PAINT AS A VAPOR BARRIER FOR WALLS OF OLDER HOMES

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ABSTRACT

Insulation added to walls of an older home without vapor barriers may cause moisture condensation problems. Such problems appear to be minimal in the Madison, Wis., climate so long as mechanical humidification is not used. However, where a relative humidity of 35 percent or higher is maintained in the older home, troublesome condensation in the walls is likely without remedial measures. And even in homes without peeling paint or other overt moisture problems, buildup of moisture in walls may reduce the effectiveness of insulation.

To obtain information on the effectiveness of some commercially available paints as vapor barriers, three types of paint (interior semigloss acrylic latex, exterior acrylic latex, and exterior soya-alkyd resin) were applied to the plaster on selected wall sections. A relative humidity of 35 percent was maintained in the test structure through one winter, and moisture levels were observed in the wall cavity. All of these paints served as adequate vapor barriers (where applied in two coats) to keep moisture in walls at acceptable levels. Labeling commerical paints with perm ratings would help the consumer determine those most suitable for use as vapor barriers.

This information should be useful to homeowners and home-improvement contractors.

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Introduction

Insulation is being blown or foamed into the wall cavities of many homes built prior to 1940 because it was usually not included at the time the house was built. The added insulation has the effect of moving the zone in which condensation occurs toward the inside face of the wall, which sometimes results in moisture condensing in the insulation.

In many structures where insulation has been added without benefit of a vapor barrier, no damage from moisture buildup has become apparent. However, there is no way of knowing the exact conditions inside the wall cavity without removing the covering materials. In other structures, condensation in walls has resulted in serious problems of paint peeling or extractives from sheathing or siding running down the face of the exterior wall.

Condensation problems are aggravated when mechanical humidification is used in the older home. Even where condensation presents no visible problems, research has shown that moisture does reduce the thermal efficiency of insulation **(1)**.[2] Also, when the moisture content (MC) of wood reaches high levels and temperatures are 35° F or higher, decay can occur with consequent deterioration of the structure.

It is quite difficult to stop condensation in walls of older homes by adding a membrane-type vapor barrier to an existing wall. (In new construction, such a vapor barrier is applied to the wall framing before the plaster or drywall is installed.) An alternative solution to the condensation problems described might be the use of paints resistant to vapor penetration for interior walls. In effect, the paint itself then might become a vapor barrier. The possibility of such an application of paint was first suggested by Joy, Queer, and Schreiner in 1948, but no research was conducted to verify their suggestions **(4)**.

This paper reports the testing of three paint types that are commercially available to determine their effectiveness as vapor barriers. They were applied to stud walls built to simulate walls of older homes which lack vapor barriers.

Background

During the winter of 1974-1975. a simulated older structure with insulation added to the wall cavity was instrumented with moisture sensors **(5)**. The variables included

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Numbers in parentheses refer to Literature Cited at the end of the paper.

three types of wall construction and two indoor humidity conditions. Indoor relative humidity conditions resulting from normal household activities were simulated in part of the building. The remainder of the interior space was maintained at 35 percent relative humidity. Walls tested incorporated the usual plaster with oil-base paint, unmodified and with two types of remedial modification (two coats of aluminum paint, exterior 1-inch vents at top and bottom of stud spaces). Only plaster walls with oil-base paint were used as controls because that is typical of houses built prior to 1940.

Test data showed that insulation added to walls of an older home subject to the climate at Madison, Wis., may not cause visible moisture problems where mechanical humidification is not used. However, where a relative humidity of 35 percent is maintained in the house, condensation in the walls is likely without remedial measures. Two coats of aluminum paint on the plaster were an effective vapor barrier and thus kept moisture in the walls at acceptable levels even where indoor relative humidity was maintained at 35 percent. One-inch-diameter vents installed near the top and bottom of a stud space provided little help in keeping the wall cavity dry, and low temperatures resulting from air moving through the cavity indicated increased heat loss through the wall. The vents did keep moisture levels lower at the sheathing-siding interface, which may help prevent paint peeling.

Although aluminum paint provided an adequate vapor barrier, it is difficult to mix and apply, and the house must be completely redecorated. A readily available premixed paint that would result in a finished surface could be used to much better advantage. To determine the effectiveness of premixed paints as vapor barriers, selected paints were applied to the walls of the simulated older house used in previous tests and moisture measurements were made in the walls through a winter season.

Construction and Test Conditions

A 16- by 24-foot building was constructed near Madison, Wis., in 1964 to be used for the study of moisture distribution in walls of new construction **(3)** (fig. 1). It was later adapted for the study of moisture in a simulated older home conducted during the winter of 1974-1975. The building had been constructed with conventional floor and roof framing, but vertical support was provided by nominal 4- by 4-inch posts at 8-foot spacing to permit the use of seven 8- by 8-foot removable wall panels. Each of the seven wall panels was divided into four spaces with nominal 2- by 4-inch studs, resulting in 28 test spaces (fig. 2, table 1). Only five of the wall panels were used in the tests presented here. A nominal 1- by 6-inch board coated with aluminum paint was placed adjacent to each stud and extended to the outside to prevent moisture transfer between spaces and the sheathing or siding covering each space.

