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Bad air: it's enough to make you sick

HOWARD SEIDEN M.D.

Building air systems may make you sick

INDOOR AIR: IS IT DANGEROUS TO YOUR HEALTH?

A recent nationaly syndicated, medical column which appears in major Canadian newspapers discussed indoor air quality. The columns, written by a doctor, underline the ignorance that exists among the general population about the importance of a sound maintenance program for household mechanical equipment.

A leaky roof or tap is easy to see and fix, but improperly functioning equipment will not be recognized quickly. The problems often are invisible.

For the low energy builder, and the R-2000 Program, the challenge is to educate the public and overcome fears about tightly built houses. There are problems with new construction practices, but these have been, and are continuing to be, dealt with in a systematic fashion by the program.

Unfortunately, copy-cat houses built outside the regulation of the R-2000 Program, often at the insistence of owners who want to cut corners but don't quite understand the consequences of not following a carefully tought out building system, are prime targets for problems. The most important R-2000 criteria is the requirement for balanced ventilation

The author of the column (talking about his new house) points out that

> *the house didn't come with any instructions. All we were told was that the thermostat controlled everything. I discovered that the furnace had filters, and then discovered that the humidifier sat on the side of the furnace.*
>
> *I removed the lid to find a.... sponge made so hard by mineral deposits that it would have cracked had I dropped it... The water... was yellow and covered with a slimy, greasy sludge. What had this marvel of technology been discharging into the air we beathed...?*

He goes on to talk about legionnaires disease andd other respiratory diseases that have been identified with faulty air conditioning systems.

The implications are clear - faulty or poorly maintained ventilation systems can create considerable health problems. There is considerable documented evidence to prove this.

Recently, a series of television stories have dealt with indoor air quality problems, mainly in office and commercial buildings - the so called 'sick building' syndrome. In most cases these are directly related to completely sealed buildings that rely on central heating/ventilating (HVAC) plants, where design or maintenance faults can lead to conditions that make it difficult to maintain good air quality.

The use of these central HVAC systems is relatively recent. It is only since the 1950's that widespread reliance has been made of mechanical systems to provide conditioned and liveable conditions inside buildings.

A major feature of the modern building with a central HVAC is that the building is completely sealed - windows don't open, so the only source of air is through the central stystem. If there is a problem with the HVAC system all occupants of the building will suffer.

Energy conservation activity spurred by the energy crisis of the 1970's has meant that systems now are being built to the limit - energy conservation has become a major design criteria. Systems are being designed to recycle maximum amounts of air, draw minimum amounts of fresh air and rely on filters and scrubbers to clean the air. All are new techniques and approaches.

However, these HVAC systems, like the choke on your car, can be throttled down too far. If this happens, the quality of the indoor air will not be adequate, and can lead to the various problems that are only now begining to be recognized.

In recent years, people have begun to sense that something is wrong with these central systems as they exist in their work environments. This is why they become very concerned about talk of *airtight* houses.

As any low energy builder will appreciate, even the tightest house does not present the same situation because the house still has windows that open - and in each room at that! So that the resident can easily control his own environment. If it gets too stuffy, the window can be opened. As well, a properly built "tight" house will contain a ventilation system of some sort. Unfortunately, too few of the general public understands that. Ventilation systems for houses is too new an idea for most people.

In recent years, most conventional houses have been tightened up, so much so that the newly revised National Building Code has recognized the need for some form of mechanical ventilation. Up to now, balanced ventilation systems in traditional housing have been the exception rather than the norm. Continued R-2000 Program monitoring has proven that indoor air quality in a well built and designed house will be better than in conventional houses.

R-2000 builders are already familiar (and hopefully thoroughly committed) to the need for balanced ventilation. For the new code changes to be succesful, a considerable amount of builder and public education is still needed.

One interesting development we have heard about is a proposal by the Greater Victoria Homebuilders Association to make attending an R-2000 builder's workshop a condition of membership.

