Research & Development Highlights

Technical Series
90-240

Wet-Sprayed Cellulose Insulation in Wood-Frame Construction

Introduction

Cellulose insulation is usually installed dry in horizontal cavities such as attics. Manufacturers claim it can be used in vertical cavities with an adhesive binder if water is added as it is blown into the cavity. The water activates the binder, which sets the cellulose.

Manufacturers claim wet-sprayed cellulose insulation is cheaper to install and works better than glass-fibre baus because it leaks less air, transmits less noise and does not absorb as much moisture. They also claim that the water will not damage wood framing and sheathing.

CMHC commissioned a test project to evaluate these claims. The project's objectives were to determine:

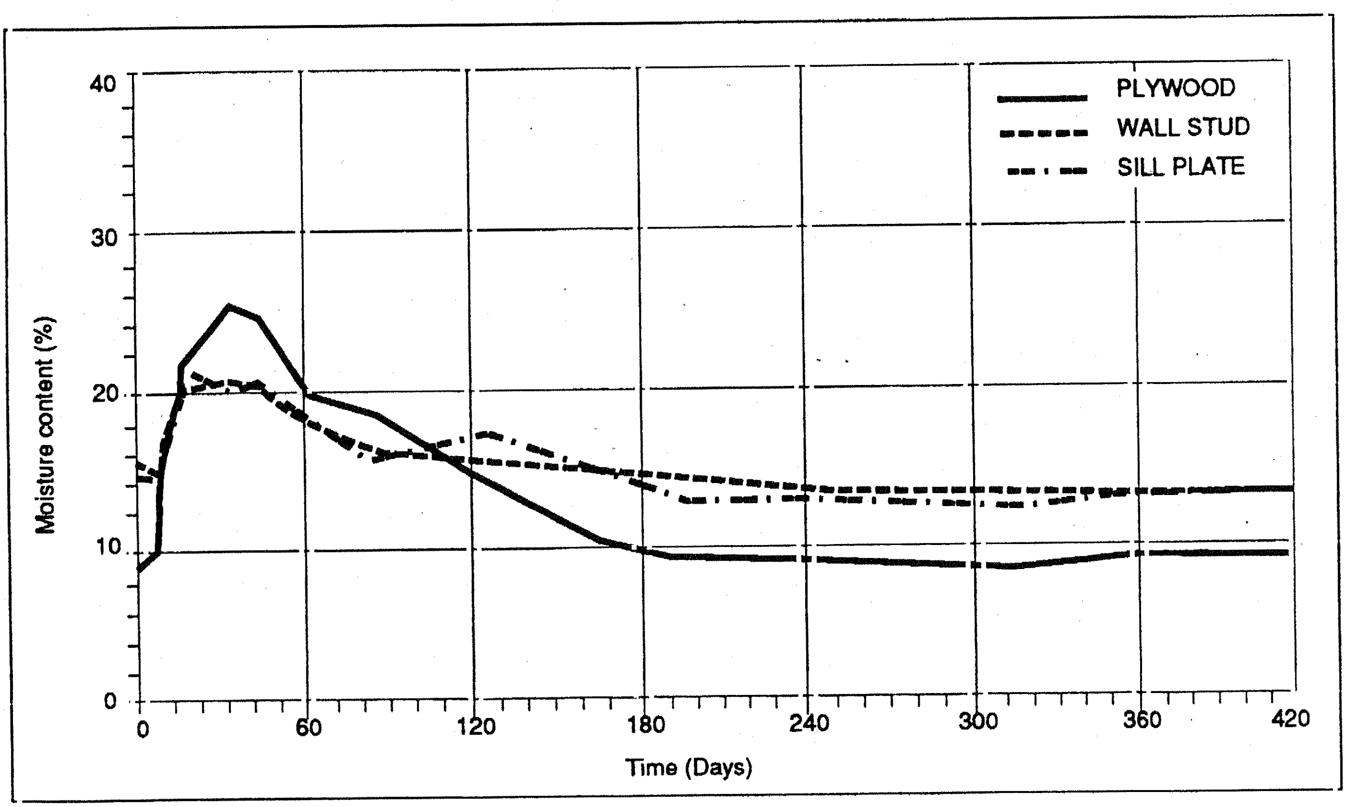
the drying rates of building materials surrounding the cellulose insulation;

- whether building materials would suffer moisture damage; and
- whether cellulose insulation would be an effective air barrier

The Test House

Testing took place in a two-storey, detached wood-frame house in Alberta. The house was built to R-2000 airtightness standards. Its attic and subfloor rim joist junctions were not gasketed and its electrical outlets were left unsealed so that the tests would show how airtight the cellulose alone would make the house.

Dry-blown cellulose was installed in the ceilings and wet-sprayed cellulose in the walls and rim joists. To evaluate the effects of different construction techniques, the south wall of the house included four sections:



Average wall moisture contents

CMHC SCHL
Helping to house Canadians

- standard construction;
- standard construction without a polyethylene vapour barrier;
- standard construction without a polyethylene vapour barrier, and with several 25 mm vent holes through the exterior wall (maximum ventilalion through the wall); and
- standard construction with a tightly sealed cavity (minimum ventilation through the wall).

Moisture and temperature sensors were inserted in sections of the north, south and east walls.

Findings

Wood Moisture

Sections of the frame adjacent to the dry insulation showed normal absorption and drying rates. After the wet-sprayed cellulose was installed, the plywood's sheathing moisture level increased to 26% after 30 days, decreased to near original levels (15%) after 160 days, and dried 1% more by the end of the test (420 days).

The framing timbers' moisture level increased to 22% in the first 10 days, dried to slightly over original levels (9%) after 80 days, and then dried 3% more by the end of the test (420 days). From these observations, the study concluded:

- plywood absorbed more moisture and dried out more quickly than framing timbers; and
- wall and sill timbers had similar absorption and drying rates.

Moisture Damage

The study looked for four kinds of moisture damage:

Corroded metal fasteners

Siding nails tend to corrode, so galvanized nails were used and the siding was made as watertight as possible. About 30% of the siding nails examined were at least partly corroded, especially where they penetrated wood, because both the nails' protective coating and the amount of moisture varied.

Wood fungi

The cellulose insulation contained a wood fungicide, but traces of fungi were found in the north wall between the plywood and the framing timber. The fungicide probably did not reach this location because it had no direct contact with the cellulose.

Shrinking and Warping

Saturated wood usually returns to its normal dimensions when it dries. The wall timbers did not shrink or warp abnormally.

Deteriorated bonding in plywood

A year after the insulation was installed, the plywood panels were firmly bonded and apparently unaffected by moisture.

Airtightness

When the house was fully constructed and still very wet, researchers measured a rate of 1.58 air changes per hour (ac/h) at 50 Pa

During the year, tests found air change rates of *1.95,* 2.01 and 2.00 ac/h, at 50 Pa. Where rim joist cavities were completely filled with cellulose, very little air leaked from the duct openings. In the walls, only electrical outlets showed any trace of air leaks.

Pressure drop tests were used to determine which wall components blocked the most air.

The plywood exterior sheathing was the principal air barrier, followed by the gypsum board, polyethylene and cellulose. The joints in the sheathing, originally 3 mm wide, had swollen almost tight; this increased the plywood's airtightness. Wing holes in the interior gypsum board interconnected many cavities and reduced its airtightness. If the electrical outlets had been sealed or the plywood joints made a little looser, the results of these tests might have been differenL The cellulose was not very effective in reducing air flow.

Occupants' Comments

The occupants of the house made three major comments:

- Heating costs were low during the year of the test.
- The house was quieter than any other they had lived in.
- The cellulose insulation in the basement should have been covered to protect it and prevent the release of cellulose fibres into the air. Cellulose fibre is not known to be harmful, but the insulation binder could contain chemicals which might be.

