

RESEARCH REPORT



Drainage and Retention of Water by Cladding Systems

Part 7 – Air Tightness and Vapour Permeance of Joints in Siding Systems

DRAINAGE AND RETENTION OF WATER BY CLADDING SYSTEMS

Part 7 – Air Tightness and Vapour Permeance of Joints in Siding Systems

Presented to

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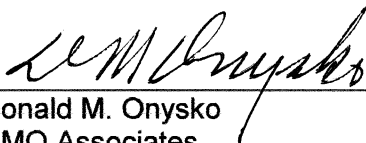
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SUMMARY

Air and vapour flow through siding joints are two of several mechanisms that enable these claddings to dissipate moisture that may collect behind them. Siding representing most of the siding products that were included in the drainage/drying studies at Forintek were shipped to Syracuse University where large specimens were fabricated to determine their air and vapour tightness. Three replicates of each type were fabricated for test. Only the wood siding samples were not tested as that shipment did not arrive at the laboratory.

The size of each sample assembled was 876 mm by 876 mm (34.5 by 34.5 inches) with a 2x4 lumber test frame with studs at approximately 406 mm (16 inches on centers). Two vinyl siding profiles, two hardboard profiles, and one fibre-cement board siding profile were represented in this test series.

Special aluminium pans were fabricated to act as chambers into which each specimen was mounted and sealed. The air flow characteristics of the joints were obtained first. This was followed by conducting ASTM E96-00 wet-cup tests to obtain their water vapour transmission rates (WVT). For this test the aluminium pans were filled with water to a depth which allowed the total weight of the assembly to fall within the limitations of the accurate weighing scale employed.

While the air pressure tests could be done quickly, the WVT tests took very long to do because only three tests could be done at a time in the special chamber that was built to establish steady state test conditions and the rate of dissipation was very low, especially for the vinyl siding specimens.

On completion of the analyses, it was found that there was a correlation between the unit joint air flow characteristic (at 1 Pa) and the unit joint vapour flow (at 1 Pa vapour pressure differential). While the strength of the correlation was not strong, likely due to the difficulty in performing the WVT tests accurately, this does suggest that the arduous test could be avoided in the future if this correlation were better established.

RÉSUMÉ

L'écoulement d'air et de vapeur par les joints de bardage sont deux des nombreux phénomènes qui facilitent la dissipation de l'humidité qui peut s'accumuler derrière la façade. Des bardages représentatifs de la plupart des produits de parement qui ont fait l'objet des études de drainage/séchage à Forintek ont été expédiés à la Syracuse Université, où de grands spécimens ont été fabriqués afin de déterminer leur étanchéité à l'air et à la vapeur. Trois échantillons de chaque type ont été répliqués pour l'essai. Seuls les échantillons de bardage de bois n'ont pas été mis à l'essai étant donné que l'expédition n'est pas arrivée au laboratoire de l'université.

La grandeur de chaque échantillon assemblé était de 876 mm sur 876 mm (34,5 sur 34,5 pouces) avec un cadre d'essai en bois d'œuvre de 2 x 4 avec des poteaux à entraxes d'environ 406 mm (16 pouces). Deux profils de bardage de vinyle, deux profils de panneau dur et un profil de bardage de fibrociment ont été représentés dans cette série d'essais.

Des plateaux spéciaux en aluminium ont été fabriqués et servaient de « chambre » dans laquelle chaque spécimen était monté et scellé. Les caractéristiques d'écoulement d'air des joints ont été analysées en premier lieu. Ensuite des essais à la « tasse mouillée » conformes à la norme ASTM E96-00 ont permis d'évaluer les vitesses de transmission de vapeur d'eau (TVE). Dans cet essai, les plateaux d'aluminium ont été remplis d'eau jusqu'à une profondeur qui permettait au poids total du mur de correspondre aux limites de la balance qui était employée.

Les essais de pression d'air ont pu être effectués rapidement, mais les essais de TVE ont pris beaucoup plus de temps parce que trois essais seulement pouvaient être entrepris à la fois dans la « chambre » spéciale, conçue pour établir des conditions d'essai à l'état constant, et la vitesse de dissipation était très faible, particulièrement dans le cas des spécimens de bardage de vinyle.

