EVALUATION OF WIND EFFECT ON MOISTURE CONTENT OF FRAME WALLS WITH AND WITHOUT AN AIR-INFILTRATION BARRIER

H.R. Trechsel *ASHRAE Member* **P.R. Achenbach** *ASHRAE Fellow* **H.J. Knight** **G.W. Lou** *ASHRAE Member*

ABSTRACT

Increased airtightness of buildings has been promoted for energy savings. One method for achieving greater airtightness is the installation of an air infiltration barrier on the exterior of building sheathing. Although most barrier materials promoted for this application have high water vapor permeance, it has been a concern that such installations could lead to moisture problems.

In previous tests, the effect of warm indoor air circulating vertically through wall cavities (due to stack effect) on the moisture content of the wall insulation and the sheathing was studied. In a follow-up series of tests, discussed in this paper, the effect of wind-induced air movement (transversely through the wall) on the moisture content of the wall insulation and sheathing was measured. The test specimen simulated walls with two different leakage areas, both with and without the installation of an air-infiltration barrier.

Under the test conditions, it was found that the addition of a water vapor permeable air infiltration barrier on the outdoor side of the sheathing did not increase moisture condensation and accumulation in the thermal insulation or sheathing. On the contrary, the results indicate that, again under the test conditions, the installation of an air infiltration barrier reduced the overall potential for condensation and accumulation resulting from wind effect as compared to the same constructions without air infiltration barrier.

INTRODUCTION AND TEST SETUP

Two recent field studies indicate that the installation of an air infiltration barrier reduced air infiltration and energy use of the houses tested by seven to twenty percent (Davidson and Eyre 1983; Luebs and Weimar 1984). In laborabory tests, the installation of an air infiltration barrier over sheathing with known air leaks reduced the thermal transmittance by approximately 10% to 40% depending on wind speed (Henning 1983). To investigate the effect of a water vapor permeable air infiltration barrier on the moisture content of the sheathing and insulation of frame walls, two series of tests were conducted.

A first test series was conducted to determine the effect, if any, of the installation of an air infiltration barrier consisting of polyethelene spunbonded olefin on moisture buildup due to stack effect within residential wall cavities, when openings near the top and bottom of the cavities caused warm and moist indoor air to circulate through the cavities under cold weather conditions. That series of tests was presented at the 1985 summer ASHRAE conference in Honolulu, Hawaii (Trechsel et al. 1985). A second series of tests were conducted to determine

Heinz R. Trechsel, Member ASHRAE, H. R. Trechsel Associates, Germantown, Maryland; Paul R. Achenbach, Fellow ASHRAE, Consultant, McLean, Virginia; H. Jackson Knight, E. I. DuPont de Nemours & Co., Inc., Richmond, Virginia; and Gene Lou, E. I. DuPont de Nemours & Co., Inc., Old Hickory, Tennessee

the effect of an air infiltration barrier on moisture condensation and accumulation under wind induced pressure differences. This report describes the second series of tests and discusses their results.

The earlier tests involved the construction in an environmental chamber of a full-size test wall specimen consisting of three four-foot-wide and eight-foot-high (1.2 metres wide and 2.7 metres high) panels with three stud spaces each. The three panels together have the installation of about 100 individual measurement locations for temperature and moisture, which were hooked up to a computer for programming, control, and data acquisition. Most of this installation was reused for the tests described here. The panels consisted of an interior, essentially vapor-tight plywood sheet, which had air openings as described in the next section, 2 x 4-inch (40 by 90 milimetre) studs spaced on 16-in (0.4 metre) centers, an R11 glass fiber insulation blanket, a perforated sheathing with two leakage areas and two different sidings (see Table 1, reproduced for convenience from Trechsel et al. (1985)). In the new tests, for the first three tests an air barrier was installed between the sheathing and the siding. For the final three tests, no air infiltration barrier was installed. Figure 1 shows the environmental chamber and the test wall in elevation, plan, and section.

REVISIONS TO TEST SPECIMEN

Before starting the second series of tests, it was decided to visually inspect all the thermocouples installed in the specimen. Some that had provided inconsistent or suspicious data were replaced. The air loops originally installed to provide vertical forced air movement were removed from the warm side of the test specimen. The openings where the loops connected to the plywood panels were left open, providing four holes in the center stud-space of each panel, two on top and two on the bottom, each hole with a diameter of 0.5-in (13 mm), for a total opening area of approximately 0.8 in^2 (50 mm^2) per stud space (for rationale of size of openings, see Trechsel et al. (1985)). Three additional 0.5-in (13 mm) diameter openings were drilled on the centerline of the plywood panels in each of the center stud spaces, one 2-in (50 mm) above and one 2-in (50 mm) below, respectively, the bottom and top air ports formerly connected to the air loops, and the third in the center of the panels. These openings were closed with rubber stoppers taken from vacutainers. The purpose of these openings was to allow for injecting tracer gas (center opening) and withdrawing air samples (top and bottom) for determining the direction of vertical airflow within the wall cavity. Figure 2 shows a schematic warm-side elevation of the panels.

