Ask Jon Eakes

Air Spaces in Walls -- Myth and Science -- Overview

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Walls often have air spaces hidden somewhere between the siding on the outside and the drywall on the inside. Some are accidental -- some on purpose, even code required -- some served a purpose at one time in history but because of the evolution of construction, are no longer useful -- some are wasteful -- and some can cause damage.
After years of answering questions on this web site I realized that I had quite a scattering of information about air spaces in walls. So let me try and organize and explain as many of these air spaces as I can here in one place. I have debated as to how to approach the air spaces and I decided not to do an historical evolution of walls, but rather work my way through a wall and discuss each of the air spaces commonly found in cold climate walls. Yes, walls must be made differently in different climates.

WHERE IS THE WALL LOCATED?
Most of this article will deal with walls that separate the indoors from the outdoors but at the end of the article is the one air space that is important between two heated spaces – air spaces with sound proofing batts. For the rest, the first important thing to understand is that walls that are buried in the ground, usually called basement walls, do not function in the same way as walls above grade – so here they will be dealt with separately.

WHICH AIR SPACE ARE YOU INTERESTED IN? Click on the title for direct access, or scroll to read the whole story.
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ABOVE GRADE WALLS
What are the critical elements of an above grade wall?
- A surprisingly important aspect of an above grade wall is the fact that the temperature of the wall on the outside of the house is rather uniform from bottom to top while inside the house each floor has significant temperature differences between the wall near the floor and the wall near the ceiling – and of course, in the winter, the inside is all warmer than the outside of the wall.
- Some part of the wall is structurally sound, holding up what is attached to the wall and carrying what

is above the wall, including the roof with its changing weights of snow and wind.
- The habitable side of the wall is aesthetically pleasing – most commonly decorated drywall.
- The outside of the wall can withstand the elements as well as being decorative.
- In our cold climate, there is some kind of insulation in and/or on the wall.
- Air barriers block air from flowing through the wall, and vapour retarders control the movement of moisture. Both are big topics with many articles to be found in this website via the search tab.
- Then there are air spaces...

AIR SPACE – UNDER SIDING
Most siding in Canada is installed with an air space between the siding and the wall itself. That air space is a key element of building what we call a “rain screen” wall. Click here to see an animation of the rain screen principle, and other links to more details of this critical air space that helps walls to stay dry throughout Canada.
In fact after a lot of research by the Institute for Research in Construction and the CMHC it was determined that a rain screen was so important for the drying capacity of a wall that in certain regions and certain types of siding it is a building code requirement.
Maintaining the draining, pressure equalization and air drying functions of this air space is the reason why we should never try to insulate an older house by spraying foam insulation into the space behind brick. That is not to say that a brick façade cannot be placed in front of a foam sprayed wall, but even here there is a functioning air space. A brick facade is designed to be a rain and wind screen for the house itself. It is designed with an air space behind the bricks and weeping holes at the bottom to the outside. When the wind hits the wall, it also forces a little air up the weeping holes, creating an almost equal air pressure on both sides of the bricks. This prevents the wind from driving water through the bricks or even through cracks in the mortar. The building paper or house wrap on the inner wall sheds any water that manages to get across the gap and directs it down and out the weep holes. The presence of a vented air gap is an integral part of how a brick facade protects a house from rain and wind. The air barrier, located somewhere on or in the wall, prevents the wind from blowing into the house – the siding does not serve this function.
The air space behind brick is irregular and very difficult to fill properly with insulation anyway. Foam shot into this cavity can produce a moisture barrier where it could cause a lot of condensation. If the insulation fails to completely fill absolutely every part of the cavity, which is always the case, the gaps will direct water right into the house. Polyurethane foam tends to expand if wet and hot, which could throw the whole brick wall forward into the flower patch.
While I am at it – this air space behind siding is the reason that aluminum siding that is filled with insulation has no insulation value for the house. The ventilation space brings cold air to the house side of the siding, negating any insulation properties it might have had. Actually, the insulation inside aluminum siding is a really poor insulation anyway, it varies in thickness all over the wall and even at its thickest it is so little insulation that it would actually cause moisture problems inside the wall if that space was not ventilated. Its real function is simply to help give the aluminum strength and reduce denting. It can make for good siding, but it is not wall insulation.

