

# RESEARCH REPORT



## Drainage and Retention of Water by Cladding Systems

### Part 4 – Drainage Testing of Vinyl Siding Test Walls

# **DRAINAGE AND RETENTION OF WATER BY CLADDING SYSTEMS**

## **Part 4 – Drainage Testing of Vinyl Siding Test Walls**

Presented to

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## SUMMARY

Three walls clad with direct applied vinyl siding were subjected to a wetting/drainage/drying test protocol to study the retention of water between the siding and the base wall. Two vinyl siding profiles and two WRB materials were used.

Due to some leakage from the test walls which resulted in wetting of the wood frame, not all of the retained weight of water may be attributed to that held by the drainage cavity. There was insufficient information obtained to be able to assess the relative contribution to performance by either WRB sheathing membrane used. The edge sealing technique recommended for use in further tests of walls involving siding was expanding urethane foam versus latex caulking.

The direct applied vinyl siding retained moisture largely within the top courses in which the water was deposited. While the siding was installed loosely to allow expansion without buckling, the ability of the siding to allow drainage was not facilitated. If it is intended that drainage be possible for “loosely installed” direct applied cladding systems, more explicit installation recommendations are needed. Most of the water trickled into the space behind the top course of siding passed through the small drainage holes provided by the siding. The siding is designed to retain water in the profile to allow a head to build up and to allow drainage through the holes provided and lateral flow beyond the point of entry to other potential exits. While these installations were intentionally nailed to allow siding expansion, field installations with nailing into wood framing that will eventually dry and cause some nail popping which may allow greater vertical passage of water to siding courses below the point of entry.

Systems possessing drainage cavities allow the water input to that space to wet a significant area from the point of entry to the bottom of the wall where flashing is needed to divert it. The moisture retained by a relatively impermeable direct-applied system, such as vinyl siding, retains the moisture in a more concentrated area. The actual area affected is not known but might be assessed with a more discriminating moisture sensing technique than used here. While moisture that was retained in the vinyl siding joints as free water is not held in contact with the WRB and wood framing, it may contribute to a local micro climate that in the long run may lead to problems in some elevations of a building, particularly if the wetting is chronic.

The absence of an effective drainage plane leaves the vinyl siding dependent on the ability of the small drainage holes to function well. Clogging of these holes by dirt would reduce the ability of vinyl siding to handle intrusion of water in the future. From an experimental point of view, the distribution of water behind direct applied cladding of this type requires more detailed information to fully understand their drying behaviour.

# RÉSUMÉ

Trois murs dotés d'un bardage en vinyle posé directement sur le support ont été soumis à un protocole d'essai de mouillage/drainage/séchage afin d'étudier la rétention d'eau entre le bardage et le revêtement intermédiaire du mur. Deux profils de bardage de vinyle et deux matériaux de membrane de revêtement intermédiaire (MRI) ont été utilisés.

À cause de fuites dans les murs d'essai qui avaient mouillé l'ossature de bois, tout le poids de l'eau retenue ne pouvait pas être attribué à ce qui a été emprisonné dans la cavité de drainage. Nous n'avons pas obtenu suffisamment d'information pour être en mesure d'évaluer la contribution relative de l'une ou l'autre des MRI à la performance. Dans d'éventuels essais sur des bardages, il est recommandé d'obturer les rives des murs à l'aide d'une mousse d'uréthane expansé plutôt qu'un calfeutrage au latex.

Le bardage en vinyle appliqué directement sur le support retenait l'humidité surtout dans les rangées supérieures par où l'eau était introduite. Même si le bardage a été installé de façon lâche afin de permettre l'expansion sans gonflement, l'aptitude du bardage à permettre le drainage n'a pas été facilité. Pour qu'un bardage « installé lâchement » sur son support permette le drainage, le fabricant doit fournir des recommandations d'installation plus explicites. La plus grande partie du filet d'eau s'est engagée dans l'espace derrière la rangée supérieure de bardage par les petits orifices de drainage dans le bardage. Le bardage est conçu pour retenir l'eau dans le profilé afin de permettre une accumulation puis de permettre le drainage par les orifices prévus à cet effet et l'écoulement latéral au-delà du point d'entrée vers d'autres voies d'évacuation possibles. Ces murs étaient clouées intentionnellement de manière à permettre l'expansion du bardage, mais les installations sur place avec le clouage dans l'ossature de bois qui séchera éventuellement et produira des soulèvements de clous pourraient permettre le passage à la verticale d'une plus grande quantité d'eau dans les rangées de bardage sous le point d'entrée.

Les systèmes dotés de cavités de drainage permettent à l'entrée d'eau dans cet espace de mouiller une surface significative de mur depuis le point d'entrée jusqu'au bas, où il faut prévoir un solin pour la repousser. Un système qui utilise, par exemple, un bardage en vinyle posé directement sur un support relativement imperméable, retient l'humidité dans une zone plus concentrée. La zone réelle mouillée n'est pas connue, mais pourrait être évaluée à l'aide d'une technique de mesure d'humidité plus précise que celle qui a été employée dans le cadre des essais. Même si l'humidité retenue dans les joints de bardage en vinyle sous forme d'eau libre ne reste pas en contact avec la MRI et l'ossature de bois, elle peut contribuer à la formation d'un microclimat local qui peut engendrer à long terme des problèmes dans certaines élévations d'un bâtiment, particulièrement si le mouillage est chronique à ces endroits.

L'absence d'un plan de drainage efficace fait en sorte que le bardage en vinyle dépend de l'aptitude des petits orifices de drainage à bien jouer leur rôle. L'encrassement de ces orifices peut éventuellement réduire l'aptitude du bardage en vinyle à gérer l'intrusion d'eau. D'un point de vue expérimental, la répartition d'eau derrière un parement de ce type, appliqué directement sur le support, fait appel à de l'information plus détaillée pour bien comprendre son comportement de séchage.



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# PREFACE

CMHC proposed that a series of drainage tests of exterior cladding assemblies be undertaken to produce data to quantify the ability of several types of cladding and methods of application on wall systems to manage and evacuate water that has intruded behind them. The test program has concentrated on the drainage characteristics of the tested systems, the amount of water that is retained and the drying ability of the cladding tested. The present report provides the results of tests on vinyl clad siding systems.

The reports are organized by the wall types tested and with additional supplementary tests done in support of the work. In summary, the different “Parts” of reporting in this project are:

- Part 1 - Experimental Approach and Plan
- Part 2 - Testing and Measurement Methodologies.
- Part 3 – Drainage Testing of EIFS Wall Systems
- Part 4 - Drainage Testing of Walls with Vinyl Siding
- Part 5 - Drainage Testing of Walls with Wood-based and Fibrous Cement Siding
- Part 6 - Air Flow Characteristics of Wall Systems Having Drainage Cavities
- Part 7 - Air Leakage and Vapour Permeance of Joints in Some Siding Systems
- Part 8 - Summary Report

Reporting has been compartmentalized into this series of “Parts” because of the extensive detail involved in reporting on the many wall variants that have been included. Comparisons were considered more manageable for the reader to face by providing the details separately in each segment of the work.

# DRAINAGE AND RETENTION OF WATER BY CLADDING SYSTEMS

## Part 4 – Drainage Testing of Vinyl Siding Test Walls

### 1 INTRODUCTION

This portion of the report concentrates on results that were obtained from tests of three walls clad with vinyl siding. This type of siding is normally attached directly to supporting backup walls. In the National Building Code of Canada [1], vinyl siding is classified as being loosely applied. This is a requirement that falls out of the necessity to allow this type of siding to expand and contract freely to prevent buckling due to its comparatively higher coefficient of thermal expansion. From the point of view of drainage capability, while not stated explicitly, this type of siding is assumed to allow adequate drainage and drying to take place. Whether this assumption is fully justified in the event that water gets behind the cladding is not yet known.

In Part 2 “Testing and Measurement Methodologies” the means by which the testing was undertaken was provided. Only a limited restatement of some of that information will be repeated in this report to provide a context for the specific test results obtained for these vinyl wall systems.

### 2 TEST WALL CONSTRUCTION

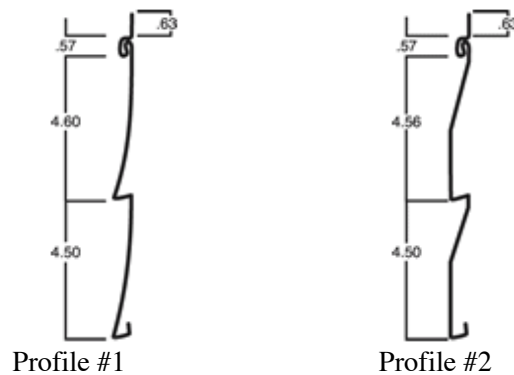
#### 2.1 Materials

Materials required for construction of the vinyl siding test walls were purchased in Quebec City and shipped to Forintek facilities during the second week of January 2005. Wood framing and OSB panels required for construction of the test walls was purchased by Forintek sufficiently prior to the assembly of the test walls to allow all materials to reach moisture equilibrium in the laboratory space where tests were to be conducted.

The wall specimens were all fabricated at the laboratory. Forintek staff fabricated the wood frames and installed the vinyl siding along with the water resistant barrier according to the specifications stated by the distributor and by discussion with the CMHC project leader. All the 1.22 by 2.44 m (4ft x 8ft) wood frames consisted of 38x89 mm (2x4 inches) SPF S-DRY studs at 400 mm (16 inches) spacing including a single bottom sill plate and double top plates. The double top plates were used to reinforce the wall for handling and for being hung from the weight balancing system during drainage/drying testing. The construction sheathing consisted of 11.1mm (7/16 inch) OSB manufactured to CSA O325. Nailing of the OSB sheathing to the wood-frame was done at a spacing of 150 mm at the perimeter of the OSB sheathing and at 230 mm in the field of the panels. The panels were placed with the grade stamps facing the framing.

Two different profiles of vinyl siding were used for the purpose of this project. They were both manufactured by Mitten Company. Profile #1 was a double 4.5 inches horizontal siding (white colour)

and Profile #2 was a double 4.5 inches dutchlap siding (brownstone colour). The specifications for both profiles and for the starter strip used are presented in Appendix I. One specimen was fabricated using Profile #1 siding and two walls were built using Profile #2 siding. These profiles are shown in Figure 1.



**Figure 1** Cross section of Profiles #1 and #2

## 2.2 Construction of test walls

The three vinyl clad test walls examined in this test program were built over a 2-day period. A description of each test wall and the steps involved in the fabrication are presented below;

(Photos of the construction sequence are provided in Appendix I)

Wall 1; Vinyl siding Profile #1 direct applied to a paper-based sheathing membrane (15lbs) (WRB)

Wall 2; Vinyl siding Profile #2 direct applied to a spun bonded polyolefin sheathing membrane (SBPO)

Wall 3; Vinyl siding Profile #2 direct applied to a paper-based sheathing membrane (15lbs) (WRB)

*Application of WRB:* Two specimens were built using a paper-based sheathing membrane and one was built using an SBPO membrane. For these specific test specimens the weather resistant barrier covered the specimen flush to the edges without being returned around the edges of the specimens. The WRB materials were applied over the whole wall area stopping about 5 inches from the bottom to allow the installation of the metal gutter. The WRB materials overlapped the top edge of the gutter to allow the drained water to be collected by the gutter. The courses of building paper were overlapped about 100 mm as required to drain water behind the siding. The SBPO was installed as a single sheet covering the entire wall.

*Installation of a metallic gutter at the bottom of the wall:* Gutters were installed approximately 6 inches from the bottom of the wall framing, directly against the sheathing using four standard wood screws. The top of the gutter was sealed to the sheathing with Mono super latex sealant.

*Installation of the Mitten starter strip on top of the WRB:* This starter strip is required to clip the bottom edge of the first course of siding to the wall. The starter strip was installed using the same type of fasteners as detailed below for siding.

*Installation of the vinyl siding:* The vinyl siding was direct-applied to the OSB sheathing through the WRB with electro-galvanised 32 mm (1.25-inch) roofing nails. Nailing of each siding course was done at 400 mm c/c (16 inches) only at specific slots in the top edge of each course of siding directly into the lumber studs in most cases. Special care was taken to make sure that each nail was not nailed tightly to permit expansion of the siding if subjected to thermal changes. This is a normal installation practice for vinyl siding. The siding was applied from the bottom course to the top, with each course clipping into the top edge of the course below it.

*Application of Mono super latex sealant on both ends of each course of vinyl siding:* The sealant was used to block the ends of each course of siding to prevent lateral flow of water out of the test walls. It was expected that this sealant would bond to both the WRB and the vinyl siding to prevent leakage.

*Application of construction tape over the ends:* The tape was used as a second layer of protection for sealing the ends of the vinyl siding to the wood framing.

*Top gap opening:* Water entry behind the siding was allowed by providing a gap between the top edge of the top course of siding and the WRB. The gap was standardised for all siding installations in this test program at 4 mm.

## 3 TESTING AND MEASUREMENTS

The test set-up for accurately weighing the change in wall weight caused by the addition of water into the space behind the siding is fully described in the Part 2 report on the testing methodologies employed. Three balance beam set-ups permitted all three test walls described above to be tested on the one occasion.