TEST CONDITIONS

The nominal temperatures and relative humidities were 70 F (21^{o}C) and 30% RH for the warm room, and 30 F (-1^{o}C) and 70% RH in the cold room. For Tests 1 and 4 a positive air pressure of 0.1 in H_2O (25 Pa) (simulating the effect of a 15 mph (25 km/h) wind blowing against the wall) was applied to the cold side of the test wall. For Tests 3 and 6 a negative air pressure of 0.1 in H_2O (25 Pa) (simulating the effect of a 15 mph (25 km/h) wind blowing away from the wall) was applied to the cold side of the test wall. For Tests 2 and 5 no pressure was applied. Table 2 gives the nominal test conditions in tabular form. The test conditions were selected based on the results of the earlier tests (Trechsel et al. 1985) which indicated that the "warm" winter climatic conditions are more severe in terms of causing moisture accumulation within the sheathing.

The actual test conditions varied substantially from the nominal values and are given in Table 3. Averages were used because accumulation of moisture in building construction is a slow process measurable only over several days.

Additional tests were conducted at the end of the test series to determine the air leakage rate of the sheathing with and without the air infiltration barrier. These tests were conducted under nominal pressures of 0.3 and 0.1 in H_2O (75 and 25 Pa), corresponding to wind speeds of approximately 25 mph and 15 mph (40 and 25 km/h). Actual test pressures did not differ significantly.

CONDUCT OF TESTS

General

The concept of the tests was to subject the test specimen simultaneously to temperature and relative humidity differentials and, for Tests 1, 3, 4, and 6, to pressure differentials. The objective was to determine whether, and to what degree, the placement of an air infiltration barrier affects the moisture content of the sheathing and the insulation under the specified test conditions.

Moisture Measurements

The moisture accumulated within the sheathing was measured by weighing sheathing samples from the top and bottom sample ports in each panel and by three electric resistance gauges located just below the top and above the bottom ports and at the intermediate height. The moisture accumulation in the insulation was only measured by weighing samples from the top and bottom sample ports. All measurements of moisture content by weight were conducted at the start and end of each test. All measurements of moisture accumulations by electric resistance gauge were manually observed and recorded two to three times daily. The cold and warm room air relative humidities were recorded every quarter hour, averaged for every six-hour period, and again averaged for the last three of each five-day test period. Only the three-day averages are used in this report. Figure 2 shows sample port and gauge locations. Figure 3 shows details of the two typical panel sections with the location of the stations for temperature measurements and the electric resistance gauges.

Air Leakage Tests

The air infiltration tests were conducted using a portable window tester according to ASTM E 783-84.

Air Movement Within Wall Cavities

Tests were performed to determine the air movement within the wall cavities. Tracer gas (SF_6) was injected at the center of each of the three test stud spaces and samples were withdrawn at regular intervals at the top and bottom of the panels. The results suggest the direction of the airflow within the stud spaces. These tests were conducted on Panels A and B only, and only during Tests 2, 3, and 4, with the warm room side air ports open. They included panels with and without an air infiltration barrier and panels with more and with less perforations. The test conditions included both positive, negative, and no pressure differentials.

Temperatures

Air temperature was measured in the cold room at an intermediate height. Surface and mid-insulation temperatures were measured near the top, bottom, and middle of each test stud space and near the top of one adjacent ("dead") stud space in each panel. The warm room temperature was measured top and bottom. The location of the thermocouples are shown on Figures 2 and 3.

The individual surface temperatures at each location were measured on both sides of the sheathing and on both sides of the interior plywood sheet. Surface and mid-insultation temperature measuring stations are shown on Figure 3 as Stations 1 through 5.

All temperatures were recorded every quarter hour and averaged for every six-hour period and again for the last three days of each five-day test periods. Only the three-day averages are used in this paper.

TEST RESULTS

Moisture Content

Table 3 also provides a summary of the actual test conditions and the corresponding increase in moisture content of the sheathing and insulation, as measured by weighing of samples from the top and bottom sample ports. Air temperatures and relative humidities of the air in the warm and cold rooms are averages of the last three days of the five-day test periods.

As can be seen from Table 3, in a few instances the moisture content of the sheathing and insulation decreased during the tests. To investigate this further, Table 4 was prepared, which gives the increase in moisture content of the sheathing as measured by electric resistance gauge. As can be seen, the values obtained by the gauges differ substantially from those obtained by weight. Not only are the absolute values for moisture content increase substantially lower when measured by gauge, but in 29 out of 72 cases (or 40%) the moisture content appeared to decrease, while for the results by weight only 2 out of 36 (or 6.25%) showed such a decrease. This discrepancy may be related to the physical parameters involved in the electric resistance measurements.

