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HOW TO ACHIEVE AN AIR TIGHT VAPOR BARRIER IN A SUPER INSULATED HOUSE

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ABSTRACT

The recent upswing in the popularity of super insulated houses is paralleled by a need for detailed information on how to make such a house air-tight. Usually the vapor barrier (VB) is noted as being continuous, but exact details are often lacking. This paper is an attempt to remedy the situation somewhat. It is acknowledged that, due to regional variations in materials and techniques used (or available) in the construction of houses, some specific details may be rendered invalid, but most can be modified to quite an extent without appreciably changing the end result - an air-tight house.

1.0 INTRODUCTION

The term 'super insulation' can refer to almost any building with a greater-than-normal amount of insulation in the walls and ceiling. Depending on the region in question, this can mean anything from R_{si}3.5 (R 20) to R_{si}10.5 (R 60.) Unfortunately, without a sufficiently tight air barrier, no amount of insulation is going to have much of an effect on heat loss due to infiltration and exfiltration. Since the VB on a building is supposed to stop the flow of moisture-laden air out through the walls , it seems logical to improve its tightness to such an extent that the natural air change rate (A/C) is reduced to a minimum. One of the first houses in Western Canada to attempt this level of air tightness was the Saskatchewan Conservation House (SCH) in Regina, built in 1977. An R_{si} 7 wall was built, using a double stud technique. The ceiling was R_{si} 10.5. The VB used was 150µm (6 mil) instead of the usual 50µm. By lapping all joins in the VB over solid backing, by continuous sealing of all joins, and by protecting the VB with solid covering, the natural AC was decreased to $^{1}/_{20}$ change per hour. At this rate, induced air change is necessary to control odour and humidity.

2.0 SEALING TECHNIQUES

The three most critical requirements were briefly mentioned above.

2.1 SOLID BACKING is necessary anywhere two sheets of VB are joined together. If the join is made between two studs (or rafters) it is impossible to achieve an air-tight seal. The end of one sheet of VB must be stapled to a stud, rafter or plate before starting the next sheet. Overlapping joins by at least one stud space (400mm or 16") is highly recommended.

2.2 SEALANT, in the form of a continuous bead running the full length of each and every join between two sheets of VB is absolutely critical to air-tightness. As the sealant acts as a form of glue, as well as an air barrier it must be a type of sealant that will never dry out. It must also adhere to polyethelene, and not peel off. During construction of the SCH, it was found that acoustical sealant was the best type for this particular application. Brands commonly available in Western Canada are "Chemtron Metraseal" and "TRC". Both come in large tubes requiring an oversized caulking gun. It should be noted that acoustical sealant does not set up or harden, even on clothing, or on skin, or in hair, so care during application is recommended.

2.3 RIGID COVERING over the VB serves two purposes. It protects the VB from wind pressures which can easily rip the thin plastic off walls and ceilings if it is applied before the exterior finish is in place. The rigid covering also protects the finished VB against rough treatment by workers during the construction process. Rips and tears in a 'continuous' VB render it somewhat less than air-tight, and can be very troublesome to repair. The rigid covering is usually drywall (sheetrock) but can be any interior finish desired.

3.0 WHERE TO SEAL

If walls and ceilings were continuous and unbroken by doors, windows, light switches, etc, it would be no problem to easily install an air-tight VB. In the real world, though, such is not the case. Doors, windows, electrical outlets, chimneys, plumbing stacks, attic hatches, joints between the wall sill and the floor, and the joint between the top of the wall and the ceiling all present hard-to-seal points. Each of them require special sealing techniques. (All the following apply to standard 'stick frame' houses.)

3.1 ELECTRICAL OUTLETS should be reduced to a minimum on outside walls. Necessary outlets and switch boxes can be backed by heavy-guage plastic placed by the builder, or by commercially made 'polypans'. These are placed between two studs, with extra blocking above and below. Electrical wires are run in through the stud or blocking and the hole is filled with sealant. The final sheet of VB is sealed to the polypan as described in 2.2. Insulation is put in and behind the polypan.