### 3.1 Instrumentation

The weight change was monitored and recorded by compression load cells (Tedea-Huntleigh model 1040) having a capacity of 30 kg. The acquisition system included a Tracker series 240 signal conditioner with an 18 bit A/D to provide a high degree of resolution (0.2 g), and a RS 485 to RS 232 output to transfer the data to a notebook computer. The software used to control sampling rate was designed by Intertechnology.

### 3.2 Load cell sensitivity verification

The verification of the load cell calibrations was done prior to testing to assure that no damage to the load cells had taken place during installation of the test walls. As each wall was set up with the tare load applied, a single calibrated 500 g weight was added to the wall weight to confirm that the initial calibration still applied. This weight was put on top of the bottom sill plate of each wall in turn for a period of 1 minute while the weight monitoring was being recorded.

### 3.3 Water flow rate

The water was piped to the trickle trough at each wall in turn by an air pressure system. Twelve (12) kg of water in a glass carboy was continuously weighed on a calibrated scale [Mettler Model PM 30000-k] having a resolution level of 0.1g. This amount of water was sufficient for testing one wall. Controlled air pressure was supplied to this container to expel water from within it through tubing to the wall being wetted. The change in weight of the carboy was monitored on a minute by minute basis and the weight increments were automatically stored in a computer file. In parallel to this monitoring, the flow rate was calculated and the flow was adjusted with a micro valve to ensure that a total of 8 kg of water was delivered to each wall within the 1-hour wetting period. To make certain that the water used for each wall was at the same ambient temperature, another glass carboy filled with 20 kg of water was prepared in advance to reach those conditions. This amount of water was sufficient for testing the remaining two walls.

### 3.4 Trickle trough

As explained in the Part 3 on testing methodologies, the water was delivered to each wall in turn to a Plexiglas distribution trough which allowed the water to dribble or trickle in the drainage cavity. This trickle trough was 610 mm long (24 inches) and 95 mm wide (3.75 inches) with a bottom slope of 20%. Holes with a diameter of 2 mm (0.08 inch) were drilled every 38 mm (1.5 inch) c/c in the bottom corner to allow drainage. For this test program the troughs were designed to allow the flow to be directed to specific wall surfaces. This was done by outfitting the troughs with a thin plastic sheet bonded to the face along which flow occurred from the holes drilled in the bottom corner. The bottom edge of the sheet was serrated to gather the flow to single locations. Tilting the trickle trough allowed the flow of droplets to be directed to specific planes. By assuring that the trough was installed horizontally, and by observing the uniformity in width of the “lake” of water while water dripped into the trough, this provided assurance that flow into the wall was uniform along the length of the trough. In the case of the walls with vinyl siding, since the siding was direct applied and there was no distinct drainage cavity, the droplets were directed into the middle of the gap provided for water entry at the top of the siding.

### 3.5 Test Procedure

The water was delivered to the trickle trough at the top of the drainage cavity of each wall for a period of approximately 1 hour (until 8 kg of water had been delivered). The flow rate was 133g/min. It was intended that water that drained into each wall would eventually emerge in some way and be collected by the sloped galvanized gutters installed at the bottom of the wall. The actual behaviour did not occur as expected and will be described later in some detail.

After supplying water for one hour at the calibrated rate, the water flow to the wall was turned off. The glass carboy was replaced by another container with tempered fresh water (20 kg) to be used for the next two specimens to be tested. Each wall specimen was allowed to drain for one additional hour after flow to it was halted. The water remaining in the trickle trough at the end of this 2-hour test time and water adhered to the collection gutter and to the outside surface of the vinyl wall was mopped up delicately with paper tissues. This was to assure that the recorded weight, to best possible extent, represented only water that was retained behind the siding. Due to the loss of some water that dripped on to the floor, this information could not be used to check on the quantity of water retained within the wall at the end of the two-hour test period. Only the weight recording could be used for this assessment.

During the first two hours of the test (wetting and drainage) the wall weight data was stored in the computer file for each load cell at the rate of one sample per second, each of which was the average of 20 individual readings. All three walls were evaluated together over the same period and the data were stored in one file at this sampling rate for a period of approximately 5 hours. When the drainage test on the third wall was completed, load monitoring was temporarily halted and the storage rate was changed to 3 samples per minute to avoid creating an excessively large data file during the next stage of the test protocol. This data, at the slower sampling rate, was stored in a separate file and monitoring was continued for a period of at least 48 hours. The trickle troughs were left in place throughout the entire wetting and drying periods.

Plots of the weight change measurements for each wall are provided in Appendix III of this report.

### 3.6 Measurements of moisture content changes behind the siding

As explained in Part 2 (Measurement and Testing Methodologies), the decision was made to use a capacitance meter to obtain a qualitative assessment of the moisture distribution because of the severe moisture gradients expected. The meter used was a Wagner L620 meter that had sufficient data storage capacity to allow numerous readings to be taken. The meter was employed to take readings on a spacing of 150 mm on each vertical scan. Two vertical scans per stud space were taken for a total of 6 scans

resulting in collection of 90 moisture content readings per wall both before and after the drainage test. The moisture readings were taken while the wall was laid horizontally exposing the back of the OSB sheathing. For practical reasons, the final measurements were obtained only after the walls were dismantled from the balance beam setup after the drying phase was completed.

During the drainage testing, it was found that water entering the wall did not appear to get past several of the upper courses of siding. As it was suspected that a greater concentration of water would be found there, the moisture measurements were repeated at the upper regions of the test walls using a spacing of 75 mm along the same measurement grid used for the original baseline measurement.

The contour maps of moisture content changes between the first set of readings and after the walls had been removed from the test frames are included in Appendix IV.

### 3.7 Measurement of environmental conditions

The laboratory conditions are set to be maintained at 20°C and 50% RH on a year-round basis, except temporarily when the large laboratory doors are opened for movement of materials into the laboratory. Monitoring of these conditions was obtained using temperature and RH sensors, and recorded as specified in the next section. Some additional discussion about variations in conditions that occurred during the test period for each set of tests is provided in the discussion section of this report.

Four RH and temperature sensors were installed at the top part of each wall specimen to monitor the conditions of air exiting the top of the drainage cavity. These were spaced uniformly across the top of each wall. Two of these sensors were positioned below the trickle trough and the other two were at about the same level but symmetrically placed away from both sides of the trough. All sensors were placed at about 25-25 mm (1-2 inches) from the top of the cladding. The aim was to compare these measurements with the ambient conditions in the lab. To monitor these conditions, four additional monitoring stations were installed. Two stations were positioned above the test frame, one station was on top of a table in the vicinity where the instrumentation was located and one station was close to the floor at the height of the bottom of the cladding. These results are shown plotted in Appendix V together with a description of the sensor locations.

## 4 RESULTS

For the direct-applied vinyl clad walls, each wall was only tested once with water directed into the middle of the 4 mm gap provided at the top edge of the siding. Only walls with identifiable drainage cavities were tested twice allowing the water entering to slip down along the WRB or down the back of the siding as was reported in Part 3 for the EIFS walls tested.

The intent of the tests on walls with vinyl siding was to have all water enter the 1200 mm wide wall and be available for drainage/retention. This was the purpose of sealing the ends of each siding course with caulking. In practice, walls are not sealed that way and water entering behind the siding is either free to flow laterally (if a head of water develops depending on the rate of water entry) and potentially find sufficient drain holes for the majority of the water to pass through, or to find its way down to lower courses. The siding is designed to retain water and to allow it to drain out.

During the wetting phase of Wall 1 (which involved Profile #1 and building paper) water entering the first course of siding immediately started draining out of the small drainage holes provided by the vinyl siding profile for this purpose. Some head of water developed there and this was sufficient for some water to leak out through the imperfectly sealed edges. Some of this water was not caught by the gutter and ended up on the floor. Most of the water drained out of the wall by passing through two or three drainage holes

located in the first course of siding. The shape of the vinyl profile simulated bevelled wood siding. The momentum of the water leaking out of these holes and flowing down this slope caused some of the water to escape from contact with the wall. This drainage wetted the floor in front of the wall for a distance of about 0.4 m.

Water escaping from both edges, near the top of the wall, drained down and wetted some of the wood framing that was not protected by the WRB. This wetting was found at the junction of the edge studs and the sill plate (on both sides of the specimen). Water may also have found its way behind the edges of WRB and be absorbed by the OSB.

Walls 2 and 3 (utilizing vinyl siding having Profile #2 with SPBO and building paper WRB membranes) demonstrated similar, though not as extensive, moisture loss by side leakage as Wall 1. The profile of this siding simulated a different type of wood siding having significant portions of the siding face parallel to the back plane of the wall. Water draining from these drainage holes did not build up sufficient momentum to escape from the wall face, but was retained close to that surface and permitted it to drain down for collection by the gutter. Photos of the walls undergoing test are shown in Appendix II.

When the walls were dismantled from the test frame at the end of the test, some of the free water still held by the siding drained out on the floor. The water that drained out was recovered by wiping the floor and weighing the wipes. About 10 to 40 grams was recovered this way. Wall 3 (Profile #2 with building paper) had the most water spill out (43 grams). In this case, the moisture content maps showed an increase in MC where the free water was expected to be found. This will be discussed further when the moisture difference contour plots are discussed.

A summary of drainage and retention results for the three test walls is provided in Table 1 below. The values noted are the 1-hr weight (approximate) at the time water flow was discontinued, the 2-hr retained weight value and the 48-hr level (at 50 hours). Drainage of free water usually ended by 10-15 minutes after supply of water was terminated. The weight change plots are all provided in Appendix III.

Table 1- Drainage performance evaluation results

<i>Time</i>	<b>Wall 1 Vinyl-P1-BP</b>	<b>Wall 2 Vinyl-P2-SBPO</b>	<b>Wall 3 Vinyl-P2-BP</b>
<b>1 hour (reading &amp; retention)</b>	<b>698</b>	<b>500</b>	<b>327</b>
<b>Retained weight of water after 2 hours (g)</b>	<b>364</b>	<b>236</b>	<b>224</b>
<b>Retained weight of water after 48 hours (g)</b>	<b>283</b>	<b>130</b>	<b>135</b>



## 5 DISCUSSION

### 5.1 Experimental methodology

While cladding systems that are provided with identifiable drainage cavities have no problem in allowing most of the intruding water to pass through, direct applied systems can be more problematic. As such they require much more instrumentation to fully understand how and where water is retained. Some of the difficulties experienced with water leakage were related to imperfect sealing at the ends of the vinyl courses. This manner of sealing was subsequently discarded and polyurethane foam spray was used in place of caulking. This worked quite satisfactorily in all the other systems tested, although the level of internal ponding of free water in siding profiles did not occur in those tests.

Secondly, the use of construction tape over the edge seals was ineffective and ended up being cosmetic in nature. All other systems were taped, as these vinyl walls had been, but there was no lateral leakage and the presence of tape was not necessary. For these tests, it would have been useful to see where the water was leaking from. The presence of the tape hid that information and may have contributed to hold water against the wall and allowing some to flow behind the WRB, if that did indeed happen.

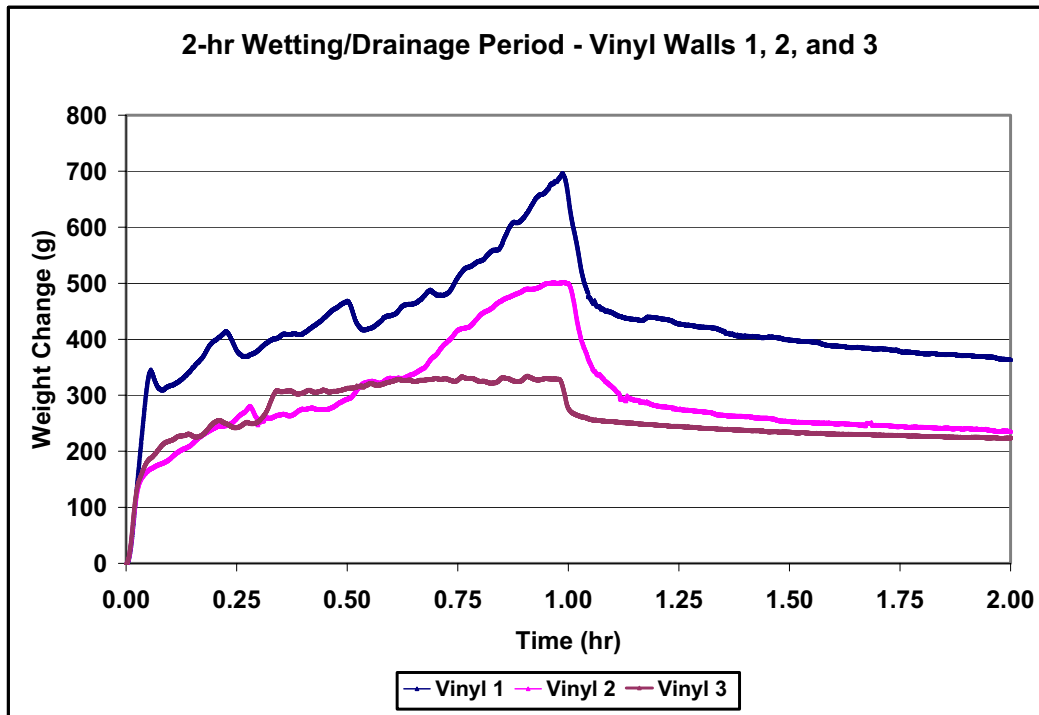
To prevent water entry behind a WRB, the material used should be folded around the edge of the framing. This was done for all subsequent wall tests.

