RESEARCH HIGHLIGHT

Technical Series 01-105

Case Study on Basement Renovations

INTRODUCTION

The objective of the study is to identify the measures required to reduce humidity in basements of homes with excessive moisture levels, to remediate the basements, and to measure the results of these changes.

RESEARCH PROGRAM

CMHC hired Consortium Airmax/Dallaire et associés to perform the work in October 1998.

More than forty (40) homeowners applied after reading about this study that was advertised in various newspapers. They were then required to answer a questionnaire over the phone, and 15 of the 40 were selected for an initial assessment visit.Twelve homes were then chosen. Finally, work was recommended and performed in ten homes, which were selected to be representative of the best cases—a history of humidity problems, health problems, etc.

Follow-up (on-site) visits were made from April 1999 to May 2000. Most of the remedial work was done in the spring and summer of 1999. Some was completed in the spring of 2000.

FINDINGS

Some of the characteristics of the homes visited appear in the Table 1. The main work done and the findings are indicated for each house. The wood moisture content is the average of the moisture contents in the framing of the exterior basement walls.

On the whole, the corrective measures taken reduced basement wood humidity 1.3% from 10.5% to 9.2%. Given that the humidity of very dry wood cannot be under 6%, this decrease represents a 30% reduction of the potential humidity.

Analysis and Comments

1. The graphs on the following pages show:

   - The relationship between the relative humidity on the ground floor and that of the basement has been relatively constant.

   - The temperature of the basement is lower than that of the ground floor.

   - The spreads between the various wood humidity levels for each home tend to decline over time. For example, in the spring of 1999, wood humidity averages of between 8.1% and 14.8% (a 6.7% variance) were recorded, whereas in the spring of 2000, these averages were between 7.4% and 11.6% (a 4.2% variance). Various corrective measures were taken to bring the humidity levels down, and the wood humidity measurements were more uniform as a result.

2. Of all the corrective actions taken, the replacement of drainage tiles (which includes the waterproofing of the foundation walls) and the installation of a heat recovery ventilator (HRV) had the greatest effect. The repercussions of these measures on the wood humidity levels in the homes concerned appear in the following table. (Readers must, however, take into consideration the small sample size.)

3. Humidity readings in the wood joists of the basement ceiling did not change from one season to the next and from one house to the next. In general, the readings were between 6% or 7%.

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Table 1 Summary of Homes Visited

	HOUSES VISITED (number)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Basic data										
Year built	1954	1977	1966	1969	1972	1959	1959	1978	1966	1976
Finished basement (% finished)	100	80	100	0	85	80	80	20	v. s.	70
Air exchange rate per hour (measured by a blower door at 50 Pascals)	4.96	2.12	2.66	2.42	4.30	3.69	3.87	2.74	4.89	2.51
Number of occupants	2	4	2	2+1	2+2	2	2	2+1	2	2+4
Wood humidity - average (before work)	10.8	15.3	15	8.3	10.7	11.2	11.8	13.6	12.3	10
Wood humidity - average (follow-up no.1)	8.4	11.9	14.8	8.1	9.4	10.4	9.5	12.5	10.2	9.9
Wood humidity - average (follow-up no. 5)	8.6	9.3	11.6	8.2	8	8.2	8.7	11.2	7.4	10.6
Percentage of improvement obtained compared to an objective of 6% humidity (follow-up no. 1 (May 1999) vs follow-up no. 5 (May 2000)	**-8.3**	**44.1**	**36.4**	**-4.8**	**41.2**	**50.0**	**22.9**	**20.5**	**66.7**	**-17.9**
	Average 29.6%									
Main corrective action taken during visits:										
Seal cracks	✓♦	✓♦	✓		✓♦	✓♦				
Correct the slope around the house	✓♦	✓♦	✓♦	✓♦		✓	✓♦	✓	✓♦	
Replace the drainage tile	♦	♦					♦			
Add an HRV	♦	✓♦	✓♦	✓		♦		✓		
Add air returns to the central heating system	✓♦			✓♦	✓			✓♦		

✓♦ Corrective action **suggested** and **acted on**

✓ Corrective action **suggested** and **not acted on**

♦ Corrective action **not suggested** but **work done**

Table 2

Measures	**Homes**	**Average wood humidity (%)**					
		winter 98-99	winter 99-00	variance	spring 99	spring 00	variance
Replacement of the drainage tile	1, 2 and 7	12.6%	8.5%	4.1%	9.9%	8.9%	1.0%
Addition of an HRV	1, 2, 3 and 6	13.1%	9.1%	4.0%	11.4%	9.4%	2.0%
Replacement of the drainage tile and the addition of an HRV	1 and 2	13.0%	8.8%	4.2%	10.2%	9.0%	1.2%
The most significant decreases were recorded in the winter as opposed to the spring.							