Conclusions

- Wet-sprayed cellulose insulation nearly saturates wood framing, but within six months the framing will dry almost to the level before installation, even during winter.

- **Sill** plates and wall studs gained and lost moisture at about the same rate. This suggests that most of the sprayed moisture did not drain through the sill plates.
- The insulation dried faster in the wall sections where there was high ventilation and no polyethylene. Insulation exposed to the indoors dried faster than insulation in closed-in cavities.
- The drying rate was affected by air temperatures, humidity, ventilation of the insulated cavity, orientation, time allowed before installing gypsum board and other construction conditions.
- One year after construction, the house had deteriorated little. Some nails were slightly corroded and a few fungi were found in one wall.
- Cellulose insulation is not an effective air barrier.

Project Manager: Norbert Koeck

Research Report: Field Monitoring of Cellulose in Walls—Edmonton

Research Consultant: Building Envelope Engineering

A full report on this research project is available from the Canadian Housing Information Centre at the address below.

Housing Research at CMHC

Under Part IX of the National Housing Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This factsheet is one of a series intended to inform you of the nature and scope of CMHC's technical research program.

This Research and Development Highlights factsheet is one of a wide variety of housing-related publications produced by CMHC.

For a complete list of Research and Development Highlights, or for more information on CMHC housing research and information, please contact:

The Canadian Housing Information Centre
Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa (Ontario)
K1A 0P7

Telephone: (613) 748-2367
Fax: (613) 748-2098

Cette publication est aussi disponible en français.

Energy

J. D. Ned Nisson, Editor

Vol. 8, No. 7

July 1989

NEWS

Wet Walls Signal Caution For Spray Cellulose Applications

An investigation of wall moisture content in two buildings insulated with wet-spray cellulose insulation has raised concern over the ability of the material to dry quickly enough under certain conditions to prevent moisture damage. Preliminary testing at two multi-family housing projects in New England found wood moisture content as high as 70% in the wall stud framing. More than half of 40 moisture measurements taken in the 1½-year-old buildings showed greater than 30% moisture content — the fiber saturation point where rot may occur.

For more information, see the feature article on wet-spray cellulose, page 6.

In This Issue

DOE Moisture Handbook To Present Radical New Construction Techniques

Ten years ago a young Canadian engineer jolted the residential building community with the introduction of a radical construction system — the "Airtight Drywall Approach" (ADA) — that allowed houses to be built without polyethylene vapor retarders. Today that engineer, Joseph Lstiburek, now with Dames, Moore and Trow of Chicago, is heading up a team to write a comprehensive manual on moisture in residential construction for the U.S. Department of Energy. The recommendations to be presented in the manual are still considered controversial, but with the credibility of DOE endorsement, they may well be adopted into standard construction practice and building code provisions.

Specific guidance on controversial topics

The DOE manual will address several of the most difficult and controversial areas of moisture control in houses. Lstiburek told EDU that specific instructions will be provided for building walls with or without polyethylene vapor retarders in any climate, when and how to build unvented cathedral ceilings, and how to properly build both vented and unvented crawlspaces. These topics have all received widespread attention but little consensus in recent years.

Assisting in the preparation of the manual will be a team of three Canadian and American building scientists with guidance from a

FEATURE ARTICLE

Wet-spray Cellulose — Questions About Drying

Questions without answers

How long does it take wet-spray cellulose to dry after installation in wall cavities? How dry must it get to avoid problems and/or loss of R-value? Should the material dry before the wall is closed in? If so, how long? Does a polyethylene vapor retarder prevent the insulation from drying fast enough? If so, is it OK to leave the vapor retarder off? Are there some regions or types of construction where wet-spray cellulose simply should not be used?

The above questions have no conclusive answers — at least no answers with consensus among members of the building community. In general, manufacturers and contractors make up their own rules, often based on intuition rather than building science. So far things have gone well. Except for one experimental study in southeastern Canada where wet-spray cellulose was installed in walls with wet framing lumber and double vapor barriers, no documented cases of moisture problems with spray cellulose have been reported.

The following is a report on two recent investigations of the drying potential of wet-spray cellulose in walls. While not conclusive, both studies suggest caution. It appears that rapid and complete drying is not assured and could depend on the method and quality of installation plus the presence or absence of interior and exterior vapor retarders.

Case 1: Soaking lumber after 18 months

A moisture investigation in a 1½-year old public housing project in New England found that wood framing moisture content in the walls insulated with wet-spray cellulose was well above 30% in many areas and as high as 70% in some (see News story, page 16). Two buildings, one with 2x4 walls and the other with 2x6 walls, were investigated. Both showed wet wall framing. In one building, the moisture content of the cellulose insulation was found to range from 31% to 61%.

Worst case situation?

Based on reports from the project architect and consultant, this case may represent the most severe conditions for using wet-spray cellulose. First of all, the material was evidently installed at an extremely high moisture content — five to six gallons per 30-pound bag of insulation. Second, the drying pathways were limited by installing a double vapor retarder — polyethylene on the inside and extruded polystyrene on the outside — that was meticulously sealed for energy conservation.

While further testing may produce more definitive conclusions, it appears that the combination of excessive water loading and insufficient drying pathways prevented these walls from drying.

Case 2: Partial drying after 60 days with polyethylene vapor retarder

Electra Manufacturing is one of the oldest and most reputable cellulose manufacturers in the U.S. Last year it hired Bowser-Morner laboratory of Toledo to measure the drying rate of its Forest Wool brand spray insulation.

Samples of the wet-spray insulation were collected during installation at two houses in Perrysburg, Ohio, on November 8 and 9, 1988. The measured moisture content ranged from 44% to 106% on a dry-weight basis (weight of water divided by weight of dry cellulose). Sixty days later, additional samples were extracted from both houses at approximately the same wall locations. In every case, the insulation had dried some-what, but the moisture content was still around 50% in three samples and 77% in the fourth (Figure 1). Both houses had double vapor retarders — polyethylene on the inside and foam sheathing on the outside — on the walls.

One answer and two questions

The Electra study showed that the insulation was drying slowly, even with double vapor retarder on the walls. The remaining question, however, is whether the drying will continue rapidly enough to prevent wood rot, mildew, or other moisture problems.

Another question has to do with R-value during the drying process. During that first winter when the insulation was drying from 100% to 50% moisture content, what was the R-value of the walls of the two Ohio houses? No answers yet.

Case 3: Longer term drying -with and without vapor retarders

Electra also hired Bowser-Morner to look at seven other houses with wet-spray installations ranging in age from two weeks to one year. Two of the seven, located in Michigan, had polyethylene vapor retarders on the walls (but not foam sheathing).

In each house, two insulation samples were withdrawn for moisture analysis. Moisture measurements

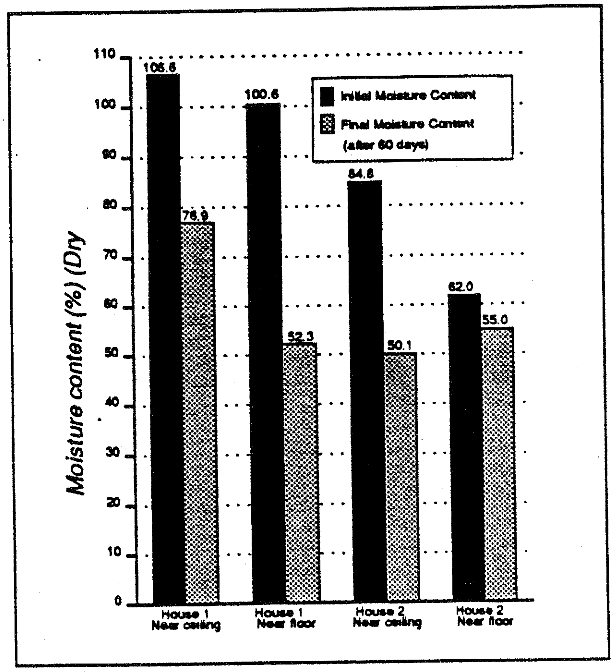


Figure 1: Moisture content of spray cellulose in two houses at time of installation and after 60 days. Source: Bowser-Morner Inc.

were also taken on the studs and drywall. The results are listed in Table 1.