Sheathing was of 1- by 8-inch boards spaced slightly to simulate older construction in which the boards often shrink and leave a slight gap. A 15-pound asphalt-impregnated sheathing paper was applied over the sheathing boards, and ½- by 6-inch beveled siding was added. Siding was given two coats of oil-base paint. The interior was finished with gypsum lath and plaster, and given two coats of an interior oil-base paint. An older house would have wood lath, but both the wood lath and gypsum lath have very high permeability, so this substitution should have no effect on moisture transfer through the walls. Each space was insulated with 3-½-inch-thick glass fiber batts. Identical construction was used for all spaces in this study.

Variables for the study included orientation of test walls (north or south), interior paint, and the presence or absence of exterior ventilation for the wall cavity. For this study the lower vent was plugged on half of the ventilated cavities to observe the effect of vents at the top only.

The building was heated to 72°F ± 2° by electric heaters and humidified to 35 ± 5 percent relative humidity by a commercial humidifier. Location of wall panels with various treatments is identified in table 1. In addition to panels with aluminum paint and ventilated cavities, the plaster on some wall panels was painted with readily available commercial paints known to have good

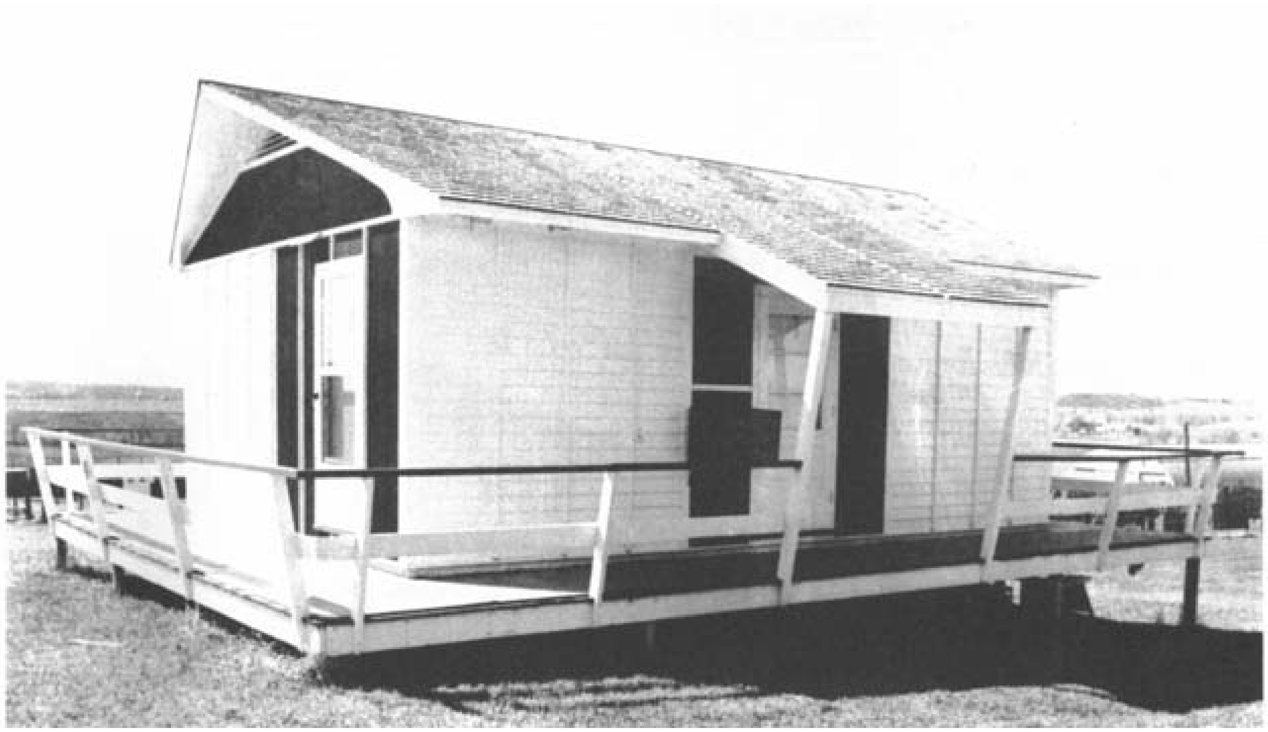

Figure 1. - - The U.S. Forest Products Laboratory test house located on the exposure site near Madison, Wis. (M 144 205-3)

