AIR LEAKAGE
CONTROL

GUIDELINES FOR INSTALLATION
OF AIR LEAKAGE CONTROL
MEASURES IN COMMERCIAL
BUILDINGS

A&E Services Branch
Technology Sector
RD&D Division
PREFACE

This project on Air Leakage Control Retrofit Measures for High-Rise Office Buildings was proposed by Technology, Research, Development and Demonstration and funded by the Real Property Program. I managed the project and the report was prepared by Canam Building Envelope Specialists Inc. with assistance from Carson Woods Architects Limited and EMS Marketing Communications Inc.

Every year, Public Works and Government Services Canada (PWGSC) spends vast sums of money on the repair and retrofit of buildings. Improved technical knowledge and better understanding of building envelopes, particularly on air leakage and thermal characteristics are extremely important. Cost-effective air-sealing measures in the management of existing buildings and renovation of old buildings will help in achieving maximum energy efficiency by reducing energy consumption and maintenance costs, improving indoor environment and utilizing energy resources in an environmentally responsible and cost-effective fashion. The implementation of the air leakage control retrofit measures outlined in this report could result in very significant savings.

The air-leakage control guidelines developed from this project will become a most frequently used tool in the construction industry.

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PRACTICAL GUIDELINES FOR DESIGNERS, CONTRACTORS AND DEVELOPERS, ON THE INSTALLATION OF AIR LEAKAGE CONTROL MEASURES IN NEW AND EXISTING HIGH-RISE COMMERCIAL BUILDINGS

Section 1: INTRODUCTION AND GENERAL PRINCIPLES

1.1 Scope and Use of Document

1.1.1. This document should always be used in conjunction with the Air Barrier TEK-AID, available from Construction Specifications Canada at 100 Lombard Street, Suite 200, Toronto M5C 1M3. Tel: (416) 777-2198. Fax: (416) 777-2197. Several very important reference works are listed, together with sources in the TEK-AID itself.

In addition, valuable information is contained in the following:


1.1.2 Covers all new and existing buildings of more than three stories intended for commercial use.

1.1.3 The purpose of this document is to reduce the negative economic, environmental and human impacts of inadequate, improperly designed, improperly installed and improperly maintained air barrier systems. Too many examples exist in Canada's high-rise commercial building stock. Practical techniques exist which can be used to virtually eliminate poor air barriers. The authors of this document have chosen to focus on areas which will provide the fastest and most noticeable benefits.
Inadequate air barrier systems allow leakage of air through holes, leaks, cracks and gaps. The leaking air carries humidity as well as assorted particles of dust, dirt and other contaminants. These unfriendly elements are deposited in building materials through which the air passes on its way into, out of, or through the structure. For leakage to occur, there has to be an imbalance of air pressure from one side to the other side of the air barrier. Such imbalances are easy to find in high-rise buildings. Sometimes they are caused by wind pressure on the exterior; sometimes by stack effect, as warm air travels quickly upwards through the building; sometimes by exhaust systems getting rid of stale air; and sometimes by the mechanical system operator trying (against the odds) to condition the indoor environment for maximum comfort.

Faulty air barrier systems affect buildings and occupants in several ways. The most frequent and noticeable include: uncomfortable indoor environments; unnecessarily high heating and air conditioning costs; accelerated decay of building materials, particularly in walls, cladding systems, windows and roofing; and deteriorating aesthetic appearance of the outside of the building. All of these problems can in some part be attributed to faulty air barrier system design and/or installation.

In most instances, geographical location and indoor environmental requirements are not the major causes of air leakage. In the experience of the authors, the worst areas of leakage are: Mechanical Penthouses; Soffits; Parapets; Punched Windows; Overhang Parapets; Links Connecting Below Grade Areas to Other Buildings; Joints Between One System and Another; Doors.

What is a good air barrier system?

It should be continuously impermeable to air. According to the National Research Council of Canada, suggested maximum permeability for each class of air barrier is as follows:

Class 1 (Relative Humidity less than 27%): 0.15 L/s/m²; Class 2 (Relative Humidity 27-55%): 0.10 L/s/m²; Class 2 (Relative Humidity greater than 55%): 0.05 L/s/m². For relative air permeability, see Chart 1: Relative Air Permeability of Various Materials.

It should also be structurally supported so that it cannot shear; durable; and accessible for maintenance and repair.

Where should it be located?

In theory, anywhere in the building envelope, providing it can achieve all
of the above. Traditionally, this means placing it on the warm side of the insulation. It should be in firm contact with the insulation. It may also be located on the cold side of an insulated assembly, but care should be taken to avoid the possibility of moisture problems inside the assembly if the air barrier system is also acting as a vapour barrier. In this location, the air barrier system should have a water vapour permeance greater than that of a Type 2 Vapour Barrier (57.5 metric perms). In all cases, experts should be consulted for advice on the location of the air barrier system and the vapour diffusion retarder.

Compartmentalization and Decoupling

In retrofit applications, where it is possible to create continuity of the air barrier, the interior corners of the building should be sealed in order to 'compartmentalize' each floor area. The effect will be to reduce the pressures caused by the flow of air around the building inside the wall system. It is also advisable to 'decouple' the building vertically in order to reduce the stack effect. This is achieved by a variety of measures, e.g., creating elevator lobbies on each floor, and controlling air leakage through fire doors and all vertical penetrations. The National Building Code requires floor perimeters to be fire-stopped. They should also be sealed to create an air barrier, which will also prevent smoke transfer.

Good luck, and remember:

There are holes that are left and
There are holes that are made
So whoever can fill them
Has an excellent trade!

1.2 The issues

1.2.1 Energy Conservation

1.2.1.2 Background

In a commercial building, the heating, ventilation and air-conditioning (HVAC) system maintains the indoor environment. The HVAC system provides the required conditioned air to different locations based on specific needs, and in a high-rise commercial building, it is also able to satisfy the ventilation requirements. In most high-rise buildings, the
supply of fresh air ventilation does not rely on air leakage through the building envelope. Instead, the mechanical ventilation system is usually designed to counteract the flow of air leakage through the envelope by keeping a slightly positive indoor air pressure. Providing this positive pressure results in the loss of some conditioned air through the envelope's air leakage paths. The leakage has two effects: (i) it increases the moisture loading on the envelope, and (ii) it increases operating costs because of the loss of conditioned (heated or cooled) air.

1.2.1.3. **Potential Cost Benefits**

It is difficult to gauge the effect of air leakage through building envelope in commercial buildings. Since there is very little information available in published literature. According to data published in the ASHRAE Handbook, air leakage in high-rise commercial building typically represents 15 to 30% of the building's thermal load or roughly 4 to 8% of the total energy requirements. This is a significant component. Any reduction in such uncontrolled air leakage, without sacrificing indoor air quality, will have the potential of reducing the overall peak heating and cooling demand and the energy costs. There are, however, a growing number of before-and-after studies of how energy consumption, demand and costs can be reduced by air leakage control measures in high-rise buildings. Some building scientists have reported theoretical savings in a very wide 20 to 60% range based on detailed energy input/output audits. These same sources have observed air leakage control retrofit measures achieving a documented saving of close to 40% for a U.S. six-storey office building.

A recent study published by PWC showed that for a 17-storey office building (Brooke-Claxton-19,730 m² floor area), the whole building airtightness test results showed an improvement in airtightness of 37% after implementing window weatherstripping and caulking, and the sealing of vertical columns from the inside. The exterior metal panel of a 20-storey, 12,800 m² floor area, high-rise office building (Dunton Tower) was replaced with a curtain-wall cladding system. This remodelling improved the airtightness by 43% and reduced the annual energy consumption by more than 11%.
A survey of four electrically-heated high-rise residential buildings\(^1\) in Ontario showed that the peak heating demand varies from 35 to 70 W/m\(^2\) of floor space. During the peak winter conditions (below -18 deg. C. ambient temperature and greater than 5 m/s or 18 km/hour wind velocity), the air infiltration component contributed to the heating load by 12 to 25 W/m\(^2\) - roughly 25 to 40% of peak heating demand.

In 1991/92, Ontario Hydro sponsored a field study to evaluate the impact of air-sealing retrofit measures on energy and peak demand requirements of two high-rise (21-storey and a 10-storey) residential buildings. This study provided startling results that can be summarized as follows:

- Air sealing of gross leaks of building envelope (windows, exterior doors, baseboards, shafts and other envelope and vertical penetrations) improved the airtightness by 30 to 40%;

- Air leakage control offered a reduction in peak space heating demand by 4 to 7 W/m\(^2\) of floor space, and the reduction of annual heating energy was 7.5 to 11.5 kWh/m\(^2\)/year;

- The indoor air quality tests performed and after the air sealing showed that there was no negative impact on the general conditions of comfort and air quality in both buildings;

- The simple payback period for air sealing retrofit was four to six years.

There are several tools available to assess the potential energy and costs benefits of air leakage control. One such assessment method is the air leakage control assessment procedure, ALCAP, developed by Ontario Hydro for high-rise residential buildings, and its success led to ALCAP’s use on more than one hundred and eighty low and high-rise multi-unit residential buildings for Ontario Hydro’s Non-Profit Housing Retrofit Program. ALCAP can be easily adapted for commercial buildings by using a more sophisticated model for

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\(^{1}\) The high-rise building is defined as a building with three or more storeys.
Structural Integrity and Building Life Expectancy

As will be shown in Sections 2 and 3 of this document, wind pressure and stack effect have devastating effects on high-rise buildings with faulty air barriers. Wind on the outside of a building creates tremendous pressures on the structure. If there are holes available through which air can migrate, the pressure imbalances caused by wind and stack effect will help it do so. Stack effect causes air to rise through the building and exfiltrate from the higher floors in any way it can. As this happens, humidity, corrosives and contaminants present in the air do untold damage to everything they touch, from insulation and brickwork, through cladding and every kind of decorative facing. As corrosion and decay progress, the integrity of the structure is weakened and its life expectancy is reduced.

Safety and Liability

From the building owner's point of view, the economic implications of decaying building materials are very serious. The life of a costly building can be cut drastically, operating costs for energy increase, tenant complaints increase, maintenance costs increase, and perhaps most expensive of all, the safety of people passing by the exterior of the building is threatened and the prospect of liability is present, when eventually exterior pieces of the building start to drop off. Injury and damage caused by smoke can also be reduced if vertical smoke transfer is prevented by properly decoupling a building (see 1.1.3. Where should it be located?)

Occupant Comfort and Health

Uncontrolled air leakage also causes problems for people working in a building. Strong drafts caused by stack effect within the building can be unpleasant or even dangerous. A leaky building often features low humidity levels during winter months, which have been shown to affect comfort, morale, health and absenteeism. Research conducted in twelve public schools by Prof. D.H. Green, University of Saskatchewan, showed absenteeism reduced by 20% when relative humidity in the classrooms was raised from 20 to 35%. A further study conducted by the staff of Theodore Sterling Ltd., Vancouver, set an optimum range of relative humidity in the workplace (40 to 60%). The study showed that airborne bacteria, viruses and fungi become more evident when RH remains below or above this range for extended periods of time. (See Chart 2: Optimum relative humidity ranges for health). When humid, contaminated air fights its way out through the building exterior, a common result is fungus or mold, with
their associated health hazards.

1.2.5 **Aesthetics**

One way to recognize a leaky building is by the 'Scars of poor air barrier design and installation'. Efflorescence, water staining, flaking bricks, rust streaks, large holes in masonry, and cracked and peeling finishes are the identification marks of many high-rises with air barrier problems.
Chart 1:
Relative Air Permeability of Various Materials (CMHC), measured leakage at 75 Pa.