The attribution of retention performance by the different types of WRB used in these circumstances cannot be attempted without a significantly greater investment in sensors for both RH and T inside the spaces behind the siding as well as use of spot measurements using resistance type probes to supplement the capacitance based meter used. The microclimate established behind the siding at each level would have been of interest as a means of detecting if vertical drainage to lower courses occurred.

One question that might be raised about the concept of the test for this type of system is whether a 1200 mm wide wall was sufficiently wide to simulate the drainage performance of walls with vinyl siding. Certainly, for the rate at which water was input to the space behind the top course of siding, a head of water developed to allow water to drain through the small drain holes provided. However, despite allowing the walls to dry for two additional days, free water was still held in the joint profile at the end of that period. Having a wider wall would not have changed the unit retention possible in those joints. For the purpose of comparing quantities of water that could be held by siding, as an arbitrary value, the 1200 mm wall width was as useful in describing likely performance as was needed. The issue of actual drying ability in real walls depends on many factors and this experiment provides only some indications needed to understand potential performance under the circumstances being simulated.

### 5.2 Retention of water by the vinyl walls tested

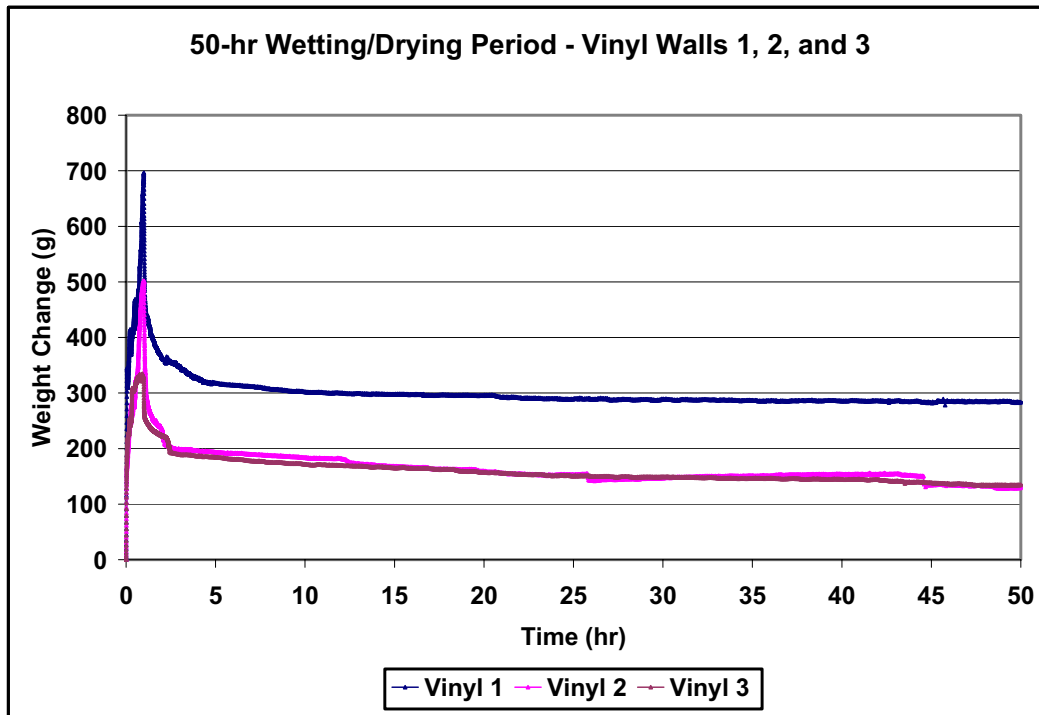
The weight change plots were combined to allow the results for all three walls to be compared. That information is provided in two figures. Figure 2 shows the results for the 2-hr test, and Figure 3 shows the combined results for the 2-hr and 48-hr test period. In both cases, zero time represents the start of wetting of each wall in turn.



**Figure 2** Summary weight change plots for 3 vinyl siding walls

The three plots in Figure 2 are instructive in revealing how water was retained during wetting. This opinion is based on observations during the tests and the shape of the resulting plots. Wall 1 experienced the most retention and leakage, leakage that involved wetting of the wood framing, and hence storage. The sharp increase in weight to the end of the wetting phase of the curve implies that more water would have been retained if the wetting had been allowed to continue. To a lesser degree, this also happened for Wall 2 which had a different profile. The retention at this stage seems largely dependent on the degree of failure to hold water within the siding space to be drained through the holes provided. Wall 3 on the other hand which experienced little extraneous leakage reached a near plateau of retention in 20 minutes, so the head of water attained remained sufficient to expel the water as rapidly as it was supplied to the wall. Due to the extraneous leakage, it is not possible to compare the ability of the two types of profiles to shed water that may enter a defect as was being simulated here.

In Figure 3, the wetting and drying results are presented over the full 50 hours of wetting/drainage/drying. Walls 2 and 3 which experienced less storage by wetting of the wood framing than Wall 1 dried almost identically. The drying rates for Wall 1, 2, and 3 (obtained by regression of the drying curves to the end of the period for each wall) were 0.38, 0.91, and 0.86 g/hr respectively between the 10-hr and 50-hr points on the plot. The total retention at that time was about 130 g for each wall. The free water retained in the joint profile was still sufficient to partially spill out when the walls were dismounted and turned over on their faces for measurement of moisture changes using the capacitance meter. By doing so, rewetting of the WRB may have occurred to allow the contour maps shown in Appendix V to show a larger extent of wetting than actually occurred when these walls stood in place.



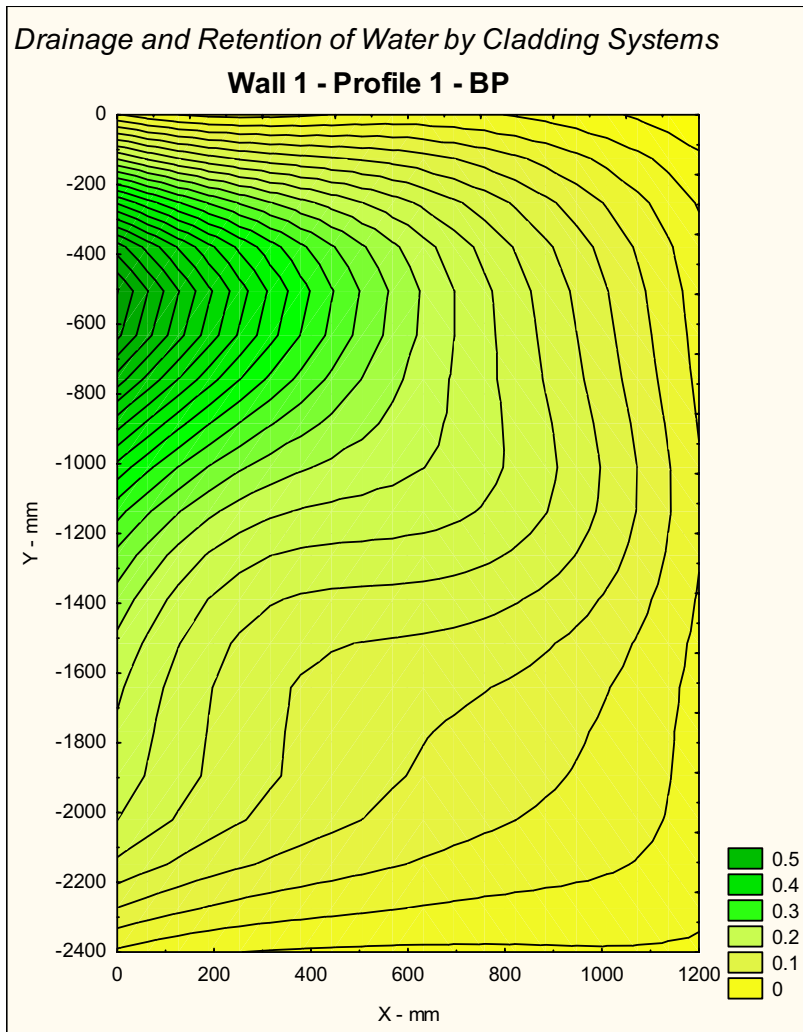
**Figure 3** Weight change for the entire 2-hr plus 48-hr time period

### 5.3 Moisture distribution

The moisture mapping figures provided in Appendix IV show areas of the wall that, when viewed face on, show portions of the wall having higher moisture content changes that correspond with regions where we observed leakage. For purposes of this discussion the plot for Wall 1 is repeated below.

It was anticipated that the concentration of moisture might have been more localized than shown. For example, one might expect some moisture to have been retained on the contact between the siding and the wall. To assess if a closer spacing of readings would be able to detect more information in the upper region of the wall, the following day a more detailed examination was made. The measurements were made on a 50 mm grid in both directions in the upper portion of the wall where water had been placed. This added an additional 126 readings for the mapping. The resulting contour plots did not display any significant detail that is not already shown in Figure 3 below. The baseline set of readings prior to the test had not been taken in this detail. An average “dry” value had to be used as a reference for these additional locations.

As noted in the report on the testing of EIFS wall systems (Part 3), the ability to discriminate detail as to where water retention was concentrated would have been enhanced if the measurements had been made shortly after drainage of free water was complete.



**Figure 4** *Moisture map for Wall 1 showing where there was a higher concentration of moisture retained at the conclusion of the 50 hr drying period*

## 5.4 Environmental effects

The drying curves shown in Figure 3 and those in Appendix III show a reasonably linear pattern during the drying phase. Examining the variations in environmental conditions over that entire period presented in Appendix V would lead one to expect some cycling in the Figure 2 plots. However, there was no correspondence. The vinyl cladding was not susceptible to those minor changes. The fact that no effect was measured implies that the exposed wood framing and OSB were not readily susceptible either. Therefore, changes noted during tests on EIFS walls suggest that those changes were largely attributable to pickup of moisture by the EIFS portion of the walls tested and not by the wood framing.

In summary, the analysis related to drainage performance on vinyl siding systems showed that wall 2 and 3 performed almost equally, which means that the difference related to the WRB is not significant in that particular case. The level of moisture retained at the conclusion of the test was still substantial but insufficient information is available about how much of that weight had diffused into the OSB. No conclusion can be made about the differences between the two profiles because extraneous leakage and wetting had taken place.

## 6 SUMMARY AND CONCLUSIONS

The above discussion highlighted certain improvements in the sealing techniques. These recommendations were implemented for the remainder of the project for both the direct-applied and other tests involving distinct drainage cavities.

The direct-applied vinyl siding retained moisture largely within the top course in which the water was deposited. While the siding was installed loosely to allow expansion without buckling, the ability of the siding to allow drainage was not facilitated. If it is intended that drainage be possible for “loosely installed” direct-applied cladding systems, more explicit installation recommendations are needed.

The vinyl siding walls exhibited drying, but some of that drying was from wood framing that had been wetted. The loss in weight had several routes for escape including diffusion through the OSB. At this time no specific conclusion is drawn concerning the level of retention compared with other systems. What can be stated generally is that water retention by systems with drainage cavities allow the retention to be spread over a significant area, so the unit concentration is low. The moisture retained by a relatively impermeable direct-applied system, such as vinyl siding, retains the moisture in a more concentrated area. The actual area affected is not known but might be assessed with a more discriminating moisture sensing technique than used here. Moisture that was retained in the vinyl siding joints as free water is not held in contact with the WRB and wood framing, but this moisture may contribute to a local micro climate that in the long run may lead to problems in some elevations of a building, particularly if the wetting is chronic.

The absence of an effective drainage plane leaves the vinyl siding clad wall durability susceptible to blockage of the small drainage holes. Clogging of these holes by dirt would reduce the ability of vinyl siding to handle intrusion of water in the future. Despite the apparent simplicity of drainage testing, particularly with the difficulties encountered, more questions have arisen about how direct-applied siding systems deal with water that penetrates the primary cladding. A greater intensity of detailed information is required to investigate direct-applied cladding systems, particularly those involving very low effective vapour permeability. Air and vapour permeability testing of siding systems in Part 7 of this report series provides additional information on this topic.

## 7 REFERENCES

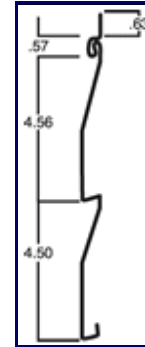
- [1] National Building Code of Canada .2005.