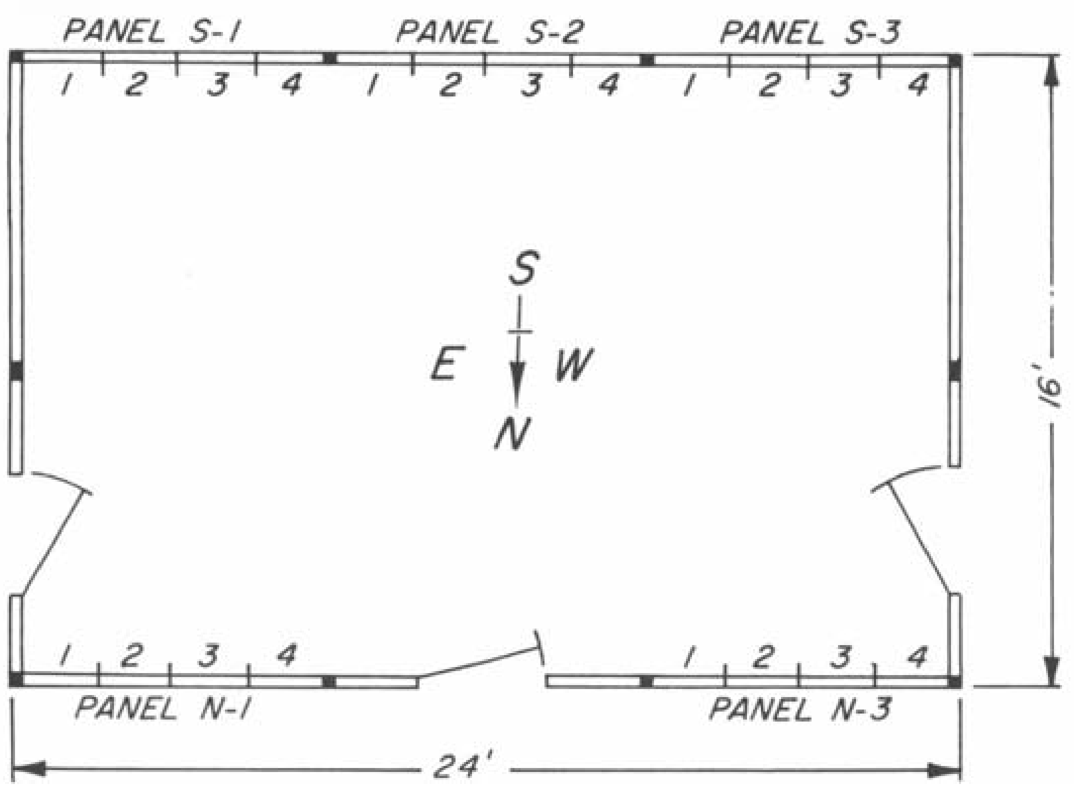

Figure 2. - - Arrangement of panels in FPL test house. (M 144 897)

Table 1.--Location and variables for monitored test species

Variables	Location code[1] Panel	Space
No preventative measure	S-1	1
	N-1	1
Interior semigloss acrylic latex (one coat)	S-1	3
(two coats)	S-1	2
Exterior acrylic latex (one coat)	S-2	1
(two coats)	S-1	4
(two coats)	N-1	3
Exterior soya-alkyd resin (one coat)	S-2	3
(two coats)	S-2	2
(two coats)	N-1	4
Aluminum paint (two coats)	S-3	3,4
(two coats)	N-3	1,2
Vents (top only)	S-3	1
(top only)	N-3	3
(top and bottom)	S-3	2
(top and bottom)	N-3	4

[1] To locate the panels and spaces, see fig. 2.

Table 2.--Weather conditions during test period[1]

Month	Low temperature	High temperature	Degree days	Normal degree days
	°F	°F		
November 1976	-6	62	1,102	909
December 1976	-17	50	1,602	1,336
January 1977	-22	29	1,898	1,494
February 1977	-19	54	1,188	1,252
March 1977	11	70	772	1,079
April 1977	20	87	409	591
Total for test period			6,971	6,661

[1] Data from the Madison Weather Service Office, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

moisture-excluding effectiveness. The three types of paint selected were exterior soya-alkyd, exterior flat acrylic latex, and interior acrylic latex semigloss enamel.

Weather conditions for the period covered by this study (November 1976 through April 1977) are shown in table 2. These data indicate that the period covered by the study was slightly colder than usual for a winter in Madison, Wis. Degree days for the period were about 5 percent above the mean.

Instrumentation and Measurements

The method used for measuring moisture within the walls is detailed in the following paragraph.

Moisture Content

The moisture content (MC) of small wood sensors was measured at three locations in each space (fig. 3). Actual installations are shown in figures 4, 5, and 6. A total of 60 locations were measured for wood MC with small wood-type sensors but MC of actual components was not determined. The relative humidity within the rooms was monitored using a sling psychrometer.

A sensor capable of remote reading was required because most of the locations for moisture measurement were relatively inaccessible. The system used employed a calibrated wood sensor element and a commercial moisture meter. Construction and details of the operation of this sensor are given by Duff (2). The probes were calibrated in humidity rooms to an accuracy of ±2 percent MC over a relative humidity range of 35 to 90 percent which was considered sufficiently accurate for this study. This corresponds to an MC in the wood probe of 7 to 20 percent. Determination of MC beyond these limits was less accurate due to difficulties in measuring extreme ranges of resistance. Also, beads of condensed water were often present on probe surfaces at probe readings of 20 percent or higher.

