THE SOLUTION

TO

ACHIEVING AIR TIGHTNESS

IN BUILDINGS

"Where Envelope Performance Matters"

BUILDING SCIENCES LTD

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AN OVERVIEW OF BUILDING SCIENCES LTD

We are Building Envelope Consultants providing expert knowledge in respect to the control of *heat, air and moisture* flows out from and in through the envelope. Over the last few years there has been much greater attention to the issue of building air tightness and this market sector now represents a major element in our business.

Based upon our many years of experience in this field we are, we believe, the leading UK specialists in respect to building air leakage identification and control. We maintain our premier position in this market sector by regularly tackling some of the most stringent requirements for air barrier separation and we also maintain close working contacts with key Canadian specialists in this field, who are considered to be amongst the world's leaders in air leakage control.

Our air tightness consultancy services can be applied to the design and construction of new buildings and to the upgrading of tightness in existing buildings. We can also provide specialist air sealing contracting services to tighten up existing leakage envelopes.

Building Sciences Ltd was established in 1986 and over the years we have provided consultancy services to a broad and impressive list of major organisations and we are well known to the Building Research Establishment and the Air Infiltration and Ventilation Centre, two internationally renowned organisations in the air leakage control field.

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BUILDING AIR LEAKAGE

THE UK SITUATION

It is really only fairly recently that the issue of building air leakage has started to be seriously considered. As a result, unlike some other areas of the world, we do not have a long history of documented test results but all of the evidence confirms that many of our buildings are indeed very leaky and considerably leakier than their North American or Scandinavian equivalents.

Test results published by BRE in 1992 show that for offices our buildings are around 2 to 4 times more leaky than North American or Swedish equivalents and our industrial buildings are more than 4 times as leaky as Swedish buildings. These results are fully supported by ongoing test data and confirms the fundamental leakiness of many of our buildings.

Over the last few years many of the major retail store groups have had tightness levels incorporated into their building specifications and have their stores fan pressurisation tested prior to hand over. All of these store groups are ultimately aiming for a tightness level of $5m^3/hr/m^2$ at 50Pa, and while some are currently insisting on this level being achieved, others are aiming for short term target levels of up to $10m^3/hr/m^2$.

Because of the pace of new store development over the last few years there have now been a great many tests conducted in this building sector. In spite of this focus on tightness, many stores are still failing tests and many are failing multiple tests. Over a significant sample of stores tested the average was over $17m^3/hr/m^2$ and the leakiest was $32m^3/hr/m^2$ at 50Pa.

In spite of the need for tightness being specifically addressed at the design and construction phases, many buildings fail to meet their specified tightness level by a large margin. It is of concern to consider how leaky many of our "other" buildings may be where no tightness levels are specified and where no special attention has been paid to the issue of tightness.

We spend a large part of our business life inspecting buildings which have some performance problems due to air leakage. We undertake Envelope Air Leakage Audits of such buildings and provide a detailed report identifying those significant areas of leakage requiring to be sealed. If necessary we can also provide our specialist air sealing contracting service in

order to tighten up such leaky envelopes. Where we have undertaken such services our clients have always been fully satisfied with the results and the perceived problems of performance have been overcome. Most such buildings have not been (and in many cases due their size cannot be) fan tested. There is therefore no quantitative figures on the actual leakage of such buildings before and after sealing, but based on the fact that tightening eliminated the performance problems and from our very wide knowledge of what constitutes excessive leakiness, we are very clear that these buildings were initially very leaky indeed.

Summarising, from all of the qualitative and quantitative data available it is apparent that a great many of our buildings are excessively leaky. This can be very visibly demonstrated by building occupier complaints which can be directly attributed to excessive air leakage, poor tightness performance compared to North American and Scandinavian buildings and extensive test results which show that our buildings routinely do not meet their specified performance levels.

PERFORMANCE PROBLEMS

ASSOCIATED WITH LEAKY BUILDINGS

The following are the problems typically associated with uncontrolled air leakage:

* Occupier discomfort due to draughts as a result of excessive air leakage through the envelope.