Air Leakage Tests

The results of the air leakage tests are given on Table 5. It will be noted that the installation of the air barrier reduced the air leakage rate by a factor of a little less than four (Panel B) to over six (Panel A). Panel A without an air barrier had a leakage rate of 41 cfm (0.019m^3/s and 20 cfm (0.009 m^3/s) under 0.3 and 0.1 in H_2O (75 Pa and 25 Pa) respectively, and with an air barrier, a rate of 6.2 cfm and 3.1 cfm (0.003 m^3/s and 0.0015 M^3/s). Panels B and C without air barrier had a rate of approximately 47 cfm and 28 cfm (0.022 m^3/s and 0.013 m^3/s) under about 0.25 in and 0.1 in H_2O (62 Pa and 25 Pa) and with air barrier a rate of approximately 11 cfm and 6 cfm (0.005 m^3/s and 0.003 m^3/s).

Air Movement Within Wall Cavities

The vertical movement of air within cavities in a wall subjected to wind pressures and having openings into one side of the wall has not been studied extensively and was investigated as an adjunct to the moisture tests. The results of the tests indicate that, for the injection and sampling methods used, air moves both up and down within the wall cavity, but that the down movement predominates.

Regardless of which Panel (A or B), whether or not a pressure was applied, or whether the panels had or had not an air barrier installed, the results were similar in that a broad peak of tracer concentration was observed after about two and one half minutes at the bottom, and a similar, but less well defined, peak was observed after about four to five and one half minutes at the top of the panel.

Temperature Profiles

Table 6 gives the average temperatures averaged for the last three test days for the cold room, exterior surface of sheathing, interior surface of sheathing, mid-insulation, surface of interior plywood finish facing the stud space, surface of interior finish facing the warm room, and the warm room. Only the top and bottom gauge locations are shown.

DISCUSSION

Moisture Levels

When measured by weight (see Table 3), the moisture content of the sheathing increased on the average during all the six tests discussed here. The moisture content of the sheathing at the top of the panel in the tests without an air barrier (Tests 4, 5, and 6) increased, on the average, about twice as much as the moisture content in the sheathing in the tests with an air barrier (Tests 1, 2, and 3). At the bottom of the panel, the average moisture increase was less. However, in the top location of Panels A and C, the moisture content of the bottom sheathing sample decreased slightly during Test 6 (no barrier). Both positive and negative wind pressures showed a greater moisture increase in the sheathing than the condition without any wind pressure.

Looking at Table 7 and the Dew Point Temperature relationship developed from it, the sheathing was below the D.P. temperature of indoor air most of the time in Test 3 and should have accumulated moisture. Moisture may also have accumulated in or on the siding. Then in Test 4 the cold, dry outdoor (D.P. 25) air under positive pressure probably moved the moisture inward from siding to sheathing, but did not actually dry it out during the one-week test thus accounting for the higher moisture content in Test 4 than in Test 5. This is speculative, but possible. The absolute initial moisture contents at the beginning of each test is of some significance with respect to the ensuing change. The air leakage was localized on the warm side and diffused in the cold side. With negative pressure the warm room air entered the insulation space as a jet and was gradually spread out over the sheathing leakage holes to the air barrier. With positive pressure the cold dry air entered the insulation space in small jets spread out over the entire stud space to gradually converge to the holes top and bottom in the warm side. These transverse flow patterns could have affected the measured air leakage and the distribution of moisture in the sheathing. The D.P. of the indoor air was below the sheathing temperature, top and bottom, during all tests except Test 3 so little or no change caused by convection in moisture content would be expected, in Tests 1, 2, 4, 5, and 6.

When measured by electric resistance gauge (see last 2 lines in Table 4), the all panel average moisture content of the sheathing at the top and mid-height locations decreased over the duration of Tests 1, 2, and 3 (with an air infiltration barrier) but increased slightly (by 0.06%) at the bottom location during the same tests. During Tests 4, 5, and 6 (without the air barrier) the moisture content increased on the average for all gauge locations.

Based on the above, it could be inferred that the installation of a water vapor permeable air infiltration barrier reduces the potential for moisture condensation and accumulation in sheathing materials. This result would be consistent with the results of the earlier tests reported by Trechsel et al. (1985). However, it should be noted that the increases of moisture content observed were relatively small and not totally consistent, with individual values for panels with the air barrier ranging from a decrease of 2.1% to an increase of 5.25% and for panels without the barrier from a decrease of 1.25% to an increase of 5.5%.

The changes in moisture content in the insulation varied from a decrease of 0.5% to an increase of 0.8%. In the average, the increases were within 0.1% or less. These changes are probably within the experimental error.