The Homeowner's Part

You can have the best designed ventilation system, but if it is not maintained properly, it will not do any good. As the doctor pointed out in his columns, some parts of the system may well provide the ideal conditions for breeding bacteria strong and nasty enough that breathing in the house could be hazardous to the health of the resident.

We know that many people are not familiar with or keen enough to maintain their house properly. Those of us in the building community may find this hard to understand. After all, it's not that hard to change a filter in the furnace, is it? But then because that is our livelyhood, it is second nature to us. It seems so simple to tell a new homeowner to "be sure the filters are changed 2 or 3 times a year, and etc..." But you have to remember to do it!

But the homeowner, who may be a doctor, banker, salesman, teacher, stockbroker, or whatever is often much more interested in other things. To him, an ordinary furnace or hot water tank is a technological marvel with strange knobs, screws, and pipes whose meaning and purpose is totaly unknown (and he may be afraid of breaking the whole thing if he touches something the wrong way).

To do any regular maintenance, he has to remember that the equipment is there. If it is located in some dim part of the basement or crawl space, it will be forgotten (or not even dicovered!) until something goes wrong.

(Personaly, that's the way I deal with my car - I know where to put the gas and how to turn the key, but if something goes wrong, it's panicsville! Just what are all those things under the hood?)

Why place so much stress on ventilation systems and their upkeep?

We know that in recent years natural air leakage into houses has been reduced by improved construction techniques. Aside from issues of increased concentrations of pollutants in the house, there is a greater risk of carbon monoxide poisoning or asphyxiation to the occupants if combustion appliances do not have adequate provisions for combustion air.

A 1982 report estimated that about 10 people die in Canada each year and another

100 are hospitalized as a result of carbon monoxide poisoning due to incomplete combustion.

Balanced ventilation systems for occupancy are not meant to provide combustion air but if there were an inadequate supply of combustion air, the ventilation system will tend to reduce build up of toxic gases and ensure that the indoor air was constantly flushed clean.

So what is the solution to a healthy, sound design? There are a few points the builder should keep in mind.

Firstly, above all, the system design should follow the KISS principle: *keep it simple, stupid*.

Secondly, Murphy's law should be accepted as a given. If something can go wrong, it will. A simple design, with a minimum of complex parts that can break down should be used. Always assume the worst possible scenario.

Thirdly, when selecting equipment, look for the best, most durable, easily serviceable equipment. If it is worthwhile to use a complex piece of equipment, look for its track record, warranty provisions, and availability of service and parts. (Why use a piece of equipment that can only be maintained by factory trained service personnel in a location where such personnel are not available and if parts are needed, it will take two weeks to airlift them?)

If the equipment has filters that require periodic maintenance (and ideally that would be several times per year) don't place the equipment in a spot that only a 4 foot tall Olympic gymnast can easily get at. Some HRV's have filters inside the main unit, which should be cleaned several times a year, yet we have seen units located in very shallow crawl spaces, hard to get at attic spaces, or hanging high in a workshop - any guesses how often those filters will be changed? How many homeowners (assuming they've been told) will remember to change or clean the filters after two years of occupancy? We won't even think about the second purchaser.

And finaly, a simple user's manual should be provided - something simple - even a one page typewritten list of points to check and maintenance to perform. This could be attached next to the electrical panel (everyone sooner or later finds it).

CONCERNS ABOUT VENTING

by David Hill and Yvonne Kerr

Stack Action Against the Ventilation Industry

Has anyone in the energy efficient housing industry not heard the line "but I don't want my home too tight. I like the idea of some fresh air getting in"? What follows is usually a difficult sales pitch: the benefits of stopping *natural* ventilation (which costs money) and the benefits of *forced*, *mechanical* ventilation (which costs even more money).

Which sounds better to you: "The *natural* taste of orange juice" or "the *forced*, *mechanical* taste of orange juice"? Just how *natural* is natural ventilation?

A Crude Awakening

The only reason to call natural ventilation *natural* is because it's common to the traditionally built home. But there's nothing natural about it. A more accurate word would be "crude". Because leakage spots are at random locations, air change is different in all parts of the home. It changes from season to season and even throughout the day as temperatures change. The building envelope is the crude ventilation.