* High space conditioning bills. As an example a building with a leakage rate of $20m^3/hr/m^2$ could use up to 100% more space conditioning energy compared to a similar building with a leakage rate of $5m^3/hr/m^2$.

* Space heating systems are sized based on an assumed air change rate. If the change rate is significantly higher than planned then the heating system will not be able to achieve acceptable temperatures.

* Poor air quality due to the ingress of fumes, dust, noise, etc.

* Inability to achieve acceptable pressure conditions in controlled environment buildings.

* Degradation of the building fabric due to moisture built up from humid exfiltrating air. While vapour barriers are usually included in building envelopes, it is frequently overlooked that humid exfiltrating air will carry much more moisture into the fabric than will vapour diffusion.

* Difficulties in balancing air handling systems.

BUILDING TIGHTNESS -

THE AIR BARRIER SYSTEM

We have found that discussions with designers/contractors will usually reveal an acknowledgement of an envelope vapour barrier requirement, but often this will not extend to the recognition of the need for or design of an "air barrier system". In essence this can often mean that the design and construction of the air barrier, ie the plane of air tightness around the envelope, has not been adequately addressed.

In essence a continuous air barrier system must be incorporated into the building envelope during the design/construction process which will effectively control the flow of air out from and in through the fabric. An air barrier may be a specially dedicated system such as a continuous membrane incorporated around the envelope, or more typically as building envelopes usually contain many components which are themselves effective air barriers, then the solution may simply be the more effective linking together of these various air barrier components, ie improved attention to air barrier continuity. To be effective the air barrier system must comply with the following requirements.

* Be continuous around the envelope.
* Comprise materials/components which are air impervious or virtually so.
* Have acceptable mechanical strength.
* Be readily installed.
* Be durable or accessible for maintenance.

THE SERVICES AVAILABLE FROM BUILDING SCIENCES

FOR NEW BUILDINGS

To assist design and construction teams to achieve acceptable and predictable tightness levels for new buildings, Building Sciences Ltd can provide a full range of air tightness services through from design support to final fan testing. The three elements of this service are:

* **Envelope Design Review**

  We would review architects and envelope subcontractors detailed drawings with particular emphasis placed on junctions between subcontractors packages e.g. steelwork to masonry junctions, masonry to cladding, etc. This review would allow us to identify details which may require further consideration by the design team in respect to air tightness.

  Our comments on details which may require refinement or modification would be made on a set of marked up prints or in written format. The designers would then be in a position to make a final decision on the design after giving consideration to our comments.

* **Construction Phase Review**

  While it is anticipated that the majority of air leakage details would be identified during the design review phase, we have found that as some elements of the envelope details are not always included in such drawings we recommend that site inspections are conducted during the construction phase. Site visits are also critical in order to explain the basic design concept and importance of the air barrier to the various specialist envelope subcontractors and also to the site agent/clerk of works who is monitoring the work on a day to day basis. We normally recommend that this construction phase review is conducted in two phases as follows:

  1) With the structure in place and at an early stage in the formation of the envelope air barrier elements, initial site visit to explain to the subcontractors' operatives the concept/importance of the air barrier and to visually inspect the envelope for air tightness. This site visit would be followed by a brief report listing those areas of leakage identified and requiring upgrading.

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2) At a later date with the fabric completed, visit site to inspect the envelope for air tightness. This inspection would be undertaken with the use of hand held smoke pencils, which with the natural differential pressure which always exists across the building envelope will be used to identify areas of air leakage requiring to be upgraded. An alternative and preferable option is to conduct such an inspection with the zone depressurised using the building's air handling systems. We therefore recommend that this visit is scheduled when the air handling systems are in place and operational and these should be arranged for the extract to be in operation with the air supply system shut down.

* **Testing/Inspection on Completion**

Where buildings are specified to achieve a tightness level, then it is usual to conduct a final test using a transportable fan system to pressurise the building to check that the tightness is in compliance with the specification. Such fan testing is frequently undertaken on buildings such as major retail stores, factory units, etc.