À la fin des analyses, on a trouvé une corrélation entre la caractéristique d'écoulement d'air dans les joints de murs (à 1 Pa) et l'écoulement de la vapeur d'eau au même endroit (à un différentiel de pression de vapeur de 1 Pa). Même si les coefficients de corrélation n'étaient pas probants, vraisemblablement à cause de la difficulté d'exécution des essais de TVE de manière précise, ceci suggère que la difficulté pourrait être aplanie à l'avenir si on établissait mieux cette corrélation dans l'essai.



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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 air flow testing and water vapour transmission tests of joints in large siding samples constructed for this purpose.

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 7 - Air Tightness and Vapour Permeance of Joints in Siding Systems

1 INTRODUCTION

This report concentrates on testing of air tightness and vapour permeability of siding systems represented in the wetting/drainage/drying tests of large wall specimens. Two vinyl siding profiles, two hardboard siding profiles, and one fibre-cement board siding type were employed in these supplementary tests.

The earlier reports in this project addressed the test methodology for wetting and drainage of cladding systems and the purpose and goals of the test program. The third and fourth reports examined the drainage/retention and drying performance of six (6) EIFS walls and three (3) vinyl siding walls respectively. The fifth report included similar testing of wood siding, hardboard siding and fibre-cement siding systems. The sixth report reported on air flow measurement testing of the test walls having distinct drainage cavities. The current report addresses the air and vapour permeability testing of some siding systems noted above using facilities at Syracuse University. The specimens were fabricated there using siding sent to Syracuse from Forintek Canada Corp. The methodology used for the tests reported herein is described in detail because the conduct of tests on large samples of this size, while following the principles of small specimen testing, required extra care and variance from standard tests.

In the following report we will refer to the product designations by product number tested, and as defined in earlier reports. However, they will be defined by source at the outset. It should not be construed that there is or is not acceptance of the performance of these materials in the applications employed. These materials were chosen for this project to provide a range of performance for the drainage tests mainly because of their type. Furthermore, the information provided herein is unique to the test samples built for the purpose. This work provides order-of-magnitude information that may be useful in a more general way, particularly for computer modeling.

The performance of systems undergoing drying of retained moisture under isothermal conditions depends on the different moisture transport pathways that are available for water held in the drainage cavity, stored as free water in joints or absorbed into wetted surfaces. While some systems could dry primarily by ventilation other siding systems that were applied directly to base walls had limited means for dissipation of moisture retained behind the siding and in joints. The purpose of the research in this report is to assess and provide the results for two of several avenues of moisture dissipation that are possible through these types of siding systems – air exchange through joints and vapour flow through those same joints.

This part of the project focused on laboratory characterization of air flow and moisture transport occurring through the laps in different types of siding assemblies. The air flow characteristics were quantified using the ASTM D737-96 “Standard Test Method for Air Permeance of Building Materials” [1]. Moisture transport characteristics were quantified based on the wet cup test described in the ASTM E96-00 “Standard Test Method for Water Vapour Transmission of Materials” (WVT) [2].

2 TEST SPECIMEN CONSTRUCTION

2.1 Materials

Siding materials for the air leakage and vapour permeability tests were provided by Forintek Canada Corp. and shipped to Syracuse University. These represented some of the materials employed for studies of drainage behind cladding. Due to some communication difficulties in Syracuse, the wood siding samples shipped from Forintek were not delivered to the lab and hence, were not included in the test program. Detailed information about each type of siding may be obtained on the Internet; the links to the appropriate sites are provided in Appendix I of Part 5 in this report series.

Vinyl Siding – Profile details

Two different vinyl siding profiles were used in this project. They were both provided 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).

Hardboard siding – Profiles details

Hardboard siding used for this study was manufactured by Canexel. Two (2) profiles were selected. The first was a 9-inch fastening-spline system (Ced'R-Vue™) and the second was a 12-inch lap siding with an interlocking system (Ridgewood D-5™). In Part 5, they have been referred to as H1 and H2 respectively.

