# Control of air leakage is important

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**Publisher's version / Version de l'éditeur:**
https://doi.org/10.4224/40000814
*Canadian Building Digest, 1965-12*

**Canadian Building Digest**

Division of Building Research, National Research Council Canada

**CBD 72**

# Control of Air leakage Is Important

*Originally published December 1965.*

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## Please note

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"Large icicles are hanging from my curtain wall."

"My new roof is leaking and it hasn't rained all winter."

"Mortar joints near the top of my new building are spalling."

These are but a few of the problems brought to members of the Division of Building Research by owners, architects and builders.

Analysis of many such complaints has shown that a great many common building problems occur because of air leakage. It is not difficult to control, but it does require special attention throughout the design and construction of a building.

Air leakage has been discussed in considerable detail in **CBD 23** and **CBD 42**, but because of its importance this Digest will emphasize how to recognize it and prevent the problems associated with it.

Air leakage is the uncontrolled movement of air through walls and roofs, both into a building (infiltration) and out of it (exfiltration), and the interchange of air from the building with that in spaces in the building envelope. Pressure differences that cause infiltration and exfiltration are produced by wind, chimney effect, and the operation of mechanical ventilation systems.

Chimney effect, which occurs when the air masses on opposite sides of a separating element are at different temperatures, is also responsible for the exchange of air inside the building with that in cold spaces in walls, windows and roofs. Openings through which air can leak are unfortunately numerous in most normal constructions at cracks, junctions of materials or elements, and through air-permeable materials.

Air leakage is important because it normally means dirt and odour entry, increased cost of winter heating and summer cooling, cold drafts, and more difficulty in maintaining a controlled relative humidity. Condensation resulting from exfiltration during cold weather can cause rapid deterioration of the building fabric, producing both hazardous situations and the need for costly repairs.

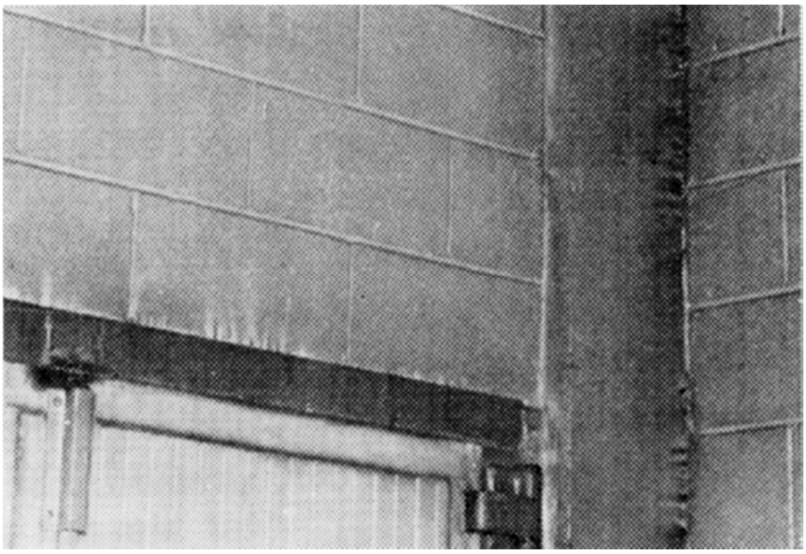

*Figure 1. Dirt patterns as evidence of air leakage.*

There is often no easy identification of air leakage, but smoke can be used to make air movement visible. Evidence that it has been occurring, however, is shown by the feather pattern of dirt deposits that appear adjacent to cracks or joints, such as may be seen in Figure 1 where air has been leaking through the crack between the masonry wall and the structural column. It has also been occurring between the door frame and the wall. The door head detail of Figure 2 shows that air leakage between the door and its frame had been considered, for a compressible gasket was incorporated as weatherstripping, but there was not sufficient recognition of the fact that a masonry wall is air permeable. Although the paint film on the block wall reduced the air permeance of the surface, the joint between this film and the door frame was not sealed.