Stack action is the force which makes hot air rise. Cold outdoor air is drawn inside to replace the hot air which is lost into the attic or upper wall cavities. Cold air is heavy and will "pool" on the floor. Unfortunately this force is silently at work in all of our houses. These drafts are far less dramatic than wind-driven drafts, but have far greater impact. Unlike winds, the drafts from stack action continue non-stop throughout the heating season. These drafts strike two and three storey homes hardest and are most severe during cold weather. A building envelope with leakage spots is an unsatisfactory and crude form of ventilation. It 'works' whenever it wants and rarely, if ever, when you want it to.

Assuming a warm summer outdoor temperature, open windows for ventilation are quite acceptable. During the fall, however, the combination of moist, foggy outdoor air and the need to close windows for warmth confines moisture, making window condensation a common problem. With little or no wind or stack action during the autumn months, homes become very stuffy.

A very different situation develops during the cold, winter months. Tremendous stack action driven by the indoor/outdoor temperature difference hyper-ventilates the home and dries it out. During this season, the crude ventilation is totally out of control. When the milder spring returns, stack action is reduced and the home again tends to become stuffy. Crude ventilation stands little chance of success when up against the natural elements.

Primitive Fan Fare

Two forms of primitive ventilation have indirectly pointed the ventilation industry in the right direction. About twenty-five years ago, homeowners who were not satisfied with 'hit and miss' crude ventilation demanded more control. Small cfm kitchen and bathroom fans were installed to provide localized exhaust. Cold outdoor air is drawn in even faster through leakage spots to replace the stale, moist air that (if properly ducted) is flushed outdoors. Aside from increased drafts, there are two major drawbacks to this form of primitive ventilation: small cfm fans move even smaller amounts of air once you add ductwork; and the less expensive fans are noisy. This type of ventilation does give the homeowner some control over exhaust, but does nothing for supply air control. And because of the noise, these fans are seldom used. Unless equipped with a sealed backdraft damper, these fans become just another hole in the building envelope.

An improved form of primitive ventilation relies on the homeowner to open and close windows on a well-built, draft-proofed home. Sealing leakage spots in the building envelope establishes the first step towards control of ventilation. Wind and stack action no longer have a dramatic effect on the air change of the home. Combined with openable windows, the homeowner has manual but accurate control of ventilation. The primary purpose of windows, however, is to provide natural light and passive gain into the home, and to create a view to the outside. North Americans would never accept small, high openable windows which would provide ideal cold weather ventilation.

A Step in the Tight Direction

From a control standpoint, a sealed building envelope with an intermittent or continuous exhaust fan is the first step towards a 'refined' ventilation system. The fan is controlled by a dehumidistat providing localized, humidity-sensitive exhaust with a manual over-ride option. This system is limited to electrically heated or sealed combustion appliance homes because there is no allowance for the supply air. Supply air must be sucked by 'brute force' through the few leakage spots remaining in the building envelope. Supply air comes in when you want, but not necessarily where you want it to.

Ventilation Systems Refined

A quality draft-proofed home equipped with a well installed HRV meets almost all of any homeowner's demands for a healthy, comfortable environment. Controls such as timers and dehumidistats boost the low, continuous air change to a higher level on demand. The control of supply air allows installation of filtering to any degree the customer requires.

Because the capital cost of these systems is high and the cost is directly dependent on installed capacity, the cost-conscious housing industry is asking, legitimately, how much air do we need?

Sizing Up the Future

Experts have tested for specific pollutants in both conventional and airtight homes: formaldehyde, carbon monoxide, carbon dioxide, nitrogen oxides, humidity, moulds and dust, bacteria, viruses, radon and many others. The conclusion: provide enough ventilation to keep these pollutants at an acceptable level and perhaps provide an additional capacity 'just in case'. This additional capacity would hopefully take care of those pollutants we haven't yet discovered and act as a 'cushion of caution' for the industry. What if this caution cushion isn't enough? How much bigger is better?