Notice that with the exception of House #1, none of the houses without vapor retarders showed insulation moisture content above 30%. The highest moisture content was found in the two houses with polyethylene vapor retarders on the walls (#5 and #6). Those houses also showed the highest wood mois-

TABLE 1 - Measured Moisture Content In Walls Of Seven Houses Insulated With Forest Wool Brand Spray Cellulose Insulation.

				MOISTURE CONTENT % OF DRY WEIGHT				MOISTURE CONTENT % OF DRY WEIGHT		
House No.	City	Age of Installation	Sample Location	Insu-lation	Dry Wall	2x4 Stud	Sample Location	Insu-lation	Dry Wall	2x4 Stud
1	Perrysburg, OH	10.5 mos.	4" from ceiling	75.8	19.2	18.9	6" from floor	18.1	16.7	12.5
2	Holland, OH	10.5 mos.	6" from ceiling	14.4	17.4	5.3	6.5" from floor	13.8	17.3	n/a
3	Maumee, OH	10.5 mos.	3" from ceiling	25.4	15.4	n/a	3" from floor	11.6	18.0	14.6
4	Whitehouse, OH	2 weeks	2' from ceiling	16.3	n/a	n/a	6.5" from floor	31.1	16.2	n/a
5	Almont, MI	7 mos.	4.5' from floor	60.5	21.6	20.0	2.5' from floor	40.5	21.7	18.4
6	Dayton Plains, MI	8 mos.	4' from floor	61.0	17.0	25.4	1' from floor	67.1	17.3	20.0
7	Maumee, OH	1 year	7.5' from floor	17.0	17.6	10.0	2.5' from floor	16.6	17.7	10.6

NOTE: Houses #5 and #6 had interior polyethylene vapor retarders on the walls. Houses #1,2,3,4 and 7 had no vapor retarder. Source: Bowser-Morner Inc., Toledo, Ohio.

drywall. The results are listed in Table 1.

Notice that with the exception of House #1, none of the houses without vapor retarders showed insulation moisture content above 30%. The highest moisture content was found in the two houses with polyethylene vapor retarders on the walls (#5 and #6). Those houses also showed the highest wood moisture content in the studs (18% to 25%).

Answers and questions

The seven-house Electra study suggests that in most cases, walls without vapor retarders can dry to less than 20% moisture content in less than a year. It also suggests, however, that vapor retarders impede the drying process, even without exterior foam sheathing.

Should the vapor retarder be left off to allow drying? Maybe. Note, however, that the samples in the Electra study were taken on October 6 — the beginning of winter. The question remains whether or not the walls become progressively wetter over the course of the winter due to moisture diffusion into the stud cavity.

Conclusions and recommendations

We still have no definitive answers, but the results of the New England investigation and the Electra Forest Wool study suggest that certain precautionary measures are warranted pending further research:

1. Excessive moisture should be avoided in any wet-spray application.

According to Scott Spiezle, who trains cellulose installers, the installed moisture content should be no more than 50% on a dry weight basis.

2. Unless the insulation is allowed to dry thoroughly before the wall is closed in, the wall must not have a double vapor retarder, i.e. poly on one side and foam sheathing on the other.

If a poly vapor retarder is installed on the inner wall surface, the exterior sheathing ought to be a high permeability material such as "blackboard." If extruded polystyrene, foil-faced iso board, or exterior plywood is used on the outside, the vapor retarder should be left off the inner surface.
[NOTE: The latter is recommended only in moderate climates and when the exterior foam sheathing is at least one inch thick. In those situations, the foam should maintain the wall cavity at high enough temperature to prevent excessive condensation in winter. In cold climates, the poly vapor retarder must be installed.]

For more information

For information on the Electra study or Forest Wool insulation, contact Dave Johnson, Electra Manufacturing, P.O. Box 306, Holland, OH 43528; (419)866-0711. The results of the New England study are not yet publicly released. EDU will carry further updates as more information becomes available.

PRODUCTS

Manville R-8.3 Per Inch Phenolic Foam Sheathing

Having purchased the production facilities from Koppers Corporation, Manville Sales Corporation of Denver, Colorado, has introduced its new weathertite Premier phenolic foam residential sheathing. Originally produced and sold by Koppers under the Rx brand name, this foil-faced product is the only residential phenolic sheathing made and has the highest R-value of any foam sheathing product on the market — R-8.3 per inch.

Weathertite Premier is available in either ¾-inch (R-6.2) or 1-inch (R-8.3) thicknesses.

Energy

J. D. Ned Nisson, Editor

Vol. 8, No. 9

September 1989

NEWS

Window Manufacturer Fined $200,000 for Deceptive Energy Claims

Charged with claiming their "windows would pay for themselves" and that consumers could save 34% on their energy consumption, Season-all Industries Inc., maker of Thermal-Gard replacement windows, has consented to pay up to $175,000 to 44 Wisconsin customers plus $25,000 in civil forfeitures. The charges were brought against Season-all by Wisconsin Attorney General Don Hanaway. In addition to the restitution payments, Season-all will also offer repairs and extended warranties to 59 other purchasers of Thermal-Gard windows.

A copy of the judgement is available from the Wisconsin Department of Justice, 114 East State Capitol, P.O. Box 7857, Madison, WI 53707; (608)266-1221.

In This Issue

More Caution on Wet-spray Cellulose Insulation

Amidst rising popularity and promising research results, new reports of moisture problems with wet-spray cellulose continue to surface. We described one serious problem in the July 1989 **EDU**. And now this, reported by a technical marketing rep from a midwestern utility company.

In January, a builder insulated a new house with wet spray cellulose. The walls were sheathed on the outside with extruded polystyrene and covered on the inside with a polyethylene vapor retarder. The house was occupied by the owners soon after the insulation job.

The owners immediately noticed wetness on the gypsum board plus a small amount of water leaking from the baseboards. In March, an electrician found puddled water in electrical boxes. In June, removing a section of exterior sheathing revealed that the insulation was still noticeably wet to the touch.

According to the utility rep who reported this case to **EDU**, heating energy consumption for the first winter was considerably higher than expected, possibly due to the wet insulation.

No mystery — but a serious problem

This report is one of three similar stories received at the **EDU** offices during the past two months. For each incident, it appears beyond any doubt that the wet-spray cellulose insulation was installed much too wet and then closed in with a double vapor retarder which prevented drying.

These incidents alone do not eliminate wet-spray cellulose as a safe and effective insulation system, but they do underscore the need for adequate training and quality control for applicators to prevent moisture problems and to assure proper performance of the system.

Window Market Peaks in 1988 — Insulating Glass Use Continues to Grow

Residential window sales peaked at 38.8 million units in 1988, with remodeling and replacement window sales overtaking new construction sales for the first time since 1982 (Figure 1). The market is expected to drop off slightly in 1989 and return in 1990, according to the annual "Industry Statistical Review & Forecast" just released by the American Architectural Manufacturers Association (AAMA).

For remodeling, wood and vinyl window sales both increased significantly in 1988 (Figure 2). Vinyl windows also showed a healthy increase for new construction (Figure 3). Sales of aluminum windows decreased for both new construction and for remodeling.