<table>
<thead>
<tr>
<th>Test Material</th>
<th>Thickness in mm</th>
<th>L/s/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Various bitumen based membranes</td>
<td>2 to 3</td>
<td>None</td>
</tr>
<tr>
<td>Plywood sheathing</td>
<td>9.5</td>
<td>None</td>
</tr>
<tr>
<td>Extruded polystyrene insulation</td>
<td>38</td>
<td>None</td>
</tr>
<tr>
<td>Foil backed urethan insulation</td>
<td>25</td>
<td>None</td>
</tr>
<tr>
<td>Phenolic insulation</td>
<td>24</td>
<td>None</td>
</tr>
<tr>
<td>Cement board</td>
<td>12</td>
<td>None</td>
</tr>
<tr>
<td>Foil backed gypsum board</td>
<td>12</td>
<td>None</td>
</tr>
<tr>
<td>Sprayed-in-place polyurethane foam</td>
<td>53</td>
<td>None to 0.0024</td>
</tr>
<tr>
<td>Flake board</td>
<td>16</td>
<td>0.0069</td>
</tr>
<tr>
<td>Rainscreen exterior insulated finish system (E.I.F.S.)</td>
<td>-</td>
<td>0.007</td>
</tr>
<tr>
<td>Gypsum board (moisture resistant)</td>
<td>12</td>
<td>0.0091</td>
</tr>
<tr>
<td>Flake board</td>
<td>11</td>
<td>0.0108</td>
</tr>
<tr>
<td>Particle board</td>
<td>12</td>
<td>0.0155</td>
</tr>
<tr>
<td>Reinforced perforated polyolefin</td>
<td>-</td>
<td>0.0195</td>
</tr>
<tr>
<td>Gypsum board</td>
<td>12</td>
<td>0.0196</td>
</tr>
<tr>
<td>Particle board</td>
<td>16</td>
<td>0.0260</td>
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<tr>
<td>Tempered hardboard</td>
<td>3</td>
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</tr>
<tr>
<td>Expanded polystyrene Type 2</td>
<td>-</td>
<td>0.1187</td>
</tr>
<tr>
<td>Roofing felt #3</td>
<td>-</td>
<td>0.1873</td>
</tr>
<tr>
<td>Non-perforated asphalt felt #15</td>
<td>-</td>
<td>0.2706</td>
</tr>
<tr>
<td>Perforated asphalt felt #15</td>
<td>-</td>
<td>0.3962</td>
</tr>
<tr>
<td>Glass fibre rigid insulation board with spun-bonded olefin film 1 face</td>
<td>-</td>
<td>0.4880</td>
</tr>
<tr>
<td>Plain fibre board</td>
<td>11</td>
<td>0.8223</td>
</tr>
<tr>
<td>Asphalt impregnated fibre board</td>
<td>11</td>
<td>0.8285</td>
</tr>
<tr>
<td>Spun bonded olefin film</td>
<td>-</td>
<td>0.9593</td>
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<tr>
<td>Perforated polyethylene #2</td>
<td>-</td>
<td>3.231</td>
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<td>Perforated polyethylene #1</td>
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<td>4.032</td>
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<tr>
<td>Glass fibre insulation</td>
<td>-</td>
<td>36.73</td>
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<tr>
<td>Vermiculite insulation</td>
<td>-</td>
<td>70.49</td>
</tr>
<tr>
<td>Cellulose insulation</td>
<td>-</td>
<td>86.96</td>
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Chart 2: Optimum relative humidity ranges for health

<table>
<thead>
<tr>
<th></th>
<th>% RH</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
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</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Viruses</td>
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<tr>
<td>Fungi</td>
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<tr>
<td>Mites</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Allergic rhinitis and Asthma</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Respiratory infections</td>
<td></td>
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<td></td>
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<tr>
<td>Chemical Interactions</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Ozone production</td>
<td></td>
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</tr>
</tbody>
</table>
Section 2: AIR LEAKAGE BY BUILDING COMPONENT

(Methods and Materials are detailed in Section 3)

POINTS TO SEAL

2.1 Below Grade

Basement and Ground Floor Junction
Building Core Walls
Floor Slab/Wall Joints
Mechanical Rooms/Electrical Rooms
Laundries and Garbage Rooms
Corridors, Vestibules and Elevator Lobbies
Pipe Duct and Conduit Penetrations
Service and Inspection Hatches
Loading Bay

2.2 Exterior Walls

2.2.1 The Primary Air Barrier

2.2.2 Junctions in the Building Envelope

Exterior Wall to Roof
Floor to Exterior Walls
Window to Wall
Walls to Soffits
Walls to Foundations
Junction between Dissimilar Materials in Building Envelope

SECTION 3 REFERENCE #

3.5.1.2.
3.5.1.3.
3.5.1.4.
3.5.1.5.
3.5.1.6.
3.5.1.7.
3.5.1.8.
3.5.1.9.
3.5.1.10.
3.5.2.1
3.5.2.2.1
3.5.2.2.2.
3.5.2.2.3.
3.5.2.2.4.
3.5.2.2.5.
3.5.2.2.6.
3.5.2.2.7.
Compartmentalization of Cavities in the Building Envelope 3.5.2.2.8.

2.3 Exterior Wall Openings

External Doors 3.5.3.1
Revolving Entrance Doors 3.5.3.2
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Electrical Penetrations in Exterior Walls 3.5.3.6.
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Incremental Through the Wall Units 3.5.3.8.

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Fire Rated Doors and Partitions 3.5.4.2.
Plumbing Holes, Electrical and Communication Conduit 3.5.4.3.
Ductwork Penetrations 3.5.4.4.

2.5 Roofs and Roof Openings

Drains and Cold Vents 3.5.5.1.
Chimneys and Hot Vents 3.5.5.2.
Skylights, Curb Mounted Equipment and Smoke and Access Hatches 3.5.5.3.
Mechanical Penthouses 3.5.5.4.

2.7 Shafts 3.6.
Many materials have the characteristics required of air barriers while others qualify only in part. Some materials having acceptable air permeability ratings may not be suitable for air barrier construction for other reasons such as susceptibility to degradation, thermal instability, moisture sensitivity, chemical incompatibility, insufficient strength to take pressure loads or difficulty in making durable joints.

Unsupported polyethylene film cannot be recommended as an air barrier material for high-rise buildings because of susceptibility to damage by high wind loads and the difficulty of sealing joints effectively and durably. Some trowel-applied mortars or pargings tend to become brittle and cannot maintain a seal if the building moves or the substrate shrinks. These materials also cannot bridge gaps or cracks in the substrate and so must often be combined with some other air sealing technique.

Other materials have characteristics which may influence where they can be used. Bituminous membranes, asphalt impregnated gypsum board, foil backed gypsum board, foil backed rigid insulations and extruded polystyrene foam insulation have resistance to vapour diffusion, so they must be used with care in exterior situations where they may create secondary vapour barriers beyond the dew point. Relative air permeabilities of various materials measured at 75 Pa. are listed in (Chart 1 at the end of Section 1).

3.1. Jointing Materials and Membranes

The weakest points in most air barrier systems are the joints - between materials and different components forming the system, where services penetrate, and around operable openings such as doors and windows. Depending upon the design of the air barrier system, a variety of jointing materials are available. These can be classified under 4 headings: (1) Sealants: caulking materials, mastics, coatings, etc. (2) Weather-stripping: gaskets, packing, etc. (3) Foams: single and two-component polyurethane. (4) Membranes.

3.1.1. Sealants

Apart from the usual considerations relating to these products i.e., durability, colour, ease of use, economics, paintability, etc., a primary concern, particularly, in retrofit, is odour. Most sealants contain solvents which will smell when freshly applied but which will fade fairly quickly. Some will not. Some clear materials will yellow with aging. For most air leakage control installations, to avoid colour matching problems, clear, rubber based paintable products which are stipulated by the manufacturer, as suitable for interior use, should be used. For some applications, e.g., large cracks, sealants must be used together with "backer rods".
De-coupling of floors in existing buildings built prior to 1985 may require the installation of appropriate sealants to supplement the existing mineral-fibre, fire-stopping materials stuffed into vertical penetrations and around floor edges. Such sealants may have to be installed from underneath where access is available above ceilings. Materials such as special mortars are available which are self supporting and will meet appropriate fire-rating requirements when tested in accordance with CAN 4-S115-M "Standard Method of Fire Tests of Firestop Systems", ASTM-E814-83 "Standard Method of Fire Tests of Through-Penetration Fire Stops" and CAN 4-S114-M "Standard Method of Test for Determination of Non-Combustibility in Building Materials.

3.1.2. Weatherstripping

Tightening windows, as a retrofit measure, is usually cost-effective. Weather-stripping systems are available for all types of windows. A whole variety of plastic extrusions, replacement pile, in-situ gasket forming and closed-cell rubber and plastic foam products can be used, in combination, to upgrade existing windows. Durability is a primary consideration with steel and commercial doors. Experience has shown that heavy-duty moulded V-seal type products installed on the jamb, or vinyl-clad foam compression-type materials mounted on the stop, will last longer and stay tight even when doors warp. Door bottom seals should be installed on front and rear faces of doors and checked every year. Refer to Section 3.5.3. "Exterior Wall Openings".

3.1.3. In-situ Foams

These fall generally into two groups: two component and one component. Urethanes are the most common type of foam and, as two-component types, come in a vast range of formulations - created with a variety of densities, rates of cure, permeability, and levels of fire and smoke resistance to suit a wide range of applications. For air barrier use, densities of 16 to 50 kg/m³ (1.0 to 3 lb/ft³) range are typical where the lower density is used to reduce cost, although the greater open cell characteristics of such foam will reduce its bonding and structural strengths. Curing is by chemical means, Product and Installation Standards have been established, plus Environmental concerns dealt with to the satisfaction of the Canadian Construction Materials Board (C.C.M.B.).

Two component foams can be used as insulating air/vapour barriers, spray applied, and as sealants where larger gaps and holes have to be filled, such as roof/wall intersections, window perimeters and mullions, and hard-to-access areas. They are generally applied using specialized truck-mounted
equipment in large scale projects, however, for smaller and more difficult areas, self-contained, portable and disposable kits are available in different sizes.

One component foams are all formulated as slow-reacting urethanes and are cured by moisture in the air. A variety of brands are available with basically the same chemical structure and density but variable rates of post-expansion and cure. Post expansion rates range from 10% to in excess of 100% and cure times vary from one minute to several hours. They are available in cans or large cylinders, in special cylinders with applicator guns, and are used primarily as insulating air/vapour barrier sealants around windows, door perimeters and other penetrations through exterior walls.

3.1.4. Membranes

These materials have a high resistance to air leakage but they also fall generally into two groups: Sheet membranes and liquid applied membranes do not have the structural properties to transfer pressure loads directly to the supporting structure and generally must be supported by a masonry or board substrate. Sheet membranes usually consist of prefabricated flexible, modified bituminous sheets. They are installed by heat fusing, self-adhesive or as separately adhered system with all laps sealed. Commonly used in masonry construction where blocks, columns and membranes work together to create a continuous structural plane of air-tightness. Liquid applied membranes are trowel or spray applied to masonry surfaces to form a continuous monolithic film. The membrane cures to provide a flexible, elastic film with crack bridging capabilities. They are particularly suitable for applications where sheet materials are awkward to cut and fit such as around brick ties. In general, they are located within the wall assembly as components of "non-accessible" air barrier systems. As an example, consider their use in brick veneer and concrete block walls. Fig. 3.1.4.a.

Brick veneer is a very popular cladding material. It can be applied over steel stud or concrete block back-up-walls.

Concrete block masonry by itself offers very little resistance to the passage of air, heat, water vapour, or liquid water. It does have considerable storage capacity for heat and moisture. Its most important function is to provide support for the brick veneer and the insulation, air and vapour seals and finishes. Its ability to resist lateral loads is limited so, beyond a certain length, it must be stabilized at regular intervals with pilasters or intersection walls. It should be noted that with a good air barrier, the back-up walls'
Brick veneer (first stage of wind screen) is recommended.

Flashing

Weep hole

Rope and sealant

Cavity (40-50 mm) is recommended.

Membrane (air & vapour barrier)

Sealant

Wind pressure

Wind

Figure 3.1.4.a
Brick Veneer Block Backup (Rain Screen) Wall
structural requirements may increase. In a wall that offers little resistance to the passage of air, the wall actually feels only a portion of the total wind pressure. Once the wall has an airtight membrane applied to it, it will feel the full wind load. The structural engineer must take this into account.

The air barrier for a concrete block back-up wall must do more than just seal up the pores of the blocks. The air barrier materials must bridge cracks that develop in the masonry, withstand expansion and contraction due to aging and changes in temperature and humidity. It must also bridge any gaps left in construction between the concrete block infill walls and the structural frame and slabs of the building. The continuity of the air barrier junctions between different assemblies such as windows or other wall assemblies must also be provided.

The air barrier material or system must incorporate the following in the design:

- a certain amount of elasticity to accommodate movements in the substrate;
- the adhesive strength and compatibility to bond to the substrate and other assemblies surfaces;
- the cohesive strength not to tear or creep under sustained air pressure loadings, especially where it is not supported continuously.

Because a brick veneer cavity wall has metal brick ties spaced about 400 mm (16") o.c. vertically and 1000 mm (40") o.c. horizontally, staggered from course to course, the air barrier must be capable of being fitted around the wire connectors while maintaining continuity of airtightness.

An air barrier installed on the outside of the concrete block makes it easier to maintain its continuity. The recommended air barrier system is a torchable grade rubberized asphalt sheet, that is fused to the block and lapped at the membrane joints. Because this type of membrane is strong, gaps between block and structural concrete frame can be bridged with the same materials. If necessary, the material can be reinforced with a strip of the same material fused over areas where gaps need to be bridged. The membrane can be folded into openings; door frames and window frames. The gap between these frames and the rough opening can be sealed with a backer rope and a compatible sealant or with polyurethane foam. The joint must be properly detailed to support the sealant.
Other types of membrane available include polyethylene sheet, spun bonded polyolefin membrane, EPDM sheets, butyl, polyvinyl chloride. All of these membranes must generally be supported by a substrate such as masonry or a board product.

3.2. Primary Air Barriers (Rigid)

These materials and systems (prefabricated assemblies) have sufficient strength and stiffness to be fastened to an intermediate support or directly to the primary structure of the building. They are generally air impermeable and have self-supporting structural properties.