## APPENDIX I

### Construction of Vinyl Siding Test Walls

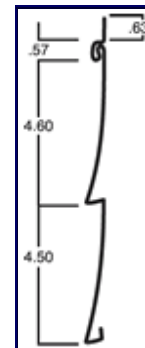
### **Double 4 1/2" Dutchlap**

<b>PACKAGING</b>	<b>IMPERIAL</b>	<b>METRIC</b>
Panels/Ctn.	22	22
Length/Piece	12'1"	3.68m
Width/Piece	9"	22.86cm
Coverage/Ctn.	200 sq. ft.	18.58m <sup>2</sup>
Nominal Thickness	0.042"	



### **Double 4 1/2" Horizontal**

<b>PACKAGING</b>	<b>IMPERIAL</b>	<b>METRIC</b>
Panels/Ctn.	22	22
Length/Piece	12'1"	3.68m
Width/Piece	9"	22.86cm
Coverage/Ctn.	200 sq. ft.	18.58m <sup>2</sup>
Nominal Thickness	0.042"	



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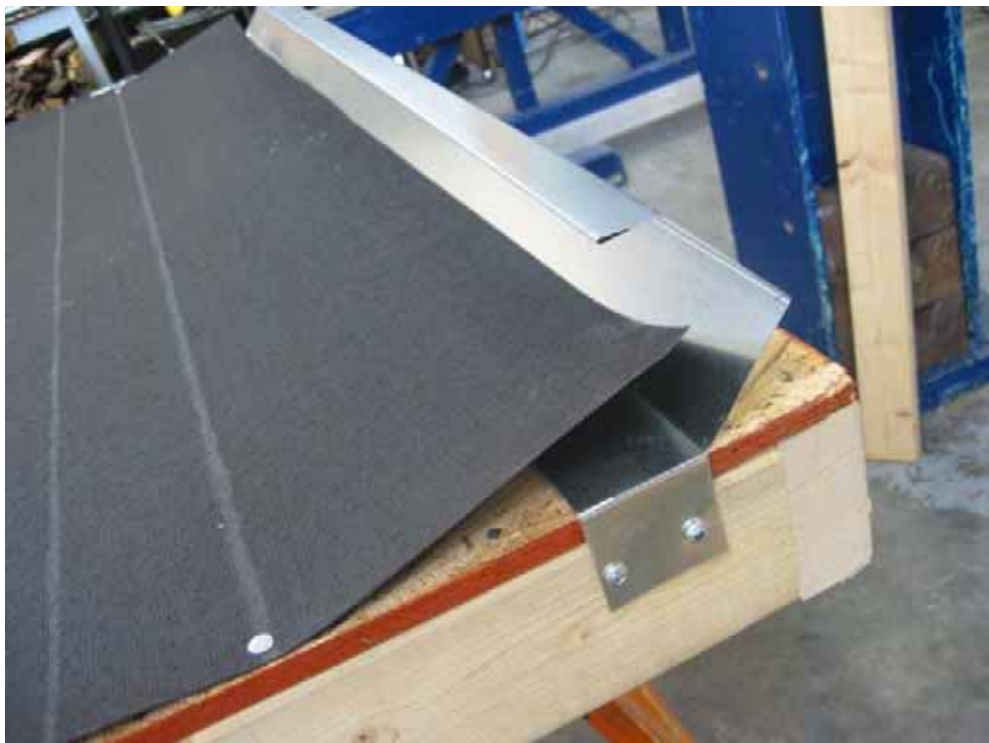
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**Figure I -1 Installation of WRB**



**Figure I-2 WRB overlapping the gutter installation**





**Figure I-3 Installation of starter strip**



**Figure I-4 Installation of first course of siding (Profile #1) by clipping it to the starter strip.**



**Figure I-5 Sealing the ends of the vinyl siding by means of caulking**



**Figure I-6 Touching up sealing the ends of the vinyl siding using caulking**



**Figure I-7 Normal progression installing vinyl siding from the bottom of the wall up, Profile #2**



**Figure I-8 Profile #2 at connection to starter strip**

## APPENDIX II

### Drainage Testing of Vinyl Clad Test Walls



**Figure II-1 View of overall test set-up Walls 1-3, left to right.**



**Figure II-2 Wall 1 undergoing test with rivulets cascading down surface of wall from the top.**



**Figure II-3 Wall 2 showing water cascading from top siding course and from leak at side.**



**Figure II-4 Wall 2 showing close-up of cascading water rivulets.**





**Figure II-5 Wall 3 showing water cascading from drainage holes provided in the siding profile at the top course. Note the drainage is largely held along the siding surface by the design of the profile.**



**Figure II-6 Wetting of framing, Wall 1**

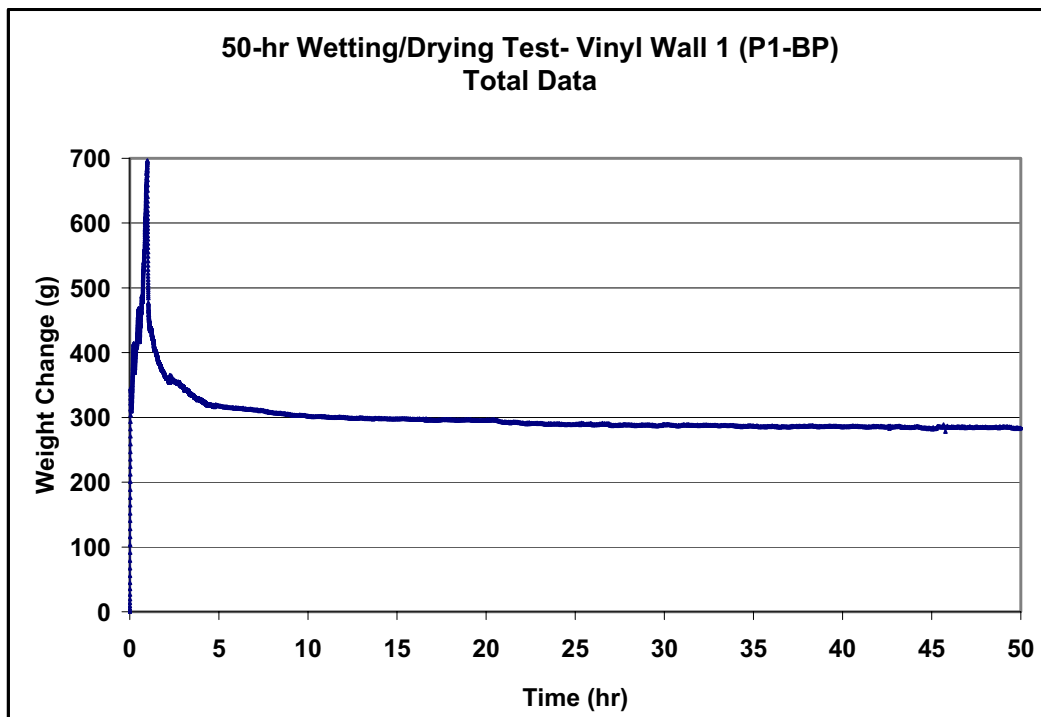
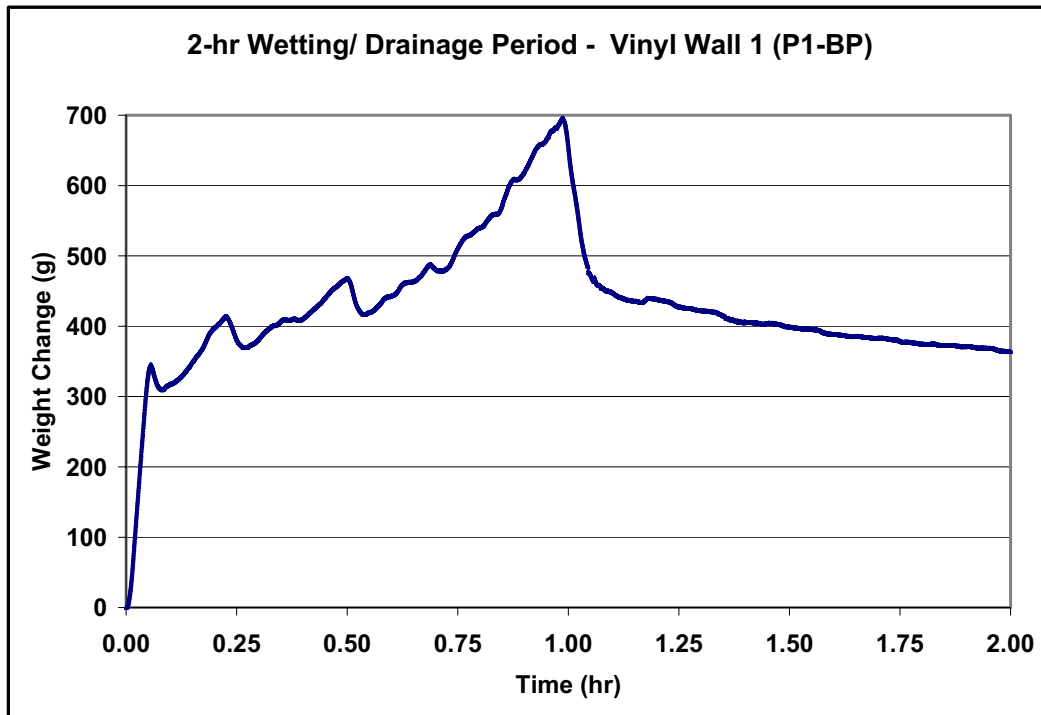