The ability to pressure test buildings is however limited by the size of the enclosure and single fan systems are not currently available to accommodate very large buildings. Using multiple fans is a possibility but while there are a number of fairly large fan rigs in this country, to the best of our knowledge these have never been utilised in unison to test large buildings, although this could possibly be considered in future.

Another option which is sometimes considered for large zones is to use the building's air handling systems. In essence these systems can be temporarily modified to include ducting/measuring systems from which the leakage characteristics of the building can be established. This system has however some fairly significant limitations to its use and to the best of our knowledge this has not been widely (if at all) used in the UK, although this option could be developed for the future.

Given the limitations to the pressure testing of very large buildings, we outline below the other options which are available.

- **The Step-by-Step Quality Control Process**

  In Canada there has been a tightness requirement in their Building Code since 1985. With large buildings it has not been practical or cost effective to try to fan test these and thus the Canadian's have opted for a quality control procedure whereby the tightness quality is effectively controlled through the step-by-step review process as outlined above whereby tightness is considered throughout the design, construction and pre-handover phases. With the severe Canadian climate, any defects in air tightness very quickly show themselves and thus this process has been demonstrated to be effective in ensuring an acceptable level of overall envelope air tightness.

- **The Infrared Scanning Process**

  Another option is an infrared scan of the building envelope. Scans are most commonly used to detect defects in the insulation system, but such a scan professionally undertaken will identify any significant areas of air leakage around the envelope. Such a scan will not quantify the air leakage, but will certainly be able to pinpoint if and where this is occurring.

  All areas of air leakage identified during the scan would be mapped for subsequent identification/checking for tightness. Upon return to our offices detailed interpretation of the thermograms would be undertaken and any additional areas of concern will be communicated to the contractor.

  For most buildings we are confident that this infrared scanning process would provide an acceptable means of ensuring that areas of excessive air leakage are avoided thus resulting in a tightly constructed envelope.

THE SERVICES AVAILABLE FROM BUILDING SCIENCES

FOR EXISTING BUILDINGS

For existing buildings with discomfort problems and/or where energy savings are desirable Building Sciences Ltd can provide a full range of air tightness services including identification of all significant areas of leakage, remedial sealing works and testing/inspection on completion, if necessary. The three elements of this service are as follows:

* **Air Leakage Audit**

  This would involve a detailed inspection of the inner envelope of the building. This would be undertaken with hand held smoke pencils using the building's natural differential pressure or more usually with the zone depressurised using the buildings air handling systems which would necessitate switching off the air supply and leaving the air extract in operation.

  After completion of the site element of the audit we would provide a detailed Air Leakage Report identifying all significant areas of leakage requiring to be sealed. The report would be on an envelope component by component basis and would be supported by photographs where appropriate.

  If having reviewed our Air Leakage Report a client was interested in our proposals to undertake the remedial sealing works then we would provide our detailed offer which would include our price and also a Method Statement specifying how the work would be carried out.

* **Remedial Sealing Works**

  We normally recommend that the significant areas of leakage identified are effectively air sealed by linking together the various existing envelope components into a continuous layer. This linking together must be undertaken with products which comply with the following performance specification.

- Be air impervious or virtually so.
- Appropriateness for the crack/gap/hole dimensions.
- Suitable to adhere to the various substrates, some of which cannot be made properly clean or dust free.
- Will be long lasting and will not dry out, crack, etc.
- Be capable of accommodating the anticipated movements in the substrates.
- Be capable of being applied in very difficult to access areas.
- Acceptable post application odour.
- Be capable of being over-painted where this is required.

To achieve these performance requirements necessitates the use of a specialist range of air sealing products which would be applied by our trained installers. Such sealing works would be undertaken by a number of our Site Installers under the direction of one of our Senior Consultants. The effectiveness of the remedial sealing works undertaken would be constantly checked for acceptable tightness by the use of local smoke sensors.

* **Testing/Inspection on Completion**

Where a building has to meet a tightness specification then final fan testing can be carried out as described above for new buildings.

Where a tightness level is not specified or where fan testing is not practical a post sealing check by infrared scan can be undertaken as described above which will confirm the elimination of significant envelope leakage.