Fibre cement siding – Profiles details




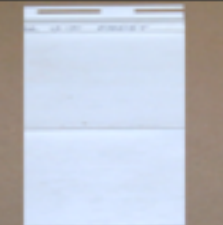














Fibre cement siding used for this study was manufactured by James Hardie North America. Only one profile was selected for this project. The profile in question was a 6¼-inch Hardiplank® lap siding (Colorplus Select Cedarmill®). Installation instructions recommended by the manufacturer are provided on the manufacturer's internet web site. In Part 5, this siding product has been referred to as FC.

2.2 Designation of Types of Siding Materials Tested

The test program included air flow and water vapour transmission (WVT) tests performed on three types of siding materials. The three different types of siding materials included: two types of vinyl siding, two types of hardboard siding, and one type of fibre-cement board siding for a total of 5 product types. Three replicate specimens were fabricated for each type for a total of 15 specimens. The water vapour transmission tests (WVT) were also performed on the same 3 replicate specimens for each type when the air flow tests were completed.

Table 1 shows the panel profiles of different siding products tested. For the purposes of this report, these siding products have been designated as siding “types” from 1-5. Also, the designations used for these materials in the other reports in this series they have been included for continuity.

Table 1 Panel profiles of different siding products tested.

Test number	Type of siding tested	Siding profiles			Siding elevations
		Back	Side	Front	
1	Vinyl siding (type 1)				
2	Vinyl siding (type 2)				
3	Wood based siding (type 3)				
4	Wood based siding (type 4)				
5	Cement board siding (type 5)				

The first 4 types have very specific joining methods. The vinyl siding products have interlocking joints which allow them to provide an effective rain shedding capability. The hardboard siding type either had a spline or a designed lap to facilitate assembly. The fibre-cement siding boards had a uniform cross section and required more effort to install. This was because the laps had to be measured and aligned. The fibre-cement boards were predrilled during installation, and care was taken to avoid chipping and breakage at the corners of the panels as this product was somewhat brittle.

2.3 Design and Fabrication of Specimens

The siding panels were delivered to Syracuse University on June 15, 2005. The boards were delivered on a palette, stacked, and wrapped with plastic. Prior to specimen fabrication, the delivered materials were stored for a period of at least two weeks in room conditions at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 5\%$ RH. The size of the test assemblies was big enough to provide representative test results that might be expected in the field. Yet, they were small enough to be handled by two people. Typically, air permeability tests of construction materials are conducted with specimens measuring approximately 3 ft by 3 ft. The specimens for this test program were fabricated to 876 mm by 876 mm (34.5 by 34.5 inches). Enough space was provided for the liquid seal, i.e., a hot wax seal was applied between the pan and the frame of the specimen (Figure 1).

Square frames were constructed from 2 x 4 lumber as shown in Figure 2. This frame simulated studs at about 16-inch spacing. The components of the frame were planed and fastened together using 4-inch long epoxy coated steel deck screws. The frames were painted with three coats of low permeability paint. The interior sides of the frame exposed to the pan environment were additionally treated with 3 coats of polyurethane varnish to further increase resistance to water vapour absorption into the wood frame. The siding panels were pre-cut to 32 inch lengths and were lapped and mounted on the wooden frames. Each vinyl siding panel was nailed at the top to the edge of the frame using 1.5-inch long galvanized roofing nails having a 5/16-inch diameter heads. The hardboard siding and the fibre-cement board siding were fastened to their respective frames using 3-inch long finishing nails. The fibre-cement boards were predrilled with a 1/16-inch diameter bit to prevent splitting and cracking during nailing.