Temperature Measurement

The MC as indicated by the probe requires correction- only for temperature changes of 10° F or more. Inside room temperature was used for correcting the moisture probes located immediately adjacent to the interior wall lining. Outside air temperature was used to correct the probes immediately beneath the siding. For moisture probes within the wall between the insulation and sheathing, actual thermocouple measurements were made for each probe. Placement of a probe and its associated thermocouple for temperature is shown in figure 5.

All temperatures were measured using Type T (copper-Constantan) thermocouples and an ice bath reference.

Data Recording and Conversion

The system for monitoring MC consisted of the moisture probes connected through a scanner to a commercial moisture meter, digitized through a voltmeter, and read manually. Thermocouple readings were also digitized through a voltmeter and read manually.

Raw data from each moisture sensor were first converted to MC readings via a calibration curve, and then corrected to actual MC for the temperature associated with the specific probe. The last step corrected the probe readings for species of wood used in the probe – giving a final, true MC. The corrected data were then keypunched for computer plotting.

Readings were taken at about 2 p.m. twice a week from November 8, 1976, to April 29, 1977.

Results and Discussion

Data from moisture readings are reported through the critical range of moisture levels. Values of wood MC greater than 20 percent were observed in the probes. However, because percentage readings over this level are of questionable accuracy, values above 20 percent were not plotted. Probe readings above 20 percent generally indicated the presence of beads of condensed water on surfaces and thus a risk of decay if sustained. The structure is in danger at any sustained probe MC over 20 percent when temperatures are 35°F or higher, so that the amount by which the 20 percent reading is exceeded is not highly relevant. However, the length of time the probe reading remains

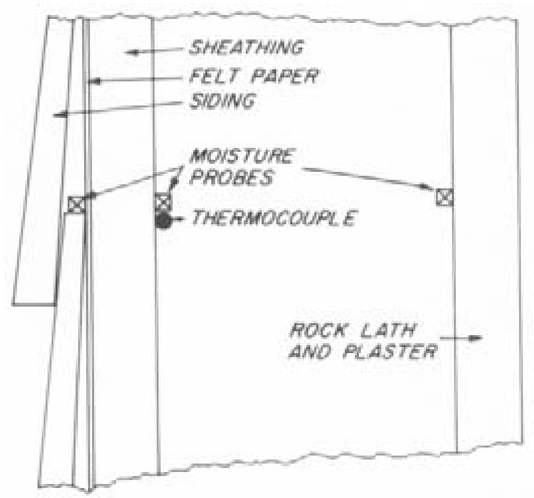

Figure 3. - - Cross section of stud space showing location of moisture probes and thermocouples. Probes were located at both one and seven feet from the floor. (M 144 899)

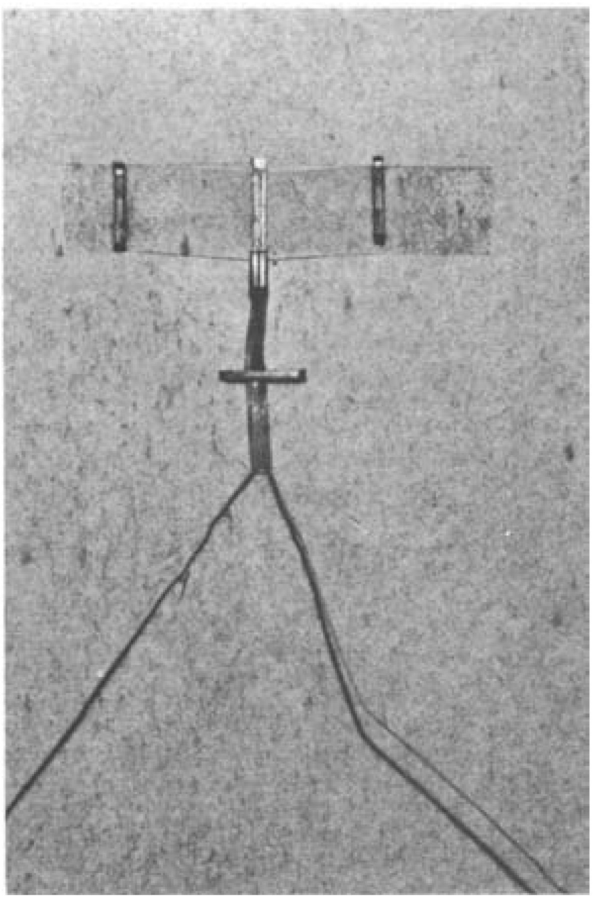

Figure 4. -- Moisture probe attached to surface of rock lath. (M 144310)