Insulating glass continued to penetrate the residential market in 1988 with 83% of total sales (Figure 4). The AAMA report forecasts 87% penetration by 1991.

For more information

Prepared for AAMA by Drucker research, the complete "Industry Statistical Review and Forecast" is available for $50.00 from AAMA, 2700 River Rd., Des Plaines, IL 60018; (312)699-7310.

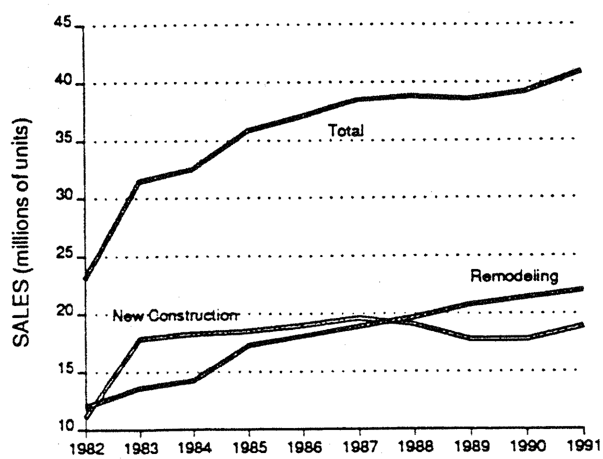


Figure 1 — Total window sales, 1982-1991 (projected). *Source: AAMA*

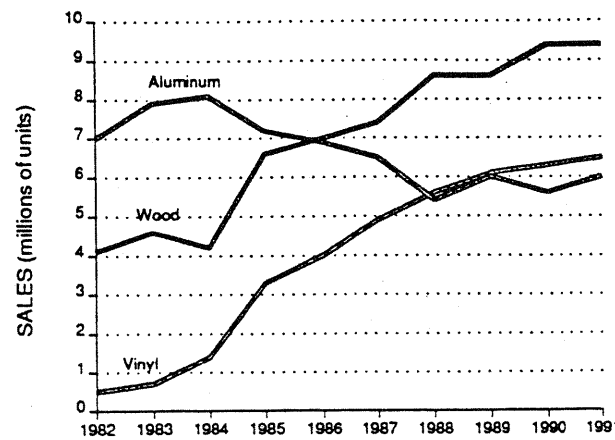


Figure 2 — Remodeling window sales by type. *Source: AAMA*

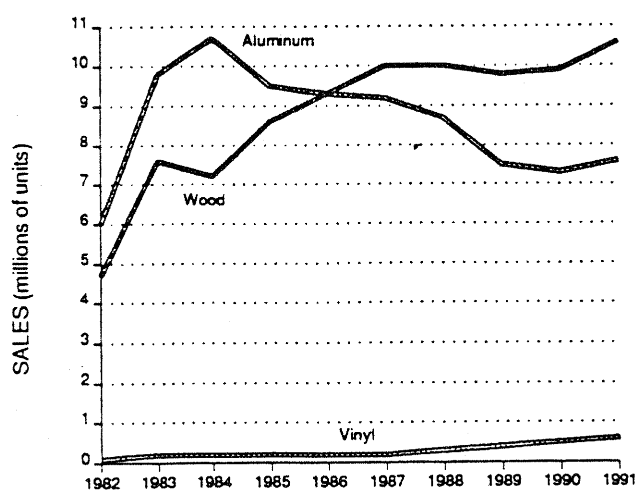


Figure 3 — New construction window sales by type. *Source: AAMA*

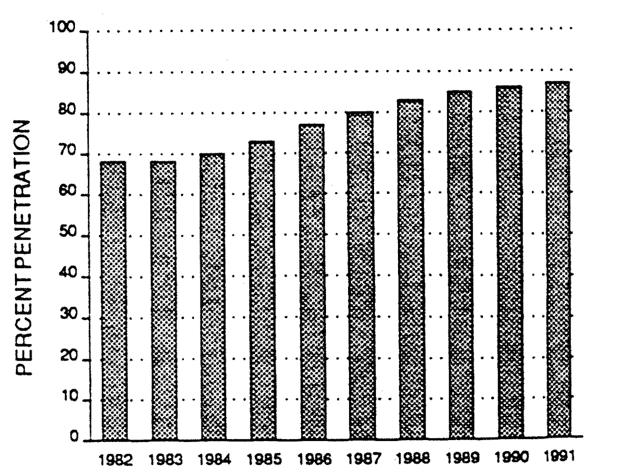


Figure 4 — Insulating glass market penetration, 1982-1991 (projected). *Source: AAMA*

RESEARCH AND IDEAS

Effect of Wet-Spray Cellulose on Walls

A whole-house monitoring project of wet-spray cellulose has shown that when properly applied, the insulation can dry properly with or without a polyethylene vapor retarder and should not cause moisture problems in walls.

This very detailed study, which we originally mentioned in the December 1988 **EDU**, examined several variables that might affect the drying of wet-cellulose and the moisture content of wall framing and sheathing. The final report of the one-year project, funded by the Canada Mortgage and Housing Corporation (CMHC) and conducted by Building Envelope Engineering in Calgary, Alberta, was released this month. With only a few qualifications, the results look quite good.

Vapor retarders and wall ventilation

The test house in the study was a typical 1,200-square-foot Alberta house built by Lincolnberg Homes of Calgary. Wall construction consisted of 2x6 studs, 16" o.c. with plywood sheathing covered with building paper and vinyl siding. Polyethylene vapor retarders were installed on the interior stud surfaces underneath the gypsum board sheathing.

Normally, Lincolnberg uses a system of gaskets to seal against air leakage as part of its "Total Environment Control" (TEC) energy package. For this experiment, however, the gaskets were eliminated to assess the ability of the wet-spray cellulose insulation to reduce air leakage.

The south wall of the test house was modified to test for the effect of vapor retarder and wall ventilation. Figure 1 shows four different variations tested:

Section A — Standard construction with two-mil polyethylene vapor retarder.

Section B — Same as A but with no polyethylene vapor retarder.

Section C — Same as B but with seven one-inch holes drilled in the sheathing, top and bottom to allow ventilation to the outdoors.

Section D - Standard construction (with vapor retarder) but with all gaps in the exterior sheathing sealed to minimize ventilation to the outdoors.

Insulation density and moisture content

The walls were fully insulated with "Weathershield TA" brand wet-spray cellulose manufactured by Can-Cell Industries Ltd. of Edmonton. The insulation was installed at 2.9 lb/ft^3 density and 53% moisture content (wet weight).

Results

Three important practical observations came out of this study — all good news.

1. ***Although wood moisture content rose considerably during the first 30 days after installation, the sheathing and framing dried to near normal levels after two to five months.***

Figure 2 shows the average moisture content of the plywood sheathing, wall studs, and sill plates. Notice that the plywood sheathing rose to near saturation moisture con-

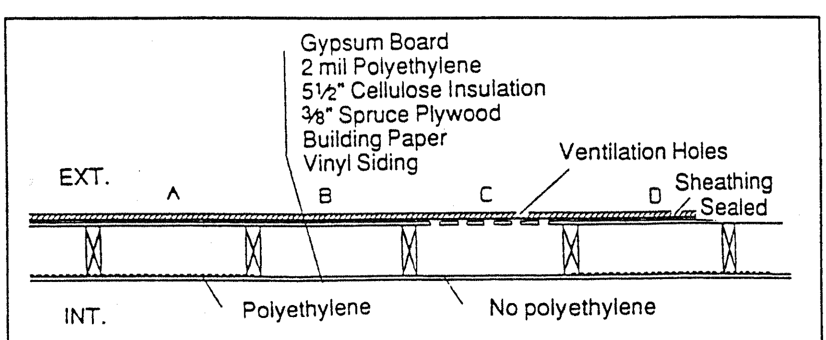


Figure 1 — Wall section showing various test sections, with and without vapor retarder and different amounts of exterior ventilation.