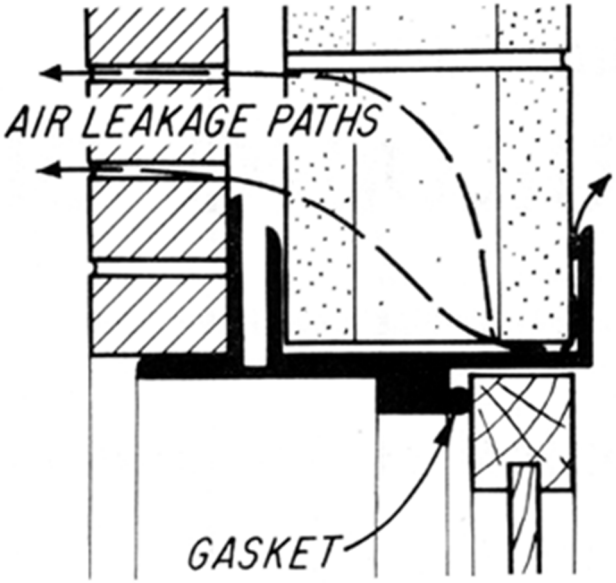


*Figure 2. Door head section showing air leakage paths.*

A double window, as a transparent section of wall containing an air space, presents a good opportunity to observe the effects of air leakage. Evidence that infiltration occurs at windows is clearly shown by accumulations of dirt on sills. Exfiltration through the same windows during cold weather, especially when the building is humidified, causes excessive condensation

between panes. The convective interchange of air between the building and the window space, regardless of whether exfiltration occurs or not, will produce the same result (**CBD 5**).

Windows of this type also provide an opportunity to observe the variation with height of the pressure differences due to chimney effect in a building. Infiltration will keep the windows of the lower floors almost clear, while exfiltration at the upper floors may cause vision to be completely obscured by condensation. Variations of condensation between double windows from one elevation to another also indicate the influence of wind on the direction of air leakage.

Air leakage occurs through a building wall or roof in the same way it occurs at windows. At these locations, however, the condensation is not readily visible and is less frequently recognized. Furthermore, although condensation at windows may not always present a serious risk of damage to the building fabric, in a wall or roof there is cause for concern. Excessive efflorescence, mortar joint spading, discoloration of stone work, masonry unit displacement, corrosion of metals, or icicles hanging from walls are indications of an excess of water in the wall that may be due to air leakage.

Vapour barriers are frequently incorporated to resist the migration of water vapour by diffusion, but they can also be used to great advantage in preventing or minimizing air leakage. To prevent it entirely, however, a vapour barrier must be continuous, without gaps, and sealed at all joints and edges.

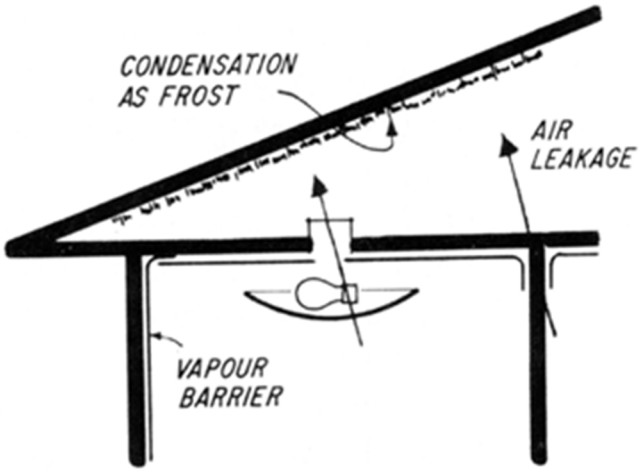


*Figure 3. Detail of the roof indicating air leakage paths.*

The effect of air leakage through a building envelope can sometimes be seen in a heavy frost accumulation on the under side of the roof in an attic space. Upon melting the frost will produce the same effect as a roof leak. Openings through ceilings that will permit the leakage of moist air into a roof space are indicated on the roof detail of Figure 3. Severe accumulations of frost can develop over a prolonged period of extreme cold weather despite generous allowance for natural ventilation. Although ventilation is of considerable value in reducing the severity of condensation problems, it is not a substitute for preventing leakage of moist air into a cold space.