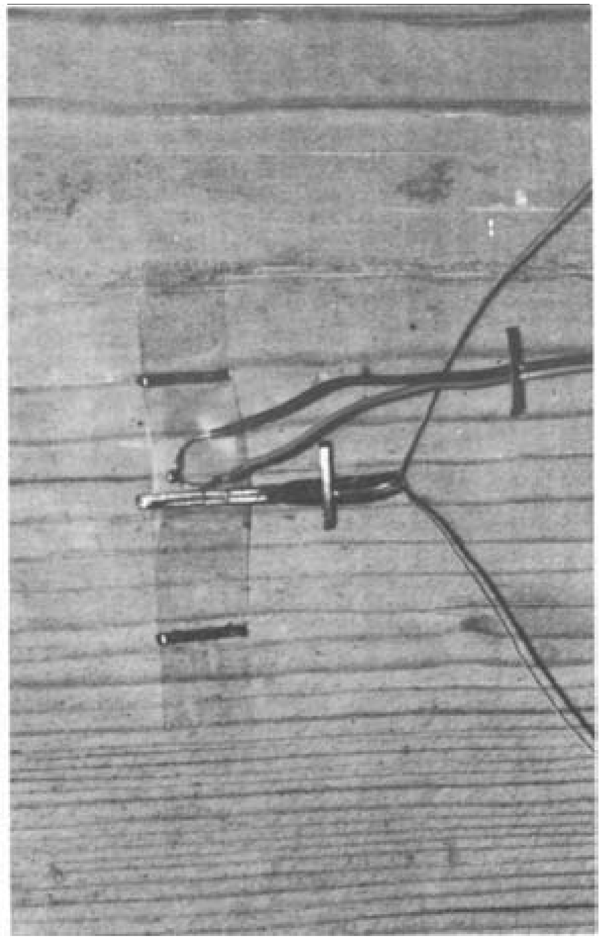

Figure 5. - - Moisture probe and thermocouple attached to interior surface of sheathing board. (M 144 309)

above 20 percent is important and is recorded in the data. The presence of free water also could increase the rate of heat loss if distributed through the insulation, and sustained free water creates a potential for paint peeling on siding.

Representative plots for walls with no remedial treatment, for each type of paint, and for both vented systems are presented in figures 7, 8, and 9. Plots shown are from north walls where condensation is most severe. A discussion of these figures is given in the sections which follow.

The MC in walls with no remedial measures (fig. 7) shows that the moisture level at the sheathing-siding interface exceeded 20 percent during most of the winter. Moisture content at the plaster-insulation interface was constant at 7 percent except near the end of the winter when there was a rise in

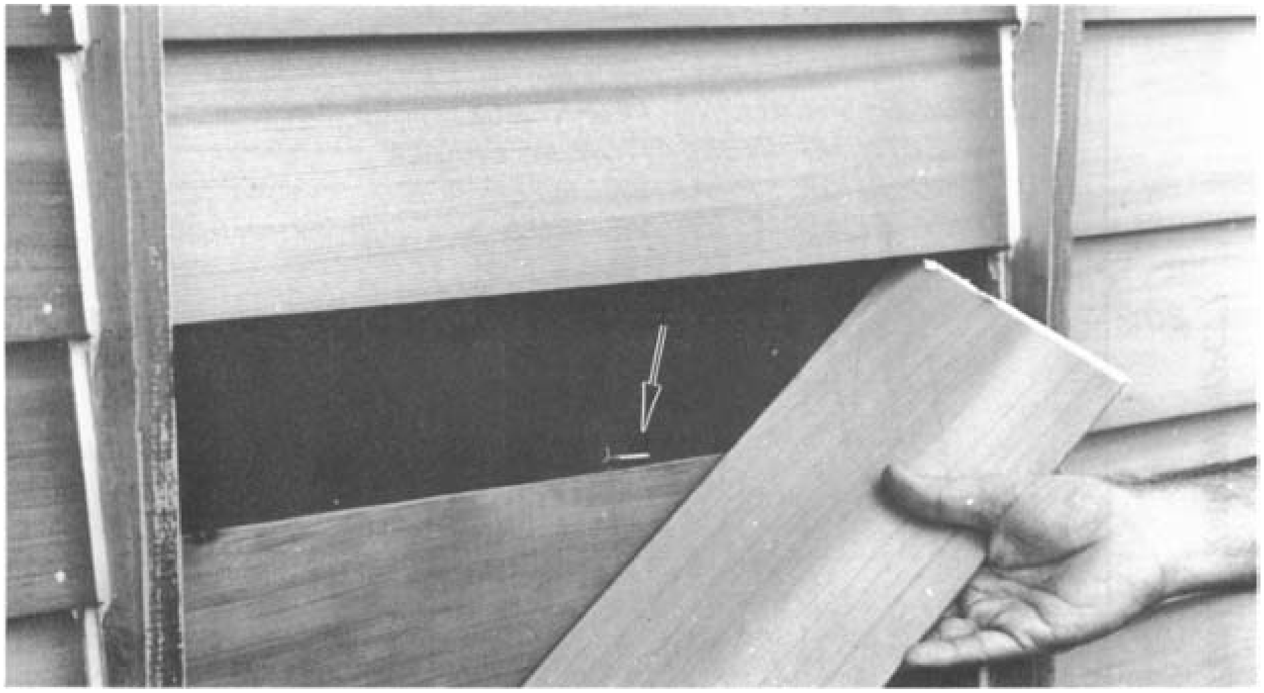

Figure 6. -- Moisture probe located immediately beneath siding
(M 142 642-9)

MC at that location. This rise coincided with a drop in MC at the siding indicating a reverse moisture drive. Throughout the season, MC at the siding-sheathing interface remained higher than in walls having paints applied for moisture-excluding effectiveness.