Consider for a moment: is it really the building industry's responsibility to consider each and every possible action that a homeowner may or may not take? Should a builder build every home with six bedrooms just in case a couple decides to have a large family? Must every home have carport space for two large cars? Should space be provided in every house on the off-chance that a homeowner wants to build a sauna at some later date? Of course not. If a builder must provide for every possible activity and cottage industry that a homeowner could get involved with he would soon go broke.

Primary and Secondary Ventilation

Ventilation requirements that are common to every homeowner in every house must be considered PRIMARY VENTILATION. All else is SECONDARY.

Secondary ventilation needs can not be uniformly regulated across the country. If the home building industry accepts responsibility for secondary ventilation requirements, the following would occur:

1) comprehensive studies to identify radon areas would never take place;
2) No force would be directed at the building products industry to reduce formaldehyde levels;
3) homeowners would continue to load up their homes with harmful pollutants from paint studios, hardressing salons, automotive repair shops and other irregular activities; and
4) the ventilation industry would have to assume responsibility for any new pollutant developed or discovered for years to come, a situation that would get totally out of control.

The buck has to stop somewhere!

The only logical solution is to stop secondary pollutants at the source, preferably before they enter the home. The 'simple' solution until now has been to assume that virtually all air pollutants can be dealt with by ventilation. As a general rule, secondary pollutants should be barriered off or excluded from the home altogether. Or, if ventilation is determined to be the most cost effective solution (frequently in retrofit situations), then each case must be considered individually.

Two significant steps have already been taken to acknowledge the difference between primary and secondary ventilation. In Canada, the R-2000 Program has recognized the venting of combustion products as a secondary need. They require the use of sealed combustion or induced draft fuel-burning appliances.

Internationally, France has recognized the difference between primary and secondary ventilation needs. In 1980 they relaxed their continuous ventilation requirement in housing. They now permit a system which has equal continuous capacity as before, but which remains all but closed at times of low need. This decision focusses directly on the primary ventilation needs of the home, to the exclusion of secondary problem pollutants.

Increasing energy costs and homeowner's demands for increased comfort have resulted in tighter homes. Today more and more building products are being made from synthetic materials. With no emission regulations in place, harmful pollutants are out of control. The combination of these practices and our increasing awareness of other harmful pollutants such as radon forces us to take action. The ventilation industry has two choices: lump primary and secondary needs together and develop 'hurricanes', or separate the needs and develop standards for quiet, controlled, quality primary ventilators.

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VENTILATION: EXHAUST ONLY ALTERNATIVE

In the past few years, new construction techniques such as better insulation levels and draftproofing have not only cut heating bills but also improved the quality of housing construction in general.

With these developments has come the recognition for the need to controll indoor air quality. In our cold climates, it was quickly recognized that if we are going to provide fresh air, we had better reduce to a minimum the heat loss due to ventilation and air infiltration - hence the development of the residential heat recovery ventilator.

HRV's provide a continuous air exchange, bringing fresh air into the home and exhausting stale, moist air, recapturing up to 78% of the heat from the exhaust air. These systems require a considerable amount of ducting, and in some cases, can be costly.

The ventilation requirements in Canada are based on ASHRAE recommendations for the control of carbon dioxide in houses. At the residential scale knowledge in this field is new. Past experience is related to commercial and institutional buildings, so there are legitimate questions about what are safe and appropriate ventilation levels for houses.

R-2000 Program monitoring activity is begining to indicate that in some cases safe levels are lower than the half air change per hour presently called for, and required ventilation rates are being reduced slightly. However, any publicly funded program will tend to be cautious, with concerns for liability keeping requirements on the safe side.

Similar concerns are being expressed in other countries. France has had building code ventilation requirements since 1969. The energy concerns of the past decade have spurred a re-examination of standards, and a gradual decrease of required ventilation rates.

One French company has taken a different approach to meeting ventilation needs. AERECO has assumped that pollutant generation is directly related to occupancy, suggests that humidity is the best indicator of pollution generation. Their basic principle is to adjust air flows as a function of the humidity.