3.2 DOORS AND WINDOWS should have a 30 cm wide strip of VB sealed and stapled to the outside of the frame before being installed in the rough opening. This extra strip of VB must be lapped at each corner to form 'pleats', as the VB is folded flat against the wall and sealed to the main sheet of wall VB after the door or window is properly positioned. If the 'pleats' are omitted the VB will not fold flat to the wall. If this procedure is not done, an alternative is to use a spray foam insulation (such as "Polycell One" or "Great Stuff") between the rough opening and the window or door frame. The expansion factor of this type of foam must be considered as too heavy an application of foam may cause the door or window frame to experience undue pressure, which may cause warping or jamming of the unit. Excess foam can be trimmed off with a knife after it has set.

3.3 METAL CHIMNEYS can be sealed fairly well by placing two metal firestops face-to-face, sealing them together at the edges with acoustical sealant and then sealing the VB to the edge of the firestop. Fiberglas or rockwool insulation is stuffed into this assembly before sliding the chimney itself through the firestop opening. Allowance must be made for expansion and contraction of the metal. Check local codes for clearance limits to combustible materials. Ordinary masonry fireplaces with brick chimneys should not be allowed in air-tight houses due to their negative energy efficiency and the impossibility of sealing a solid masonry chimney. Masonry also has no R value.

3.4 PLUMBING STACKS are easy to seal if an expansion joint is installed below the top wall plates where the stack leaves the house and enters the attic. The section of stack above the expansion joint can then be anchored securely (since it will not move due to expansion or contraction.) Acoustical sealant is then used to seal the VB to the stack wall. Holes where stacks, etc, break through top plates should be cut carefully to fit tightly around the pipe - in other words, don't cut square holes with a chain saw. Size the hole and use a hole saw.

3.5 ATTIC HATCHES are no problem at all if they are an outside access type. If the attic access absolutely must be from inside the house, the hatch should be fitted with a top quality compression type weather strip and latches so it can be pulled shut and secured. (It should also be insulated to the same level as the rest of the ceiling around it.) The VB is sealed to the framing around the hatch opening.

3.6 JOINTS between walls and floors or between walls and ceilings can be sealed fairly easily. For wall/floor joins a large bead of caulking compound underneath the sole plate combined with the wall VB being sealed to the floor VB should stop all infiltration. At the top of the wall, simply seal and staple the ceiling VB to the wall VB. For multi-story buildings the VB must be continuous from one floor to the one above. This entails wrapping a strip of VB around the joist header before it is nailed in place. Since the VB must always be on the warm side of the insulation, this means the VB around the joist header must be insulated on the outside. If it is left uninsulated, condensation may occur on the wood in the winter, leading to wood rot. If the entire exterior of the building is to be sheeted with rigid insulation, there is no problem. If no exterior insulation is planned, the header could be recessed to a depth equal to the thickness of a sheet of rigid insulation, which is then placed over the header only.

4.0 DOUBLE WALL CONSTRUCTION

Two well-known superinsulated houses, the Indiana Lo-Cal House and the SCH both use double-stud walls with a cavity between. The LoCal House design has two rows of 2X4 studs, staggered, with the VB on the inside of the inner row of studs, similar to conventional framing pratice. All of the abovementioned sealing techniques apply to a LoCal design. The SCH also used two rows of studs, in this case at different centers. The inner row of 2X4s is the load-bearing wall, so the studs are at 400mm O.C. The outer wall, being non-load-bearing, can be 2X4s (or 2X3s) at 600mm O.C., as all it has to hold up is the siding and insulation. Initially the VB was placed in the 'normal' position, but subsequent research has shown the following variation to be superior. The inner (load-bearing) wall is framed up normally, then the VB is placed on the outside of the wall and covered with sheathing. The outer (non-bearing) wall is then framed up on top of the inner wall (to ensure alignment of openings, etc) and then a 2X6 block is placed between the walls and a 30cm wide strip of plywood is nailed to the sole plates and to the top plates, holding the walls apart. The entire assembly is then stood up and put in position. See Figure 1, below.