As a general observation, it is noted that for some tests and some locations the percentage changes are quite small. The reasons for this are probably the selected test conditions. The selected conditions were found to be rather severe for the earlier tests reported in Trechsel et al. (1985); for the tests reported in this paper, both the temperatures and the relative humidities in the warm and cold rooms may not have been the most useful for the tests. It should be kept in mind that the conditions simulated in these tests (wind/no wind) would be transient in actual service and would thus be expected to affect the moisture content less than the condition of stack effect (vertical air movement) simulated in the earlier tests, which in real buildings is of longer duration.

Air Leakage

As was noted above, the installation of the air barrier reduced the air leakage rate by factors of a little less than four in Panels B and C and over six in Panel A.

Considering the fact that Panel A had an approximately eight times lesser installed leakage area (number of perforations) than Panels B and C, the small differences in air infiltration rates between Panel A on the one hand, and Panels B and C on the other (see Table 7) are unexpected and unexplained. Possible causes might be:

- o The leakage area of 0.78 in^2 on the warm side was the principal restriction to air flow for panels B and C.
- o The exterior sheathing may have covered entire rows of holes in Panels B and C.

- Panels B and C may have had substantial additional leakage paths.
- The fiberglass insulation plugged some of the holes in Panels B and C (though why a similar proportion of holes would not have been plugged in Panel A is unclear).
- Although all holes had been de-burred, those in Panel A (with fewer holes) may have been de-burred more effectively.

Air Movement Within Wall Cavities

The predominant downward air movement within the wall cavities having openings top and bottom on the warm side validated the choice made in the earlier tests reported in Trechsel et al. (1985), where the forced air movement through the wall cavities was also set from top to bottom. The "natural" air velocity was about 1.4 feet per minute (0.007 metre per second), corresponding to about 0.5 cfm (2.4×10^{-4} m^3/s), or to one-half of the nominal induced flow rate per stud space in the earlier tests.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of tests described in this report and on those reported earlier, the installation of an air infiltration barrier outside of the sheathing did not increase the condensation and accumulation of moisture within the sheathing or insulation under the test conditions. On the contrary, the results suggest that the installation of an air infiltration barrier may reduce the overall potential for such moisture condensation and accumulation.

However, while the results obtained to date are encouraging, they were obtained solely on the basis of laboratory tests. Particularly, in the tests described in this report, test conditions were applied that may or may not be typical of different critical climatic conditions in this country: cold and dry, cold and humid, warm and humid. Specifically, the tests only simulated cold climate winter conditions. Warm weather summer conditions in air conditioned buildings were not included in the tests. Thus, care should be used in extrapolating the test results to any specific climatic region until field validation studies can be completed.

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TABLE 1
Panel Specifications

Panel	Sheating Perforations	Effective Leakage Area per Stud Space	Air Infiltration Barrier	Siding
A1	3/32 in. holes, 5 and 6 in. o.c.	0.3 in^2	Yes	Aluminum
B1	3/32 in. holes, 2 in. o.c.	2.3 in^2	Yes	Aluminum
C1	3/32 in. holes, 2 in. o.c.	2.3 in^2	Yes	Wood
A2	3/32 in. holes, 5 and 6 in. o.c.	NA	None	Aluminum
B2	3/32 in. holes, 2 in. o.c.	NA	None	Aluminum
C2	3/32 in. holes, 2 in. o.c.	NA	None	Wood

All panels framed with painted 2" x 4" studs, 16 inch on center, 2" x 4" sill plate and header, warm side (interior) face of 1/2 inch painted Marine grade plywood, 1/2 inch unpainted softwood sheathing, tongue and groove jointed. Wood siding pre-painted, lap joints not caulked or otherwise sealed. All siding fasteners at studs only. Between tests 3 and 4, the siding was removed, an air infiltration barrier installed over all three panels, and the siding reinstalled.

The air infiltration barrier used in the tests was a sheet of ultra-fine fibers made from high density polyethelene with a thickness of 0.006 in. and a water vapor premeance of 94 perms.

Multiply in by 25 to obtain mm.

TABLE 2
Nominal Test Conditions

	With Air Barrier			Without Air Barrier		
	Test #1	Test #2	Test #3	Test #4	Test #5	Test #6
Warm Room Air						
Temperature F	70	70	70	70	70	70
Relative Humidity %	30	30	30	30	30	30
Cold Room Air						
Temperature F	30	30	30	30	30	30
Relative Humidity %	70	70	70	70	70	70
Wind Load in H_2O	+0.1	0	-0.1	+0.1	0	-0.1

NOTES: Positive Wind load indicates higher pressure in cold room, simulating wind blowing against the outdoor face of the wall.