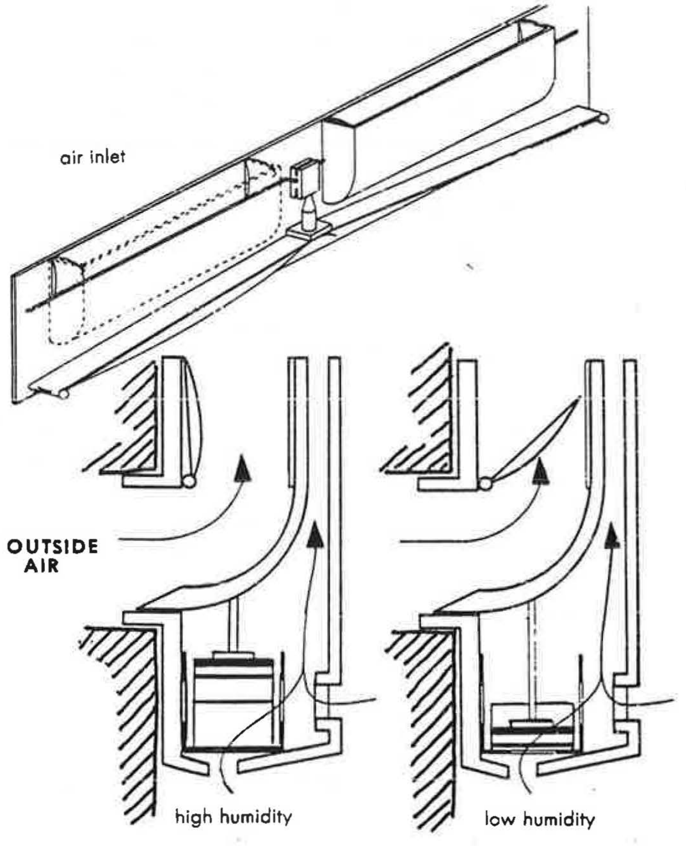
The premise is that occupants in a dwelling add moisture: water vapour is generated by people, pets, cooking, hobbies and other activities, mainly in the kitchen and bathroom. Except for pollutants such as chemical odours and carbon dioxide, relative humidity in the house is a good indicator of the need for ventilation as it increases with occupancy and activity levels, increase in outdoor temperature, and the lowering of interior temperatures. Even carbon dioxide generation is generally associated with occupancy (people, animals exhaling). A person's breath is always moist, thus increasing relative humidity.

AERECO has developed a self regulating humidity controlled ventilation system. It ventilates moisture based on people and people related activities. The system operates on negative pressure and is ideally suited to non-forced air heatied houses. Fresh air is admitted into bedrooms and living areas and extracted from kitchen and bathrooms.

Humidity controlled exhaust units are located in the kitchen and bathrooms. They determine how much air is exhausted. Humidity controlled inlet units are located in each bedroom and main living areas. In essence, the layout is not unlike a conventional HRV.

The air inlets are located on exterior walls. Fresh air enters through a screened rain hood, passing through a sleeve in the wall, and enters the home via a controlled inlet damper. The damper is not connected to any central fan, but is self adjusting to local humidity conditions, admitting air only to the room in which it is located. A major drawback is that the incoming air is not tempered, so that cool drafts can be expected at times of extreme cold weather.

However, as the inlet units are independent, fresh air is only provided to those areas that need fresh air. Other areas that may be unoccupied and do not have as high a fresh air need not be ventilated. In a central ventilation system, the whole building gets fresh air whether it needs it or not. This is what is leading to complaints in certain cases that houses are being over ventilated and causing occupant discomfort.



The humidity-controlled air inlet

The exhaust unit is located in each moisture generating area on the ceiling or high on a wall. The exhaust unit contains a humidity sensor which automatically varies

AIR LEAKAGE THROUGH POLYETHYLENE: TEST RESULTS

Current construction practice relies heavily on polyethylene films for use as air barriers and vapour diffusion retarders. Recently, there has been some concern about the long term durability of these materials. (See SOLPLAN REVIEW #3)

Much of the concern has focused on material durability. This has led to development of new performance standards that are about to be implemented. Soon, polyethylene films will be manufactured that will have a life expectancy lasting as long as the building envelope.