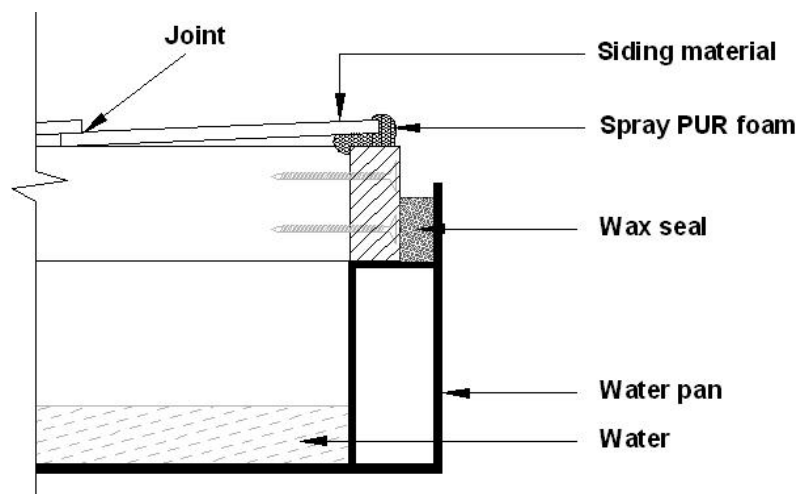


Figure 1 Cross section of the pan with the hot wax seal.

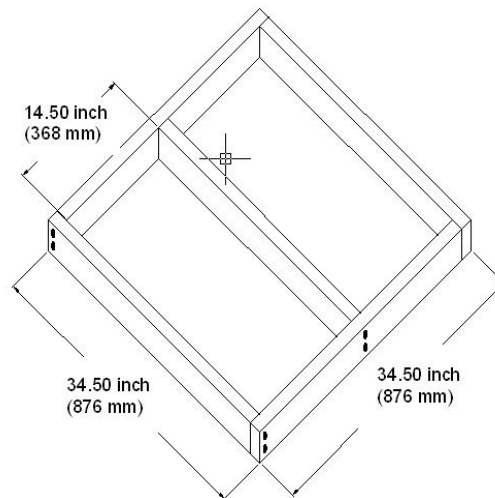


Figure 2 Wood frames constructed for mounting siding.

To impart an air tight seal for the siding at the perimeter of the boards, high density closed cell spray polyurethane foam was applied. The foam was applied in two passes on opposite sides of the frame to ensure that lateral leakage at the perimeter of the frame would not occur (Figure 3 and 4).

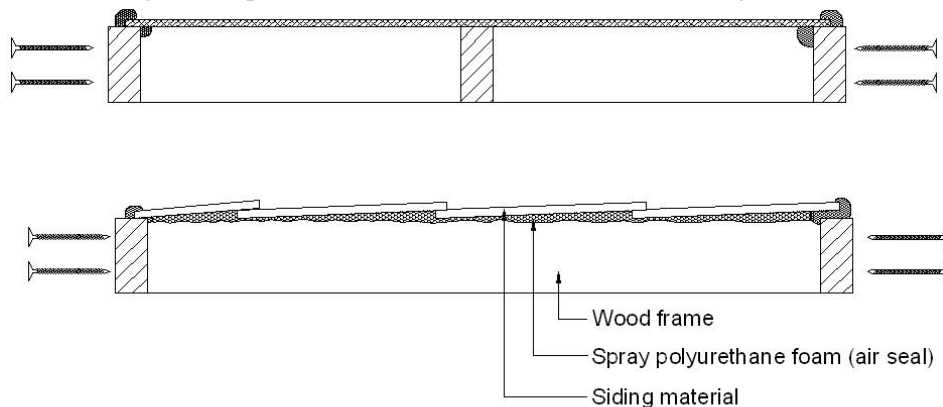


Figure 3 Cross section detail of the siding board/wood frame interface with sprayed in place polyurethane to impart air tightness around the perimeter of the assembly.