3.2.1. Materials

Materials that qualify include:

- Cast-in-place Concrete
- Precast Concrete
- Gypsum Board Products
- Plywood and Particle Boards
- Sheet Steel
- Glass

Where these materials form part of an air barrier system, the performance of the system will depend strongly on the sealants and gaskets used to maintain continuity between elements.

The following examples describe how an air barrier can be achieved using gypsum board.

Two different techniques are used. Their essential difference is in the locations of the plane of airtightness.

- the Accessible Drywall approach, and
- the Non-accessible Drywall Approach.

3.2.1.1. Accessible Drywall Approach

In the Accessible Drywall Approach, the interior (exposed) layer of gypsum board constitutes the main component of the air barrier system. The joints between boards are taped and finished and high performance sealants or gaskets are used to seal the gypsum board.
to other materials. The Accessible Drywall Approach offers the advantage of providing easy access to the air barrier from the interior, providing for easy inspection and repairs.

The Accessible Drywall Approach works well with all concrete structures. A variety of air seal materials can be used to seal the gypsum board to the concrete floor and to the underside of the slab (Fig. 3.2.1.1.a). Since the concrete floor itself is virtually impermeable to air, it ensures the continuity of the air barrier through its thickness. In areas where more air movement is anticipated such as the interface between gypsum board and concrete slab ceiling, a strip of reinforced elastomeric membrane is often used. A suggested detail for the air barrier continuity at party wall connections is provided in Fig. 3.2.1.1.b.

In a steel structure, achieving an airtight enclosure with the Accessible Drywall Approach may be complicated. It is difficult to achieve a durable seal between the wall air barrier and the metal deck or spandrel beam/column intersection. In this case, to facilitate achievement of continuity of the plane of airtightness, the Non-accessible Drywall Approach is often the better option (Fig. 3.2.1.1.c).

3.2.1.2. Non-Accessible Drywall Approach

In this system, gypsum board sheathing is the main component of the air barrier system. The joints between boards are taped with a reinforced self-adhesive tape, and joints between the boards and other components are sealed using strips of elastomeric membrane. If aluminum foil backed gypsum board is used, the foil should face the inside stud cavity as the sealant and strips of elastomeric membrane adhere better to the paper liner than foil. To avoid condensation problems, insulation should be fastened to the outside of the gypsum board not inside the stud cavity.

This approach usually requires fewer penetrations than the Accessible Drywall Approach (outlet boxes, supply piping, and wiring to mechanical services, etc.). Brick ties are the main penetration. The external location is particularly advantageous with a steel structure because the air barrier can usually be extended past the steel columns and floors with few complications.
Figure 3.2.1.1.a
Accessible Drywall Approach

Gypsum wallboard

Air seal

Concrete floor slab

Suitable for construction

Note:
Gypsum board air barriers must be structurally designed for wind loads

Figure 3.2.1.1.b
Air barrier Drywall Across Party Wall

Suitable for construction
Figure 3.2.1.1.c
Non-accessible Drywall Approach

Note:
Gypsum board air barriers must be structurally designed for wind loads

Gypsum wallboard
Tape (air seal)
Rope and seal (air seal)
Membrane strip (air barrier)
Since gypsum board and air seal materials will be inaccessible once the insulation and exterior cladding are installed, the materials specified must be durable and attached in a way that ensures the long term performance of the system. As a result, waterproof flexible membranes are usually preferred to sealants for connections between airtight materials. Construction and inspection are also important, since the air barrier system is inaccessible for repair or maintenance. At a minimum, a daylight walk through the building before the insulation and interior finishes are installed will highlight holes and cracks in the air barrier that have been missed. Field testing before closing should also be mandatory.

3.2.2. Prefabricated Assemblies

These systems consist of multiple cast or assembled components which may be face-sealed or contain a non-accessible plane or airtightness within the assembly. Types of system, which are structured to support and transfer wind loads, include:

- Precast Concrete Cladding and Sandwich Panels
- Curtain Wall Systems
- Windows and Doors

3.2.2.1. Precast Concrete Cladding

Precast concrete is relatively impervious to air and water. It is also rigid and usually structured to support and transfer wind loads. For this reason, a precast panel can provide an effective air barrier component to the wall system, be it as a simple exterior panel or as a vented and drained sandwich panel. However, joints require particular attention.

The most common air seal method is to use a polyethylene foam rope and a sealant. However, because the panels are external to the structural columns and beams, it is often difficult to air seal joints from the outside and impossible from the inside. Installation from the outside involves installing backer rope and sealant to a depth of 100 mm (4") or more. This can be done providing the joint is wide enough (at least 25 mm (1")) to allow access to the interior face of the panel. Horizontal joints between panels incorporating an interior upstand are not accessible and must be sealed from the inside.
Installation of the air seal from the inside gives better access to most of the joint lengths except where spandrel beams, floor slabs and columns are in the way. These obstructions can represent a considerable proportion of joint length. To a certain extent, this problem can be reduced by the design of the panels, but it will never be eliminated. In the case of such obstructions, it is usually necessary to seal the gap between the panel and the structural framework of the building. This often does not provide a complete solution either because vertical building services such as ductwork or piping are often located at the perimeter of the building.

The choice of a precast cladding system and its detailing should be influenced by the ease with which the air barrier system can be installed. Contractor should demand a detailed explanation of the air barrier installation system from the architect.

3.2.2.2. Curtain Wall Systems

In pre-engineered curtain walls, the air barrier system comprises glass, metal pan, metal extrusions, and a variety of gaskets, tapes and sealants (Fig. 3.2.2.2.a). The air barrier is complex and leakage paths may occur through the interconnected passages in hollow sections at junctions and corners. These are not easy to identify in two-dimensional-drawings. They can however be discovered by careful on-site inspection and testing.

Because of this complication, curtain walls are the only wall system where an air leakage standard has been in use for some time. They can be tested to widely recognized standards for air leakage and rain penetration. The test procedures are set out in ASTM standards such as E331-86 Standard Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference. A similar test (ASTM E547-86) measures rain penetration through curtain walls under cyclic (i.e. variable or gusty) static air pressure differentials (measured in Pascal (pa) per square metre (m2)). ASTM E283-84 sets out a test method for measuring air leakage through windows, curtain walls and doors.

The Architectural Aluminum Manufacturers Association (AAMA) has defined acceptable air infiltration levels (0.3 L/s/m2 @ 75 pa). When tested for water penetration, the wall must support a 290 pa pressure difference (equivalent to a 76 km/hr windspeed) with no water leakage.
Figure 3.2.2.2.a
Metal Air Barrier in Curtain Wall
Most Canadian curtain wall systems easily meet these requirements. In fact, most systems have one third to one quarter the air leakage called for by AAMA. Test results are usually available for standard systems. Custom systems must be tested. The Institute for Research In Construction (IRC) at the National Research Council (NRC) has developed graded air leakage requirements. These could be applied where greater control is required as would be the case for high humidity buildings or for particularly severe exposures.

The requirements for airtightness and vapour diffusion control are met by most curtain wall systems because of the inherent properties of glass, aluminum tubing and steel panels that comprise the system. Leakage of air and water occurs most commonly at expansion joints in mullions, at intersections of rails and mullions (four way joints) and along members subject to excessive deflection. Some mullion and rail systems are made up of two components and are known as split mullion systems. The screw chases required in these members tend to leak, and they have no sealed thermal break.

3.2.2.3. Exterior Insulation Finish (E.I.F.S.)

These systems are proving popular for retrofitting older structures because they are a simple but effective method of locating insulation and air barrier on the outside of the structure and are available as field-installed components or as prefabricated panels. They have evolved from simple insulation and coating systems (Fig. 3.2.2.3.a). A recent development is a pressure equalized rainscreen system. Earlier use of combustible foam plastic insulation and combustible coatings lead to problems with Building Codes so that there are now four categories of which the following three may be used on high-rise buildings:

1. Combustible insulation with combustible cladding - tested to CAN4-5134 Standard (Full Scale Wall Test). Systems that pass this test, as outlined in Section 3.1.5.5. of the National Building Code of Canada (N.B.C.C.), are acceptable for use on buildings up to three storeys if unsprinklered or unlimited height if sprinklered. There is an additional setback restriction equivalent to 25% openings.

2. Combustible insulation with non-combustible cladding - tested to CAN4-5114 (non-combustible) and CAN4-5101 (minimum 15 minute furnace) Standards. Systems that pass these two tests, as outlined in Section 3.2.3.7.(3) and 3.2.3.7.(3)(c)
TYPICAL COMPONENTS OF EIFS SYSTEM

- Insulation
  - mechanically or adhesively attached
- Reinforcing mesh
  - glass fiber
  - alkali resistant
- Base Coat
  - polymer-modified (PM) or polymer-based (PB)
  - primer
    - optional
- Textured finish
  - not to be installed on surfaces to receive

FIGURE 3.2.2.3.a
of the N.B.C.C., are acceptable for use on buildings required to be of non-combustible construction without height restrictions. There is a setback restriction equivalent to 25% openings.

3. Non-combustible insulation with non-combustible cladding. These types of systems meet the N.B.C.C. with no code restrictions.

The Rainscreen system (Fig. 3.2.2.3.b.) developed over the last year meets all N.B.C.C. requirements and has been tested successfully to meet ASTM E 283, E 330, E 331 and E 547 standards.

Air leakage of the assembly was 0.007 L/S/m2 at 75 pa. and .025 L/S/m2 at 300 pa.

When using such systems, it will be important for the designer to carry out a Dew-Point assessment to avoid risk of moisture problems within the wall.

3.2.2.4. Windows and Doors

Glazing and exterior doors form good air barrier components. Care must be taken in the continuity and quality of the connection of their frames to the wall air barrier system. Adhered Membranes or One Component Polyurethane Foam are the usual materials for sealing these gaps that will occur.

The quality of the air barrier system within the frames and sashes of glazing system is also of concern since both form part of the air barrier system. There is a performance standard, CAN/CSA-A440-M90, which stipulates maximum allowable air leakage rates per unit of crack length measured at 75 pa pressure, for different criteria of window use. The allowable rates are as follows:

<table>
<thead>
<tr>
<th>Window Rating</th>
<th>Level of Performance</th>
<th>Selection Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm</td>
<td>Maximum Air Leakage Rate - (m3/h.) m-1</td>
<td>8.35 (max) 5.00 (min)</td>
</tr>
<tr>
<td>A-1</td>
<td>2.79 (0.50 CFM/LIN. FT.)</td>
<td>A-1 intended for use primarily for low rise residential, industrial and light commercial.</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>A-2</td>
<td>11.65 (0.30 CFM/LIN. FT.)</td>
<td>A2 - intended for use primarily in medium to high-rise residential, industrial, institutional and commercial use.</td>
</tr>
<tr>
<td>A3</td>
<td>0.55 (0.10 CFM/LIN. FT.)</td>
<td>A3 - intended for use in high performance institutional and commercial applications.</td>
</tr>
<tr>
<td>Fixed</td>
<td>0.25 (0.05 CFM/LIN. FT.)</td>
<td></td>
</tr>
</tbody>
</table>

(The Standard also stipulates performance levels of water leakage, wind load resistance and condensation resistance and includes a User’s Guide which allows a designer to select appropriate levels pertinent to a given building.) Experience has shown that windows can be retrofitted to meet these levels of air tightness when tested to Test Standards ASTM - E.283 (Laboratory) or ASTM - E.783. (Field)

It should be noted that these Standards only apply to the window unit and do not include the joint between window and building. Nor is there currently an "Installation" Standard.
### 3.3 Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Bondability</th>
<th>Paintable</th>
<th>Comments/Life Expectancy</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Sealants:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.1 Oil or resin-based</strong></td>
<td>Bonds to most surfaces</td>
<td>Yes</td>
<td>- A low performance sealant 6 months - 5 years*</td>
<td>ASTM C570  CAN/CGSB 19.6-M87  CAN/CGSB 19.1-M87</td>
<td>6,24,135</td>
</tr>
<tr>
<td><strong>1.2 Butyl rubber</strong></td>
<td>Bonds to most surfaces; particularly suited to metal and masonry</td>
<td>Yes (after one week’s curing)</td>
<td>- Suitable for sealing indoors. - Not recommended for areas subject to high moisture. - 5-10 years.</td>
<td>ASTM C1085-87</td>
<td>6,20,24</td>
</tr>
<tr>
<td><strong>1.3 Synthetic rubber</strong></td>
<td>All cracks, especially wood, metal and glass</td>
<td>Yes</td>
<td>- Flexible, good adhesion, and moisture resistance. - 10-20 years.</td>
<td>ASTM D200</td>
<td>6,20,24</td>
</tr>
<tr>
<td><strong>1.4 Polysulphide</strong></td>
<td>Ideally suited for use on stone, masonry and metal</td>
<td>Not always</td>
<td>- A good material for joints where shifting takes place. - Handling precautions required. - Not for indoor use. - 2-30 years.</td>
<td>BSI 5215-1975</td>
<td>6,50,110</td>
</tr>
<tr>
<td><strong>1.5 Water-based vinyl-acetate</strong></td>
<td>Bonds to wood, glass and metal (vinyl-acetate latex)</td>
<td>Yes</td>
<td>- Easy to use. - Safe for indoor use. - Suitable for small joints where little shifting takes place. - Not recommended for use outdoors. - 1-10 years.</td>
<td>CGSB 19-GP-17M</td>
<td>6</td>
</tr>
</tbody>
</table>