Negative Wind load indicates higher pressure in the warm room, simulating wind blowing away from the outdoor face of the wall.

0.1 in H_2O Wind Pressure is approximate pressure exerted by a 15 mph wind.

Multiply 0.55 by (F-32) to obtain ^oC
Multiply in H_2O by 250 to obtain Pa

TABLE 3
Actual Test Conditions and Summary Results

Panel	Air Infiltation Barrier	Test No.	Pressure in H_2O	Cold Room Temp. F	Cold Room Rel. Hum. %	Warm Room Temp. F	Warm Room Rel. Hum. %	Increase in Moisture Content (%) Sheathing Top	Sheathing Bottom	Insulation Top	Insulation Bottom
A	Yes	1	+0.1	33.1	75.6	68.1	26.7	+1.1	+0.6	+0.2	+0.1
	Yes	2	0.0	32.1	63.6	68.2	23.7	+0.4	+0.4	+0.3	+0.1
	Yes	3	-0.1	38.1	86.3	77.2	37.9	+2.2	+3.7	0.0	0.0
	No	4	+0.1	32.6	83.8	67.8	24.0	+5.1	+4.9	0.0	+0.1
	No	5	0.0	30.0	59.7	67.4	23.2	+0.7	+1.0	-0.1	-0.1
	No	6	-0.1	35.2	73.5	68.6	31.0	-0.1	+1.2	+0.6	+0.8
B	Yes	1	+0.1	33.1	75.6	68.1	26.7	+0.9	+1.0	0.0	0.0
	Yes	2	0.0	32.1	63.6	68.2	23.7	+0.4	+0.7	+0.2	0.0
	Yes	3	-0.1	38.1	86.3	77.2	37.9	+1.3	+7.3	0.0	+0.1
	No	4	+0.1	32.6	83.8	67.8	24.0	+5.5	+4.9	+0.3	+0.2
	No	5	0.0	30.0	59.7	67.4	23.2	+0.9	+1.1	-0.1	-0.3
	No	6	-0.1	35.2	73.5	68.6	31.0	+1.0	+0.9	+0.4	+0.6
C	Yes	1	+0.1	33.1	75.6	68.1	26.7	+0.5	+0.3	-0.1	-0.3
	Yes	2	0.0	32.1	63.6	68.2	23.7	+0.5	+0.3	+0.1	0.0
	Yes	3	-0.0	38.1	86.3	77.2	37.9	+0.9	+3.2	-0.1	0.0
	No	4	+0.1	32.6	83.8	67.8	24.0	+4.0	+4.2	-0.1	0.0
	No	5	0.0	30.0	59.7	67.4	23.2	+0.7	+0.9	0.0	-0.5
	No	6	-0.1	35.2	73.5	68.6	31.0	-0.2	+0.6	+0.2	0.0
All panels averages	Yes	1-3	-0.1 to +0.1	34.4	75.2	71.2	29.4	+0.9	+1.9	+0.1	0.0
	No	4-6	-0.1 to +0.1	32.6	72.3	67.9	26.1	+2.0	+2.2	+0.1	0.1

Notes: Cold and warm room temperatures and relative humidities are averages for the last three days of the five-day test period. Moisture content of sheathing and insulation as determined by weight of material samples.

Multiply in H_2O by 250 to obtain Pa

Multiply 0.55 by (^{o}F-32) to obtain ^{o}C

TABLE 4
Moisture Content of Sheathing Measured By Electric Resistance Gauge

Panel	Air Infiltration Barrier	Test No.	Increase of Moisture In Percent Top	Middle	Bottom	Dead* Space
A	YES	1	-2.0	-2.1	-1.75	-1.25
	YES	2	±0	-1.5	-2.25	-1.25
	YES	3	+1.25	-0.25	+3.0	+0.5
	NO	4	+0.75	+0.5	-0.25	+0.25
	NO	5	±0.0	-0.25	±0.0	-0.5
	NO	6	+1.0	+1.75	+3.75	+0.75
B	YES	1	-1.75	-2.5	-1.75	-1.25
	YES	2	-1.5	-1.25	-1.25	-1.25
	YES	3	+2.25	+1.25	+5.25	+1.25
	NO	4	+2.5	+0.5	+2.0	+0.25
	NO	5	±0.0	-1.25	±0.0	±0.0
	NO	6	-0.25	+0.5	+5.5	+1.5
C	YES	1	-1.25	-1.5	-1.5	-1.25
	YES	2	-0.75	-1.0	-1.25	-1.0
	YES	3	+1.5	+1.75	+2.0	+2.25
	NO	4	±0.0	+1.25	+0.5	+0.75
	NO	5	+0.25	±0.0	-0.25	-0.25
	NO	6	+0.75	+1.25	+1.0	+1.25
ALL PANEL AVERAGES	YES	1-3	-0.25	-0.79	+0.06	-0.36
	NO	4-6	+0.56	+0.47	+1.36	+0.44

* Dead Space refers to stud space adjacent to the one with openings on the warm room side. This space is effectively sealed from the warm room against both air leakage and moisture diffusion.