AIR SPACE – BETWEEN INSULATED SHEATHING AND THE HOUSE
A very good way to insulate a wall is to put insulating panels over the whole wall on the outside. This covers every stud and every structural element with insulation, rather than just having batts between these structural members. This foam board should be attached tightly to the house sheathing. There can be a housewrap under it, or over it or some insulation panels are specifically designed to provide their own water and air barrier. If you were to think that for some reason you wanted to strap the wall first and then put on insulation, you would be letting cold air flow behind the insulation making it another part of the siding, but not part of the home’s insulation.
In the same vein, if you put insulation panels over existing siding that was mounted on strapping, you are leaving a ventilated air space between your new insulation and the house -- totally eleminating all the insulation value of your expensive work. It would work better if you sealed that air space but the

best is to remove the old siding and strapping and then insulate tight to the wall. If you then wanted to put the strapping back on for the siding there is no problem.
In fact if you have an uneven surface, like a stone wall, and you want to apply foam panel insulation, you must first parge the wall to make it flat and smooth, then fasten the panels. Often the easiest option for these walls is to use spray foam insulation that will fill all the irregularities and stick to the wall – avoiding all air movement between the insulation and the wall.

AIR SPACE – BETWEEN HOUSE SHEATHING AND BATT INSULATION INSIDE THE WALL
For many years houses have been built like this, and the air space did in fact help circulate air inside the wall and ventilate humidity through the wall. Now, as we increase the quality of air tightness and increase insulation levels, this air space no longer serves a ventilating function. Being on the outside of modern heavy insulation, it is too cold to help much with ventilation, and the convection currents in this air space can actually make condensation problems worse. In addition, the air space is not a very good insulator. The Canada Mortgage and Housing Corporation and the National Research Council now recommend that all the space between the inside drywall or plaster wall and the outside sheathing be filled with insulation, leaving no air space. Despite this recommendation, it is often not economically feasible to open up the wall just to fill a small air space. However, when insulating an open wall, don't leave any air space.

AIR SPACE – IN CORNERS OF BATT INSULATION BETWEEN STUDS
Follow this link for an article that explains how improper working techniques with batt insulation can cost you 20% of the insulating value of the wall – air spaces in hidden corners radically increases thermal bridging through the studs. If on these same walls you have an accidental space between the insulation and the vapour barrier, an air current can loop around the insulation taking heat directly from the warm drywall to the cold sheathing.

AIR SPACE – BETWEEN INSULATION AND DRYWALL
For an air space between wall insulation and the drywall, the location of the vapour barrier is critical. If the air space is between the insulation and the vapour barrier, the air will rise because of the warmth of the house. This movement of air will find its way through or around the fiberglass insulation to the cold side, where it will fall because of the cold surface of the sheathing. When the batt insulation completely fills the space between studs this looping is minimal. When the insulation is installed less than perfectly, the looping force will accelerate. If there are open triangular corner spaces as mentioned just above, the whole thing becomes a pump moving heat from the drywall to the sheathing as if there was no insulation there at all. (In a basement this works differently – see further down.)
When there is an air space between the vapour barrier and the drywall, nothing happens. The temperature goes from cool on the bottom to warm on the on the top but the air in this space has no access to the cold side of the wall. It may circulate but it has no more effect than room air circulation.

Is there any plus value to having an air space under the drywall?
Many years ago when we insulated 2x4 walls with R-7 batts, strapping the wall at 90 degrees to the studs did in fact create an air space thermal break between the cold studs and the plaster or drywall. That was enough of a thermal break to stop condensation from forming on drywall in line with the studs. With modern construction and heavier insulation, there is no longer a problem of condensation on drywall caused by the studs being cold. (There still is heat loss and some building codes now actually require sheet insulation over all studs, either inside, or outside.) The insulating value of an air space is very small compared to the same thickness of any insulation; or the other option is to simply gain more floor space by leaving it out.
Quebec is the only place in North America that still systematically installs strapping on walls and ceilings before drywall – although it is not a code requirement. They have a hard time believing that this cultural habit has no advantage for the wall, except perhaps allowing for shimming out a poorly

built wall. There is a long tradition in Quebec of using aluminum vapour barriers and a reflective barrier with 3/4 inches of air in front of it does in fact create a bit of an R-value (but only until the air currents in this air space deposit dust on the aluminum and it begins to lose its reflective value). This aluminum/air space combination was actually used for a short time to avoid making the change from R-12 to R-20 insulation batts. In fact they strapped walls a long time before we started using poly vapour retarders and their habit today is to install the poly first, then strapping, then the drywall. Placing their vapour barrier on the insulation side of the air space means that their strapping has no real effect on the performance of the wall.
You may hear a Quebec contractor arguing that the air space created by strapping allows for running electrical wires without punching holes in the vapour barrier. Those contractors forgot to read the electrical code that does not allow unprotected wires directly behind drywall!