However, there are no standards for the installation of such materials. What good does it do to have a long lasting material if it is installed in such a way that it will allow air to leak through?

The common practice is to install the poly membrane so that it wraps the house except for door and window openings. At a joint, two sheets are overlapped, with the joint located over solid wood backing (usually a stud). Staples hold the poly sheets together and in place. At windows and doors, a rough opening is made in the poly and the edges are stapled too the surrounding wood frame.

To reduce air leakage through the gaps, acoustic caulking or duct tapes are used to hold the sheets together. CMHC has looked at using a spline to seal joints.

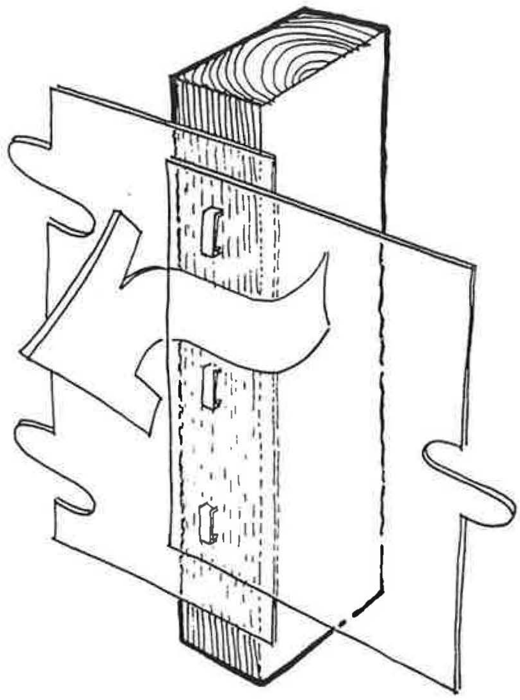
But just how effective are these various details? The National Research Council did a series of tests to determine the strength and air leakage characteristics of the joint between two sheets of polyethylene, as would occur in a frame wall. These tests have produced some interesting results.

Each air leakage test was conducted using 4 mil poly under both presssurization and depressurization conditions (at various times a typical wall can experience both). The test chamber used a wall panel 2.9m (9'6") x 2.3m (7'6").

1. 2 sheets poly, 40mm overlap, stapled

The air leakage rate increased with the pressure difference across the wall. The maximum pressurization the poly could take without tearing was 140 Pascals. Under depressurization, it was 14 pascals.

(6 mil poly could take 160 pascals).



2. 2 sheets poly, 40mm overlap, staples reinforced

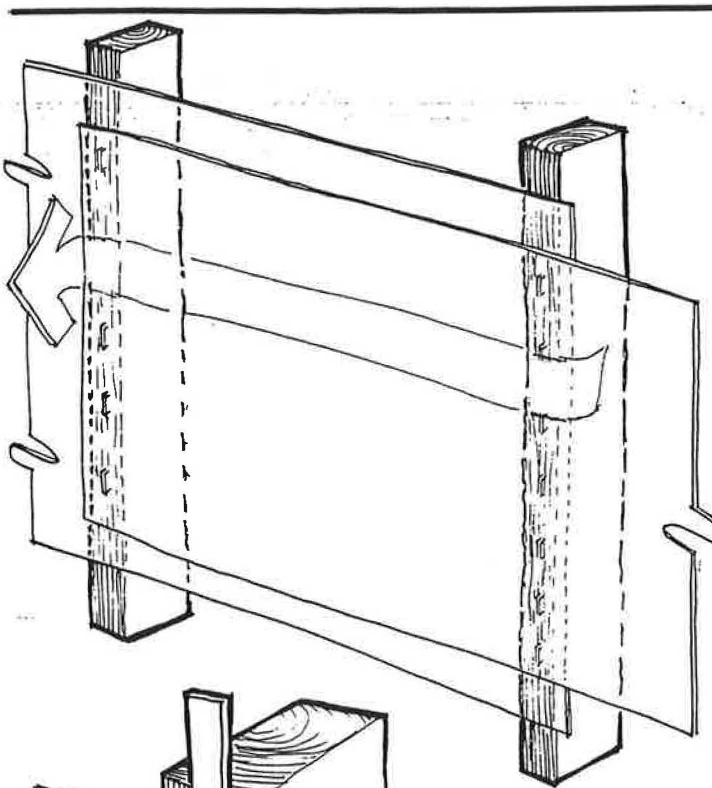
When duct tape was used to reinforce the poly, the maximum pressurization the poly could take without tearing was 700 Pascals. When depressurized, it could not be measured as depressurization helped to open the gaps between the staples.