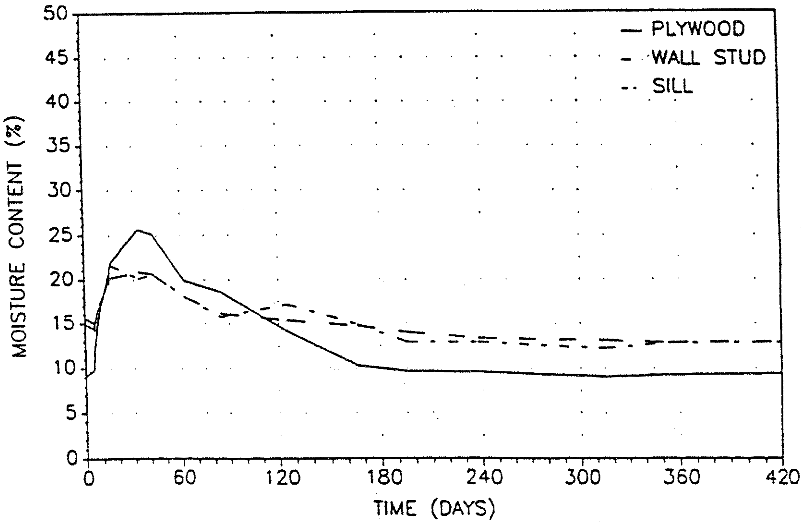


Figure 2 — Average moisture content of plywood sheathing, wall stud, and sill plate after installation of wet-spray cellulose insulation. Source: *CMHC*

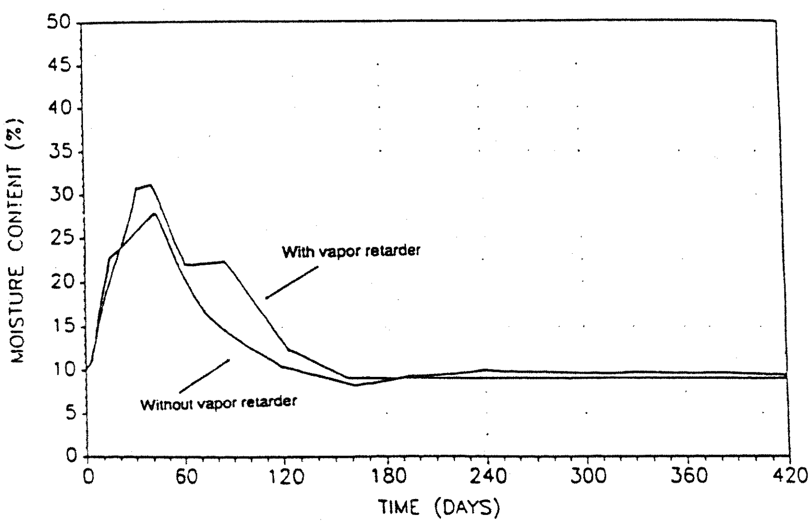


Figure 3 — Measured moisture content over time in plywood sheathing of two wall sections, with and without vapor retarder, insulated with wet-spray cellulose insulation. Source: *CMHC.*

tent (25%) after 30 days, but dried to its original installed moisture content (10%) after 160 days.

Framing moisture content did not gain as much moisture as the plywood, rising to about 22% within 10 days. But it dried more quickly, nearly reaching its original moisture content after about 80 days.

2. ***The presence of a vapor retarder and/or wall ventilation did not ultimately affect the total drying time or final moisture content.***

This may be the most important observation in this study. Most cellulose manufacturers recommend eliminating the vapor retarder to assure proper drying. In this study, the presence of a vapor retarder showed to be ultimately unimportant. Figure 3 compares the measured moisture content in the plywood sheathing for the two wall sections with and without vapor retarders (Section A and B). Notice that the wall without vapor retarder gained slightly less moisture and dried slightly faster, but that after 160 days, the moisture content in both wall sections was nearly identical.

The same observations were made concerning wall ventilation. Figure 4 compares the measured moisture content in the plywood sheathing for the wall with one-inch ventilation holes drilled in the sheathing (Section D) and the wall with all gaps sealed tightly (Section E). The ventilated wall picked up less moisture initially and dried considerably faster, but again, after 160 days, the moisture content in both wall sections was essentially identical.

Slight amounts of fastener corrosion and mold growth occurred

One year after installation, three wall cavities were opened to inspect for mold growth and corrosion of metal components in the wall cavity. About 30% of the siding nails showed a slight amount of surface corrosion, but according to project manager John Vlooswyk of Building Envelope Engineering, the degree of corrosion was very minimal and did not suggest cause for concern.

Only one colony of mold growth was observed. Again, according to Vlooswyk, it was very small, observed in

INSULATION FACTS #14

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION

Wet-Spray Cellulose Insulation Systems

Information from NAIMA

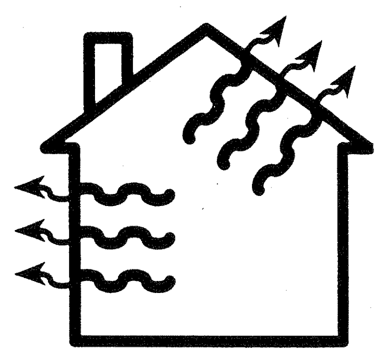
In this issue we discuss concerns that have been raised about wet-spray cellulose insulation and its effectiveness.

Over the last few years there has been an increased focus on the use of wet-spray cellulose insulation systems in the sidewalls of new construction. Wet-spray cellulose insulation is shredded newspaper, mixed (or treated) with various chemicals (up to 25% by weight) to reduce its flammability, that is installed in conjunction with water spray and adhesive so that it adheres to open wall cavities before being covered with drywall. Unlike fiber glass batt insulations which have been widely used for over 50 years and whose performance is well-documented, there is little information on the long-term thermal effectiveness and overall performance of wet-spray cellulose insulations.

In addition, there has been little research on the effect of the high moisture content (up to 50% water by weight) of wet-spray cellulose on the building structure itself. Also, new research shows that the claimed advantage of better air sealing is not true.

This paper will discuss several areas of concern regarding the use and effectiveness of wet-spray cellulose insulation.

Thermal Performance



"R-Value per Inch"

A common promotional claim for cellulose products is that their "higher R-value per inch" makes them a better value than fiber glass. These claims

Factory-made fiber glass, rock or slag wool batt insulation is the product of choice used to insulate most wall cavities. Mineral fiber batt performance is well documented. Literally thousands of thermal and acoustical tests have been performed on batt products by the North American Insulation Manufacturers Association (NAIMA) member companies and independent testing laboratories including the National Association of Home Builders (NAHB) Research Center, Inc., in their ongoing product certification program. In more recent years, tests have also been run to study the impact that various insulation systems have on air infiltration. Results have shown that cavity insulation does not affect air infiltration. (See reports cited in footnotes 15, 16 & 17 in bibliography.) These tests unequivocally demonstrate that batt insulation achieves labeled thermal performance objectives. Tests on wall systems have shown that assemblies perform well with properly installed batt insulation. Batts have become the accepted insulation material against which alternative products are measured. They are the standard insulation responsible for most of the 12 quadrillion Btus of energy savings attributed annually to insulation in residential and commercial buildings throughout the U.S.[2]

originated with comparisons of some attic products. However, "higher R-value per inch" is a consideration only in areas with little space for insulation. Even for enclosed wall cavities, this claim is clearly not true when cellulose is compared to the popular high-performance fiber glass wall batts of R-13, R-15 or R-21.