TABLE 5
Air Leakage Rates

Panel A / without Air Barrier	Total Leakage (CFM) Per Stud Space
@ .300 in H_2O (25 mph)	41 cfm
@ .108 in H_2O (15 mph)	20 cfm
Panel A / with Air Barrier	
@ .300 in H_2O (25 mph)	6.2 cfm
@ .108 in H_2O (15 mph)	3.1 cfm
Panel B / without Air Barrier	
@ .240 in H_2O (22 mph)	47 cfm
@ .108 in H_2O (15 mph)	29 cfm
Panel B / with Air Barrier	
@ .300 in H_2O (25 mph)	12.0 cfm
@ .108 in H_2O (15 mph)	6.2 cfm
Panel C / without Air Barrier	
@ .250 in H_2O (23 mph)	46 cfm
@ .108 in H_2O (15 mph)	27 cfm
Panel C / with Air Barrier	
@ .300 in H_2O (25 mph)	10.1 cfm
@ .108 in H_2O (15 mph)	5.2 cfm

Multiply in H_2O by 250 to obtain Pa

Multiply cfm by 4.72×10^{-4} to obtain m^3/s

TABLE 6
Three-Day Average of Temperatures in F

Test	Panel	Location	Stations CR.	1	2	3	4	5	WR.
1	A	Top	33.1	35.5	36.9	50.7	64.7	66.3	70.4
		Bottom	33.1	34.2	36.5	48.8	63.2	NA	65.8
	B	Top	33.1	35.5	36.8	50.7	64.8	66.5	70.4
		Bottom	33.1	33.3	35.4	45.7	63.2	63.9	65.8
	C	Top	33.1	37.6	39.6	55.9	65.8	67.1	70.4
		Bottom	33.1	37.0	38.9	63.5	66.1	NA	65.8
2	A	Top	32.1	36.0	37.5	50.9	63.9	65.3	70.4
		Bottom	32.1	35.0	37.3	49.9	63.7	NA	65.9
	B	Top	32.1	36.2	37.6	51.5	64.9	66.6	70.4
		Bottom	32.1	34.2	36.2	47.8	63.5	64.2	65.9
	C	Top	32.1	37.9	40.2	56.0	65.8	67.0	70.4
		Bottom	32.1	37.3	39.3	54.1	63.5	66.1	65.9
3	A	Top	38.1	47.7	49.5	63.1	74.8	67.3	78.9
		Bottom	38.1	44.1	47.4	61.8	74.4	NA	75.6
	B	Top	38.1	48.7	50.9	63.9	75.2	76.5	78.9
		Bottom	38.1	44.9	48.6	65.5	75.3	75.8	75.6
	C	Top	38.1	47.3	51.0	65.6	74.9	76.1	78.9
		Bottom	38.1	46.9	49.8	73.3	75.5	NA	75.6
4	A	Top	32.6	34.4	36.0	50.2	64.5	66.1	70.5
		Bottom	32.6	33.4	35.9	48.6	63.0	64.6	65.0
	B	Top	32.6	33.4	34.4	46.3	62.5	65.9	70.5
		Bottom	32.6	32.9	34.4	40.5	61.4	62.8	65.0
	C	Top	32.6	36.2	37.8	54.8	64.8	66.3	70.5
		Bottom	32.6	34.9	36.1	61.1	65.5	NA	65.0
5	A	Top	30.0	34.5	35.8	49.7	64.1	65.8	70.4
		Bottom	30.0	32.3	34.5	47.4	62.3	64.0	64.4
	B	Top	30.0	33.3	34.1	46.3	62.5	65.2	70.4
		Bottom	30.0	31.4	33.0	38.9	61.0	62.4	64.4
	C	Top	30.0	35.3	37.1	54.4	64.9	66.3	70.4
		Bottom	30.0	33.4	34.8	61.4	NA	NA	64.4
6	A	Top	35.2	48.3	50.0	61.3	68.0	68.9	70.7
		Bottom	35.2	30.6*	34.0*	49.6	64.1	65.9	66.4
	B	Top	35.2	46.5	49.7	60.6	68.6	69.2	70.7
		Bottom	35.2	35.1*	40.8	57.2	67.2	66.3	66.4
	C	Top	35.2	44.5	47.6	60.0	68.2	69.0	70.7
		Bottom	35.2	40.7	45.0	66.2*	NA	NA	66.4

* Inconsistent data, not used in preparation of Table 7

Multiply 0.55 by (F-32) to obtain ^{o}C

TABLE 7
Indoor Air Dew Point and Sheathing Temperatures in F
(Based on Tables 3 and 4)