Walls With Paint Applied As A Remedial Measure

The MC in four wall sections – each with a different type of paint, applied in two coats to reduce permeability – is shown in figure 8. All of these walls had an MC at the siding-sheathing interface well below 20 percent during the test period with one exception. The wall section with interior semigloss acrylic latex had an MC above 20 percent for a brief period during the coldest weather.

Moisture content at the plaster was constantly at 7 percent until early spring, when it increased slightly in all sections. This was due to a reverse in the moisture drive as outside temperatures increased. The increased MC at the plaster did not occur as early in the season as it did where no remedial measures were used; the reason is that other components of the wall were at lower MC than in the wall with no remedial measures.

Vented Cavities

An earlier study of vented cavities **(5)** with vents near both the top and bottom showed the draft of cold air through the vented space resulted in high MC in the walls. This was again demonstrated in this study (fig. 9). Here the lower vent was plugged in one-half of the vented cavities to observe the effect of letting moisture escape at the top without having a draft through the entire cavity. Figure 9 shows that the MC was lower in the wall section with one vent than in the section with two vents. However, even one vent resulted in higher MC than walls with selected paints as remedial measures. One vent gave an improvement over the section with no remedial measure.

Findings

The following findings relate only to the climatic conditions of Madison, Wis. Where winters are more severe, condensation problems will be greater. For milder winters, condensation problems will be less. A 20 percent MC in the wood probes is cited as critical because beads of condensed water are generally present on surfaces; wood is

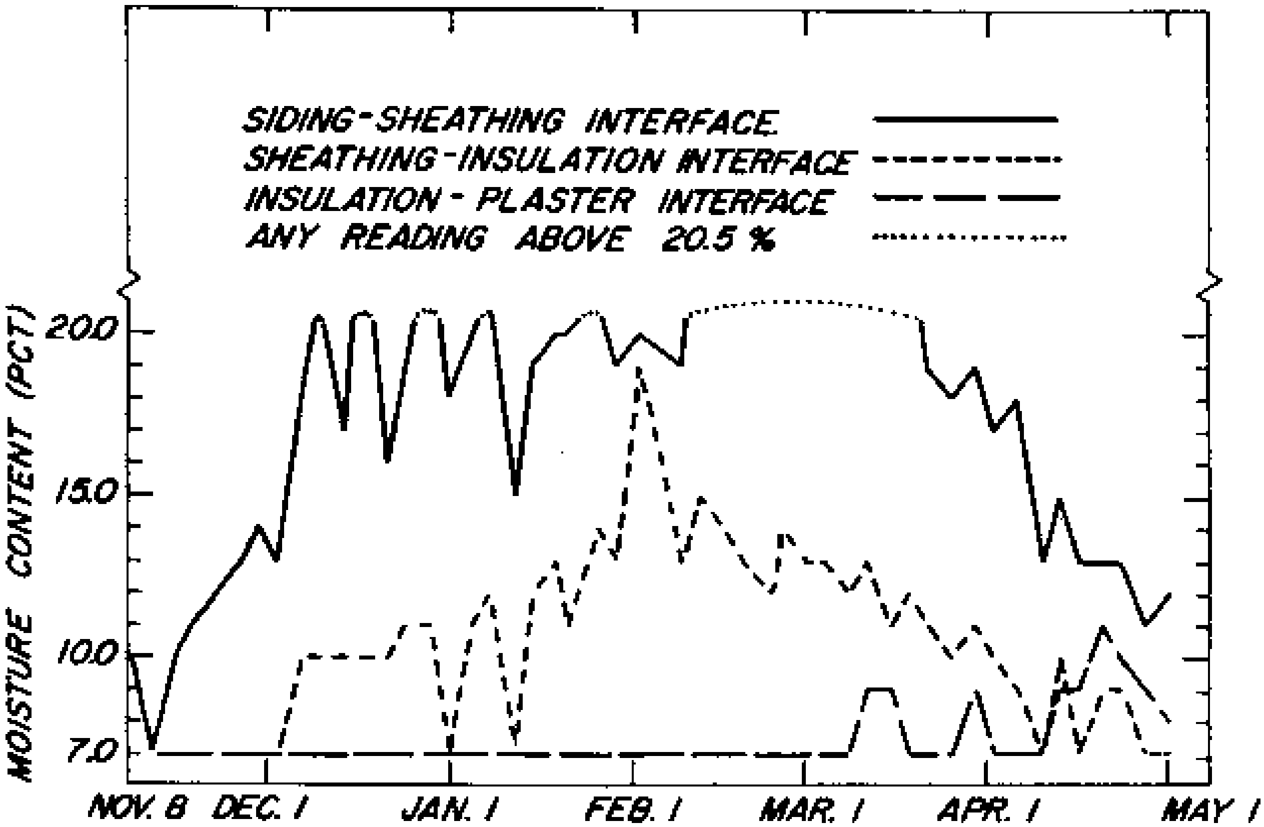

Figure 7. - - Moisture conditions through a typical wall section which incorporates no remedial measures. (M 146 537)