Performance is Based on Good Workmanship

A direct comparison of whole-wall performance with fiber glass batts versus wet-spray cellulose was made by Johns Manville (formerly Schuller Corporation).[1] The average R-values for insulated 8′x10′ frames that included utility boxes, wiring, and piping were measured. The tests showed that R-13 fiber glass batts provided whole-wall R-values equal to or better than the equivalent wet-spray cellulose or dry-blown systems.

No matter what R-value is claimed for a wet-spray cellulose application, the "true" R-value of the installed insulation is significantly dependent upon:

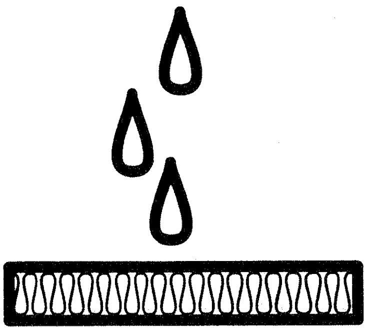
- The quality of workmanship
- The amount of insulation material that is actually installed
- The moisture content

It is very difficult to maintain consistent density due to variations in the amount of water added as well as variations in installation techniques.

Cellulose promoters claim that installations using batt insulations have voids which cause reduced thermal performance. They cite the ASHRAE Handbook of Fundamentals which references a test showing that a 4% void area in wall insulation increases heat loss by 15%.[3] However, the 4% void test is not representative of typical installation, or even very sloppy workmanship.

In sidewalls, a 4% void is equivalent to approximately a 4 inch space the entire width of every stud cavity. This would not be tolerated on a job and is an unrealistic example to cite. Reasonably good workmanship is important for any insulation product, and batts can be installed with minimal void areas. Many cellulose applications use fiber glass in areas that are difficult or impossible to spray with cellulose when they take the time to do the job properly.

Moisture Control



In general, insulations will lose R-value when wet. Cellulose fibers are "hygroscopic" - very effective at absorbing and retaining moisture. Problems can occur when installers apply too much moisture to the insulation. Many manufacturers have been allowing installers of their material to use up to 5 gallons of water per 30 lb. bag of insulation (instead of the recommended 1.5 to 2 gals per 30 lb. bag.)[4] In any wet-spray situation, the builder should wait until the material is totally dry before putting up drywall.

THE FIRST STUDY, CONDUCTED IN THE HUMID NEWFOUNDLAND CLIMATE, REVEALED THAT WHEN WET CELLULOSE WAS SPRAYED INTO A WALL CAVITY, THE CELLULOSE DID NOT DRY OUT AND THE MOISTURE CONTENT OF THE WOOD FRAMING MEMBERS REMAINED EXTREMELY HIGH: 60% AFTER TWO YEARS. THE NORMAL MOISTURE CONTENT OF WOOD IS ABOUT 12%, WHILE 30% IS THE FIBER SATURATION POINT.

Field Studies Measure Drying Times

Actual field studies have shown that wet-spray applications of cellulose insulation do not achieve their advertised R-value until dry. Moisture investigations in New England and Ohio[5], Canada[6] and elsewhere[7] showed significant moisture problems. Two Canadian field studies were sponsored by the Canada Mortgage and Housing Corporation (CMHC). The first study, conducted in the humid Newfoundland climate, revealed that when wet cellulose was sprayed into a wall cavity, the cellulose did not dry out and the moisture content of the wood framing members remained extremely high: 60% after two years.[5] Moisture problems such as rot and mold growth can occur when moisture remains above 20-25% for extended periods of time. The normal moisture content of wood is about 12%, while 30% is the fiber saturation point.[8]

CONSEQUENTLY, CONCERNS ABOUT POTENTIAL MOISTURE-INDUCED PROBLEMS SUCH AS CONDENSATION, POOR THERMAL PERFORMANCE, MILDEW, AND CORROSION ARE JUSTIFIED IN MOST CLIMATES.

Another field study was conducted in the dry Alberta climate.[9] This study showed that sheathing and framing dried to "near original moisture levels" in approximately five months (160 days).

These studies confirm that moisture escape from a wall cavity is often a slow process. Even in the dry Alberta climate, five months is a long drying time. Consequently, concerns about potential moisture-induced problems such as condensation, poor thermal performance, mold growth, and corrosion are justified in most climates.

Reliable Drying Guidelines Needed

All of these tests indicate a need for more reliable drying guidelines. Many contractors[10] acknowledge that they have no clear guidelines on the subject. They are acutely aware of the potential problems that can develop if walls are closed-in too soon. Little information, however, is available from cellulose manufacturers regarding recommended drying times. For example, one cellulose manufacturer's research report states a drying time of 72 hours when the ambient temperature is less than 70°F and 48 hours when higher than 70°F. Two other cellulose research reports state that insulation may be enclosed only after adequate curing and mention minimum time periods of three hours and 24 hours. But what is "adequate curing?" Is 72 hours (three days) curing sufficient in all cases when testing shows that after six days of curing the insulation may still require more than five months to dry to near original moisture levels?

Lab Test Shows Similar Drying Rates

A study of wet insulation drying rates by Johns Manville produced results similar to the Canadian studies. When vapor retarders were used in these tests, they were installed within two days of the sprayed cellulose application. This is considered consistent with field practice. As expected, there were significant differences in drying times with and without vapor retarders.

Several test frames insulated with sprayed cellulose were placed in environmental chambers simulating moderate (75°F — 50% Rh) and humid (90°F — 90% Rh) climates.

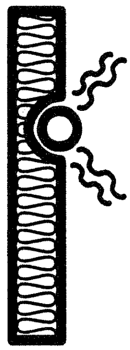
Other test frames were stored in the Denver laboratory, which represented a dry climate with temperatures ranging from 70°F to 81°F and relative humidities from 11% to 46%. In the dry environment, the insulated frame with no vapor retarders reached a stable weight, indicating complete drying, in about one month. With a vapor retarder on one side, the sample completed much of the drying in three months but did not dry completely for 10 months. With a vapor retarder on both sides, the sample was still not dry after one year.

In the moderate environment, a double vapor retarder sample had not completed drying after one year. In the humid environment, none of the three samples had completed drying after one year. Clearly, wet sprayed walls will often not dry before the building is completed and occupied.

Temptation is to Close Wall Before Insulation is Dry

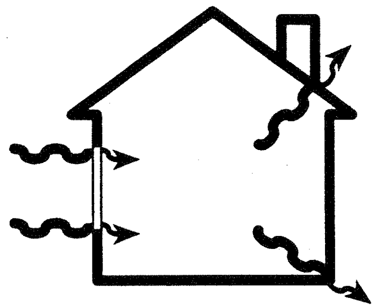
Waiting for wet insulation to dry can be a major inconvenience for a builder. It means that the scheduling of wall finishing contractors in most cases must be delayed. On the other hand, fiber glass can be covered up immediately. Delaying wall finishing also increases the likelihood of the insulation being damaged before it is covered. If scheduling is tight, there is a strong temptation to close the wall before the insulation is dry. Thus the insulation is sealed away from sight and potential repair. Because mold spores are inherent in old newspapers, and cellulose is a natural nutrient for numerous types of mold, this can create a breeding ground for mold.