BELOW GRADE WALLS

What are the critical elements of a below grade wall?
With the exception of Insulated Concrete Form (ICF) walls, you either insulate inside the basement or outside the basement.
With insulation outside the foundation, everything is rather simple because the entire wall is warm. With insulation inside the basement, because the soil is basically an insulating material, the cold from the winter air is isolated from the foundation wall more and more as you go deeper into the ground. When the basement is insulated on the inside of the house, the foundation wall is in a condition that is the complete inversion of what is going on in above grade walls – the bottom of the wall is warm and the top of the wall, behind the insulation, is freezing cold. Eight inches of concrete is worth less than R-1 of thermal resistance – so inside the top of this wall, the face of the concrete covered with indoor insulation is about the same temperature as outdoors. This inversion causes warm possibly moist air to rise and deposit that moisture on the cold wooden floor structure, with the cold air falling to the bottom. The slightest air space here turns this air looping into a pump which can actually draw moisture from the footing of the foundation and deposit it in the wooden floor joists above.
The concrete wall is a great air barrier and if you seal the concrete to wood joint at the top as well as the wooden header area and around windows, there is no air leakage in a modern basement. Vapour barriers and moisture control are far more complicated in a basement than in the above grade walls of the house. Click here for more information.

What causes condensation on the wall when there is no air space?
Of course water outside and a leak in the wall will cause moisture problems in any basement wall. Also un-sealed electrical outlets or incomplete vapour barriers can let a lot of moisture from a humid basement into the insulated wall.
In new construction, heavy condensation is often seen on the inside of the vapour barrier in a basement. This is simply the 600 or so gallons of water, used to make the wall, trying to escape. Unfortunately in modern construction we are always trying to finish a house too quickly – in the old days we waited a full season before finishing a basement after construction, allowing it to dry out. Surprising as it may seem, even in 2016 basement moisture control is an evolving science. Basement moisture dynamics are complicated, especially in new construction with all that water sitting in the newly poured concrete wall trying to dry out. Here is a link to some of the history and some of the progress.

AIR SPACE – INSIDE THE BASEMENT -- BETWEEN CONCRETE/MASONRY WALLS AND INSULATION
An air space behind basement insulation will not solve condensation problems. It can, in fact, cause condensation problems -- and create new problems to boot. The CMHC is so clear on this question that they even advise that if you are going to glue insulating panels to the wall, you do not dab the glue on the wall but apply it in a closed grid pattern that will prevent the formation of a circulating air

space -- even one as thin as the glue. Here's why.
- The concrete of a basement wall insulated on the inside will have a very large temperature difference between the top of the wall and the bottom of the wall. The top is exposed to the cold outdoors and the bottom is insulated by the earth.
- Air in a space between the insulation and the concrete wall will become cold and heavy at the top of the wall and tend to drop to the bottom.
- It is almost impossible to ensure that there is absolutely no space between the front of the insulation and the drywall. This space becomes the primary route for warm air to be forced up to the top of the wall by the pressure of the falling cold air in the back. Hence we find a very strong convection current that loops around the insulation.
- This same mechanism does not happen in such a serious way with an above grade wall totally exposed on the outside because you have an evenly cold exterior, not the large temperature differences that exist from the top to the bottom of an internally insulated basement wall.
- The convection loop will draw moisture both out of leaks into the wall from the house and out of the lower portions of the concrete itself. This concentrated accumulation of moisture then tries to escape through the small portion of the wall that is above the ground level (and probably freezing cold).
- Hence the above ground portion of a basement wall that has an air space between the wall and the interior insulation can easily become saturated with water. Wood in contact with this wall can easily develop dry rot -- including your floor joists. Repeated freeze/thaw cycles can cause spalling or flaking of the outer surface of the basement wall. Structural breakup of the wall could result with unsound walls.
- Convection loops around your insulation will essentially eliminate their insulating effect, carrying the heat around the insulation to the cold wall behind. Insulation pushed directly against the basement wall (click here for cautions about moisture proofing the wall first) will effectively prevent these air convection loops. With no air currents, the only moisture that can get through the wall is what can diffuse slowly up to the top of the wall and out through the wall without causing saturation conditions.

WHAT TO DO IF THE BASEMENT IS ALREADY BUILT WITH AN AIR SPACE BETWEEN THE CONCRETE AND THE INSULATION

Taking a cue from the CMHC recommendations to use horizontal glue lines behind ridged foam panels to stop the rise and fall of air on the cold side of the insulation, you can make one single horizontal air block that is quite effective. About 4 feet up the wall you should be close to the soil grade on the outside. Below this level the soil retains some of the basement heat – above this line the concrete does almost nothing to stop the heat loss, leaving the inside face of the foundation below zero most of the winter.