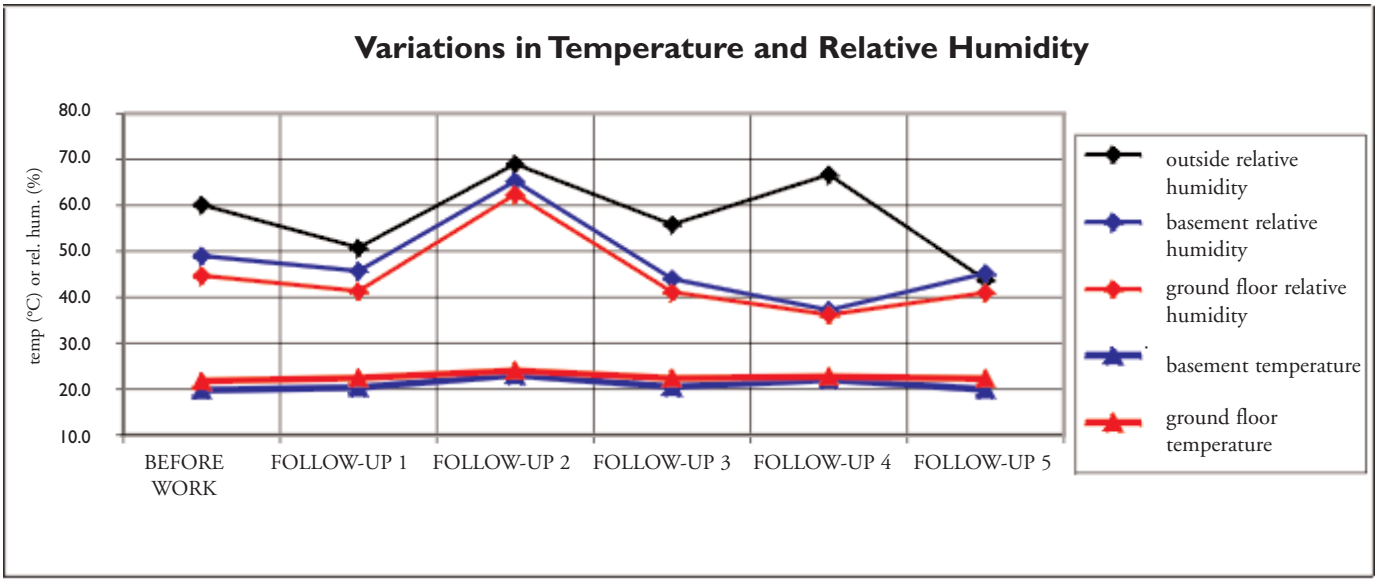
IMPLICATIONS FOR THE HOUSING INDUSTRY

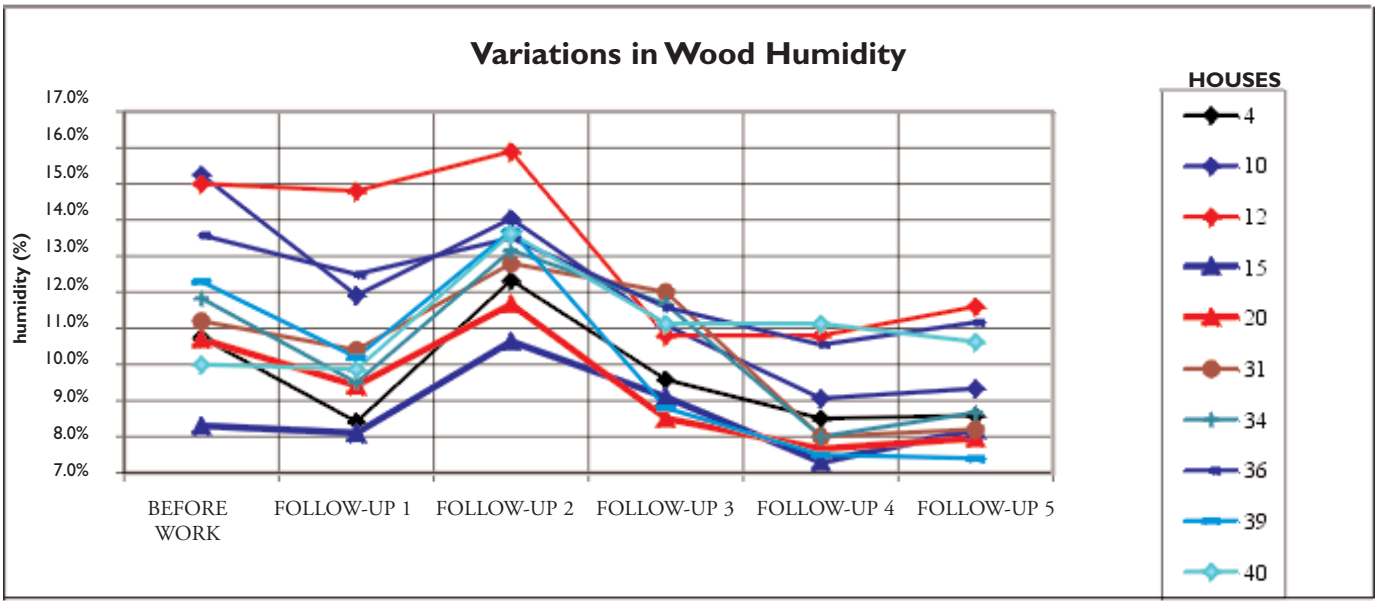
The findings would have been better if homeowners had been able to perform all the work that had been suggested. Although they all agreed with the proposed measures, some were unable to do all the work because of budget considerations. Conversely, some homeowners did more work than what was suggested, which contributed to the positive findings.