Corrosiveness



Corrosiveness is a concern because insulation treated with chemicals and installed in sidewalls can come in contact with metal fasteners, electrical boxes, pipes, ducts, etc. Corrosiveness tests have been conducted by the Oak Ridge National Laboratory[11] (ORNL) on fiber glass, rock wool, and cellulose insulation. In the presence of moisture from condensation, there was no corrosion on steel or copper coupons or on cooled copper pipes embedded in fiber glass and rock wool insulations. In contrast, the tests showed that "all of the cellulosic insulation materials tested produced corrosion of steel and copper."[11] The test report concludes that moisture absorption appears to be the primary factor in causing corrosion. Moisture weight gain due to condensation was in the range of 0.16% to 6% for fiber glass and 4% to 100% for cellulose.[11]

Air Infiltration



Colorado Study

Numerous claims have been made about the superiority of cellulose in limiting air leakage in a house. Cellulose manufacturers base their claims largely on a report by the University of Colorado School of Architecture and Planning[12] which examined the installed performance of fiber glass vs. cellulose.

For the study, two test buildings were constructed on the University's campus. Walls in Building "A" were insulated with 5-1/2 inches of wet-spray cellulose and walls in Building "B" were insulated with R-19 fiber glass batts.

An independent review of the study by David Yarbrough, Ph.D., PE of R&D Services, Inc., Lenoir City, TN,[13] a long-time insulation researcher with Tennessee Technological University and ORNL, states that the facts do not support the conclusion that cellulose insulation limited the air leakage in a building.

Yarbrough states that he sees major deficiencies in the study. He says that "Comparative studies... must characterize the structures used and the materials used in order to eliminate the possibility that differences observed are the result of construction or mismatch of the thermal values of installed insulation. Specification of nominal insulation R-values is not sufficient for a serious thermal study."[13] He adds that the Colorado study "illustrates the difficulties associated with large-scale thermal studies."[13]

> ...THE FACTS DO NOT SUPPORT THE CONCLUSION THAT CELLULOSE INSULATION LIMITED THE AIR LEAKAGE IN A BUILDING.

The study reveals that blower door tests were conducted with no wallboard on the walls. Wallboard is a critical element for reducing air infiltration. The testing was not done to isolate the effects of floor tightness, window tightness and door seals. Therefore, it is likely that some or all of the difference in air infiltration could be attributed to these sources. There is no data to prove that these factors were even considered.

From an energy standpoint, the study concludes the building insulated with cellulose used less heating energy during the test period. However, according to Yarbrough, "The reasons for the lower heating energy usage of the building insulated with cellulose cannot be identified in the study."[13]

Yarbrough suggests that the 26.4% difference in energy usage "could be explained by the difference in the insulation R-values that were used."[13]

According to Yarbrough, "[Since] the thermal resistances of insulation materials actually installed were not reported... there is good reason to believe that the thermal resistance of the installed cellulose was greater than the thermal resistance of the installed fiber glass in both the walls and attics of the test units."[13]

Alberta Study

The previously mentioned Alberta study[9] included air leakage tests which indicate that wet-spray cellulose provides some resistance to air flow but is not an effective air barrier. The air blocking characteristics of cavity insulation (density claims) are of little consequence because, as the tests verified, sheathing and drywall are substantially better air barriers than any cavity insulation. Air infiltration barriers and polyethylene are installed for this specific purpose.

G.K. Yuill Study

A 1996 study conducted by Penn State University professor G.K. Yuill, Ph.D.,[14] tested fiber glass batts and wet-spray cellulose insulations for resistance to air flow through the wall cavities of two houses. Based on the test data, the researchers found it impossible to determine which insulation material provided a more airtight structure and concluded that the difference between the two types of insulation had little influence on the air tightness of a house.

The data showed that most of the resistance to air flow through a house's walls is provided by drywall and not insulation. Drywall contributes about 77% of the total resistance of the wall, the sheathing and siding about 12% and the insulation about 11%. The study made it clear that any difference between the two insulations was insignificant when compared to the overall leakage through the other components of a house. Small differences in workmanship elsewhere in a house are likely to be more significant than differences in the air permeability of wall insulation.

RECENT TESTING HAS CONFIRMED THAT THERE IS NO AIR INFILTRATION OR R-VALUE ADVANTAGE IN USING WET-SPRAY CELLULOSE TO INSULATE WALL CAVITIES.

Union Electric Study

A study initiated in 1995 by a St. Louis, MO utility company, Union Electric,[15] tested seven homes for air infiltration. It concluded that a properly installed sealant package can significantly

...TESTS SHOWED THAT R-13 FIBER GLASS BATTS PROVIDED WHOLE-WALL R-VALUES EQUAL TO OR BETTER THAN THE EQUIVALENT WET-SPRAY CELLULOSE OR DRY-BLOWN SYSTEMS.

reduce air infiltration and save energy in a home regardless of the insulation installed (fiber glass or cellulose). The purpose of the study was to determine the effects of different types of insulation on the air changes, operating costs and comfort level of a home. The study found that a sealant package can decrease air infiltration by more than 50 percent compared to a home that does not have one. In field tests, fiber glass and cellulose insulations were considered equal in their impact on air infiltration, leading to the conclusion that air infiltration is dependent upon the sealant package, not the insulation material type.

NAHB/EPA Study

The results of a recent study[16] conducted by the National Association of Home Builders (NAHB) Research Center for the U.S. Environmental Protection Agency's Energy Star Homes Program concluded that alternative residential insulation products do not significantly reduce air leakage.

The study determined that the individual air sealing practices of the insulators had a larger impact on air leakage than the insulation products themselves.

The study compared the performance of fiber glass batt insulation to three alternative products — wet-spray cellulose, blown-in fiber glass (referenced as "Blow-In-Blanket System" or BIBS) and low density polyurethane foam insulation (also referred to as spray-applied foam or polyicynene).

Fiber glass batts, wet-spray cellulose, blown-in fiber glass and polyicynene were installed in 26 similar homes in Maryland and Virginia. The study measured such factors as house tightness by insulation type, labor time required to install the various insulations and total installed cost to reach the specified values of R-30 in the attic and R-13 in the walls of the homes.

When compared to fiber glass batts, the study found that the alternative insulation products did not significantly reduce air leakage in the homes studied. Based on the data, the study could find no significant relationship between the type of insulation used and the amount of air infiltration.

The NAHB/EPA study confirms[17] what a lot of builders suspect: it pays to be less concerned about the type of insulation being used, and more concerned about how the home is detailed.

Summary

Recent testing has confirmed that there is no air infiltration or R-value advantage in using wet-spray cellulose to insulate wall cavities. In fact, many important technical questions remain concerning the installation of wet-spray cellulose insulation in sidewalls. Besides the obvious concern about fire safety, doubts persist about thermal performance, moisture retention, and corrosiveness. Further research is needed in these areas, especially in the area of moisture control where the term "adequate drying" needs to be defined.