* Supplier Estimate
### 3.3 Recommended Air Leakage Control Materials & Systems

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<tbody>
<tr>
<td>1.0 Sealants (cont’d)</td>
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<td></td>
</tr>
<tr>
<td>1.6 Water-based vinyl-acrylic</td>
<td>Bonds to wood, glass and metal</td>
<td>Yes</td>
<td>- A general indoor or outdoor sealant. It is easy to use and is safe for use indoors.</td>
<td>CGSB 19-GP-17M</td>
<td>6,101</td>
</tr>
<tr>
<td>1.7 Water-based acrylic (acrylic latex)</td>
<td>Excellent for non-porous surfaces such as aluminum glass and ceramic tile</td>
<td>Yes</td>
<td>- A high performance sealant for indoor or outdoor use in joints where little movement takes place.</td>
<td>CGSB 19-GP-17M</td>
<td>6,24,67</td>
</tr>
<tr>
<td>1.8 Solvent-based acrylic</td>
<td>Bonds to most surfaces</td>
<td>No</td>
<td>- An excellent outdoor caulking. CGSB 19-GP-5M</td>
<td></td>
<td>6</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Difficult to spread and touch up.</td>
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<td></td>
<td></td>
<td></td>
<td>- Gives off offensive odour for several weeks; not recommended for indoor use.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Handling precautions required.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- 6 months - 5 years.*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9 Polyurethane</td>
<td>Bonds to glass, anodized aluminum, concrete, wood, masonry. Special primer may be required</td>
<td>Yes after (14-30 days curing)</td>
<td>- Suitable for use indoors or outdoors. Handling precautions required - 20 years.</td>
<td>CAN/CGBS 19.13 M-87</td>
<td>24,50,95</td>
</tr>
<tr>
<td>1.10 Polyurethane (foam)</td>
<td>Bonds to most surfaces except polyethylene teflon, or silicone plastics</td>
<td>Yes</td>
<td>- Will break down when exposed to direct sunlight Handling precautions required - 10-20 years. Flammable/combustible.</td>
<td>CAN/CGBS 51-CP 23M</td>
<td>15,26,44, 55,75,80</td>
</tr>
<tr>
<td>One or Two Component plastics</td>
<td></td>
<td></td>
<td></td>
<td>CAN/CGBS 51-80M</td>
<td>82,101,142</td>
</tr>
<tr>
<td>* Supplier Estimate</td>
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<tbody>
<tr>
<td>1.0 Sealants (cont’d)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.11 Hypalon</td>
<td>Bonds to concrete, steel most other metals, wood glass, stone, brick</td>
<td>No</td>
<td>- For outdoor use only. Handing precautions required. 10-20 years.</td>
<td></td>
<td>67</td>
</tr>
<tr>
<td>1.12 Silicones</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A) Acetoxy Cure (vinegar)</td>
<td>Will not stick to masonry. Ideal for ceramic, wood, glass, alum, and some plastic - not vinyl</td>
<td>No</td>
<td>Available in variety of types/ mfg’s. Some mildew resistant i.e., bath tub caulk - comes in clear, generally an indoor sealant 20-30 years*</td>
<td>CAN/CGSB 19.18-M87</td>
<td>6,20,24,47,67,118,143**</td>
</tr>
<tr>
<td>B) Water Based</td>
<td>Good for most surfaces. May require primer for some plastics</td>
<td>Yes</td>
<td>Not available in clear, easy to use. Cleans up with water. 20-30 years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C) Neutral Cure</td>
<td>For masonry, painted alum., wood and metal, vinyl, plastic, etc. No (moves too much)</td>
<td>No</td>
<td>No odour, high movement, generally used outdoors. No handling precautions. ±50% movement 30+ years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.13 Acoustical</td>
<td>Bonds to most surfaces</td>
<td>No</td>
<td>- Non-hardening; use should be limited to unexposed applications; excellent for sealing the joints in air-vapour barriers. 20-30 years.</td>
<td>CAN/CGSB-19.21-M87 ASTM C919</td>
<td>20,24,47,73,135</td>
</tr>
</tbody>
</table>

* Supplier Estimate
** Some application restrictions apply
3.3 **Recommended Air Leakage Control Materials & Systems**

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Characteristics</th>
<th>Appropriate Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.0 Backer Material</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>2.1 Extruded closed cell, circular polyethylene foam</strong></td>
<td>Flexible, closed cell foam rod, various diameters including 8 mm, 12mm, 25mm, etc.</td>
<td>In rough stud openings, under baseboard other large cracks or joints</td>
<td>Continuous lengths, compressible</td>
<td>Unsuitable for tapered cracks, high heat areas, or cracks with large seasonal movements</td>
<td>110,130</td>
<td></td>
</tr>
<tr>
<td><strong>2.2 Polyethylene foam sheet</strong></td>
<td>Flexible, closed cell foam sheets on rolls</td>
<td>Odd shaped cracks or large holes</td>
<td>Low cost, torn into strips or built-up cracks with large seasonal movement. Not recommended around electrical boxes</td>
<td>Cells are easily ruptured; unsuitable for high heat areas or seasonal movement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td><strong>2.3 Polyurethane</strong></td>
<td>Flexible, closed cell foam in precut sizes and shapes</td>
<td>Electric boxes and outlets; gaskets</td>
<td>Strong, precut easily installed</td>
<td>Unsuitable for cracks</td>
<td>6,101</td>
<td></td>
</tr>
<tr>
<td><strong>2.4 Rubber (including neoprene, EDPM)</strong></td>
<td>Flexible, and very durable</td>
<td>Around electrical fittings, glazings and surfaces exposed to weather</td>
<td>Strong, good elasticity</td>
<td>High cost</td>
<td>ASTM D2000 6,101</td>
<td></td>
</tr>
</tbody>
</table>
3.3 Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
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<th>Disadvantages</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 Backer Material (cont’d)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 Oakum</td>
<td>Fibrous, tar soaked hemp</td>
<td>Rough masonry, irregular cracks</td>
<td>Lost cost; easily worked into irregular cracks</td>
<td>Poor elasticity, may leak air and absorb water, will allow sealant bonding and should not be used as backing</td>
<td>Rarely used. May be found in Heritage building retrofit situations</td>
<td></td>
</tr>
<tr>
<td>2.6 Fibreglass</td>
<td>Scraps of fibreglass batt</td>
<td>Filling amount window and door jambs</td>
<td>Lost cost; easily worked into irregular cracks</td>
<td>Poor elasticity, may leak air and absorb water, will allow sealant bonding and should not be used as backing</td>
<td>CSA 101-M 21,60</td>
<td></td>
</tr>
<tr>
<td>2.7 Pyrofite Perlite Ceramic Treated Fireproof/Moisture proof</td>
<td>Spray applied for loos fill</td>
<td>Window and door jams</td>
<td>Medium cost; will not absorb moisture. Bonds well</td>
<td></td>
<td>101</td>
<td></td>
</tr>
</tbody>
</table>
### 3.3 Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Durability</th>
<th>Application</th>
<th>Performance</th>
<th>Comments</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3  Weatherstripping</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1  Felt</td>
<td>Low</td>
<td>Face-type Pressure seal</td>
<td>Ineffective</td>
<td>Easily deformed</td>
<td>CGSB-51-90-M (under development)</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CGSB 51.92-M (under development)</td>
<td></td>
</tr>
<tr>
<td>3.2.1 Foam, open cell Low</td>
<td>Face-type Pressure seal</td>
<td>Ineffective</td>
<td>May lose flexibility</td>
<td>CGSB-51-90-M (under development)</td>
<td>6,48,83, 117</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>CGSB 51.92-M (under development)</td>
<td></td>
</tr>
<tr>
<td>3.2.2 Foam, closed cell High</td>
<td>Face-type Pressure seal</td>
<td>Effective</td>
<td>Resilient</td>
<td>CGSB-51-90-M (under development)</td>
<td>6,39,48, 83,101,117</td>
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<td></td>
<td>CGSB 51.92-M (under development)</td>
<td></td>
</tr>
<tr>
<td>3.2.3 Cladded High</td>
<td>Face-type Pressure seal</td>
<td>Effective</td>
<td>Compression and resilience good</td>
<td>CGSB-51-90-M (under development)</td>
<td>48,101,126</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CGSB 51.92-M (under development)</td>
<td></td>
</tr>
<tr>
<td>3.4  Tubular High</td>
<td>Face-type Pressure seal</td>
<td>Effective</td>
<td>Highly noticeable. Some products adjust better to irregularities in the gap between the window or door and its frame</td>
<td>CGSB-51-90-M (under development)</td>
<td>39,48,117, 126</td>
<td></td>
</tr>
</tbody>
</table>
### 3.3 Recommended Air Leakage Control Materials & Systems

#### 3.0 Weatherstripping (cont’d)

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Durability</th>
<th>Application</th>
<th>Performance</th>
<th>Comments</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 Spring-loaded or self-adjusting</td>
<td>High</td>
<td>Face-type Pressure seal</td>
<td>Effective</td>
<td>Used for hinged windows and doors. Adjusts to irregularities in the gap between the window or door and its frame. May be noticeable.</td>
<td>CGSB-51-90-M (under development) CGSB 51.92-M (under development)</td>
<td>26,48,126</td>
</tr>
<tr>
<td>3.6 Ribber, closed cell</td>
<td>High</td>
<td>Face-type Pressure seal</td>
<td>Effective</td>
<td>Excellent freeze-thaw stability. Retains its original shape. Does not shrink or crack, remain flexible. Trouble accommodating long or varied gap widths.</td>
<td>CGSB-51-90-M (under development) CGSB 51.92-M (under development)</td>
<td>6,39,48,117</td>
</tr>
<tr>
<td>3.7 Spring metal strip</td>
<td>High</td>
<td>Edge-type Pressure or sliding seal</td>
<td>Moderately effective</td>
<td>Easily deformed. Long-lasting.</td>
<td>CGSB-51-90-M (under development) CGSB 51.92-M (under development)</td>
<td>48</td>
</tr>
<tr>
<td>3.8 Spring vinyl or V-type strips</td>
<td>High</td>
<td>Face- or edge-type Pressure or sliding seal</td>
<td>Effective</td>
<td>Polypropylene strips are quite resistant to shrinking, cracking or brittleness in colder climates</td>
<td>CGSB-51-90-M (under development) CGSB 51.92-M (under development)</td>
<td>26,48,117,126</td>
</tr>
</tbody>
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3-18
### 3.3 Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Durability</th>
<th>Application</th>
<th>Performance</th>
<th>Comments</th>
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<tbody>
<tr>
<td>3.0 Weatherstripping (cont'd)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3.9 Polyester or high</td>
<td>High</td>
<td>Face- or edge-type. Sliding or sweeping type seal.</td>
<td>Reasonably effective</td>
<td>Primarily a replacement seal for sliding windows and doors. Care should be taken to replace with the correct size. Can be purchased either with or without an attached plastic fin to improve the seal.</td>
</tr>
<tr>
<td>polypropylene pile with fin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.11 Flexible high vinyl</td>
<td>High</td>
<td>Face-type Pressure seal</td>
<td>Effective</td>
<td>Primarily for doors. Variety of colours. Very adjustable.</td>
</tr>
<tr>
<td>supported by aluminum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Performance Standard**
- CGSB-51-90-M (under development)
- CGSB 51.92-M (under development)
- CGSB-51-90-M (under development)
- CGSB 51.92-M (under development)
- 76

**Supplier**
- 26, 39, 48, 126
### 3.3 Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Characteristics</th>
<th>Appropriate Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0 Specialty Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 Electrical box cover plates</td>
<td>Rigid sliding cover</td>
<td>At all outlets</td>
<td>Easily installed</td>
<td>Seal around both the cover plate and the outlet and closes automatically</td>
<td>ASTM E283</td>
<td>102,119</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CSA C22.1</td>
<td>IBM</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CSA C22.2</td>
<td>No. 18M</td>
</tr>
<tr>
<td>4.2 Electric switch and outlet gaskets</td>
<td>Closed cell polyurethane, gasket precut to fit behind standard switch and outlet cover plates</td>
<td>At all outlets and switches that lack effective air/vapour barrier behind the electrical box</td>
<td>Easily installed, suitable for retrofit</td>
<td>Seals around the cover plate only, not at the switch or the outlets themselves, which require safety plugs</td>
<td>ASTM E283</td>
<td>6,117,102</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CSA #</td>
<td></td>
</tr>
<tr>
<td>4.3 Safety Plugs Polyethylene or PVC inserts for electrical outlets</td>
<td>With gaskets, at outlets that lack effective air/vapour barrier behind the electrical box</td>
<td>Effective, also serves as a safety plug to prevent children from inserting anything into the outlet</td>
<td>Must be reinstalled after every usage</td>
<td></td>
<td>ASTM E283</td>
<td>102</td>
</tr>
<tr>
<td>4.4 Window pulley covers PVC cap and gasket</td>
<td>For pulleys on counter balanced windows</td>
<td>Effective, allows full operation of window sash</td>
<td>Available in brown and white only</td>
<td></td>
<td>CCSB-51-90-M (under development)</td>
<td>CCSB 51.92-M (under development)</td>
</tr>
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</table>
### 4.0 Specialty Products (cont'd)