If you carefully slice open the wall paneling (don’t cut through the studs) at about 4 feet from the floor exposing about two inches, you can then run a knife through the insulation (foam or batts) right down to the air space. Pull out that plug of insulation carefully and set it aside. When you can see the wall, or the moisture barrier on the wall, use the spray foam in a can to fill up the two inch strip behind the insulation. Be sure to spray behind the studs if they do not touch the wall. This should create two separate compartments behind the insulation – one relatively warm on the bottom and the other cold on the top, but neither with a large temperature difference from top to bottom. That will stop the air looping.

Put back in your insulation, even put on the slice of paneling you removed. You can either use drywall tape to smooth out the wall, or a piece of trim to look a bit like an old chair rail. You might even want to do this whole operation a bit lower than 4 feet so that it really is at chair rail height.

Chair rails were common on plaster walls serving two purposes: first, hard panels were often put on plaster walls where there was a lot of activity and people would have a tendency to put holes in the plaster; and second the trim piece hiding the joint between the protective panel and the plaster wall above was placed exactly at the height where the top of chairs would touch the wall. That practice disappeared with the advent of more durable “drywall”.

AIR SPACE – INSIDE THE BASEMENT -- BETWEEN INSULATION AND DRYWALL – ON THE INSULATION SIDE OF THE VAPOUR BARRIER

Why can we have an air space between the insulation and the vapour barrier in a basement without problems when I pointed out that this could cause problems in above ground walls? On the room side, this air space is generally fairly cold at ground level and much warmer at the top of the wall – just like in the house above. However there is something radically different happening on the face of the concrete behind the insulation. Because soil insulates, the very bottom of the wall is close to the same temperature as the bottom of the wall inside the basement. The top of the wall behind the insulation is freezing cold. We already talked about NOT having an air space between the concrete/masonry wall and the insulation, which actually carries moisture from the bottom to the top and can rot out the header and joist ends.

With no air space in the back, some air will move inside the insulation, but as on the outside against the concrete wall, it wants to rise from the floor and wants to fall from the ceiling, this is not helping to create a looping with the air space in front of the insulation. So generally the air just doesn't move and the air space between the insulation and the vapour barrier doesn't cause any problems, as it can do in above grade walls.

AIR SPACE – INSIDE THE BASEMENT –BETWEEN INSULATION AND DRYWALL – BETWEEN THE VAPOUR AND THE DRYWALL

An air space between the vapour barrier and the drywall causes no problems at all because this space is not connected to flow back into the insulation or to the cold side of the wall. Air will tend to rise and if it can get out the top of the wall it will simply circulate with the air in the room or in the heated joist space.

OUTSIDE THE BASEMENT – PLACEMENT OF AN AIR GAP MEMBRANE

The best of basements are made with an “air gap membrane” on the outside. This Air Space is in fact a drainage layer. The air does not circulate at all but if any water gets past the membrane itself, it can apply no hydraulic pressure on the foundation wall as the water simply falls to the perimeter tiles and away. The air gap membranes are placed on the outside of the wall below grade with the little dimple feet in contact with the concrete or masonry. (If the membrane was placed against the concrete on the inside of the basement it would create an unwanted air space -- see above.)

If you want to add exterior insulation it is an unsettled debate as to where to install the air-gap membrane. Generally it is installed directly against the concrete and the insulation installed over the air gap membrane. Critics say that this reduces the effectiveness of the insulation -- some say perhaps as much as 10%. If the insulation is installed first and the air-gap membrane placed over the foam panels, critics say that the pressure of the soil will cause the dimples to sink partially into the foam, reducing the drainage effectiveness of the membrane. Manufacturers differ in their residential recommendations.

For commercial work the layering is often much more complex: a water-proof membrane on the concrete first (in residential this is just a water-resistant coating), then the foam insulation panels, then a special air gap membrane that has a filter geotextile adhered across the feet of the membrane and the air-gap membrane is placed with its flat side to the foam and the feet towards the soil and the geotextile holds back the soil, letting water freely into the air gap. This is very effective, but of course two extra layers of material make this much more expensive.

SOUND PROOFING AND AIR SPACES

When sound proofing between two heated spaces, we are using insulation to absorb sound, not to keep in any heat. Creating an air barrier is usually part of soundproofing, such as caulking all holes between the two living spaces, because much of the sound we want to block actually travels through the air. A sealed plastic sheet could be used as an air barrier but its vapour blocking properties has no positive or negative effect because there is no temperature difference between the two areas and the whole assembly is too warm to cause condensation.

When you put insulating or specific sound proofing batts into a ceiling/floor space, leave about 1/3rd of the space empty. That air space actually helps to break up the reverberations and frequencies of the sound that is passing through. Having an air space in a sound proofed division between two rooms usually preforms better than filling the whole space with insulation.

For more help, a great free National Resources Canada document titled “Keeping The Heat In” has a lot of carefully researched information on insulating in a cold climate in Chapter’s 6 and 7.

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