considered in danger of decay when such free water accumulates and temperatures are 35°F or higher, and thus the structure is in danger.

1. With one minor exception (noted earlier), two coats of interior semigloss acrylic latex, exterior acrylic latex, or exterior soya-alkyd resin generally all kept MC of walls below 20 percent through the entire winter season even though 35 percent relative humidity was maintained indoors. Moisture content was comparable to that in wall sections having aluminum paint.

2. Vents near the top of a stud only are more effective in keeping the wall cavity dry than vents at both top and bottom. However, the single vent is still not as effective as selected paints applied to the plaster in keeping wall cavities dry.

3. Wall cavities with no remedial measures did have MC above 20 percent where 35 percent relative humidity was maintained indoors.

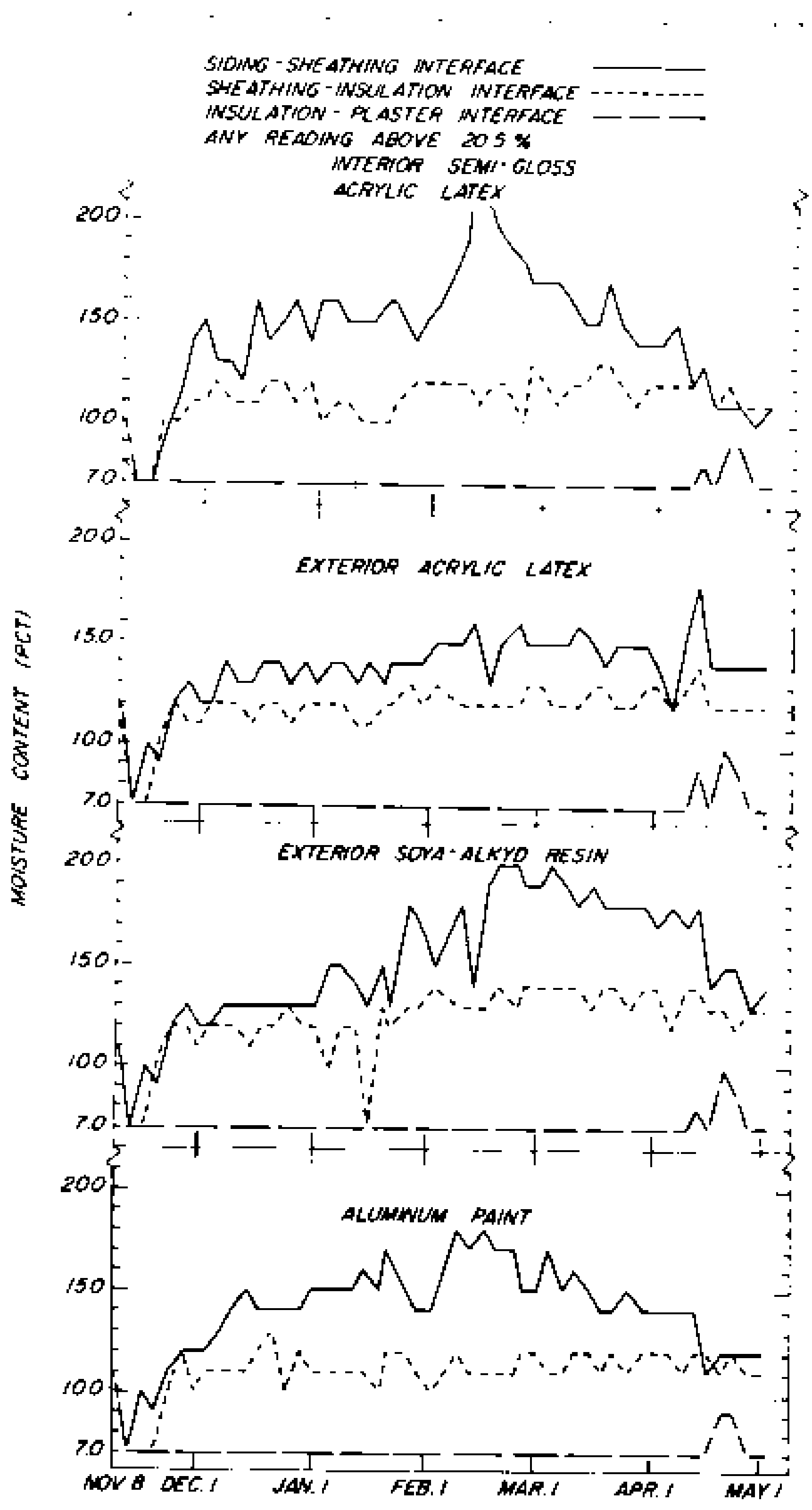

Figure 8. - - Moisture conditions through typical wall sections with paint applied to piaster for vapor resistance. (M 146 535)