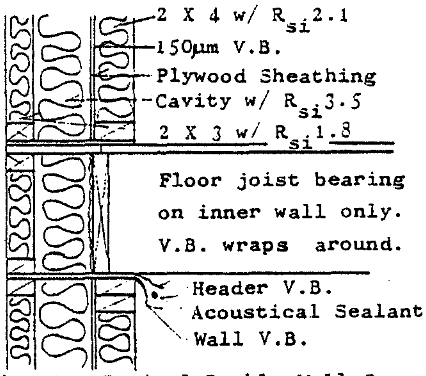

Fig. 1 Typical Double Wall Cross Section at Second Floor

In this system the VB is about $^1/_3$ of the way through the wall and thus is protected from workers while the house is under construction and from occupants after it is finished. All plumbing and electrical lines can be run through the inner wall, leaving the VB intact. Second floor joists sit only on the inner wall, allowing thick insulation levels to be placed outside the VB wrapped around the header. The doors, windows, chimneys, etc are treated as described above. Obvious advantages include a more protected VB, no messing around with polypans, and very high insulation levels. Well over 200 houses have been built in Saskatchewan and Alberta using the above-described wall system or some variation on it.

5.0 CONCLUSION

The question most often asked by people considering a superinsulated house is "Is all this extra insulation and tight vapor barrier worth the extra cost entailed?" In a location with high energy costs and a large winter heating load, the answer is an unqualified yes. In areas with low-cost fuel still available, or in areas with a smaller winter heating load, the answer appears less certain. As fuel costs rise, the value of superinsulation increases, and since it is more expensive to retrofit an existing house than it is to build it with superinsulation and tight VB in the first place, the uncertainty diminishes. Superinsulated houses also stay cooler in the summer, thus requiring less induced cooling (air conditioning) which increases their worth in regions with appreciable summer cooling loads. (There are few areas like this in Canada, so less research has been done here than in the States.) Super insulation and tight VB, combined with passive solar gain and movable insulation, can cut heating requirements to 10% of that needed by an 'average' home (with R_{si} 2.1 walls, R_{si} 3.5 ceiling, leaky VB, poor siting, etc.) For a comparision of convective heat loss only, see Table 1, below. As well as reduced heating costs, benefits include a draft-free home, more comfortable humidity levels, greater thermal comfort at lower indoor temperatures, and more effective control of odours and humidity (via use of an air-to-air heat exchanger.) Thus the extra costs of superinsulation are well worth it - in any region or climate.

6.0 ACKNOWLEDGEMENTS

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7.0 NOMENCLATURE

A/C - Air change rate
R_{si} - System International (Metric) R value R_{si} 1 = R 5.68
SCH - Saskatchewan Conservation House
µm - micro metre
VB - Vapor Barrier

8.0 REFERENCES

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TABLE 1 - COMPARATIVE HEAT LOSS BY AIR CHANGE ONLY IN A "TYPICAL" HOUSE*
(AREA 108 M^2, VOLUME 520 M^3, ΔT 57C°, HEAT LOSS SHOWN IN WATTS)

AIR CHANGE RATE PER HOUR	QUALITY OF VAPOR BARRIER INSTALLATION: STANDARD	GOOD**	TIGHT***
		(ASSUMES USE OF 75% EFF. HEAT EXCHANGER)	
1.5	15,116	---	---
1.0	10,078	2,687	2,351
0.5	5,039	1,680	1,344
0.25	----	1,176	840

* Assumes 75% of house volume is used for A/C calculation.
** Assumes a natural 'uncontrolled' A/C of 0.067 in addition to induced change.
*** Assumes a natural 'uncontrolled' A/C of 0.033 in addition to induced change.