	Dew Point	Sheathing Temperatures	
	Indoor Air	Inside	Outside
Test 1	32	35.4 - 39.6	33.3 - 37.6
Test 2	30	36.2 - 40.2	34.2 - 37.9
Test 3	50	47.4 - 51.0	44.1 - 48.7
Test 4	30	34.4 - 37.8	32.9 - 36.2
Test 5	29	33.0 - 37.1	31.4 - 35.3
Test 6	38	40.8 - 49.7	44.5 - 46.5

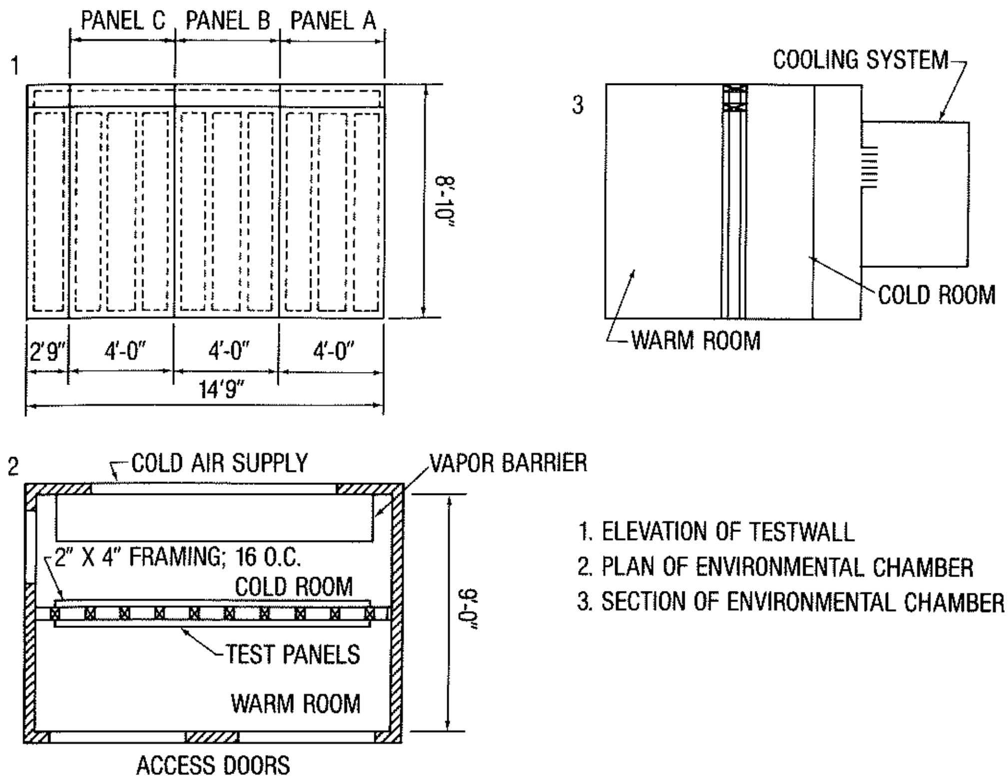