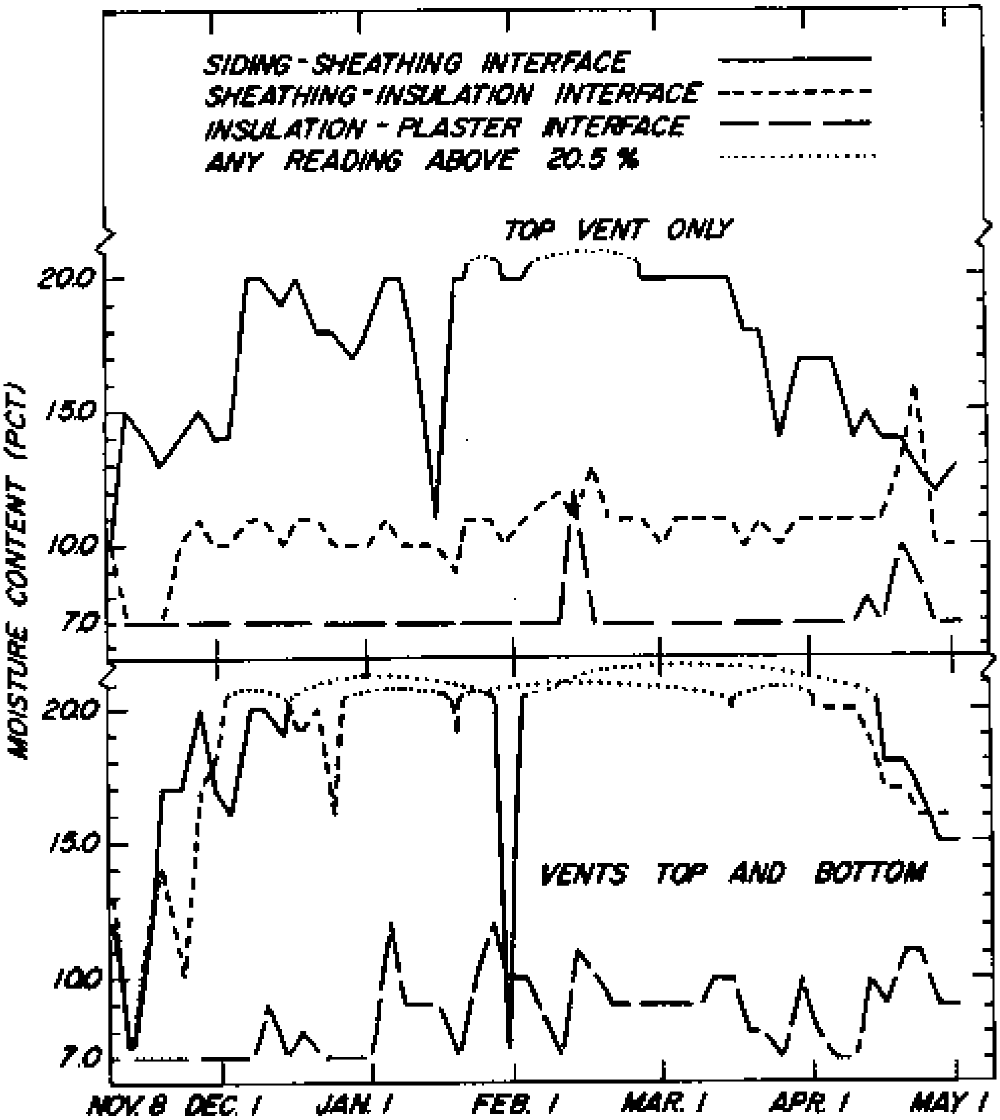

Figure 9.--Moisture conditions through typical wall sections with 1-inch diameter vents in wall (M 146 536)

Conclusions

Adding insulation to walls of an older house with no vapor. barrier subject to the climate of Madison, Wis., is likely to result in critical levels of condensation in the walls where mechanical humidification is used to maintain 35 percent relative humidity or higher.

Two coats of interior semigloss acrylic latex, exterior acrylic latex, exterior soya-alkyd resin, or aluminum paint can be effective in keeping the moisture level of wood in the wall cavity below 20 percent even where 35 percent relative humidity is maintained. A l-inch-diameter vent at the top of the wall cavity is less effective than using these paints to keep the wall dry, but more effective than using vents at both top and bottom of the wall cavity.

It would be helpful to those considering insulating walls of existing homes if commercially available paints were labeled with perm ratings.

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