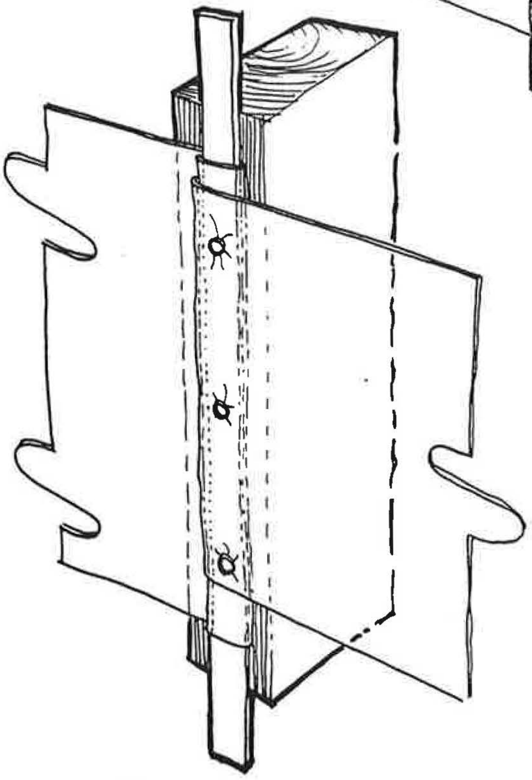
3. 2 sheets poly, 40mm overlap, gypsum board

The air leakage through the poly-gypsum board combination was too small to measure for pressure differences across the poly up to 865 Pascals. This suggests the gypsum board helped to hold the poly sheets together and in place.

4. 2 sheets poly, 400mm overlap, stapled

The wider overlap permitted the joint to be stapled to two studs. The air leakage characteristic was similar to test no.1, but the amount of air leaking was less. Permanent tearing appeared at the staples, but the poly sheets held together by the double row of staples.





5. spline method

A spline method was developed to eliminate air leakage through the joint. The was no leakage through the joint, but there was considerable leakage through the joints where two joints met each other (e.g. at corners, such as would happen at floor or ceiling).

6. 2 sheets poly, 40mm overlap, taped

The tape worked well under pressurization, but did not reduce air leakage to zero. Under depressurization, the tape failed to hold the poly together.

7. 2 sheets poly, 40mm overlap, caulked and covered with gypsum board

The air leakage through the caulked joint was greater than through the uncaulked one. This is because the non-drying caulking did not hold the two sheet of poly - in other words, the caulking is not a glue.

It appears that the caulking may prevent the gypsum board from pressing the poly sheets tightly together against the wood frame if the caulking is not applied uniformly.

The tests indicate that the best method to install poly is to have the sheets overlapped by 400mm (or 2 stud spaces). A spline system may be good, but is too difficult to apply, especially at corners.

Two sheets of poly with a 400mm overlap (2 studs) with caulking was not tried.

One ought to keep in mind that when framing dries and shrinks, a space may be created between the finish and the framing as the lumber dries. This will happen as mechanical fasteners don't shrink, and will keep the panel material in place. This can create a gap of 1/16" or so. Unless the poly is otherwise restrained, the gypsum board does not provide any help in keeping it in place.

The airtightness of houses is tested by the fan depressurization test, with the house put under a negative pressure of 50 pascals. Sometimes during the testing, pressures as high as 100 pascals are put on the house. However, the NRC estimates that a building can easily be subjected to pressures of 1000 pascals (equivalent to 20 psf) - and in extreme cases wind gusts can take it over 2000 pascals! The pressures that the test panels experienced were not more than a building could experience.