#### 4.5 Thresholds

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Characteristics</th>
<th>Appropriate Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 Thresholds</td>
<td>Wood, metal or plastic floor mounted strip that forms a surface for door bottom to meet for sealing by compression or sweep</td>
<td>At doors that open too tightly over flooring or carpeting</td>
<td>Permits use of effective compression seal or sweep at door bottom. Some have thermal breaks.</td>
<td>Some units form a ridge that may trap dirt</td>
<td>CGSB-51-90-M 39,117,126 (under development)</td>
<td></td>
</tr>
<tr>
<td>4.6 Tapes</td>
<td>Available as cloth or foil duct tape or an air barrier tape</td>
<td>Ductwork, air barrier, etc.</td>
<td>Self adhesive. Effective short term performance</td>
<td>Surface temperature, and condition affect Low durability.</td>
<td>Air barrier tape - CCMC adhesion. Duct tape - CGSB 43-GP-3Ma CGSB 43-GP-14MA</td>
<td>117, 16, 68, 98, 106, 111, 128</td>
</tr>
<tr>
<td>4.7 Air Barrier Membranes</td>
<td>Available as a liquid for trowel or spray application. Also as sheet - adhesive, self-adhesive and torch application</td>
<td>Concrete block, wide cracks or gaps.</td>
<td>Will adhere to most surfaces. Cost effective way to bridge large gaps</td>
<td>Should not be permanently exposed to elements</td>
<td>Performance Standards are under development</td>
<td>128</td>
</tr>
</tbody>
</table>

- **3-21**
### Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Characteristics</th>
<th>Appropriate Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Performance Standard</th>
<th>Supplier</th>
</tr>
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<tbody>
<tr>
<td>4.0 Specialty Products (cont'd)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>4.8 Fire Stop Sealant</td>
<td>Sealant, one component silicone</td>
<td>To fire stop openings in floor slabs, walls and fire-rated partitions</td>
<td>Permanent flexible seal</td>
<td>Shall not be applied to: - polycarbonates - bldg. materials that bleed oils - painted surfaces - wet or frost-coated surfaces - yellow brass</td>
<td>ULC listed</td>
<td>3, 5, 47, 137</td>
</tr>
<tr>
<td>4.9 Fire Stop Sealant</td>
<td>Fibre reinforced foamed cement mortar</td>
<td>To fire stop openings and penetrations through fire-rated wall and floor assemblies</td>
<td>Non-slumping and self-supporting. Maybe used for large openings.</td>
<td>Mechanical keying may be required for horizontal applications. Not to be installed below 5 deg. C (40 deg. F)</td>
<td>CAN4-5115-M</td>
<td>5, 137</td>
</tr>
<tr>
<td>ASTM-E814-83</td>
<td>CAN4-5114-M</td>
<td></td>
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</tr>
<tr>
<td>4.10 Precast Concrete</td>
<td>Simple panel or vented and drained sandwich panel</td>
<td>Cladding</td>
<td>Permanent</td>
<td>Joints require special attention</td>
<td></td>
<td>2, 13, 18, 35, 37, 53, 86, 114</td>
</tr>
<tr>
<td>4.11 Curtain Wall Systems</td>
<td>Glass, metal pan metal extrusions, gaskets, tapes</td>
<td>Cladding</td>
<td>Permanent</td>
<td>Complex</td>
<td>ASTM-E331-86</td>
<td>1, 11, 12, 59, 62, 72, 85, 92</td>
</tr>
<tr>
<td></td>
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<td>ASTM-E547-86</td>
<td>57, 84</td>
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<td>ASTM-E283-84</td>
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3-22
### 3.3 Recommended Air Leakage Control Materials & Systems

<table>
<thead>
<tr>
<th>Generic Product Type/Material</th>
<th>Characteristics</th>
<th>Appropriate Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Performance Standard</th>
<th>Supplier</th>
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<tbody>
<tr>
<td><strong>4.0 Specialty Products (cont’d)</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>4.13 Insulated steel truss systems</strong></td>
<td>Stone or granite facing, sheet steel liner, insulation</td>
<td>Cladding</td>
<td>Steel support system for heavy claddings. Cost effective</td>
<td>Care needed for corrosion control</td>
<td>Tested by C.M.H.C.</td>
<td>9,53</td>
</tr>
<tr>
<td><strong>4.14 Gypsum Board</strong></td>
<td>Rigid Board</td>
<td>Interior Finish</td>
<td>Easy access. Easy to seal joints, inspect and maintain</td>
<td>Vulnerable to damage</td>
<td>Tested by C.M.H.C.</td>
<td>22,46,142</td>
</tr>
</tbody>
</table>
### 3.4 Alphabetical List of Potential Material & System Suppliers

<table>
<thead>
<tr>
<th></th>
<th>Company Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A.F.G. Glass</td>
</tr>
<tr>
<td>2</td>
<td>A.P.S. Ltd.</td>
</tr>
<tr>
<td>3</td>
<td>Abisko Manufacturing Incl</td>
</tr>
<tr>
<td>4</td>
<td>Able Gasket &amp; Materials Ltd.</td>
</tr>
<tr>
<td>5</td>
<td>A/D Fire Protection Systems Inc.</td>
</tr>
<tr>
<td>6</td>
<td>Albion Industrial Products</td>
</tr>
<tr>
<td>7</td>
<td>Aldon Chemicals</td>
</tr>
<tr>
<td>8</td>
<td>All Custom Gasket &amp; Materials Ltd.</td>
</tr>
<tr>
<td>9</td>
<td>Allied Architectural Systems Ltd.</td>
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<tr>
<td>10</td>
<td>Almag Aluminum Ltd.</td>
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<tr>
<td>11</td>
<td>Alumicor Inc.</td>
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<tr>
<td>12</td>
<td>Architectural Glazing Systems Ltd.</td>
</tr>
<tr>
<td>13</td>
<td>Artex Ltd.</td>
</tr>
<tr>
<td>14</td>
<td>Avmor Limited</td>
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<tr>
<td>15</td>
<td>BASF Canada Inc.</td>
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<tr>
<td>16</td>
<td>Bakor</td>
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<tr>
<td>17</td>
<td>Bengard Manufacturing Ltd.</td>
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<tr>
<td>18</td>
<td>Beer Precast Ltd.</td>
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<tr>
<td>19</td>
<td>Bitumar Inc.</td>
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<tr>
<td>20</td>
<td>Bren Cor Chemicals Ltd.</td>
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<tr>
<td>21</td>
<td>Building Products of Canada Ltd.</td>
</tr>
<tr>
<td>22</td>
<td>CGC Inc.</td>
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<td>23</td>
<td>CSL Silicones Inc.</td>
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<td>24</td>
<td>Canadian Adhesives Ltd.</td>
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<tr>
<td>25</td>
<td>Canadian Elastileum (1985) Ltd</td>
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<td>26</td>
<td>Can Am Building Envelope Specialists Inc.</td>
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<tr>
<td>27</td>
<td>Canusa Limited</td>
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<td>28</td>
<td>Cappar Limited</td>
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<td>29</td>
<td>Carbochem Inc.</td>
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<td>30</td>
<td>Ceilcote Canada</td>
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<td>31</td>
<td>Chemcor Inc.</td>
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<td>32</td>
<td>Chemthane Engineering Ltd.</td>
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<td>33</td>
<td>Chemtron Manufacturing Ltd.</td>
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<td>35</td>
<td>Choc-Beton Ltee</td>
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<td>36</td>
<td>Cie D'Equipement Sanitaire Ltee</td>
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<tr>
<td>37</td>
<td>Conforce Ltd.</td>
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<tr>
<td>38</td>
<td>Cramco Inc.</td>
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<tr>
<td>39</td>
<td>Crowder, K.N., Mfg. Inc.</td>
</tr>
<tr>
<td>40</td>
<td>Custom Gaskets Ltd.</td>
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<tr>
<td>41</td>
<td>DAP Canada Inc.</td>
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<tr>
<td>42</td>
<td>DRG Sellotape Div. of DRG Inc.</td>
</tr>
<tr>
<td>43</td>
<td>Deltec Manufacturing Ltd.</td>
</tr>
<tr>
<td>44</td>
<td>Demilec Inc.</td>
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<tr>
<td>45</td>
<td>Dominion Sure Seal Ltd.</td>
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<tr>
<td>46</td>
<td>Domtar Inc.</td>
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<tr>
<td>47</td>
<td>Dow Corning Canada Inc.</td>
</tr>
<tr>
<td>48</td>
<td>Drummond, T.A.Metal Products Ltd.</td>
</tr>
</tbody>
</table>
49. Dryvit System Ltd.
50. Duochem Inc.
51. Dural Polymers of Canada
52. Dustbane Products Ltd.
53. E & M Precast Ltd.
54. Elsro Asphalt
55. Enerlab Inc.
56. Epton Industries Inc.
57. FRC Composites Ltd.
58. Fentre Metropole Inc.
59. Ferguson Glass Ltd.
60. Fiberglas Canada Inc.
61. FibreGlass-Evercoat Co. of Canada
62. Fulton Windows Ltd.
63. Garluxe Industries Inc.
64. Gemite Products Inc.
65. GenCorp Automotive
66. General Electric Canada Inc.
67. Gibson-Homans Canada
68. Grace, W.R., & Co. of Canada Ltd.
69. Guertin Bros. Coatings & Sealants
70. H.B. Fuller Canada Inc.
71. Heat Seal Insulation Equip & Supplies
72. Hickey Canada Inc.
73. Hickson Building Products Ltd.
74. Holland Chemical & Janitorial Supply
75. I.C.I Polyurethanes Inc.
76. Indalex, Division of Indal Ltd.
77. Industrial Formulators of Canada
78. Industrial Thermo Polymers Ltd.
79. Insul-Mastic & Building Products
80. Insta-Foam Products Inc.
81. International Paints (Canada) Ltd.
82. I.P.I. Canada Division of Keith Kingsley & Son Ltd.
83. Jacobs & Thompson Inc.
84. Jet-Lube of Canada Ltd.
85. Kawneer Co. Canada Ltd.
86. Kenmar Ltd.
87. Kryton International Inc.
88. Kwik Mix Materials Ltd.
89. Lawrason's Chemicals Ltd.
90. LePage's Limited
91. Lion Rubber & Plastic
92. Lorlea Inc.
93. 3 M Co.
94. Madison Chemical Industries Inc.
95. Mameco of Canada Ltd.
96. Marlig Industries Inc.
97. McAsphalt Industries Ltd.
98. Meadows, W.R., of Canada Ltd.
99. Metaltone of Canada Ltd.
100. Milne, Alex, Associates Ltd.
101. Miracan Ontario Ltd.
102. Molvan Enterprises Inc.
103. Mulco Inc.
104. Multiplex Chemicals Ltd.
105. Ninety Eight
106. Nord & Bitume Inc.
107. Ontario Panelisation Ltd.
110. PRC Canada Inc.
111. PennKote Limited
112. Permeshell Corporation Ltd.
113. Perma-Tac Industries Inc.
114. Precon Ltd.
115. Procan Manufacturing Ltd.
116. Pro Form Products Ltd.
117. RCR International Inc.
118. Rhone-Poulenc Inc.
119. RS Vapour
120. Recochem Inc.
121. Releasall-Target International Inc.
122. Robco Inc.
123. Rochester Midland Ltd.
124. Rohm & Haas Canada Inc.
125. Ross, Frank T., & Sons (1962) Ltd.
126. Schlegel Canada Inc.
127. Sika Canada Inc.
128. Soprema
129. Standard Products (Canada) Ltd.
130. Sternson Group
131. Stewart Products Ltd.
132. STO Industries Canada Inc.
133. Texas Refinery Corp. of Canada Ltd.
134. Thompson, G.F., Co. Ltd.
135. Thoro
136. 3M Canada Inc.
137. Tremco Limited
138. U.S.E. Chemicals
139. Unique Sash Balance Co. Ltd.
140. Walter, E.F., Limited
141. Waterville TG Inc.
142. Westroc Industries Ltd.
143. Zimmcor Ltd.
3.5 Methods

This section identifies locations where weaknesses in the air barrier system are commonly found or inadequately detailed. Suggestions are offered for new construction detailing and also for retrofit air leakage control measures.

Sections 3.5.3. to 3.5.6. offer more practical guidelines for the Contractor dealing with operable openings and other specific locations.