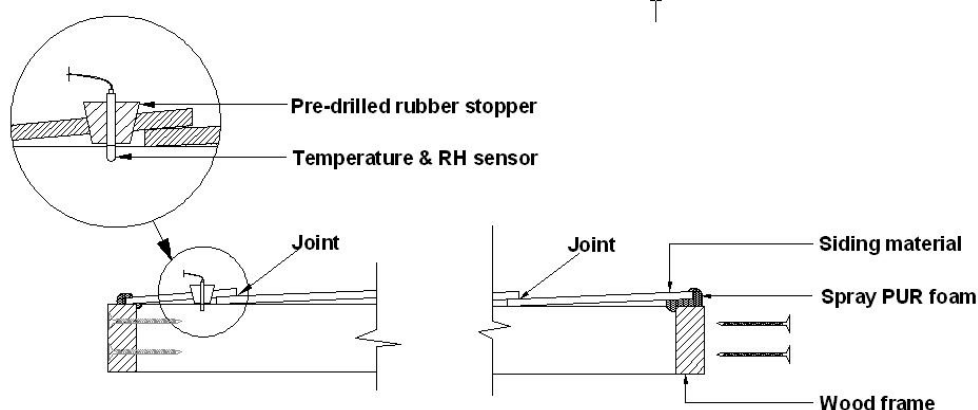


Figure 4 Cross sections through siding specimen showing placement of temperature and RH sensors.

Appendix II includes a detailed description of the specimen fabrication sequence.

3 AIR FLOW TESTING OF SIDING JOINTS

The following sections describe the air flow set-up, the experimental protocol and data analysis.

3.1 Experimental set-up

The air flow (permeability) test set-up consisted of an aluminium test pan, flow meters connected inline to the pan and to the laboratory's compressed air supply, and differential pressure gauges. Figure 5 shows a schematic representation of the system with a specimen mounted in the test pan, in-line flow meters, and connection to the differential pressure gauges.

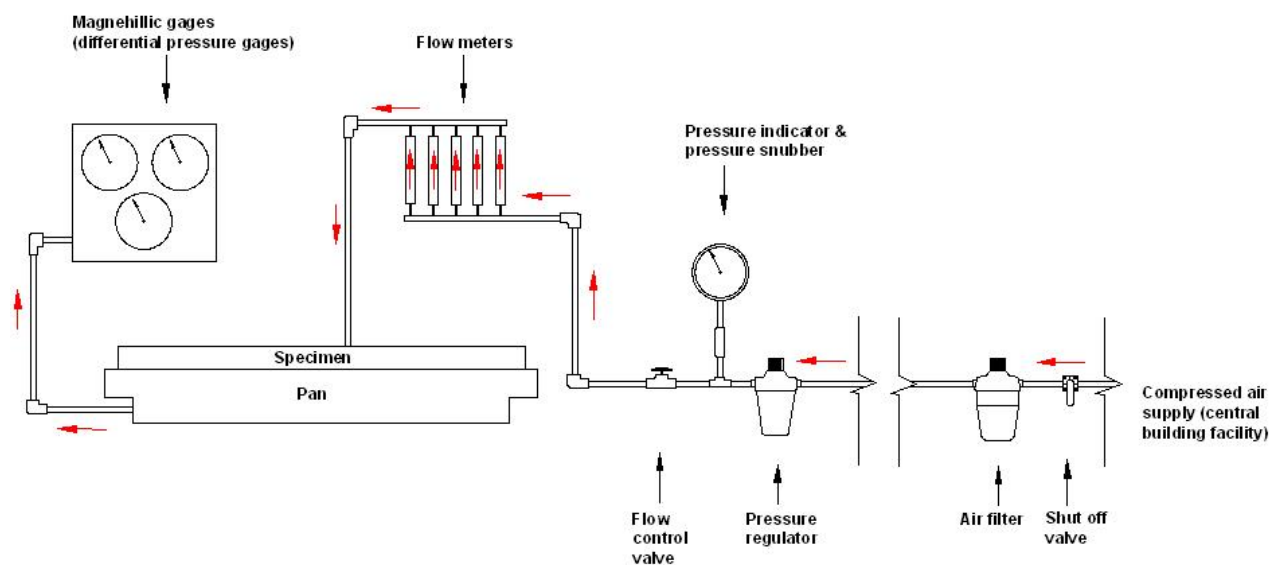


Figure 5 Schematic of the air permeability test set-up.

The square pan was constructed from a 1/16-inch thick T6061 aluminium sheet stock, and measured 36 inches in length, 36 inches in width, and 8 inches in height. The pan had a 2-inch ledge, which provided support for the specimen. The pan also had a 2-inch high rim to form a joint for the hot wax seal. Two 2-inch wide flanges were welded to the bottom of the pan to function as baffles to restrict water from splashing the underside of the siding vinyl panels when the pan was used for the vapour transmission tests.

