filling them may yield a side benefit of a noticeable increase in cupboard temperature. Draughtproofing here and at loft hatches reduces both heat losses into the roof space and the risks of condensation (see Digest 270) but it might tip the balance towards needing better lagging of the water system in the roof.

Draughtproofing — decisions and benefits

Draughtproofing in a dwelling should be limited to worthwhile measures and they must be safe. Provided the overriding ventilation requirements are met, it will generally be safe to draughtproof doors, windows and loft hatches. But there may seem to be little that can be gained with some components, because they are already a good fit; or, at the other extreme, a dwelling might be so draughty that further measures are necessary. In the absence of detailed guidance, decisions have to be based on visual inspection and the experience of occupants.

It is useful if occupants can identify sources of obvious draughts. These should be dealt with on comfort grounds provided it is safe to do so, even if they do not appear to be major leakage apertures. But apertures will usually have to be found by inspection. It is most unlikely that the overall permeability to air of the lining materials and decorations will amount to a significant element of the total leakage area of a dwelling. The important apertures are cracks and openings which create passages from indoors to outside.

The size of many apertures can be assessed from the information already given. Others might be measured, but effective leakage area depends largely on the narrowest point of what might be a tortuous passage. There will anyway be a large element of trial and error in safe but effective draughtproofing.

Points when draughtproofing

A rule of thumb for doors and windows is that it is not worth dealing with them if the average gap is below 0.5 mm, unless there are obvious draughts. If necessary, this can be checked by averaging measurements from the gentle use of feeler gauges at about 10 points spaced round the perimeter of a closed component. A complication with most doors and some windows is that there are two sets of gaps which could control leakage: between the face and stops and between the edges and frame; both should be averaged separately, and the smaller value taken.

Single-glazed components, and metal frames, can create draughts by the local cooling of indoor air, independently of the ingress of cold outdoor air. There may then be little reduction in the total draught if a component is dealt with. A further improvement can be obtained only by close-fitting heavy curtains or double glazing, or fitting secondary glazing to windows at the outset.

Suspended timber floors are likely to date from the time when the addition of effective draughtproofing was not a consideration. Underfloor ventilation is necessary to safeguard against wood rot in the floor. Any blocked air bricks in the external walls should be cleared prior to draughtproofing, but even so the amount of ventilation provided solely by cross-passage between bricks might be inadequate in some older dwellings. In doubtful cases, it would be prudent to attempt general draughtproofing only if there are obvious draughts under normal wind conditions.

Open fires may smoke after draughtproofing, even though ventilation requirements for them have been met. This can be cured only by trial and error with the draughtproofing; that may restore a draught which can be voided only by introducing an air supply direct to the fireplace.

Benefits from draughtproofing

The main benefits from draughtproofing a dwelling are fewer draughts and a reduction in excess ventilation rates, the latter with a consequent reduction in heating energy if dwelling temperatures are maintained at the same levels.

The benefit from reduced draughts is likely to be most marked in cold, windy weather and particularly when temperatures are around freezing point. Ventilation rates can then be several times the winter average, the more so on exposed sites, in addition to the ingress air being cold. Although such conditions usually occur on only a few days each year, the reduction in discomfort could be substantial.

In contrast to such short-term effects, the overall impact of draughtproofing on ventilation rates and energy use is best expressed by averages for the heating season. These averages can vary widely between dwellings, in large part due to differences of site exposure, leakiness and level of heating. For a typical dwelling, based on draughtproofing the doors and windows, the expectation would be a reduction of about 0.2 air changes per hour (ACH) and savings of about 4 per cent on space heating: this for a house on a suburban site with doors and windows of average fit.

The energy savings may not be taken as such by occupants, but rather in more comfort through slightly higher room temperatures.

Costs

The current (1987) cost of draughtstrip materials for a dwelling is likely to be from 50p to £1 per metre run overall, based on retail purchase of products suitable for general use and expected to last a decade. Cheaper products of lower durability appear to have no cost advantages over the longer term.

The total cost per dwelling varies with its size, the types of component and who carries out the work. Based on the typical dwelling size and occupant purchase and fitting (DIY), the current average cost of draughtproofing for the doors and windows in a house should be about £50. It might be four times as much if done by contractors.

Savings

The cost per dwelling should be much the same regardless of site exposure, the fit of the components, cost per unit of usable heat[5] and level of heating. But these four factors all have a multiplicative impact on the savings that could be expected.

The kinds of situation which correspond to high and low savings limits for these factors are described in Table 4. For each of them, high compared with low reflects a 2 to 1 difference or more in savings level, so there is a potential twentyfold overall range in the savings level amongst otherwise comparable dwellings (that is from a maximum when all four factors are high to a minimum when all are low). The typical expectation is well towards the bottom of this range.

It would be a rare dwelling which fell near the top or bottom of the range, but it would not be exceptional for there to be differences from down to half or up to double the typical level. Based on this, and on houses of typical size with a current (1987) average of £325 for annual space heating costs, savings ranging from £7 to £26 per annum could be anticipated from draughtproofing the doors and windows, with a typical expectation of around £13 per annum. Whilst it is difficult to make recommendations about dwellings generally, the following suggestions, related to Table 4, can be made:

> DIY work (time spent being excluded): worth doing except when three factors are near the low limit, and worth doing even then if the fourth factor is high;
>
> commercial contractor work: worth doing when two or more of the factors are near the high limit, provided that neither of the other two factors is low.

These criteria exclude the currently unquantifiable benefits from increased comfort. Such benefits would generally be a bonus on the return from DIY work. They could also tip the balance in favour of draughtproofing where commercial contractors are to be employed, say if comfort is valued as highly as energy saving.

Recommendations

Ensure that minimum ventilation requirements are met.

Use draughtstripping which can close most gaps round existing doors and windows, unless products are to be specifically matched to the components in a dwelling.

Use products which keep the opening and closing forces on operating handles and catches to 60 N or less after draughtproofing, unless greater forces are acceptable to occupants.

Use products with a life expectancy of 10 years or more and which are resistant to adventitious painting during redecoration.

If the cost of draughtproofing is more than, say, double the cost of the materials alone, consider whether the expenditure is worth while.

References and further reading

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Other BRE Digests

270 Condensation in insulated domestic roofs
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Table 4 Factors in heating cost savings from draughtproofing doors and windows

	Range in impact of factor on savings, with typical situations	
Factor	**Low** up to	**High**
Building exposure	sheltered city centre	exposed rural (possibly urban tower block also)
Fit of doors and windows	good	bad
Cost per unit of usable heat	with effient mains gas appliances	using full price electricity
Level of heating	< 8 hours per day, cool	24 hours per day, warm

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