3.5.1. Below Grade

3.5.1.1. Conventional methods of building design/construction underestimate the significance of basement and below grade parking areas as sources of air/soil gas leakage. As with roof construction, basement details are more often concerned with waterproofing. While this is appropriate for the perimeter of foundation walls in below grade areas, the focus of air barrier continuity shifts, at grade, from the perimeter of exterior walls above ground to the perimeter of the building core below ground.

Together with providing access to and from parking, the core gathers the various building service utilities; domestic water, waste and fire protection, gas, storm drainage, electricity, communications and garbage chutes, and directs them vertically through shafts and pipe chases for distribution. If permitted, the Stack and Wind Effects will treat the below grade area as a well from which air is drawn up through the building. For the air barrier system to be effective and continuous, the ground floor and below grade core areas, including below grade retail or other commercial use areas, must be effectively isolated from below grade parking and storage areas, which are vented with unconditioned air.

3.5.1.2. Basement and Ground Floor Junction

The junction of exterior walls, foundation and ground floor slab will be dealt with in Section 3.5.2. The balance of the ground floor may be wholly or only partly covered by building. To maintain continuity of the air barrier system, those areas of the ground floor slab which are covered by the above grade structure must be treated as an air-tight soffit. The primary air barrier system follows the above grade envelope and turns at grade to extend horizontally until it reaches the perimeter of the building core. Any penetration of this soffit must not only be fire stopped but also air sealed. See Article 3.5.1.8. for pipe and duct sealing.
3.5.1.3. **Building Core Walls**

Core walls form part of the air barrier system and are often constructed of cast-in-place concrete. This choice of material satisfies structural, fire protection and air barrier concerns. If sections of the wall are concrete masonry, consideration must be given to a finish for the wall to maintain the plane of airtightness. Parging with cement mortar or application of taped and sealed gypsum board may be appropriate for both new and retrofit construction.

3.5.1.4. **Floor Slab/Wall Joints**

Air barrier materials used to seal core walls must be terminated at the junction of floor and ceiling slabs to ensure continuity. Cement parging must seal tightly at the top and bottom of the walls. Gypsum board must be caulked or foamed. Refer to Section 3.3, Sentence 1.0.

3.5.1.5. **Mechanical/Electrical Rooms**

Walls and ceilings of service rooms such as, telephone switch gear, electrical, sprinkler valve and pump rooms, are perforated with pipes, ducts, cables and conduits. When these services penetrate the core walls or ground floor slab, adequate fire stopping and air seals must be maintained. Refer to Article 3.5.1.8. "Pipe, Duct and Conduit Penetrations" for details. Access doors to service rooms should be weatherstripped and have their frames sealed. Refer to Section 3.3, Sentence 3.0.

Fig. 3.5.1.5.a.

3.5.1.6. **Laundries and Garbage Rooms**

Laundries and garbage rooms, whether located below grade or not, are connected to the full height of the building by chutes. The shaft enclosing the chute, as with mechanical and electrical shafts, are pathways for air movement. In new buildings, floor slabs should be constructed tight to chutes and sealed to comply with National and Provincial Building Codes for fire rating and smoke control. Refer to Section 3.3, Sentences 4.8. & 4.9. In existing buildings, the gap between chutes and floor slabs should be sealed from within the garbage and laundry rooms using materials and methods as in new construction. Back draft door at the base of chute should be
FIGURE 3.5.1.6.0
LAUNDRY OR GARBAGE CHUTE BACK DRAFT DOOR
specified with integral seals or should be weather stripped. Damage to seals can occur with everyday use. Replacement of the door seal should be part of routine maintenance. Refer to Section 3.3., Sentence 3.0. Also weatherstrip and seal frames of all access doors into garbage rooms. Refer to Section 3.3., Sentences 3.0 and 4.0. Fig 3.5.1.6.a.

3.5.1.7. **Corridors, Vestibules and Elevator Lobbies**

Corridors, vestibules and lobbies leading to the elevators must be well sealed to decouple the elevator shafts from the balance of each floor area. Elevators are typically enclosed in the largest shafts of the building. Air is drawn by stack effect up these spaces and is pushed by the action of the elevators. Check that lobby and vestibule walls are constructed as air barriers. Weatherstrip lobby door, vestibule door and access doors to the corridor leading from underground parking and fire exit stairs. Seal junctions of frames and walls, seal tops and bases of walls using two part urethane foam and/or caulking. See Section 3.3, Sentences 4.8 & 4.9.

3.5.1.8. **Pipe Duct and Conduit Penetrations**

Continuous floor slabs and well sealed walls act effectively to compartmentalize the air at each level. A pipe or duct penetration through the completed wall or floor can leave holes for air movement even when adequately fire stopped with mineral fibre.

In new construction, service chases and sleeves should be fabricated as tightly as possible around pipes and ducts. Pack joints with non-shrink grout and seal gaps. Refer to Section 3.3, Sentences 4.8 & 4.9. Where existing services are to be sealed, ensure that adequate structural support is provided for the fill material and seal the junction as with new construction. Ensure that fill materials meet or exceed the requirements for fire resistance rating of the assembly.

3.5.1.9. **Service and Inspection Hatches**

Access hatches such as plumbing clean-outs, electrical panels, mechanical inspection, garbage or laundry chutes and smoke hatches located in ceilings or walls designed to compartmentalize areas must be weatherstripped to ensure a tight fit. Similarly, service hatches in duct work are to have durable and effective gasketing. Large service doors must be weather stripped. Refer to Section 3.3, Sentence 3.0.
3.5.1.10. **Loading Bay**

Provide weatherstripping and caulk frames around O/H doors. Compartmentalize the loading bay by weatherstripping access and ancillary doors. Seal around duct and pipe penetrations in walls, ceilings and floors. Refer to Section 3.3, Sentence 3.11.

3.5.2. **Exterior Walls**

The exterior walls and roof of a building above grade are commonly understood to incorporate the primary air barrier system of the building. Though these assemblies are generally well understood by Designers and Constructors, junctions of dissimilar materials in new construction and restoring or providing air barrier systems in older buildings remains a problem.

3.5.2.1. **The Primary Air Barrier**

In new construction, there are a wide variety of materials and systems available for cladding, insulating and supporting the building envelope. The air barrier system can be located within the assembly - "Inaccessible system" - or it can be the inside surface of the wall, - "Accessible System", or it can be located at the outside face of the wall - "Face Sealed System". As a "system" it simply requires adequate caulking at all junctions of the various components making up the exterior cladding of the building envelope. This system may be subject to accelerated deterioration through exposure to the Canadian climate. Frequent maintenance and inconvenient access renders this type of system undesirable in high rise commercial buildings.

In the Inaccessible System, air barrier materials are protected within the assembly but must be specified to perform for the life of the building. Accessible system materials are subject to damage by the occupants of the building but they are more easily inspected and maintained.

Criteria for successful installation of Inaccessible and Accessible Systems are elaborated further in the following sections:

3.5.2.2. **Junctions in the Building Envelope**

.1 Carrying the air barrier across the junctions between various elements of the envelope is of critical importance. Seven
common locations are reviewed:

- Roof to Wall
- Floor to Wall
- Wall to Window
- Wall to Soffit
- Wall to Foundation
- Junctions of Dissimilar Materials
- Compartmentalization of Cavities

The four characteristic properties of the air barrier must be designed into the junction: air impermeability, continuity, structural strength and durability. In addition to continuity of the air barrier itself, continuous support against wind loads must be provided. Also, as these critical locations are often the site of differential movements, care must be taken to ensure that the air barrier is flexible at the joints. As a general principle, any movement joints or clearance in the building structure must have a flexible air barrier membrane bridging the gap. Care should be taken to ensure that expected deflections in the structure will not exceed the elasticity of the membrane. It may be necessary in some cases to leave slack in the membrane to accommodate movement while adhering it tightly to each side of the joint.

.2 Exterior Wall to Roof

For Face Sealed Systems, a flexible membrane must wrap over the top of the parapet just beneath the flashing or masonry coping and be sealed to the building face and to the roof membrane.

For Inaccessible Systems, lap and seal together roof and wall membranes. Ensure that materials used are compatible. See Figs. 3.5.2.2.a & b. In concrete structures, it is possible to maintain continuity of the air barrier system by sealing each membrane to the outside face of the roof slab.

For Accessible Systems, the gypsum board must be installed tight to the underside of roof deck and be caulked or foamed in place. See Figs. 3.5.2.2.c & d. Alternately, a strip of flexible membrane adhered to the gypsum board and the underside of a steel or concrete deck will seal the joint.
FIGURE 3.5.2.2.a
PRECAST ON MASONRY BACKUP WALL & PARAPET
FIGURE 3.5.22.b
PRECAST ON MASONRY BACKUP WALL & PARAPET
FIGURE 3.5.2.2.c
PANEL ON METAL STUD BACKUP WALL @ PARAPET
FIGURE 3.5.2.2.d
PANEL ON METAL STUD BACK UP WALL & PARAPET
In steel buildings with fireproofing on the steel structure, the fireproofing must be removed before sealing measures are undertaken, and then must be restored. Where the roof slab above metal decking is not filled with concrete, for example, at some mechanical penthouse roofs, foam the underside of flues as you would with concrete filled deck. In addition, the hollow upper flues must be pierced and the voids filled with foam, for a depth equal to the thickness of the wall below.

In any case, ensure that membranes or sealants are selected to allow for movement of the structural components.

3 Floor to Exterior Walls

For Face Seal Systems, simply ensure that all joints in the cladding are caulked with a durable sealant.

In Inaccessible Systems, bypass the floor to wall junction with a continuous membrane, again, attention must be given to the movement joints in the structure. Membranes must be elastic enough to accommodate the anticipated movement and should be left slack at the joint. Figs. 3.5.2.2.e, f, g & h.

For Accessible Systems, the base of gypsum board is set in a continuous bead of caulking to seal it to the concrete floor. At the underside of floors, the gypsum board must be sealed to the concrete or metal floor structure. A strip of flexible membrane lapped over the joint and adhered to both drywall and floor structure is recommended. In both new and existing buildings, the joint may be foamed or caulked, particularly where it is difficult to reach.

Any opening at the joint between corrugated metal deck and support structure in steel frame buildings is to be sealed by application of two part polyurethane foam.

Fire stopping the gap between exterior cladding and floor slab is most often done with a mineral fibre material. It is effective in preventing flame spread but mineral wool materials are permeable to air and smoke. Building code amendments seeking improvement in smoke control now require a smoke sealant in this location. Apply mineral wool fire stop in the conventional manner. Air/smoke seal the
FIGURE 3.5.2.2(a)
PRECAST ON MASONRY BACKUP WALL @ FLOOR EDGE
FIGURE 3.5.2.2.1
PRECAST ON MASONRY BACKUP WALL @ FLOOR EDGE
FIGURE 3.5.2.2.9
PREFINISHED PANEL ON METAL STUD BACKUP WALL
FIGURE 3.5.2.2.h
PREFINISHED PANEL ON METAL STUD BACKUP WALL
joint with a self levelling compound. Refer to Section 3.3, Sentence 4.8. Or seal from below using foamed cement mortar. Refer to Section 3.3, Sentence 4.9.

Occasionally a building is constructed with the principal structural columns located outside the floor slab but within the cladding envelope. In these cases, a gap around the column at floor level is found. Seal this gap using fibre reinforced foamed cement.

4 Window to Wall

Standards for air leakage through window glazing and frame assemblies have become more rigid in recent years. Manufacturers perform extensive tests on their products to demonstrate compliance. In non-curtainwall assemblies, this leaves the joint between window frame and rough opening as a weak link in the air barrier system. For Face Sealed Systems, joints between cladding and window frames must be caulked with a durable sealant. For Inaccessible Systems, curtainwall technology can be used to make the plane of airtightness continuous. Curtainwall frame sections are designed with pressure plate fittings to restrain the thermal glass units and insulated panels, this same fitting can be used with an appropriately sized spacer to seal a sheet of air barrier membrane to the outside perimeter of the window frame. Once set, this flap is adhered to the air barrier material of the surrounding wall. Some non-curtainwall windows are equipped with an integral membrane attached to the frame and are installed as described above. Consideration must be given to compatibility of the membrane materials, window components and to adhesives.

In Accessible Systems, the gypsum board membrane must be sealed to the interior of window frames, head, sill and jamb with a continuous bead of durable sealant. Inspection and repair of these joints should be made part of routine maintenance programs.
Regardless of the location of the air barrier, the void between window frame and masonry or metal stud opening should be filled with a one part polyurethane foam. This will add to the insulation value of the wall and will ensure that thermally broken window frames perform to their optimum value. Figs. 3.5.2.e, f, g & h.

For techniques to seal existing windows and frames, see Section 3.5.3.4.

.5 Walls to Soffits

Soffits in new and old building are often a discontinuity in the air barrier system, and so a source of air leakage. Overhangs can be perforated with gaps and holes leading to the building interior without alarming conventional designers, contractors and custodial staff, because they are protected from rain and snow by the building above. The primary air barrier at the vertical faces of the envelope must be continued horizontally at soffit. Figs. 3.5.2.i, j, k & l.