Figure 1. Environmental chamber and test walls

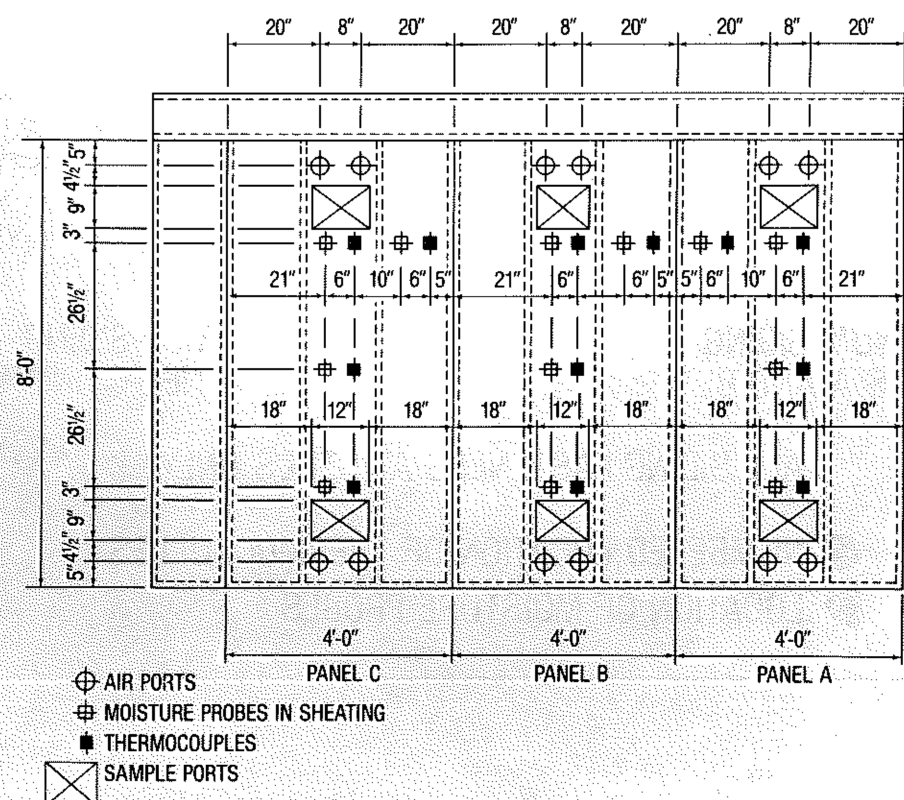

Figure 2. Warm side elevation of test wall with location of ports and gauges

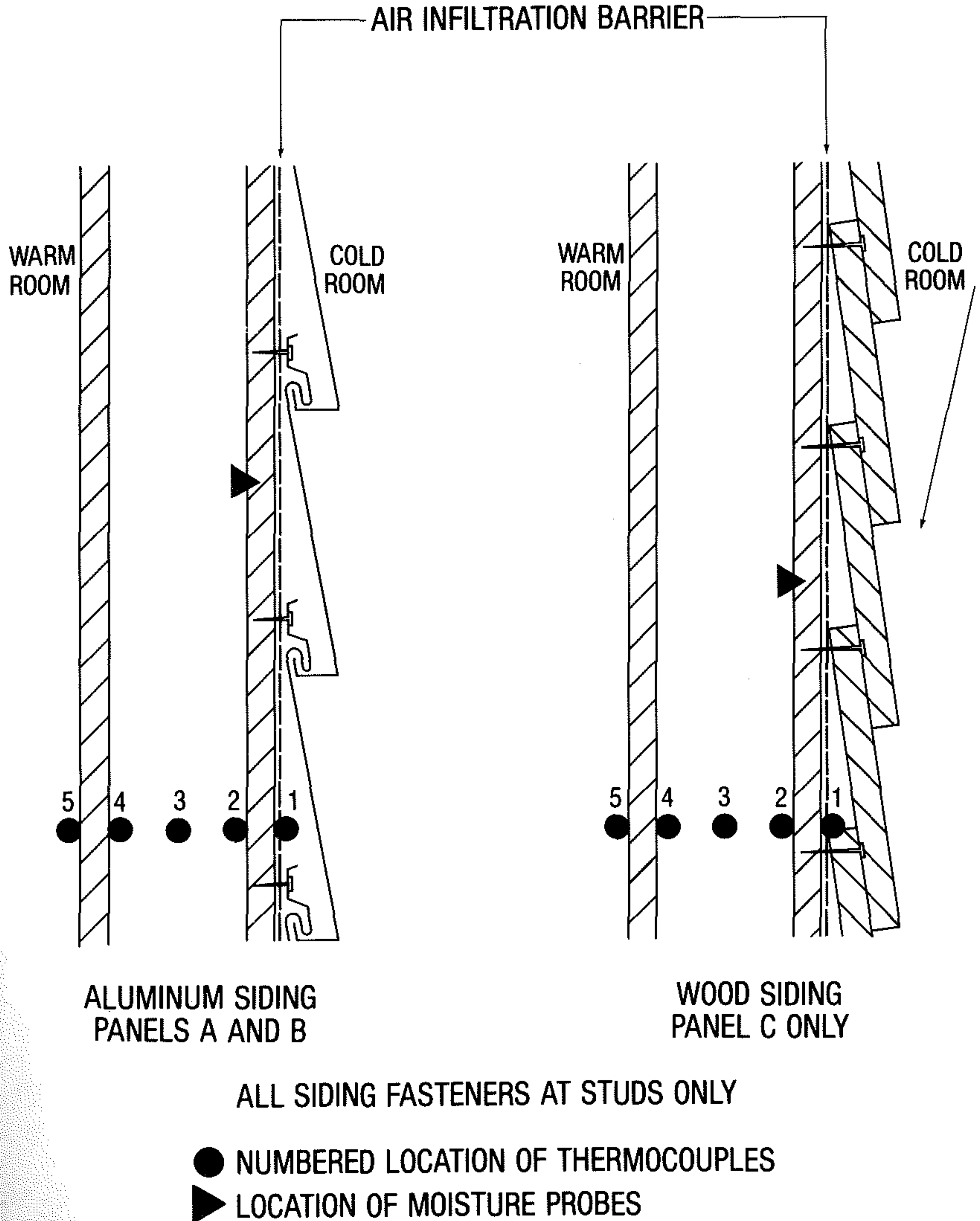

Figure 3. Section of test panels showing location of moisture probe and thermocouples