Bibliography

1. *Thermal Performance of Fiber Glass Batts and Blown Insulations in Walls*, K.J. Wills, T.R. Rohweder; Manville Research Report No. E 436 T-2050, November 29, 1988.
2. *Green and Competitive: The Energy, Environmental, Economic Benefits of Fiber Glass and Mineral Wool Insulation Products.* Report prepared by Energy Conservation Management, The Alliance to Save Energy, and Barakat & Chamberlin, Inc., June, 1996.
3. 1985 *ASHRAE Handbook of Fundamentals*, Chapter 20, Effectiveness of Building Insulation Applications, J.D. Verschoor, (USN/CEL Report No. CR78.006-NTIS No. ADAO053452/9ST).
4. *Wet Spray Cellulose Installation and Performance,* Scott R. Spiezle, National Thermal Performance Institute, February 15, 1990.
5. *Wet-Spray Cellulose-Questions About Drying*, Energy Design Update, July 1989 Edition, page 1.
6. *Effect of Wet-Spray Cellulose On Walls*, Energy Design Update, October 1989 Edition, page 3.
7. *More Caution on Wet-Spray Cellulose Insulation,* Energy Design Update, September 1989 Edition, page 1.
8. *Moisture Control in Buildings,* Heinz R. Trechsel, ASTM Manual Series, MNL 18, February, 1994.
9. *Field Monitoring of Cellulose in Walls-Edmonton*, for CMHC, Project Implementation Division, prepared by John A. Vlooswyk, Building Envelope Engineering, January 8, 1990.
10. *Wet-Spray Insulations for Homes.* Energy Design Update, September 1985 Edition, page 11.
11. *Corrosiveness Testing of Thermal Insulating Materials- A Simulated Field Exposure Study Using a Test Wall*, Report ORNL/Sug.78-7556/4, September 1988.
12. *Fiber Glass vs. Cellulose Installed Performance*, Soontorn Boonyartikarn, Arch. D., and Scott R. Spiezle, M. Arch, University of Colorado Graduate School of Architecture, 1990.
13. Review of paper *Fiber Glass vs. Cellulose Installed Performance* (Soontorn Boonyartikarn and Scott R. Spiezle, 1990) by David W. Yarbrough, 1996.
14. *A Field Study of the Effect of Insulation Types on the Air Tightness of Houses*. G.K. Yuill, Ph.D, Pennsylvania State University Department of Architectural Engineering, 1996.
15. Research and Development Project, "Maple Acres," Union Electric, St. Louis, Missouri. William Conroy, division marketing supervisor, 1995.
16. *Field Demonstration of Alternative Wall Insulation Products.* Prepared for U.S. Environmental Protection Agency by NAHB Research Center, Inc., November 1997.
17. *Does Insulation Choice Really Affect Infiltration?* Energy Design Update, July 1997 Edition, page 6.

ABOUT NAIMA

NAIMA is a trade association of North American manufacturers of fiber glass, rock wool, and slag wool insulation products. NAIMA's role is to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation products and to encourage safe production and use of these insulation products.

For additional information on building insulation contact:

NAIMA
44 Canal Center Plaza, Suite 310
Alexandria, VA 22314
Tel: 703/684-0084
Fax: 703/684-0427
E-mail: insulation@naima.org
Website: http://www.naima.org

NAIMA BUILDING INSULATION COMMITTEE MEMBERS:

CertainTeed Corporation
PO Box 860
Valley Forge, PA 19482
800/233-8990

Johns Manville
PO Box 5108
Denver, CO 80217-5108
800/654-3103

Knauf Fiber Glass
One Knauf Drive
Shelbyville, IN 46176
800/825-4434

Owens Corning
One Owens Corning Parkway
Toledo, OH 43659
800/GET-PINK

Printed on Recycled Paper

PUB. NO. BI460 8/98

FEATURE ARTICLE

Wet-spray Cellulose — Questions About Drying

Questions without answers

How long does it take wet-spray cellulose to dry after installation in wall cavities? How dry must it get to avoid problems and/or loss of R-value? Should the material dry before the wall is closed in? If so, how long? Does a polyethylene vapor retarder prevent the insulation from drying fast enough? If so, is it OK to leave the vapor retarder off? Are there some regions or types of construction where wet-spray cellulose simply should not be used?

The above questions have no conclusive answers – at least no answers with consensus among members of the building community. In general, manufacturers and contractors make up their own rules, often based on intuition rather than building science. So far things have gone well. Except for one experimental study in southeastern Canada where wet-spray cellulose was installed in walls with wet framing lumber and double vapor barriers, no documented cases of moisture problems with spray cellulose have been reported.

The following is a report on two recent investigations of the drying potential of wet-spray cellulose in walls. While not conclusive, both studies suggest caution. It appears that rapid and complete drying is not assured and could depend on the method and quality of installation plus the presence or absence of interior and exterior vapor retarders.

Case 1: Soaking lumber after 18 months

A moisture investigation in a 1½-year old public housing project in New England found that wood framing moisture content in the walls insulated with wet-spray cellulose was well above 30% in many areas and as high as 70% in some (see News story, page 16). Two buildings, one with 2x4 walls and the other with 2x6 walls, were investigated. Both showed wet wall framing. In one building, the moisture content of the cellulose insulation was found to range from 31% to 61%.

Worst case situation?

Based on reports from the project architect and consultant, this case may represent the most severe conditions for using wet-spray cellulose. First of all, the material was evidently installed at an extremely high moisture content – five to six gallons per 30-pound bag of insulation. Second, the drying pathways were limited by installing a double vapor retarder – polyethylene on the inside and extruded polystyrene on the outside – that was meticulously sealed for energy conservation.

While further testing may produce more definitive conclusions, it appears that the combination of excessive water loading and insufficient drying pathways prevented these walls from drying.

Case 2: Partial drying after 60 days with polyethylene vapor retarder

Electra Manufacturing is one of the oldest and most reputable cellulose manufacturers in the U.S. Last year it hired Bowser-Morner laboratory of Toledo to measure the drying rate of its Forest Wool brand spray insulation.

Samples of the wet-spray insulation were collected during installation at two houses in Perrysburg, Ohio, on November 8 and 9, 1988. The measured moisture content ranged from 44% to 106% on a dry-weight basis (weight of water divided by weight of dry cellulose). Sixty days later, additional samples were extracted from both houses at approximately the same wall locations. In every case, the insulation had dried some-

JAN 22 1996

OFFICE OF THE ASSISTANT SECRETARY
FOR HOUSING-FEDERAL HOUSING COMMISSIONER

Mr. Daniel Lea
Executive Director
Cellulose Insulation Manufacturers
Association (CIMA)
136 S. Keowee Street
Dayton, OH 45402

Dear Mr. Lea:

Based on the Department's review of the technical information provided by CIMA, Rock Wool Manufacturing Company, Oak Ridge National Laboratory (ORNL), Greenstone Industries, and other sources, it is our understanding that stabilized cellulose is the predominant type of cellulose insulation used in attic cavities of manufactured homes. In October 1994, several sections of the Manufactured Homes Construction and Safety Standards were rewritten and new language was introduced to address issues such as energy efficiency, indoor air quality, and attic ventilation. As a result of these changes, the required insulation R-values in manufactured homes have increased. The following questions relate to the performance of stabilized cellulose insulation in manufactured homes:

- Water is injected in the insulation during application to achieve stabilization. How much water is added? What methods are recommended to control the amount of moisture introduced in attics?
- What impact does the added water have on thermal performance of insulation and does it cause any degradation in its R-value?
- What is the recommended drying time for stabilized cellulose to cure before the roofing system is applied?
- Are there any geographic or climatic limitations on using stabilized cellulose? If not, what ensures drying of insulation in sealed attic cavities of manufactured homes located in the high humidity climate regions of the United States?
- What are the corrosive effects of high moisture contents in cellulose insulation on durability of framing members, metal parts (including fasteners), and roof covering?

- Is there any restriction for using vapor retarders in conjunction with stabilized cellulose? If so, where and how.

- Are there any installation instructions for using stabilized cellulose in manufactured homes available to the IPIAs and DAPIAs? If so, please provide this office with copies.

- An evaluation conducted by ORNL of stabilized cellulose in manufactured homes found cellulose stable at 2.0 pcf. The behavior of stabilized cellulose at the 1.3 pcf advertised density is not reflected in the ORNL report. How is the stability of cellulose at 1.3 pcf. substantiated? Have transportation settling tests been performed to determine that 1.3-pcf actually arrives at the job site of a manufactured home?

Your assistance in providing answers to the above questions is very much appreciated. If you have any questions please call Victor Ferrante at (202) 708-6423.

Sincerely,

David R. Williamson
Director
Office of Consumers
and Regulatory Affairs

cc: Frank Walter-MHI
MHI-DETAG
Terry Applegate-Applegate Insulation Mfg., Inc.
Dennis McDonnell-U.S. Fiber, Inc.
Ivan Smith-Greenstone Industries