So called, "hot soffits", those containing building services which must not be allowed to freeze, must be air sealed at the soffit face. Vertical air barrier materials should extend to the soffit face and be connected to the horizontal system. Ventilation of soffit cavity to the building interior should not be blocked with "hot soffits".

"Cold soffits", those containing no services subject to freezing, offer greater flexibility for air leakage control. Building otherwise clad with Face Sealed Systems may incorporate face sealed soffits or may have porous soffits sealed at the underside of the floor slab using inaccessible air barrier methods. If the soffit is face sealed, ensure that all joints and penetrations are caulked. Recessed light fixture housings and access panels must be sealed as well.

Membranes used in Inaccessible Systems can wrap the structure and be sealed at penetrations.

Accessible Systems rely on the integrity of the concrete floor slab above the overhang to stop air leakage. Walls below the soffit must be constructed tight to the underside of the floor above to allow continuity of exterior membrane barriers in
FIGURE 3.5.2.2.1
PRECAST ON MASONRY BACKUP & SOFFIT
FIGURE 3.5.2.2 (I)
SOFFIT DETAIL
Inaccessible Systems or to provide a joint to be foamed or sealed with a membrane in Accessible Systems.

Penetrations through the envelope for pipes and/or electrical conduit providing power to light fixtures in the soffit should be sealed with a durable caulking or foam. Figs. 3.5.2.2.m & n.

Close all other holes leading to soffits from the building. For air leakage control in existing building, access the section of wall which is between the soffit and the floor above. Seal cracks, holes and joints between dissimilar materials using foam or durable sealants. In some older buildings, this section of wall may have to be reconstructed before smaller holes and cracks are sealed.

.6 Walls at Foundations

Air can leak through the joint between the ground floor slab and above grade walls and through the junction of the ground floor slab and top of foundation walls. These joints are caulked in Face Sealed Systems from the exterior with a durable sealant. For Inaccessible Systems, joining the above grade air barrier membrane to the below grade waterproofing provides a satisfactory seal. The detail should provide for protection of the membranes from frost damage.

Accessible Systems require caulking the base of the wall at the junction with the concrete slab from the inside and caulking or foaming the joint between the floor slab and foundation from inside the basement.

Figs. 3.5.2.2.o, p, q & r.

.7 Junction between Dissimilar Materials in the Building Envelope

At joints between dissimilar materials in the building face, review the materials or systems to identify their plane of air tightness and ensure that an air barrier material is used to connect the planes through the joint. For instance, a sloped glazed atrium roof incorporates a face sealed air barrier. It may abut a masonry cavity wall incorporating an inaccessible air barrier membrane. The detail must be
FIGURE 3.5.2.2.m
SOFFIT SINGLE PENETRATION DETAIL
FIGURE 3.5.2.2
SOFFIT MULTIPLE PENETRATION DETAIL
FIGURE 3.5.2.2.0
PRECAST ON MASONRY BACKUP @ FOUNDATION
FIGURE 3.3.2.2,q
PANEL ON METAL STUD BACKUP @ FOUNDATION
FIGURE 35.22r
PANEL ON METAL STUD BACKUP @ FOUNDATION
designed and installed to connect the face seal to the inaccessible air barrier membrane. Figs. 3.5.2.2.s & t.

.8 Compartmentalization of Cavities in the Building Envelope

Cavities built into the building envelope, forming part of rain screen assemblies for example, contain a volume of air which moves around corners and up and down and across the face of buildings by the action of convection and wind. Some movement of air is necessary to vent the cavity but large displacement of air in the cavity will reduce the RSI value in some batt insulations and will increase the migration of air through the wall assembly, particularly at any weak joints.

CMHC has begun testing the benefits of compartmentalizing the envelope cavities. This study is not final, however a rule of thumb is developing:

- Prevent cavity air from travelling vertically more than 3 storeys.
- Block cavities vertically at all corners to prevent movement of air from one building face to the other.
- Install vertical barriers in the cavity approximately 1.2 metres, 3.6 metres and 6 metres from each corner. Provide additional barriers at 6 metre intervals along the building face until you approach another corner. Fig. 3.5.2.8.a.

Two part urethane foam products are recommended to form the barrier. Ensure that each compartment of the cavity is adequately vented top and bottom and that foam does not block the vents.

3.5.3. Exterior Wall Openings

3.5.3.1. External Doors

In new construction, specify and install door seals to meet or exceed minimum building code standards for air leakage. The following discussion deals with techniques for air leakage control of existing doors.
FIGURE 3.5.2.2.a
JUNCTION OF DISSIMIAR MATERIALS
FIGURE 3.5.2.2.1
JUNCTION OF DISSIMILAR MATERIALS
Figure 3.5.2.8.a
Corner Compartmentalization

- Closed or bitumen impregnated open cell polyethylene
- Positive pressure on windward face
- Brick veneer
- Cavity
- Insulation
- Membrane (air/vapour barrier)
- Concrete block
- Gypsum board
The selection of the proper type of weatherstripping is an important step. Door weatherstripping must be extremely durable and expandable, but at the same time, it must look good and not impede the use of the door.

The width of the gap between any given door and its frame varies from point to point and season to season. Therefore, when selecting new seals, preference should be given to those types which can accommodate large changes in gap width as great as 5 mm (0.2") over a period of years. If the weatherstripping can be manually adjusted to accommodate even greater changes, all the better.

Door weatherstripping works either by compression (e.g. hollow tubular seals) or by bending (e.g. plastic "v" seals). It is relatively easy to compress or bend a small section of seal. However, around a door there is usually a total length of about 6 meters (18') of weatherstripping. To close the door against the action of this length of seal, extra force is required. The type of seal should be selected so that excessive closing force is not required. Fig. 3.5.3.1.a.

.1 Selecting seals for the Strike Jamb

For convenience, the options for positioning weatherstripping at the strike jamb can be divided into three categories: edge seals, stop seals and side mounted seals. For wooden doors and frames, the side of door opposite the hinges (the strike jamb) tends to experience more warpage than other parts of the door, because it is long and because it is not attached to the frame. Therefore, when the door is closed, the gap between the door and the stop may vary considerably from top to bottom, and will also vary from season to season. Because the strike jamb experiences so much movement, not all seals are appropriate.

**Jamb Seals** are generally the best option for weatherstripping at the strike jamb. Their effectiveness is not impaired by warping of the door. They do not require much closing force, and, being installed close to the inside of the house, they are not exposed to the worst climatic temperature effects. However, they will be interrupted by and must be fabricated to accommodate lock sets.

**Face Mounted Stop Seals** on the strike jamb must have a wide compressible range if they are to be able to accommodate a wide gap variation. The wide compressible range means that the required door closing force will be relatively high, which can
FIGURE 3.5.3.1.a
TYPICAL WEATHERSTRIPPING PRODUCTS
lead to other problems. Stop seals are also more exposed to exterior temperatures, when compared to edge seals, and may not last as long. They are also more susceptible to vandalism.

**Side Mounted Stop Seals** must also be able to accommodate a wide gap variation. In some designs, this is achieved with spring loading, which allows movement of the seal up to about 6 mm (1/4"). Side mounted seals are also completely exposed to exterior temperatures. Spring loaded seals allow air to pass around the spring when it is compressed.

A combination of Jamb and Stop Seals can be very effective.

Some manufacturers offer special mouldings which give both a jamb and a stop seal. These are marginally better than jamb seals alone, since they give a good seal around the lock set.

.2 Selecting Seals for the Head Jamb:

The requirements at the head jamb are the same as for the strike jamb, though the range of the gap width may be less severe. Where possible, the same seals should be used on the head jamb as on the strike jamb.

.3 Selecting Seals for the Hinge Jamb:

The door hinges help to resist warping of the door along the hinge edge. As a result, the air gap along this edge is usually small and displays limited variation in width. Therefore, the suitability of the different sealing methods changes:

Jamb Seals are a good option because of the relatively narrow and uniform gap along the edge. Self adhesive plastic "v" weatherstrip is a suitable material to use.

Side Mounted Stop Seals are also a good option provided that the hinges are properly recessed into the jamb.

.4 Selecting Seals for the Sill/Threshold

Sill seals can be divided into two main categories: "sweeps" which are attached to the bottom of the door and "threshold seals" which are attached to the door sill.
- Measure all the dimensions of the jambs and sill, and pre-cut the weatherstripping.

- The weatherstripping should be applied to the prepared surfaces in accordance with the manufacturer's instructions. Leave room for final adjustment if necessary.

- When installed, some seals may not fit tightly to the jamb, leaving small gaps through which air will continue to leak. Where this is likely to be a problem, a fine bead of sealant should be applied to the jamb. The weatherstripping should then be installed over the bead.

- It is difficult, when installing seals, to get a good airtight joint where the seals meet at the corner of the door frame. A reasonable attempt should be made to get a good seal joint at corners, but extreme lengths to achieve a perfectly airtight seal are unnecessary.

3.5.3.2. Revolving Entrance Doors

Revolving doors are one of the first architectural components designed specifically to decouple the outside and inside environments while still permitting pedestrian traffic to move from one to the other. They are particularly effective where a high volume of traffic is anticipated and space limitation prevents creation of an entrance vestibule. They reduce drafts and limit air movement due to stack effect.

Revolving door seals must be maintained and replaced from time to time. Follow manufacturer's recommended procedures.

3.5.3.3. Pressurized Vestibule Entrances

Well sealed vestibules are an effective system to isolate the outside and inside environment while permitting passage from one to the other. Recent changes to Building Codes require power operated or power assisted entrance doors, as part of the barrier free access program. These provisions have lessened or removed the often cumbersome task of opening two sets of doors when entering or exiting a new building.

New doors and frames should meet or exceed building code standards for air leakage. Existing doorways should be sealed using
methods described in Section 3.5.3.1. Walls and ceilings of vestibules must be constructed to be airtight or, in existing buildings, should be checked at joints to make an efficient air seal. Refer to Section 3.5.3.4. for glazed vestibules and 3.5.2.2. (2) for base boards. Seal the ceiling and duct penetrations or seal the plenum above and around the ceiling if the ceiling is not an air barrier material. Ensure that vestibule ceiling plenums are isolated from the surrounding plenum spaces.

3.5.3.4. Operable Windows - Sash & Casement

Weatherstrip Moveable Sash of Hung Window

While operable windows are not common in new commercial high rise buildings, in many older structures they are a major source of air leakage.

This section describes procedures for weatherstripping the moveable sash of a hung window. Three locations require weatherstripping:

.1 Between the check rails

.2 Between the bottom rail and sill on a lower sash (or the top rail and head jamb of an upper sash).

.3 Between the stiles and the side jamb.

Each location may warrant a different type of weatherstripping.

Probably the easiest application involves the use of a compression type weatherstrip on the bottom (or top) rail, and a plastic "v" weatherstrip on the check rails and side jambs.

Lower Sash Only

- To weatherstrip the check rails, apply plastic "v" weatherstrip to the back of the check rail on the lower sash, so that the strip is concealed when the sash is closed.

If appearances are not important, the "v" weatherstrip can be applied to the upper sash rail, with the open end of the "v" pointing downwards, to the outside. This will leave the weatherstrip visible when the window is open, but normally provide a better seal.
- To weatherstrip at the sill, cut compression weatherstrip (e.g., closed cell sponge or hollow core tubular) to the exact width of the sash. Attach securely to the bottom rail of the sash. "V" seals can also be used.

- To weatherstrip the sides of the sash, use self adhesive plastic "v" weatherstrip. Apply it to the side jambs, running up from the sill to the full height of the lower sash. The weatherstrip should be positioned as close to the outside of the house as possible, with the open end of the "v" facing to the outside.

- Check to ensure that the window can still be opened easily. If not, apply a dry lubricant and adjust the stops as required.

- Check to ensure the sash clamp is operable. If not, adjust the clamp, or install a new clamp.

Figs. 3.5.3.4.a, b & c.

Variations in Technique for Upper Sash Applications

Weatherstripping the upper sash of hung windows should be handled in the same general way as weatherstripping the lower sash (described above).

Figs. 3.5.3.4.d & e.

Treat window frames and glazing gaskets as in Section 3.5.3.5.

3.5.3.5. Non-operable Windows

Sealing Window Trim

.1 Run a continuous bead of sealant around the gap between the window trim and wall. Adjust the width of the bead according to the size of the gap. Good caulking technique is required to maintain a tidy bead.

.2 Run a needle bead into the trim mitre joints, where required. Similarly, run a needle bead into any gap between the trim and the window frame. Remove excess sealant and wipe clean.

.3 Inspect glazing compound, tape or gaskets of window panes. Replace if the material has deteriorated.
Figure 3.5.3.4.a
Weatherstripping The Lower Sash

Figure 3.5.3.4.b
"V" Weatherstripping At Check Rail

Figure 3.5.3.4.c
Compression Weatherstrip Attached To The Bottom Rail
Figure 3.5.3.4.d  Weatherstripping Upper Sash Of A Hung Window

Figure 3.5.3.4.e  "V" Weatherstrip Attached To Side Jamb
3.5.3.6. **Electrical Penetrations in Exterior Walls**

**Sealing Electrical Receptacles**

.1 Apply thin bead of caulking to back of gasket, and stick gasket to the wall, over electrical outlets. Ensure caulk effectively seals flanges at top and bottom of receptacle.