**Figure II-7 Wetting of framing, Wall 2**

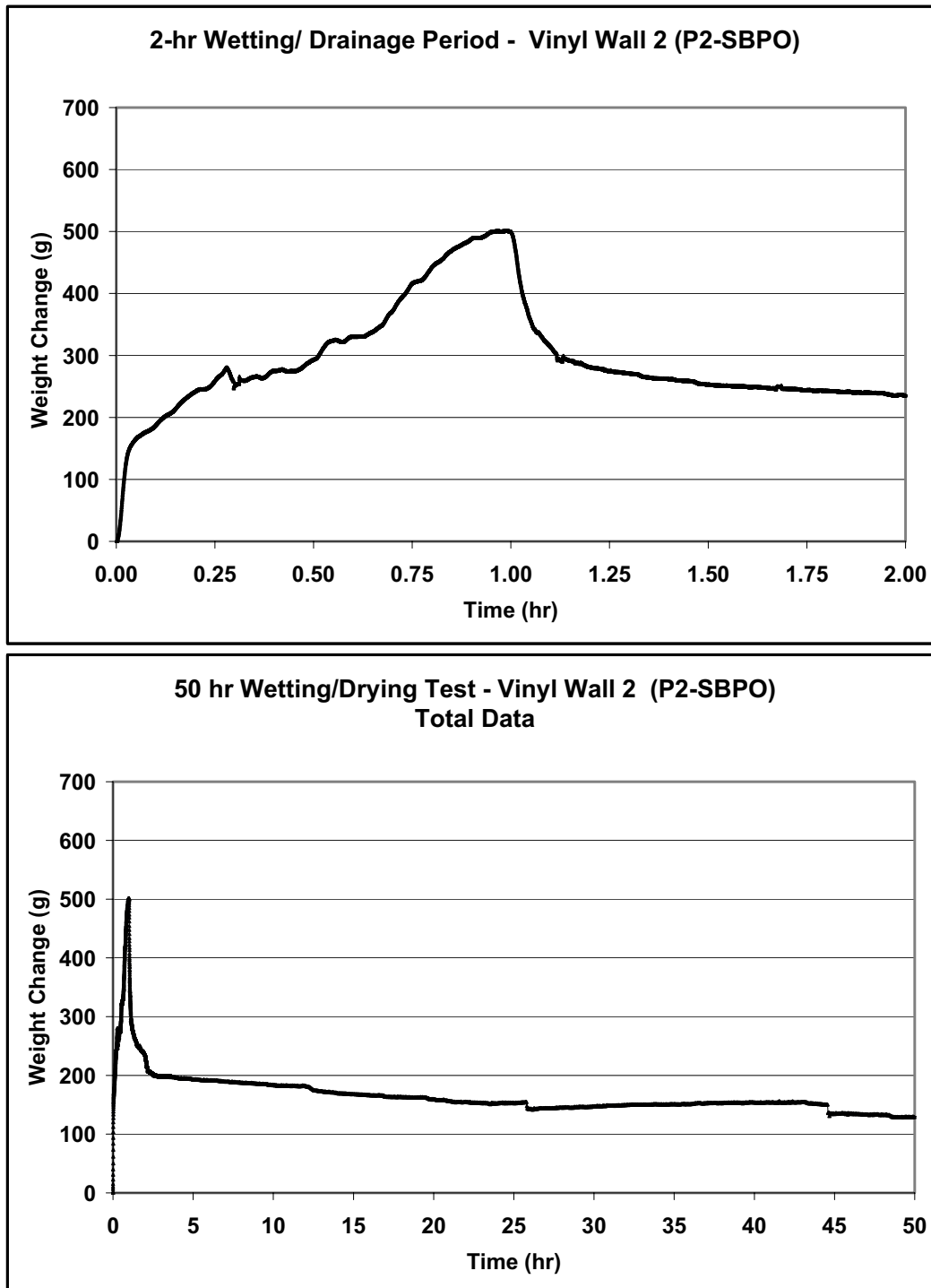
## APPENDIX III

### Drainage/Drying Records for Vinyl Clad Test Walls

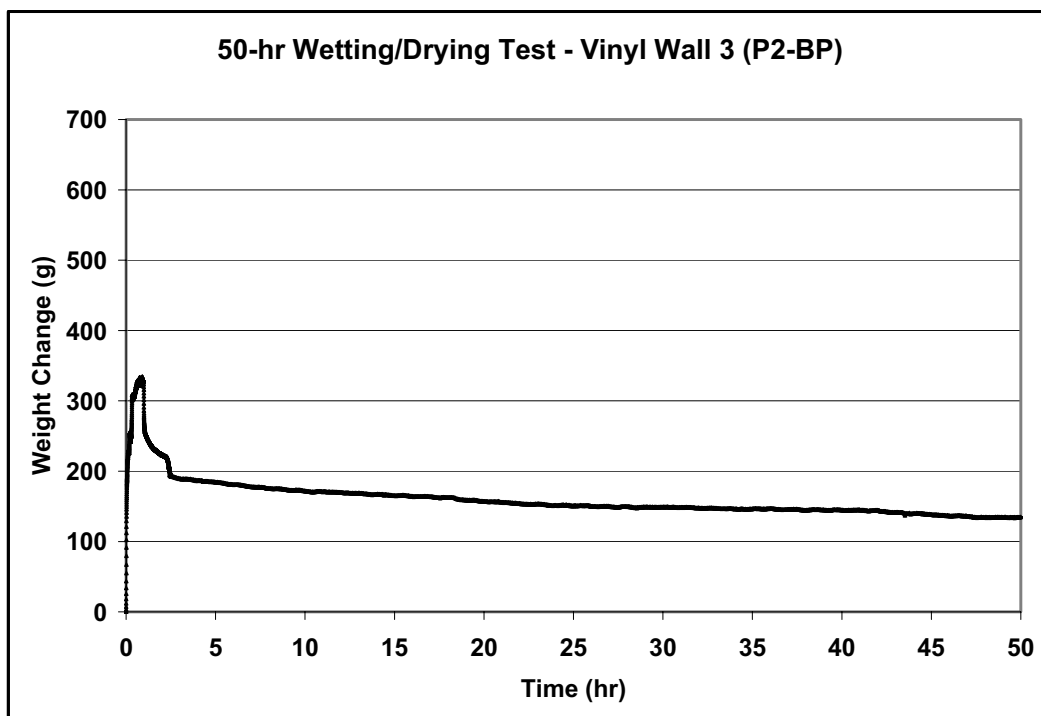
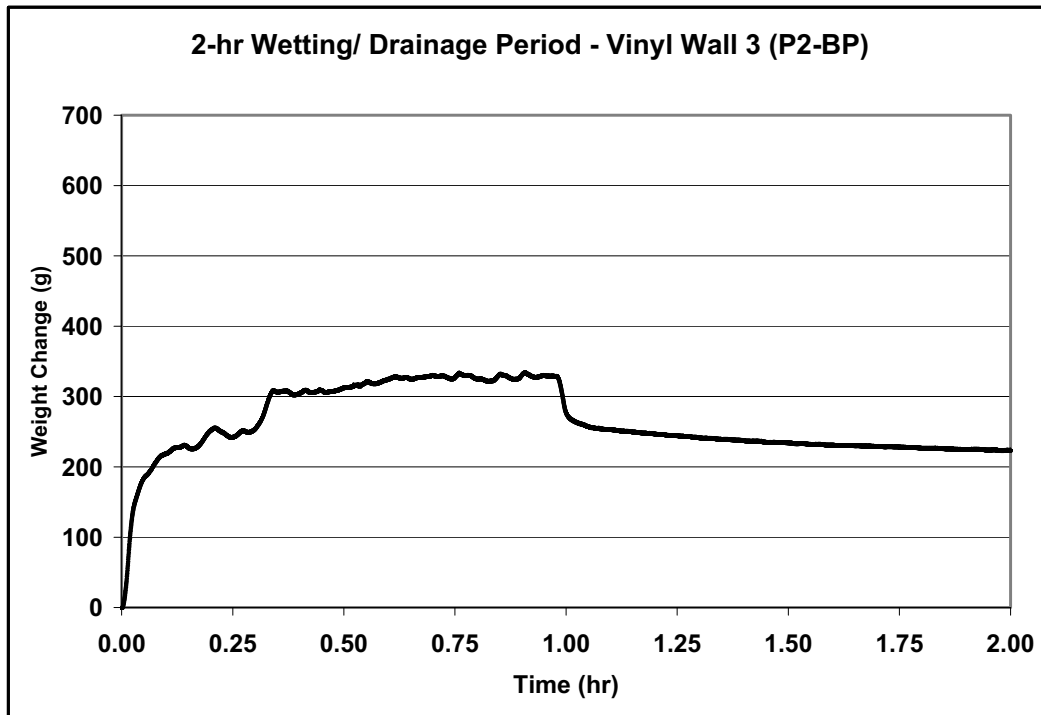




**Figure II-1** Drainage test on Wall 1 (P1-BP) showing the first 2-hr wetting/drainage period (top) and the total monitoring period of 50 hours, including the drying period (bottom).



**Figure II-2** Drainage test on Wall 2 (P2-SBPO) showing the first 2-hr wetting/drainage period (top) and the total monitoring period of 50 hours, including the drying period (bottom).



**Figure II-3** Drainage test on Wall 3 (P2-BP) showing the first 2-hr wetting/drainage period (top) and the total monitoring period of 50 hours, including the drying period (bottom).

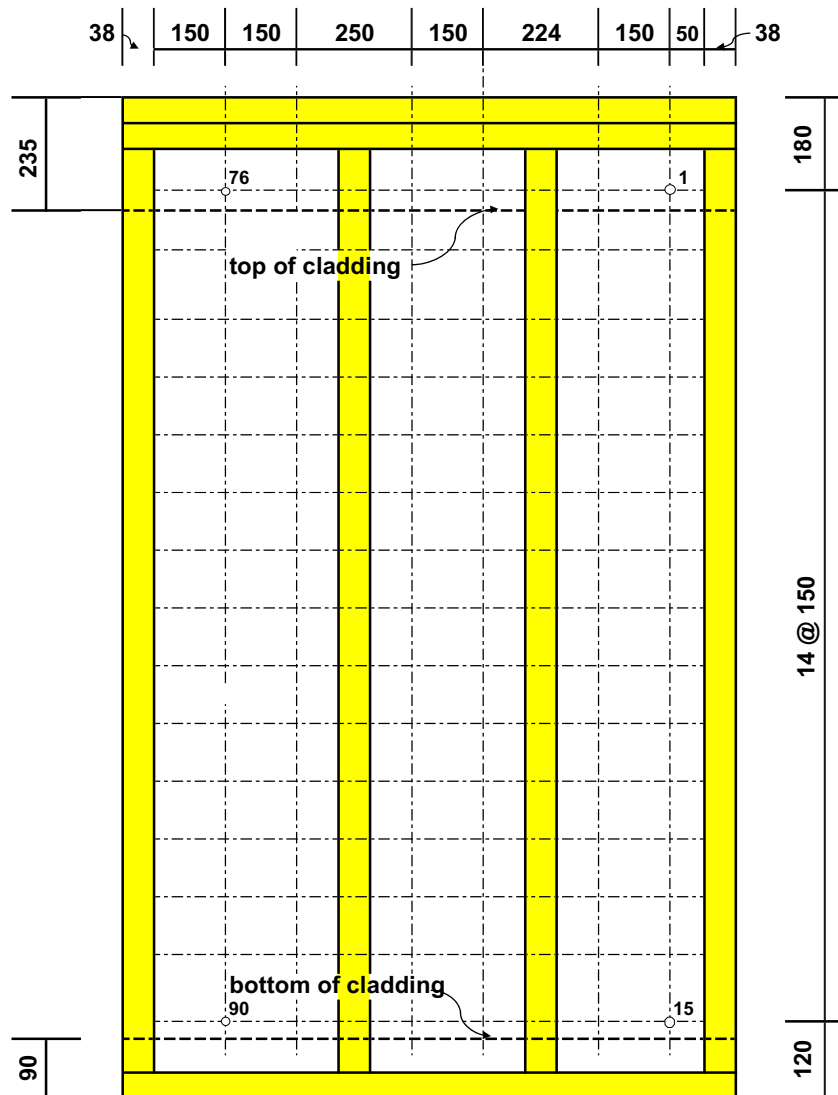
## APPENDIX IV

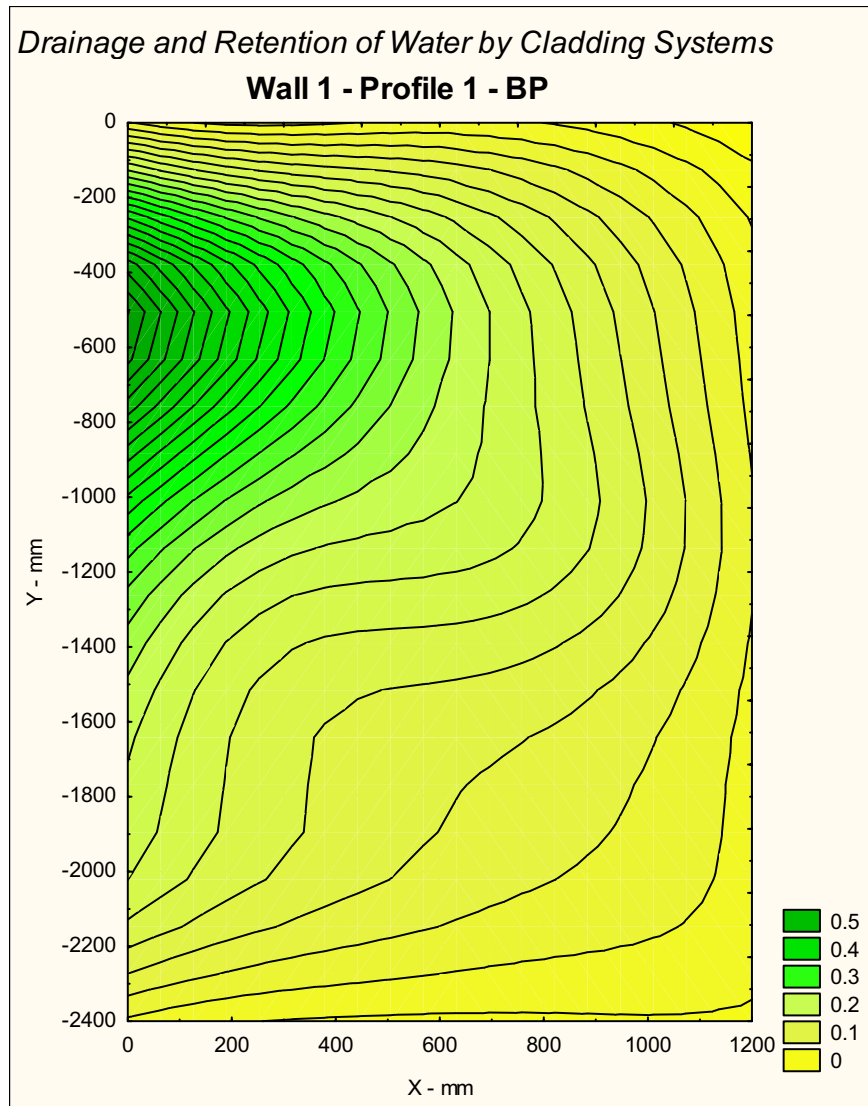
### Mapping of Moisture Content Differences for Vinyl Siding Test Walls

**Note:**

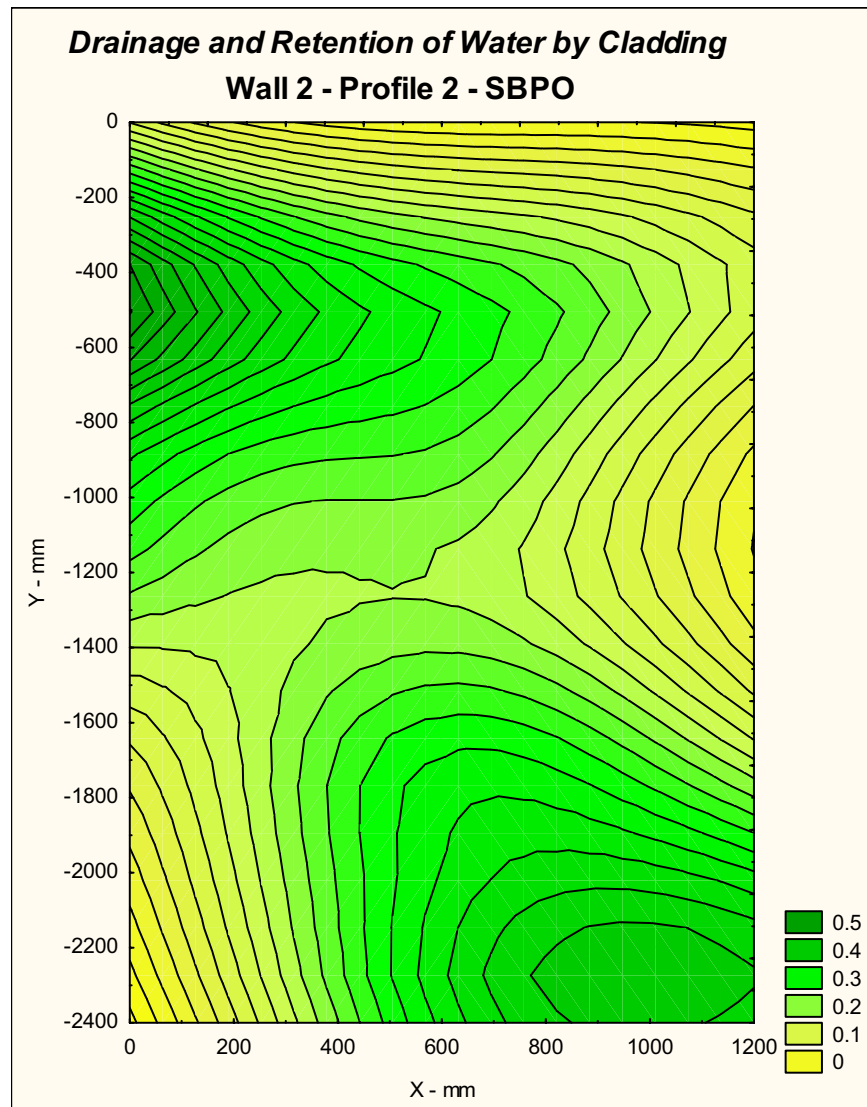
The actual size of the wall panels was 4 x 8 feet (1219 x 2438 mm). For the purpose of moisture mapping, it will be convenient to display the moisture for a 1200 x 2400 wall, with positioning of the cladding as built and defined in the individual test reports. The accuracy of placement of the capacitance moisture meter was not likely better than 2 mm and the grid line positions have been rounded to account for the slightly smaller SI wall compared with the actual wall size. Moisture difference readings for the top and bottom wall boundary have been assumed to be zero. The usefulness of the contour plots lies in their relative depiction of moisture concentration rather than the absolute numerical measure that the readings imply.