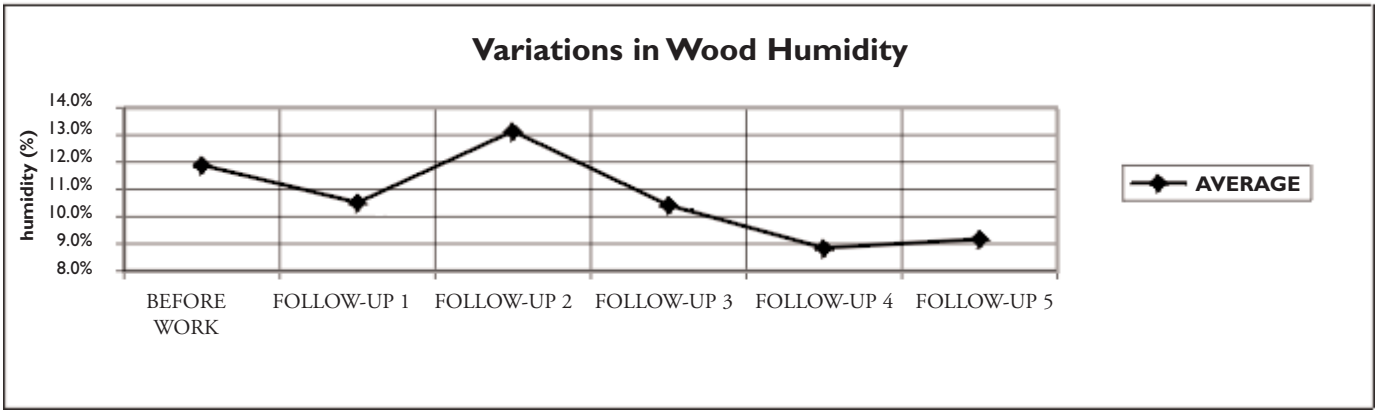
In general, the owners of heat recovery ventilators (HRVs) are not very familiar with the controls. Some make little use of them in the winter out of concern for costs and comfort.The numerous HRV control modes make it difficult to operate the device.

On the whole, the owners claim to be satisfied with the findings and appreciated the technical support provided during the study.