.2 Insert child proof safety plugs in little used outlets.

Figs. 3.5.3.6.a & b.

**Electric Service Penetration**

A variety of service penetrations occur at headers and foundation walls. Dryer vents, water pipes, gas pipes, oil filler pipes and almost all other penetrations can be sealed using standard practices. An electrical service entrance, however, is a special case. In addition to the air leakage gap around the electrical conduit itself, there is the gap between the electrical conduit and the electrical cable running inside the conduit. As well, special sealants must be used when sealing the electrical cable.

.1 If there is a large gap around the duct, pipe, etc., insert single component foam.

.2 If the duct, pipe, etc., passes through a wood header, or concrete wall, seal the gap with (in order of preference), silicone or single component foam.

Figs. 3.5.3.6.c, d & e.

3.5.3.7. **Ventilation, Louvres and Grills**

Seal penetrations of pipe and ducts at the plane of airtightness and again at the exterior face.

Sealing at the plane of airtightness ensures continuity of the air barrier system. Use materials compatible with the surrounding wall. Sealing the penetration at the face prevents water penetration into the wall assembly.
Figure 3.5.3.6.a

Figure 4.7
Installation of an Air Tight Electrical Box for Continuity of the Air Barrier System
3.5.3.8. **Incremental Through the Wall Units**

In some cases, through wall heat pump type units are installed in exterior walls to control local air conditioning needs. The units themselves are not often a source of air leakage, however, the surrounding framed openings are. Caulk or foam the frames to create an effective air seal.

3.5.4. **Interior Wall and Openings**

3.5.4.1. **Partitions to Exterior Wall Junctions**

The hollow cavity of partitions can be a pathway for air infiltration from the exterior unless the partition is adequately separated from the exterior wall at the junction. This is particularly important with Accessible Air Barrier Systems. See Fig. 3.5.4.1.a. In new construction, run the exterior wall gypsum board membrane continuously through the intersection with interior partitions. Seal top and bottom prior to butting the interior partition to the gypsum board and finish conventionally. In existing buildings drill the interior partition adjacent to the outside wall and foam the cavity with two part polyurethane. Extend this treatment above ceiling level to the underside of the floor slab above if the partition also projects above the ceiling.

3.5.4.2 **Fire Rated Doors and Partitions**

Fire rated doors are located in fire rated partitions. Together these separations are intended to compartmentalize floor areas to reduce the spread of flame. If properly constructed and maintained, they can also block air movement between floor areas and, in the case of stairwells, they can block air flow between floors. Pending provisions to the National and Provincial Building Codes require greater smoke control. At fire separations in new buildings, control of air movement effectively controls the propagation of smoke.

Fire stop and air seal top of rated partitions at underside of structure using cementitious foam fire rated to match the wall assembly.

Caulk base of walls.

Weatherstrip doors and caulk junction of walls and door frames. Refer to Section 3.3.
FIGURE 3.5.4.1.e
WALL JUNCTION - STEEL STUD WALL
3.5.4.3. **Plumbing Holes, Electrical and Communication Conduit**

Holes around service penetrations through interior unrated partitions are not important sources of air leakage and need not be sealed; however, air movement through rated partitions is undesirable. See article 3.5.4.2. Construct rated assemblies as tightly as possible to the service penetration. Seal the joint with fire-stop sealant. In existing buildings, often large areas of the fire separation have been removed to permit retrofit of a new pipe or conduit. For larger openings, reconstruct the assembly using materials which form the original fire separation. Finish the seal as with new construction. If the service penetration is difficult to access, fire rated cementitious foam may be used to seal the voids.

3.5.4.4. **Ductwork Penetrations**

Installation of ductwork can create the same holes in fire separation as pipes and conduit. Take a similar approach to sealing. Figs. 3.5.4.4.a & b.

However, with ductwork there are a greater number of joints to be sealed. A fire damper is located within the duct at the wall line. Metal frames surrounding the duct support the mechanism. Ensure that a seal is made between the partition and the frame and between the frame and the duct. Using caulking or foam sealants. Refer to Section 3.3, Sentence 1.

3.5.5 **Roofs and Roof Openings**

A well fastened, continuous roof membrane will act as the principal air barrier on the roof. Try to limit penetrations through this assembly. Combine services, where practical, to pass through one opening. Remove unused collars and vents. They are ordinarily capped to prevent water penetration, not air leakage.

3.5.5.1. **Drains and Cold Vents**

For new installation, surround the drain pipe with a flexible membrane sleeve compatible with the roofing material. Fix the membrane to the pipe with a draw band. Seal the other end into the surrounding roof membrane before installing the hopper.

In existing buildings, seal the pipe to the surrounding deck from below using two part urethane foam.
FIGURE 3.5.4.4.c
PENETRATION - MASONRY WALL
FIGURE 3.5.4.6
PENETRATION - MASONRY WALL
3.5.5.2. **Chimneys and Hot Vents**

Seal flange of metal collar to roof membrane. Seal metal collar of hot vents to the vent with high temperature silicone sealant prior to installation or rain deflection flashing.

3.5.5.3. **Skylights, Curb Mounted Equipment and Smoke and Access Hatches**

For all types of curb mounted roof accessories, ensure that roof membrane runs continuously up and over top of curbs. Seal fixed frames to top of curb by bedding the frame in a continuous bead of caulking. Check weather seal of operable hatches and replace defective gaskets. Refer to Section 3.3, Sentence 3.8.

At duct penetrations, form a sleeve around the ductwork using an elastic membrane material. Seal flange of sleeve to roof membrane at top of curb. Seal collar of sleeve to duct.

3.5.5.4. **Mechanical Pent Houses**

Mechanical penthouses sit on top of service shafts that rise from below grade. They are rooms ordinarily cooled by ventilation to the exterior through large areas of fixed or operable louvres. They are often uninsulated spaces with cracks between exterior wall materials or are otherwise made of poorly sealed metal or porous masonry. Any hole through the penthouse floor into a shaft below is at the well head of air ex-filtration in most high rise commercial buildings.

Ideally, the mechanical penthouse would be as tightly constructed as the commercially occupied floors. However, in existing buildings isolating the penthouse from the building at the penthouse floor, may be the only practical solution to controlling air leakage. Seal holes around ducts and pipes through the penthouse floor using methods described in Section 3.3, Sentence 1.8. Caulking cracks and weatherstripping doors in penthouses otherwise ventilated directly to the outside will have small effect unless the louvre vents are mechanically operated and controlled by thermostat. In that case, every effort should be made to control air leakage through the walls and ceilings of the penthouse using methods described in sections covering Roof Wall Joints, Service Penetrations, Floor Wall Joints and Exterior Doors. In new construction or in comprehensive renovation projects, consider isolating the elevator machine room from the balance of the penthouse, enclose it in an airtight structure.
and air condition the space to cool the equipment. The tops of elevator shafts are difficult to seal because of the moving cables. They are the large shafts in the structure and so represent the largest potential for air movement between floors of the building. Isolating the machine room in this fashion is an effective way to cap the shaft.

If isolation of the elevator equipment room is not possible, a compromise can be made by reducing air leakage at the top of the shaft.

These are operating elevators and therefore must be shut down before any work is started.

.1 Clean floor and frame areas around cables.
.2 Install good quality aluminum duct tape across opening, being sure not to touch cable.
.3 Apply enough tape to provide solid seal that will not blow off due to elevator operation.
.4 Start elevator and observe performance of tape seal.

Once the cable hole is reduced, observe the maintenance and equipment installation hatches. Weatherstrip equipment hatch doors using compression seal such as closed cell foam neoprene.

Replace open grate maintenance hatches with solid metal ones. Ensure that new hatchways are fitted with air seal gaskets.

3.6 Shafts

It should be clear from our earlier discussions that air movement between floor levels is undesirable. It defeats the efforts of mechanical systems and worse, it is a hazard to the building occupants in case of smoke or fire. Nevertheless, vertical shafts, elevator and stair shafts are a necessary part of high rise commercial buildings. It is important to isolate these vertical spaces as best as possible from each floor level through which they pass.

If the shaft is used exclusively for pipes or ducts, the shaft must be sealed at each floor using techniques described in Article 3.5.1.8.
In new construction, effort should be made to isolate elevator machine rooms from all other equipment penthouses. Air-conditioning these spaces rather than cooling with direct to exterior ventilation will save substantial loss of treated air.

In existing buildings where the elevator penthouse cannot be isolated from other equipment or where cooling of the space is with untreated outside air, the openings between the shaft and penthouse must be sealed or reduced in size to limit air movement. Service hatches should be solid plate steel rather than open grill work. Hatches should be gasketted or weatherstripped.

Elevator cable holes can have their effective open area reduced by application of metal plates and should have a good quality aluminum duct tape applied over the reduced openings to finish the job. Apply enough tape to resist the air pressure created by the operation of the elevations. Ensure that tape does not interfere with the action of the cables.

Fig. 3.6.a.
Section 4  DESIGN PROCESS AND CONTRACTING PROCEDURES

4.1.  Existing Buildings

4.1.1.  For Designers:

Determine Air Leakage Paths

Design Repair Solution

Verify Attributes of Air Permeability, Structural Support Requirements for Air Barrier Components.

Require Tests for Acceptable Air Leakage Rates

Identify Locations of Uncontrolled Leakage

Specify Methods and Materials

Require Prequalification of Bidders to Obtain Tenders only from Qualified Air Leakage Retrofit

Review Contractors Work and Test Results

4.1.2.  For Contractors:

Obtain Bidder’s Package

Check Drawings and Specifications

Check Performance Requirements

Check Test Methods

Check all Penetrations

Prepare Checklist of Points to Seal

Schedule and Execute Work

Restore continuity

Obtain Tests as required.
4.2 New Construction

4.2.1. For Designers:

Consult Technical Literature and/or Hire Building Envelope Consultant

Consult with Mechanical and Structural Designers to identify Boundaries of Environmental Zones within the Building and to identify Location of Movement Joints

Choose Air Barrier Friendly Details for Structural Elements within Building Envelope

Designate Values of Performance

Identify all Air Barrier Locations in Drawings with Materials and Method of Installation

Specify Sequence of Installation

Use National Master Specification 07195

Review Interior Environmental Conditions e.g. Humidity, Temperature

Observe Requirements for Continuity, Structural Support, Ability to Withstand Wind and Fan Pressures and Stack Effect: Durability, Accessibility and Reparability

Test Unproven Designs or Waive Builder's Liability for Performance of Unproven Details

Require Air Barrier Inspections Before Covering the Installation

Commission Building Envelope (This includes Monitoring Performance After Repairs, Building Operation Manual for New Air Barrier System, Commissioning Certificate to Owner, Statement of Liability for Future Performance)

4.2.2. For Contractors:

Construct for Continuity

Check all Penetrations
No Substitutions of Materials Without Written Authorization from the Consultant

Ensure Understanding and Compliance by all Sub- Trades

Inspect and Document Before Covering any Part of an Air Barrier System
5.1. **Conclusion**

This document has demonstrated that the technologies, materials and methods needed to implement beneficial air leakage control measures in new and existing high-rise commercial buildings have been proven and are readily available. Air leakage control measures reduce energy costs for heating and cooling and offer a speedy return on investment. Good air barrier design practices give a building greater life expectancy, and retrofit air leakage control measures can stop decay before it gets worse. Proper selection of materials and installation methods can also prevent building problems which may result in reduced safety and eventual liability problems. Controlling air leakage makes it easier to control humidity in the indoor environment, and therefore provide a more comfortable and healthier workplace. Finally, there is an opportunity to prevent the unsightly scarring of so many high-rise buildings.

5.2 **Recommendations**

The potential benefits of air leakage control can only be realized if the measures described are widely implemented. Awareness of the initial design requirements for proper air barrier systems must be increased in the architectural and specification community; knowledge of the materials and methods must be increased among builders and contractors; and developers and other building owners must learn that the economic benefits are worth the investment.

Until recently, there was little recognition of the link between inadequate air barriers and common building problems. Now that the cause and effects are better known, it would be wise to exploit this opportunity to improve the quality, longevity and economic performance of the entire Canadian high-rise commercial building stock.

5.3 **Definitions/Glossary of Terms**

For the best available list of definitions, refer to the Air Barrier TEK-AID (1.1.1.).

5.4 **National Building Code: Air Barrier 5.3.1.**

Draft Appendix NBC Part 5.
5.5. **Multi-purpose Air Barrier Materials**

- Air Barrier plus Vapour Diffusion Retarder
- Air Barrier plus insulation

5.6. **Effects of Air Leakage Control Measures on Indoor Air Quality**

Since high-rise commercial buildings are designed with ventilation systems to bring in outside air, this is not a significant factor.

5.7. **Other References and Sources**

5.8. **Reading Material**


5.9. **Appendices**

5.10. **Disclaimers**

5.11. **Copyright**