The figure below provides the dimensions used for establishing the grid for measurement and plotting.

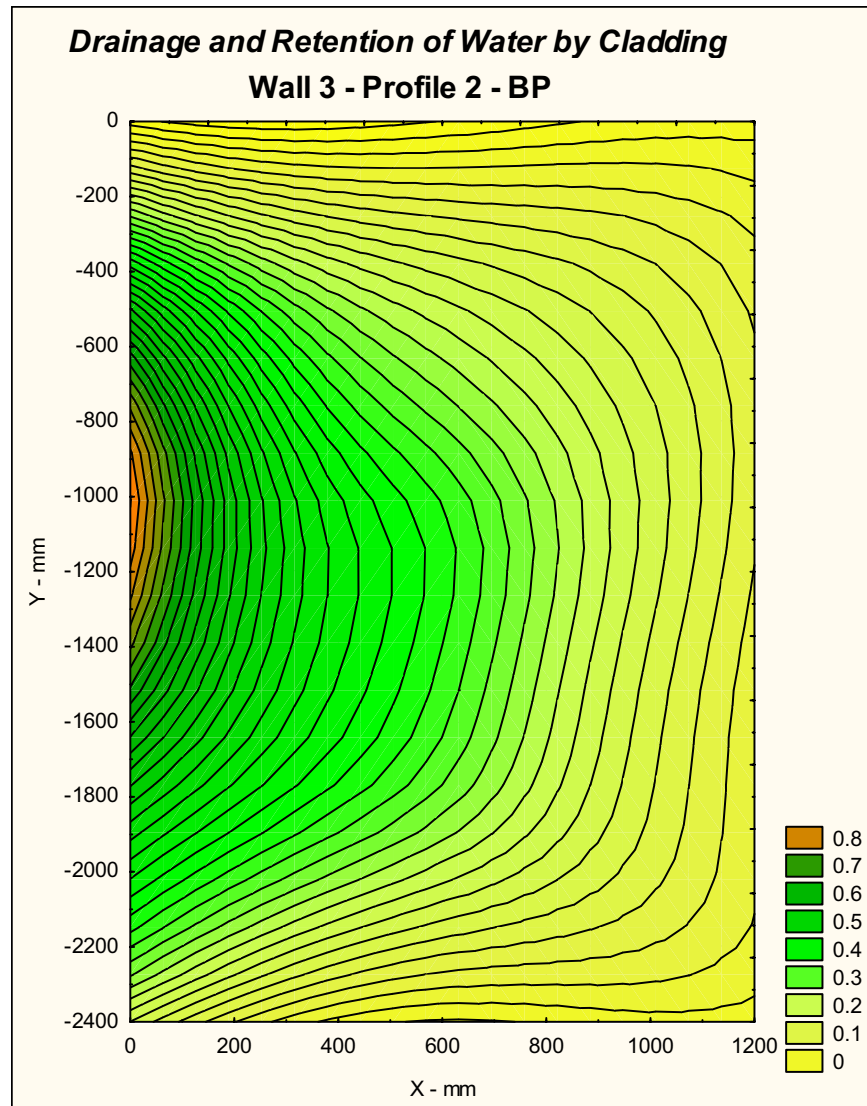




**Figure IV-1 Moisture Contours for Vinyl Siding Wall 1 (Profile #1 with Building Paper)**



**Figure IV-2 Moisture Contours for Vinyl Siding Wall 2 (Profile #2 having SBPO WRB)**



**Figure IV-3 Moisture Contours for Vinyl Siding Wall 3 (Profile #2 having Building Paper)**



## APPENDIX V

### Temperature and Relative Humidity Records

**Note:**

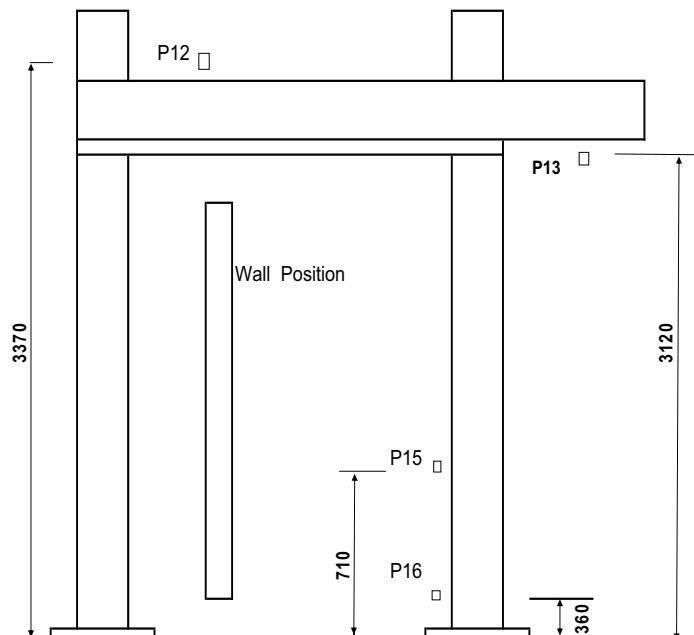
The plots shown in Appendix V for the Relative Humidity (RH) and Temperature (T) variations during the drainage tests have been arranged in the following way. The RH and T variations for the nominal 2-hr wetting drainage test are all shown first from Wall 1 to Wall 2 for sensor locations P1 to P4. This is followed by plots of the RH and T variations for the external sensors, P12, P13, P15 and P16 for this same time period. The 2-hr test period includes the time for tests on all three test walls conducted in turn which took up to 5 hours to do.

These plots are then followed by RH and T plots for the entire 2-hr plus 48-hr test period in the same order as for the earlier 2-hr plots. It is noted that recording for the 48-hr test period was not restarted until the morning of the next day when this omission was noted.

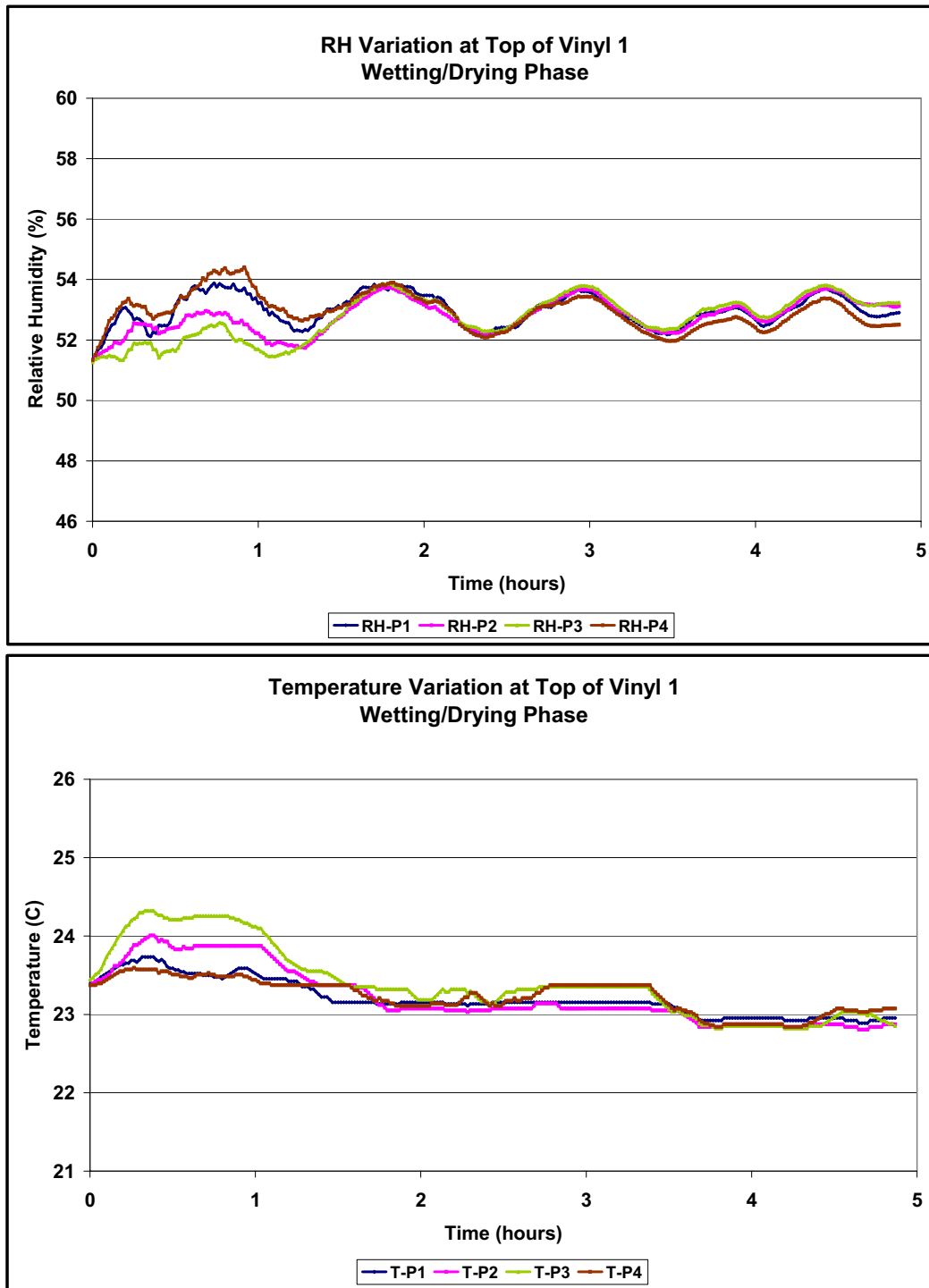
As a reminder as to the location of all sensor locations, the following two figures are repeated from an earlier report in the series (Part 2) on testing methodology. P1 to P4 are attached just above the top of the drainage cavity. P12 and P13 are just above and just below the laminated beam supporting the three test walls, P15 is at table top level, and P16 is located near the column shown at gutter height.



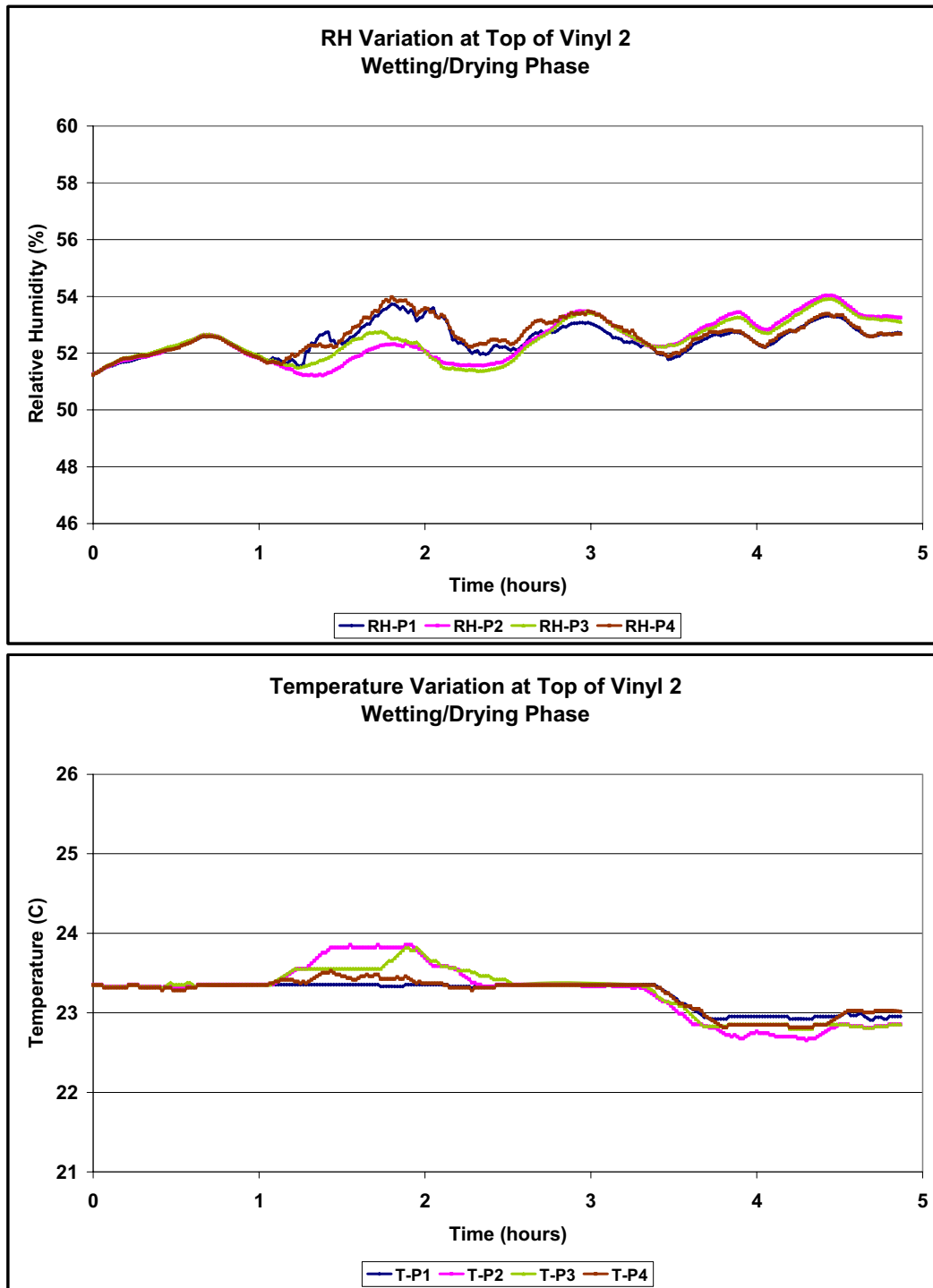
(a)