Observations (measurements) for all of the homes analyzed







Analysis and Comments – House no. 1

Problem:

The owner of house no. 1 signed up for the program after water had seeped into his basement. A few months previously, he had already started work to correct certain identified problems during this study. Eavestroughing was installed on two roof slopes, as there had been none.

Excavation to repair the cracks

Solution:

The occupants undertook all the recommended work. When the excavation was being done to repair the cracks in the foundation walls, the homeowner had someone check out the drainage tile. Some sections of the drain were missing, and others were plugged. Work to replace the drain was started, and an HRV was also installed. In the winter of 1999-2000, the occupants did not turn it on very often (about 2 or 3 hours a week).

Findings:

Wood humidity declined 1.2% between December 1998 and November 1999 based on the comparative findings. When we made our first follow-up visit, the humidity levels of the various reading points averaged out to 8.4% (April 1999). During our April 2000 visit, the average was 8.6% (both of these humidity averages are rather low).

Comments:

Given the rather infrequent use of the HRV, the decreased wood humidity can be largely attributed to the work done around the walls of the house—the replacement of the drainage tile, the waterproofing and sealing of cracks.

Analysis and Comments – House no. 2

Problem:

The owner of house no. 2 signed up for the program after encountering humidity problems in the basement. The sump pump and drainage network installed under the floor when the house was built many years ago were not performing satisfactorily. The house is located in a well-kept residential area.

The neighborhood is known to have several springs (indicating high groundwater levels).

Cracks before work done

Solution:

The homeowner did all the work we suggested during our inspection visit. Moreover, given the rot beneath the floor and the poor condition of the outside drain, he decided to undertake major work. Since he wanted to keep his home and not sell, he went ahead and changed the interior sump and the exterior drain, which enabled him to correct the other deficiencies regarding the slope of the soil. He also brought in an HRV.

Findings:

Readings during the first follow-up visit found that wood humidity for the various reading points averaged out to 11.9% on April 16, 1999. During the visit in May 2000, this average dropped 2.6% to 9.3%.

The highest readings in the structural wood members in the basement before the work was done were 30% in two locations and 23% in another. After the work, there was only one reading of 15%.

The decreased humidity can be attributed to two major projects—one to replace the drain and the other the installation of an HRV. The reading points closest to the floor showed a reduction from 19.8% to 11.6% in the wood for the six reading points. Note that the owner heated with wood 98% of the time.

Comments:

These results would not have been achieved without the new drainage tile and the new sump and pump.

The homeowner did experience problems using the new HRV (a model with 6 different control modes) properly. He learned how to control the required ventilation time more effectively, after observing it for some time. He is now satisfied with its performance.

Analysis and Comments – House no. 3

Problem:

The owner of house no. 3 signed up for the program because he had noted very high relative humidity in the basement (60%) in the summer and that his dehumidifier was unable to reestablish an acceptable humidity level. In addition, some water seeped into his basement through the foundation walls. The occupants wanted to maintain humidity levels of at least 40% at all times for their own comfort.

Solution:

The homeowner undertook the work recommended to him, namely drainage of the foundation walls and the installation of an HRV.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 14.8% (April 1999). During the February visit, this average was at 11.6%, hence a 3.2% decrease of the wood humidity.

Comments:

During the study, there was an overall decrease in the relative humidity of the air in the house and a drop in wood humidity. These declines coincided with the drainage of a foundation wall, the elimination of two vertical eavestroughs, which emptied in front of a foundation wall, and the installation of an HRV.

Analysis and Comments – House no. 4

Problem:

The owner of house no. 4 signed up for the program because he had detected traces of molds and odors in the basement. During the inspection visit, the owner had already started the reinsulation work in the basement. When he removed the existing insulation (white polystyrene which had been improperly glued on), traces of molds were detected on the foundation walls.

Insulation

Solution:

The homeowner had personally begun some of the work that had been suggested. When we made our last follow-up visit, 80% of the walls had been reinsulated. The vertical eavestrough pipe was moved away from the foundation wall (and the slope of the soil at that point was corrected). Oil furnace air returns were added in the basement. For budget reasons, he postponed the purchase of an HRV.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 8.1% (April 1999). In May 2000, the average stood at 8.2%. Wood humidity therefore remained rather stable in this particular house.

Comments:

During the follow-up visit in May 2000, the wood humidity readings were virtually identical to those obtained the year before. It must also be noted that the initial wood humidity was not very high.