This raises the question - how appropriate it is to rely on poly as the principal air barrier?

Poly is an excellent material to resist vapour diffusion, but as shown by the NRC tests, as commonly used in construction, it does not have the mechanical strength to resist the air pressures that may be applied on the building. Another strategy has to be considered for air barriers.

Air barriers are important since the driving force of moisture into the building structure is air flow. If we can stop air flows through the structure, we will minimize moisture damage.

We must remember that an average family of 4 can generate up to 20 litres of water per day, so there's a lot of moisture that can get into the structure unless we've dealt with it through proper construction and ventilation.

We can still use poly as a vapour diffusion retarder, but it should not be relied on to provide the air barrier.

the flow of outgoing air. The opening is controlled by a membrane that is sensitive to the relative humidity of the air. It inflates or deflates as ventilation is needed. The installed rating of an exhaust unit can be from 3-18 cfm to 8-30 cfm with an 80 cfm overide. (This compares to a typical '50 cfm' bathroom fan that may have an actual installed capacity of about 10 cfm).

A continuously operating fan is located in any convenient location, such as the attic, utility room, or crawl space. Ductwork only connects the exhaust units to the fan which is running continuously. It is the only mechanical piece in the whole system.

As the exhaust cuts in, it will not depresurize the house greatly, as the inlet dampers when closed do not form a perfect airtight seal. There is always a minimal air flow possible into the house. Any pressure difference placed on the dampers will open them. As the air supply is not mechanized, it will even operate at times of power failure (although only by natural thermosyphon air flows).

It's a very ingenous system that adresses the problem of ventilation where humidity is the dominant concern. It does not address the problem of pollutants that are not related to humidity. Off-gassing of other materials, such as formaldehyde, carbon monoxide, and other chemicals is not dealt with. Company representatives have indicated that the best defense against such probems is to stop the pollutant at the source. It may be a noble thought but does it overlook some legitimate concerns?

Monitoring tests have shown that in a new building chemical off-gassing will decrease within the first few months to a fairly steady state. In new construction, some form of manual override for maximum ventilation may be required with this type of system.

The main factors afecting indoor formaldehyde levels (a water based substance) are high temperatures (over 71°F), furnishings within the first 12 months, lack of ventilation, and smokers. It seems that smoking is the single most important factor. If humidity is kept down, so will formaldehyde off-gassing.

The AERECO system has no heat recovery. It has no way to temper incoming air, so it will cause discomfort if used in extremely cold areas. The manufacturer has had experience with its use in areas with climates that have design temperatures as low as -20°C. This would mean that in Canada it could be used in coastal B.C., the milder parts of Atlantic Canada and possibly southern Ontario.

As there is no heat recovery, there is a penalty to be paid for the heat losses associated to ventilation. However, because it is directly related to occupancy, the actual overall ventilation rates could be much less than half an air change per hour so it may not cost that much more than a very poor HRV.

The manufacturer suggests that at -5°C outside, a 'normally' occupied house should get about .45 air changes per hour, an empty dwelling .2 ACH, while and an 'over-occupied' house .7 ACH. At an outside temperature of 18°C under all these occupancy conditions the air change would go to about 1.1 ACH.

Is it really capable of doing the job? In France the building authorities have given the AERECO system a special exemption from code requirements, as it has been judged adequate to meet code ventilation requirements. In the past few years they have installed over 50,000 systems with no complaints.

It looks to us that this system will be of special interest for retrofit applications, where installation of a fully ducted HRV system may not be possible or too costly, but where moisture and indoor air quality is a problem. Two retrofit systems have been installed and are now being monitored in the Vancouver area. These are in electricaly heated townhouses that have experienced excessive indoor humidity levels.

In new construction, questions that still have to be answered is how this system can fulfill the new National Building Code requirements for ventilation, and how the R-2000 program will wish to consider it.

The ventilation level that can be expected needs to be known for purposes of sizing heating systems.

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