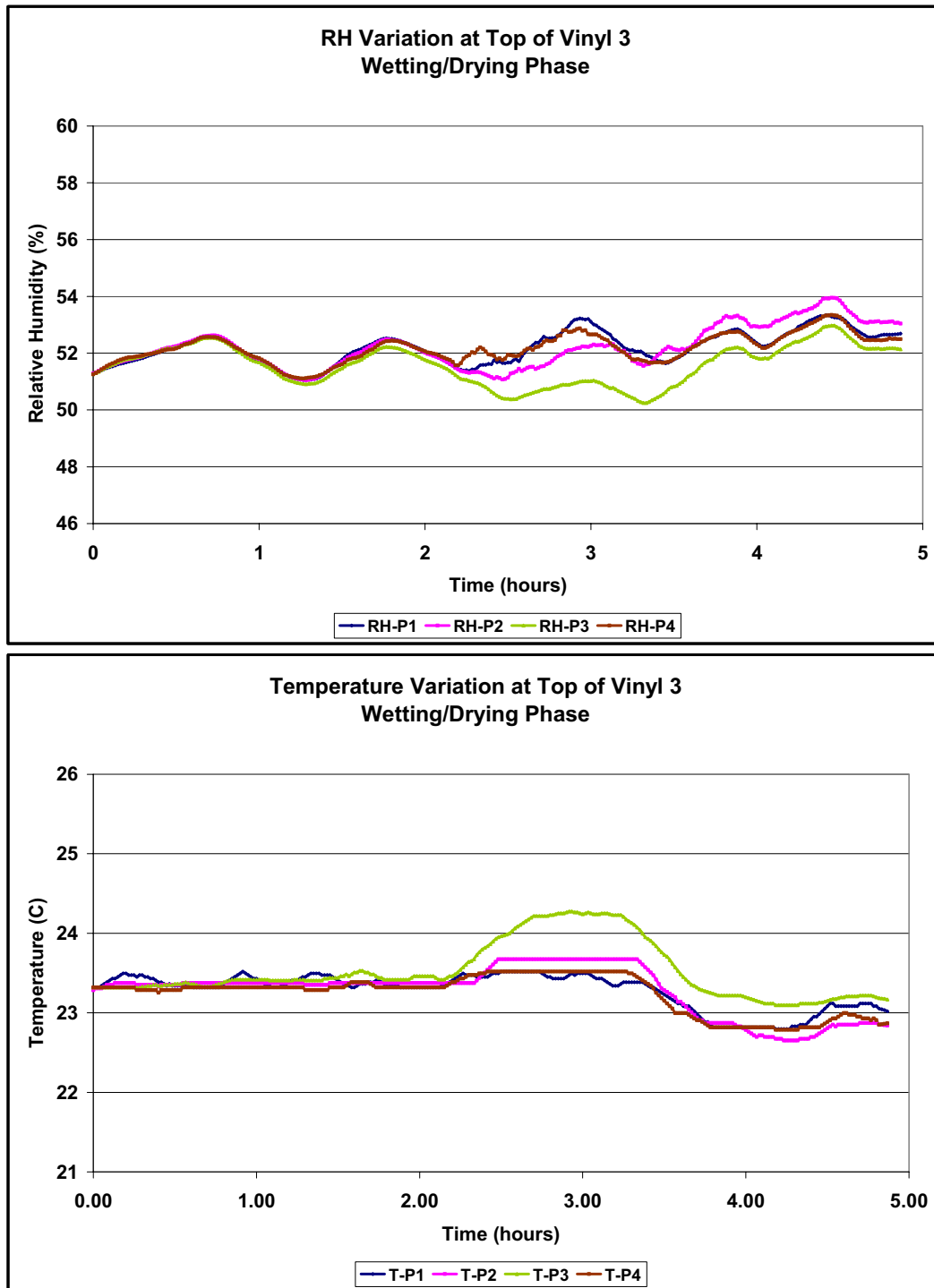
(b)



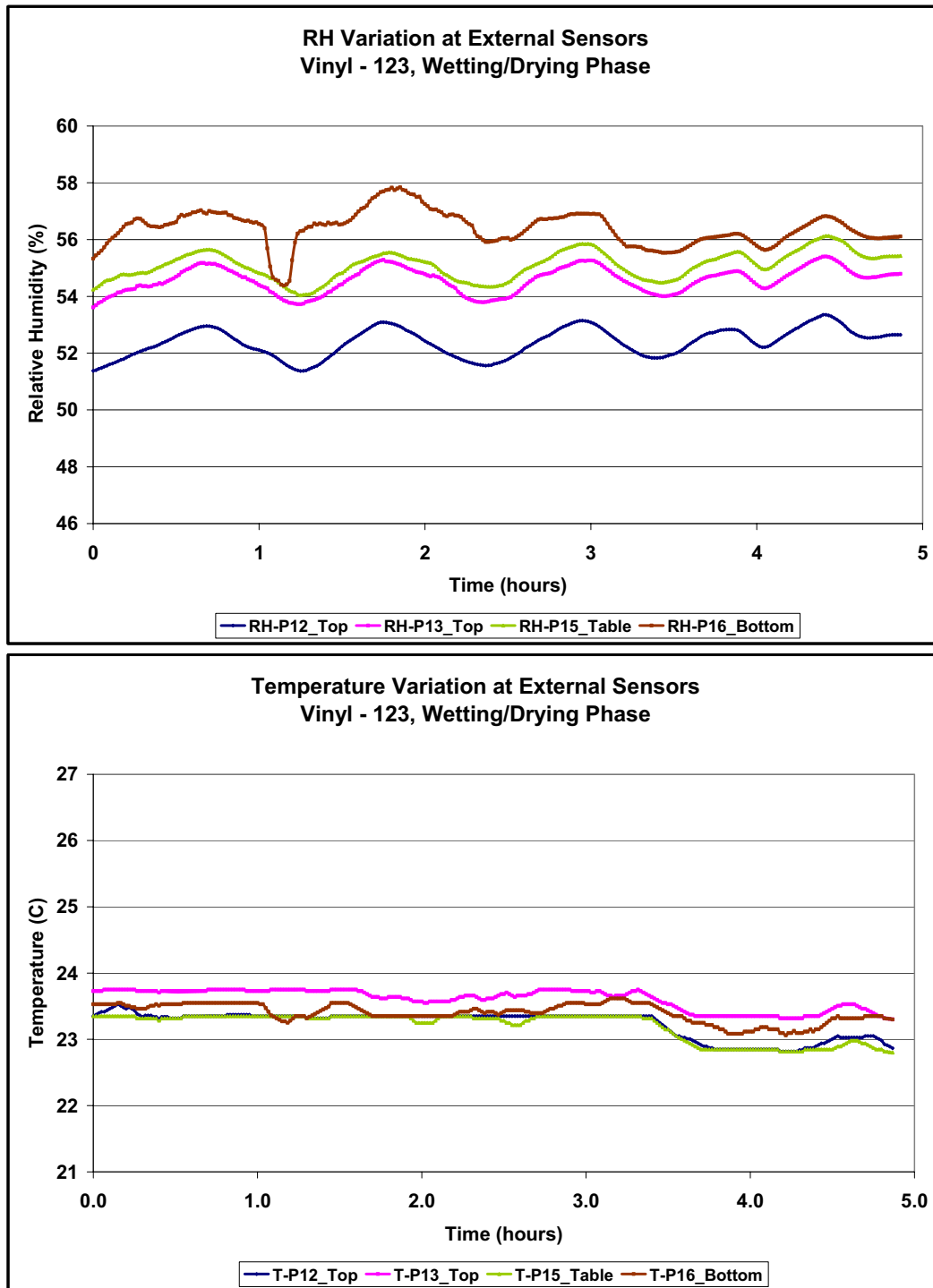
**Figure V-1** Relative humidity and temperature monitoring at the top of the drainage cavity during the wetting/drainage testing for Vinyl Wall 1 (Profile #1 and Building Paper).



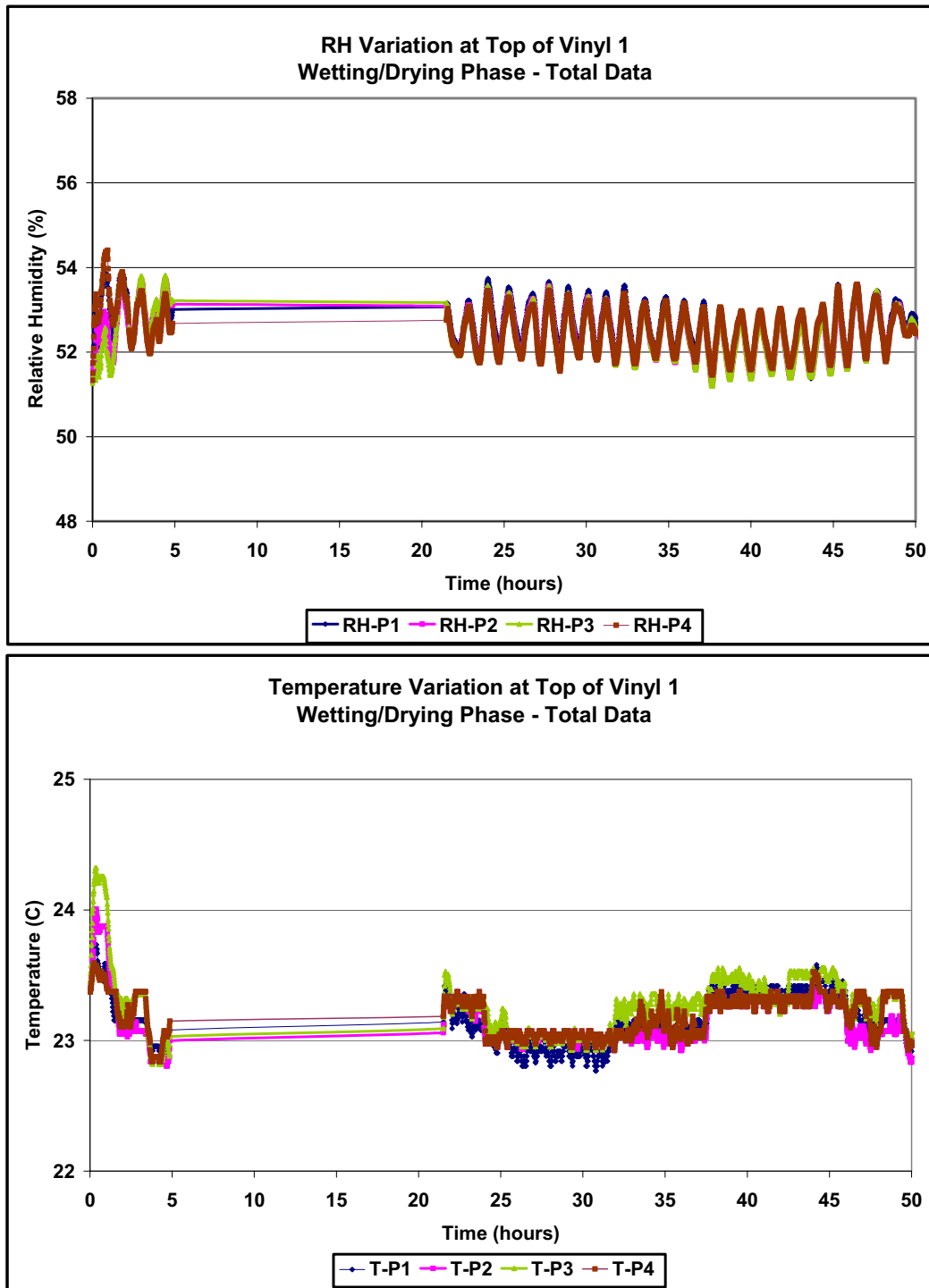
**Figure V-2** Relative humidity and temperature monitoring at the top of the drainage cavity during the wetting/drainage testing for Vinyl Wall 2 (Profile #2 and SBPO).