During the last visit, the homeowner told us he had spotted some humidity where the wall meets the slab. Is this attributable to poor air circulation at that location? In any event, the owner will have the drainage tile inspected.

Analysis and Comments – House no. 5

Problem:

The owner of house no. 5 signed up for the program because of health problems which his two young children had developed since moving into the house three years before. The house is in a well-kept residential area. Humidity of 50% was noted in the basement. The space under the whirlpool bathtub, which showed signs of possible water infiltration in the basement, was suspected to be the cause. A window had been sealed up in that location. A forced air oil furnace was installed.

Solution:

The homeowner did not do all of the work that had been suggested. She checked the foundation, the drainage tile and the window from the outside. There were no cracks, and the drainage tile was in good condition. An attempt was made to correct the chimney problems, but the results were unsatisfactory. Work to correct the heating installation (lack of combustion air, traces of soot, non-compliant chimney) will be done after this project is over. The HRV was balanced.

The homeowner discovered that the whirlpool bathtub filter contained stagnant water, even though the tub had not been used in three years. The water produced a nauseating odor. The whirlpool bathtub will be removed, even though the bathroom in the basement is attractive.

The dehumidifier has not been used this winter, as the HRV serves as a dehumidifier.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 9.4% on April 15, 1999. Two wood humidity readings were as high as 14%. In April 2000 after some of the work had been done, the reading points averaged out to 8%, which is 1.4% less than a year earlier. Only one reading point was as high as 11.3%. The average humidity of the three points closest to the basement floor was 9.1%.

Comments:

The only work which could have affected wood humidity was the HRV balancing, the displacement of the eavestroughing pipe to empty into a dry well and the cleaning of the weep holes in the brick wall.

The homeowner attributes the illnesses of his children to the following—they were minded during the day in a daycare centre located in the basement of another house, and they were exposed to the stagnant water in the whirlpool tub filter in their own home.

Analysis and Comments – House no. 6

Problem:

The owner of house no. 6 signed up for the program because there was excess humidity in the basement along with odors.

Solution:

The occupants undertook all of the work recommended following the inspection visit. All of the cracks were repaired. An air return to the electric furnace was added in the basement. The fan in the basement washroom was equipped with a dehumidistat, and an HRV was also installed. During the winter of 1999-2000, the occupants noticed that the air was much drier than usual.

Crack before repairs

Crack repaired

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 10.4% (April 1999). In April 2000, the average dropped 2.2% at a level of 8.2%.

Comments:

Since the HRV was running continuously at low speed, it is the main reason why wood humidity declined with the addition of this equipment. The homeowner ended up eliminating the excess humidity in the winter through ventilation (the addition of an air return in the basement, the installation of a dehumidification system in the washroom fan in the basement and the installation of an HRV). In the summer, the homeowner turns on the air conditioning, and the relative humidity remains rather low.

Analysis and Comments – House no. 7

Problem:

The owner of house no. 7 signed up for the program because of frequent water damage in his basement. Several times during heavy rains, the sewer would back up into his basement. Neighbors also complained to the City several times, which leads one to believe that the sewer system in the area is inadequate. Work was scheduled to start on the City sewer system.

Replacement of the drainage tile, crushed stone and membrane

Solution:

The homeowner suspected that the drainage tile around his house was not working properly and had it checked. It turned out that some sections of the drain were broken and others were obstructed. Work to replace the drain was undertaken. Wells were added to the windows, and the slope of the lot was corrected all around the foundation walls. Inside, a five metre long perforated drain was installed under the concrete slab and connected up to the sump pump. About 90% of the walls and floor in the basement were finished.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 9.5% (April 1999). In April 2000, this average dropped 1.5% to 8.0%.

Comments:

Since the work on the drainage tile was done, no water damage was incurred in the house basement. The drop in wood humidity levels can therefore be attributed to the work done around the foundation walls: the replacement of the drainage tile, the waterproofing of the walls and the changes to the slope of the lot.

Analysis and Comments – House no. 8

Problem:

The owner of this house signed up for the program after noticing that the house he had purchased still exhibited excessive humidity levels. This house, which was enlarged, is located on a knoll and exposed to the wind. The house has electric heating; some parts are heated with a forced air furnace and other parts with electric baseboard heaters. The house was not constructed by a professional builder. In the basement, the homeowner showers regularly, hangs wet clothes up to dry and stores green wood.