The cause of failures at the tops of solid masonry walls is often obscured by the fact that several phenomena in sequence are required to produce the damage. The primary factor is frequently air leakage, which results in condensation and wetting of materials. Under freezing conditions water will migrate to growing ice lenses, causing excessive expansion and displacement of masonry units. If the outward leakage of air with a dew-point temperature higher than the outside air temperature is prevented, such problems may not occur.

Severe problems resulting from air leakage can occur in metal and glass curtain walls. Following the normal practice of sealing curtain walls against rain penetration at the exterior surface, designers consider that they will also be air tight and do not attempt to seal them at

the interior. Realizing, however, that rain penetration does occur in most curtain walls sealed at the exterior, intricate drainage systems are incorporated within the wall, with openings provided to permit water to flow back to the exterior. The convective interchange of moist air from inside the building with cold spaces in the wall, plus the outward air flow through drainage holes (especially at upper floors) results in excessive condensation within the wall. During cold weather condensation occurs and accumulates as frost. Following a rise of exterior temperature to about 25°F the frost within the wall will melt and water will drain to the exterior. Here it can freeze, producing icicles, which may be large enough to present a real hazard when they fall to a busy street below. The need to prevent the flow of moist air from a building through any cold space within walls cannot be over-emphasized.

The air leakage problems of dirt and odour entry, cold drafts, increased heating and cooling costs and difficulty in maintaining humidity control can only be prevented by complete air tightness, which is often impractical. Fortunately, however, these problems can be accepted to varying degrees, depending upon the building occupancy. Some interstitial condensation can also be tolerated, depending upon how much there is, the design of the enclosure, the materials involved, and where it occurs. It is best, naturally, to prevent air leakage as far as possible. Where the ventilation of a building is dependent upon air leakage, it should be allowed to occur only through passages where problems will not develop.

Many of the building problems experienced today are the result of a lack of appreciation of the real requirements of walls and roofs, and of the importance of the ways in which materials are put together. Ignorance of the fact that air leakage contributes to so many problems, that air in the building can pass through cold wall spaces without leaking to the exterior, and that many constructions are actually air permeable has resulted in inadequate control of air leakage at interior surfaces. The mistaken idea that a building should be sealed at the outside to prevent both rain and air leakage further complicates the situation. In fact, the air seal should be achieved toward the interior and rain penetration controlled by compliance with the open rain screen principle (**CBD 40**). Serious consideration of air leakage and recognition of the real properties of building materials and constructions by designers and tradesmen alike can achieve a marked reduction in the occurrence of problems in building envelopes.

Recognizing that wall materials are not dimensionally stable (**CBD 56**) and that they move differentially from the structural frame, the location of cracks should be anticipated and an air-tight diaphragm or flexible sealant incorporated to maintain air tightness. It should be recognized also that the connections between structural steel members are not air tight. Interior surfaces of exterior walls although concealed behind convertors, panelling or suspended ceilings should be made air tight. Back-up masonry walls should be well laid with full mortar joints. The manner of installation of all pipes, ducts, conduit, and electrical outlets must be thoroughly considered to prevent the occurrence of undesirable situations. When pipes run adjacent to exterior walls and are to be furred in, not only must the exterior wall be air tight, it must also be adequately insulated to prevent cold spots on which condensation could occur in the concealed space. There must always be a continuous air seal between the air-tight part of a wall or ceiling and the frames of all openings such as windows, doors, hatches, ducts, grilles, and so on.

**Conclusion**

Air leakage has been common in most buildings, but with increasing standards of performance, the requirement for humidification in winter, and the trend to taller buildings it is becoming less and less tolerable. Air leakage is not, however, the only source of problems to be considered in the design of walls, windows and roofs. Others have been discussed both individually and collectively in several Digests. The discussion in **CBD 50**, presenting a preferred approach to the arrangement of the main functional components of a wall, provides the best opportunity for the control of air leakage while resolving other problems. Regardless of the approach adopted, the positive control of air leakage can only be achieved by careful attention in design, with adequate inspection during construction to ensure that no weaknesses arise from poor workmanship.