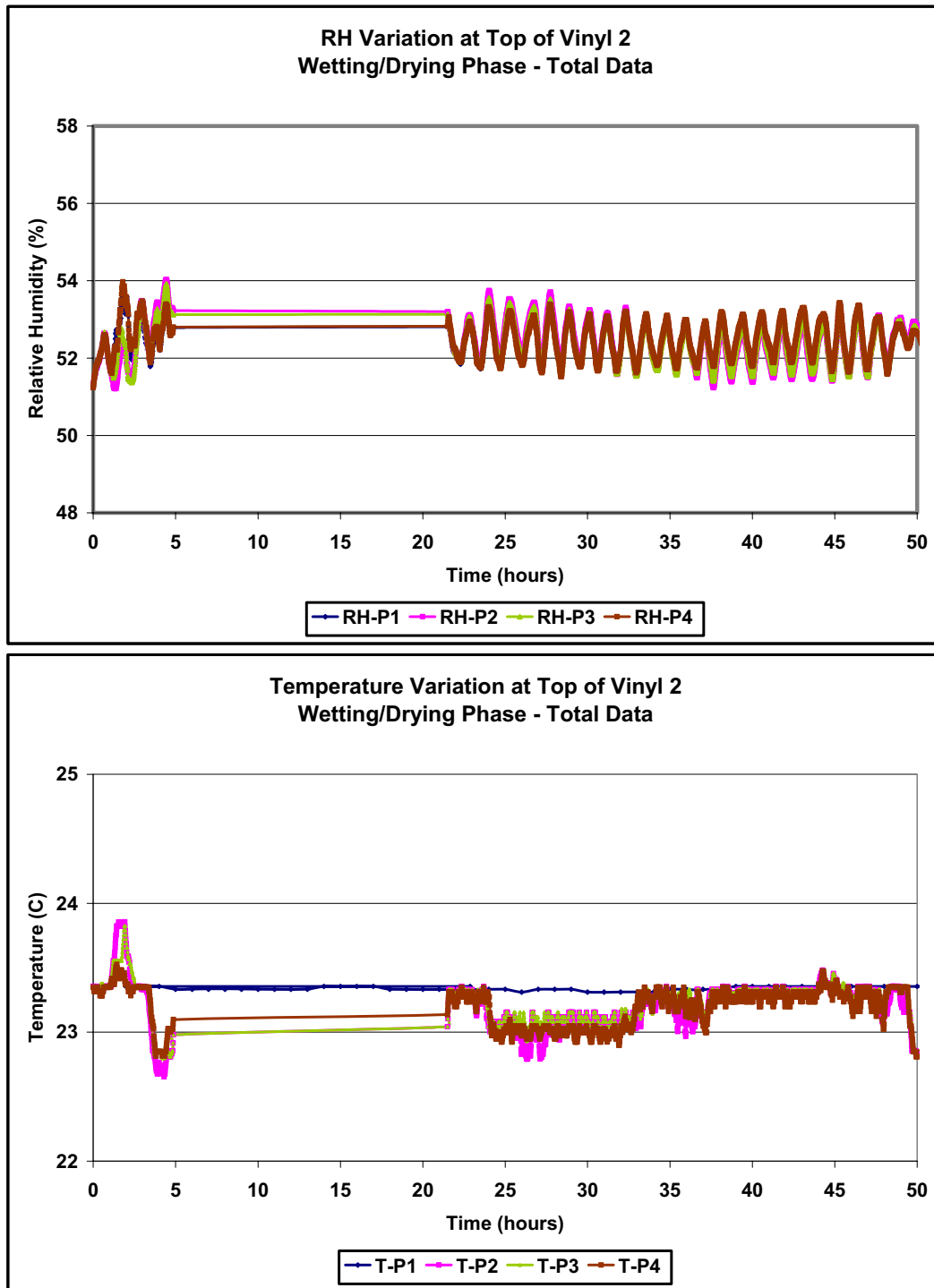
**Figure V-3** Relative humidity and temperature monitoring at the top of the drainage cavity during the wetting/drainage testing for Vinyl Wall 3 (Profile #2 and Building Paper).



**Figure V-4** Relative humidity and temperature monitoring of ambient conditions at different elevations around the test area during the wetting/drainage testing of Vinyl Walls 1, 2, and 3.

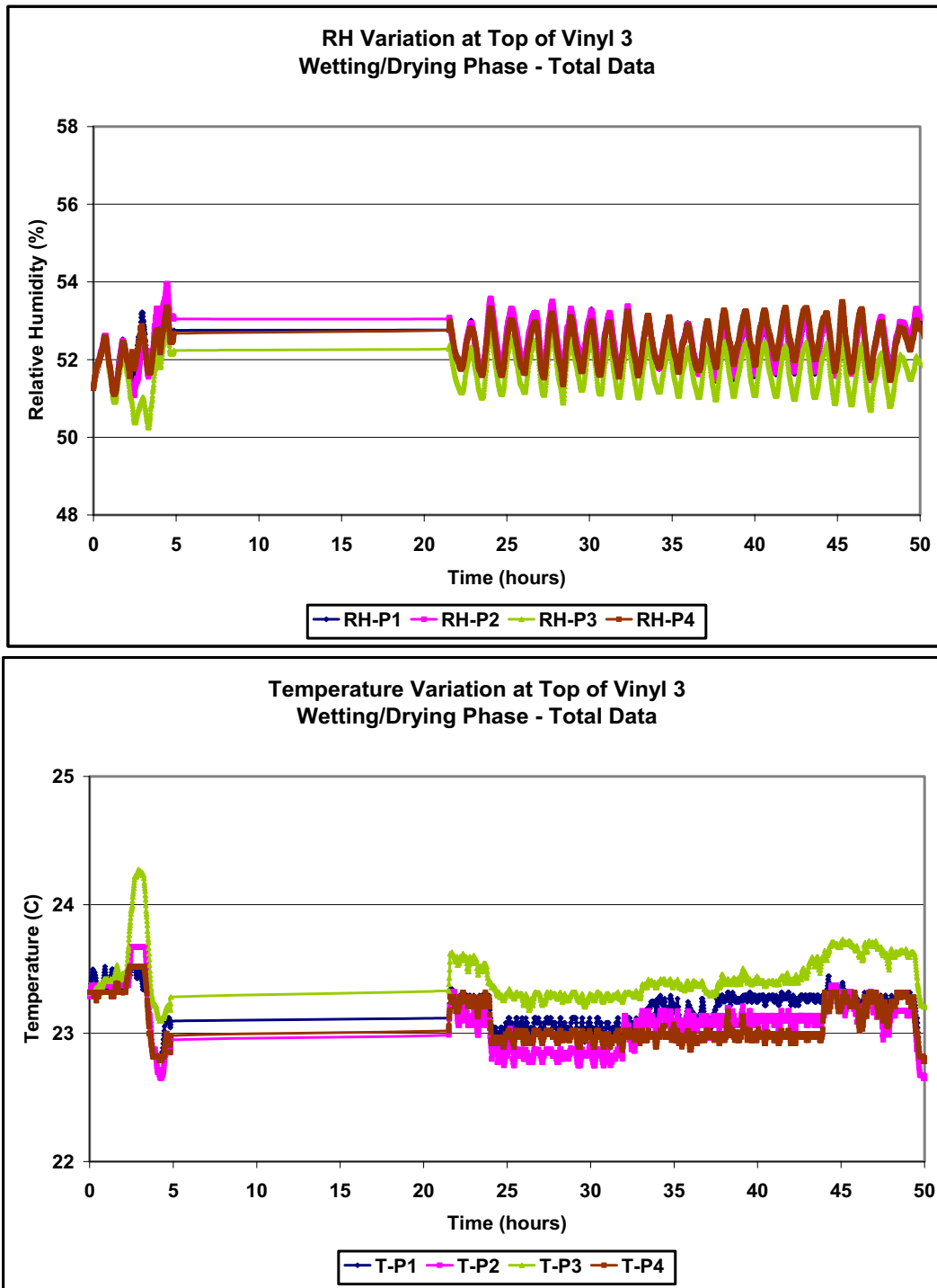


**Figure V-5** Relative humidity and temperature monitoring at the top of the drainage cavity over the whole test period including a 2-day drying period for Vinyl Wall 1 (Profile #1 and Building Paper). The data acquisition system was turned off by error for a period after the initial wetting/drainage testing was completed on the three vinyl siding walls being tested.

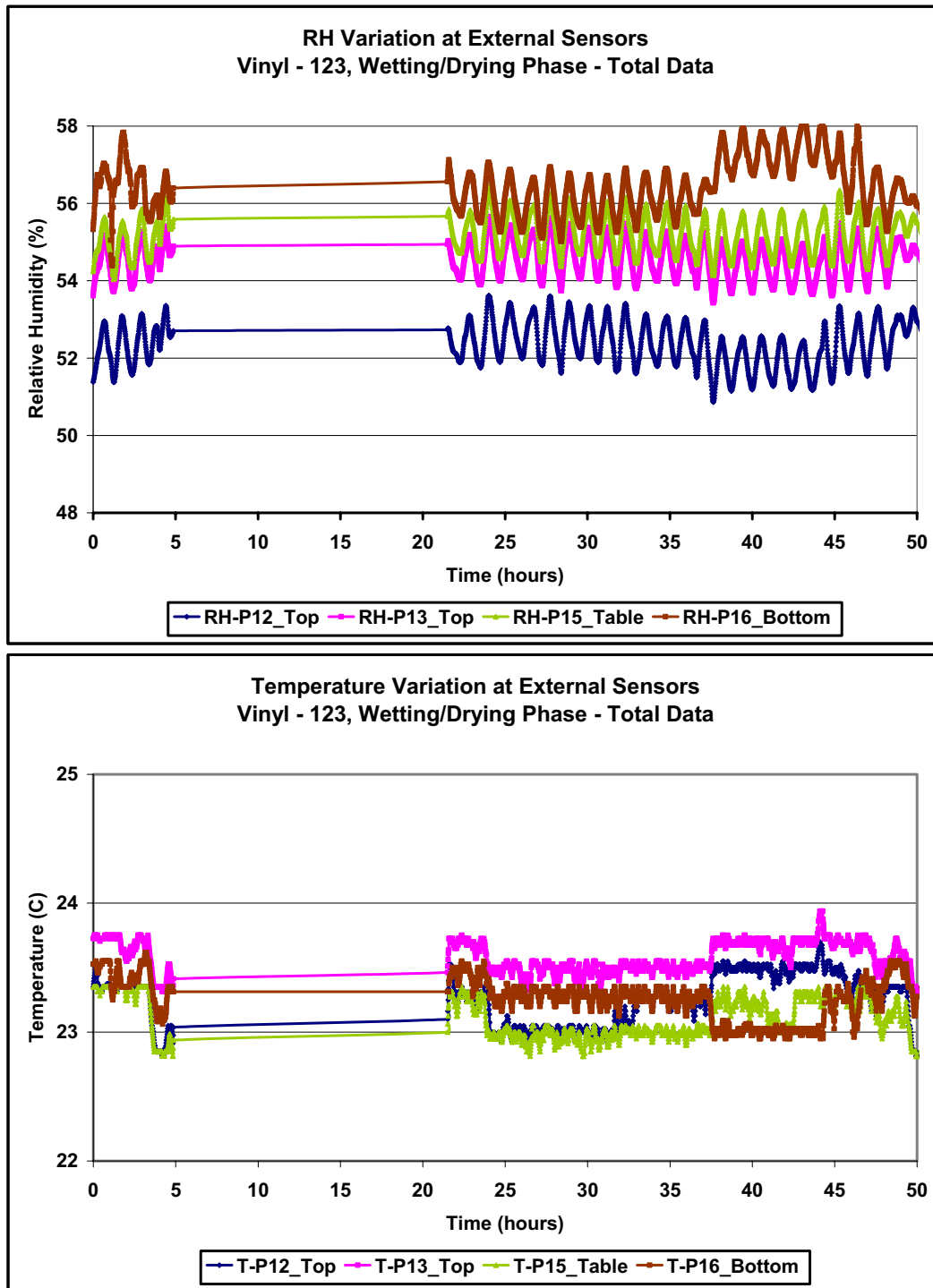


**Figure V-6** Relative humidity and temperature monitoring at the top of the drainage cavity over the whole test period including a 2-day drying period for Vinyl Wall 2 (Profile #2 and SBPO).





**Figure V-7** Relative humidity and temperature monitoring at the top of the drainage cavity over the whole test period including a 2-day drying period for Vinyl Wall 3 (Profile #2 and Building Paper).



**Figure V-4** Relative humidity and temperature monitoring of ambient conditions at different elevations around the test area during the wetting/drainage testing of Vinyl Walls 1, 2, and 3.