Counterslope - 2 eavestroughs

Solution:

The homeowner only acted on one suggested corrective measure. He replaced the inadequate heating installations with a single properly installed system. He works for a major company and is often away, which explains the slow pace of the work. Moreover, he had just changed six windows in the front before the first visit.

He does not intend to install an HRV, as suggested. He prefers instead to install an outside air intake for the new oil furnace and install an exhaust fan equipped with a dehumidistat for the basement laundry room. This combination of measures, which cost less, may suffice to solve the humidity problems.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 12,5% (April 1999). In April 2000, this average dropped 1.4% to 11.2%.

The highest recorded wood humidity reading before the work began was 17%, and on the last visit, the highest reading was 13%.

Comments:

Regardless of the analysis performed, the humidity did not reach an acceptable threshold, because the homeowner did not complete all of the work. The homeowner's new proposals will reduce humidity in the basement and bring fresh air into the house. However, such installations do not achieve any heat recovery.

The lower humidity levels in the materials may be due to the fact that the homeowner replaced his electrical heating system with an oil furnace system.

The sources of humidity still persisted during the last visit.

Analysis and Comments – House no. 9

Problem:

The owner of this house signed up for the program after noticing that humidity levels were constantly high. Located on the shore of a lake, his home was formerly a cottage which was converted into a main residence where he has lived since his retirement. At the front of the house, there is an unfavourable slope that results in water accumulating along the foundation wall. He uses electric baseboard heaters.

The ground in the crawl space consists solely of crushed stone and is ± 3 meters above the level of the lake. The space is ventilated in the summer through an opening and small pipes. The homeowner has an HRV which does not ventilate the crawl space.

The homeowner does not have an adequate understanding of how the HRV works.

Crawl space before the work was done

Crawl space after the work was completed. The walls have been insulated and polyethylene spread on the ground.

Solution:

The homeowner did all of the work. He applied polyethylene along the ground and the walls of the crawl space, made changes so that water would not collect along the wall in the crawl space and installed a well for the pump in the crawl space. He has learned how to use his HRV more effectively to control excessive humidity levels. The owner said that the air was dry during the winter of 1999-2000.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 10.2% (December 1998). In January 2000, this average dropped 2.8% to 7.4%.

The highest recorded wood humidity reading before the work began was 15%, but during the last visit, the highest reading was 12%.

Comments:

This decreased humidity is attributable to two factors::

- the work done in the crawl space (polyethylene was applied on the ground and along the walls of the crawl space, and water was directed away from the wall in the crawl space).
- better use of the HRV.

The homeowner did not know how to operate his HRV properly. The findings are satisfactory, but there is still a slight humidity odor in the crawl space, even though humidity levels are low.

Analysis and Comments – House no. 10

Problem:

The owner of this house signed up for the program after noticing that the basement was too humid. Two of his children have their bedrooms in the basement. The occupants have always noted the humidity problem in the house from the time they first moved in. It is very humid in the spring, in summer and in the fall (a musty smell). Moreover, there is efflorescence on the concrete slab.

Heat recovery ventilator (HRV)

The house was equipped with an HRV, which the owner installed according to the manufacturer's instructions. The latter called for a fresh air supply in the basement and a stale air return on the ground floor, nothing more.

Solution:

The owner completed some of the balancing and duct work (addition of supply ducts and air returns) of the HRV. He cleaned the traces of efflorescence and the molds on the concrete, put in full-length polystyrene insulation with finish covering on the foundation walls; and installed thermo foil bubble pack reflective insulation, spacers and plywood on the floors of one of the bedrooms in the basement.

Findings:

During the first follow-up visit, the wood humidity levels at the various reading points averaged out to 9.9% (April 1999). In April 2000, this average increased 0.7% to 10.6%. The humidity levels have been basically stable in this particular house.

Comments:

The increased humidity is attributable to the more frequent stoppages of the HRV from December to February 2000, which is what the successive readings taken during the winter have indicated. The owner seems to experience difficulty adjusting the numerous HRV controls to obtain the desired humidity levels during cold weather.

The readings suggest that there is a problem with the drainage tile running along one of the walls of the home. The area is known for obstructed drain problems. The owner should have a specialist check the drain.

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