A central manifold was built out of a 1.5 inch diameter acrylic cylinder. Six fittings from the manifold were connected via Tygon tubing to the six air distribution outlets inside the pan (Figures 6 and 7). These outlets were included to provide for a more uniform delivery of air to the interior of the pan. Two additional manifolds 28-inch long were fabricated using 0.5-inch copper pipe. Holes measuring 1/8 inch in diameter were drilled inline at an equidistant spacing of 1.5 inches o.c. These openings served to equalize the pressure inside the copper pipes. The two copper pipes were connected via T-shaped connectors to an analog differential pressure gage (Dwyer Magnehillic Gage) with a range between 0 to 0.25 inches of water (approximately 0 to 67.5 Pa). Mounted on the set-up were two additional differential pressure gauges with higher pressure ranges between 0 to 0.5 inch and 0 to 1 inch of water head respectively corresponding to a pressure ranges between 0 to 125 Pa, and 0 to 250 Pa.



Figure 6 *Location of the manifold and the distributed nozzles*

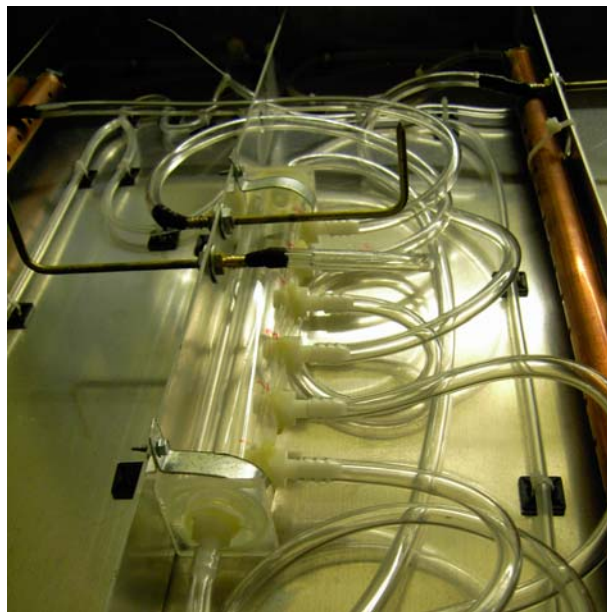


Figure 7 *Close-up view of the airflow nozzle*

3.2 Air flow Test Protocol

The fabricated specimens were placed on the ledge of the pan. The specimen was centered in the pan to provide a uniform spacing between the rim of the pan and the specimen. A hot wax seal was prepared by melting microcrystalline and refined paraffin wax in a 3:2 ratio by mass. The specimen frame was clamped at the edges to the pan and wax was poured in the space to create a 0.5 inch deep wax seal. The clamps were removed when the wax cooled and set. Tubing from the air supply manifold and the differential pressure gages was connected to the pan.

The differential pressure gages were adjusted so that they indicated zero and the set-up was prepared for testing. With the pressure regulator on the air supply manifold initially in the off position, the shut off valve was switched to the on position. The valve on the regulator was slowly opened and air began to flow through the system and into the pan. The valve was locked when the air pressure reached a required level. The air flow rates and differential pressures were recorded when they stabilized. This was repeated in steps of 0.05 inches of water head to acquire sufficient data points to describe the air permeability function of each assembly.

Some siding types were inherently leakier than others. To stay within the range of the flow meters available it was necessary to reduce the flow for some siding types by blocking flow from one or more joints. One out of three joints for type 4 siding and three out of 5 joints for type 5 siding were blocked with caulking. The caulking was left in place for the vapour transmission testing. All results reported in the following section have been normalized per meter of joint assuming that there was no unintended leakage from each assembly.

3.3 Air Flow Test Results

These tests provide the air flow characteristics of siding joints. The differential pressure was assigned to the Y-axis and the resulting flow was assigned to the X-axis for the plots shown with their corresponding power fit equations. Subsequent analysis will provide the coefficients for the inverse relationships as well. The results for three assemblies of each type are plotted in each of Figures 8 through 12 that follow.

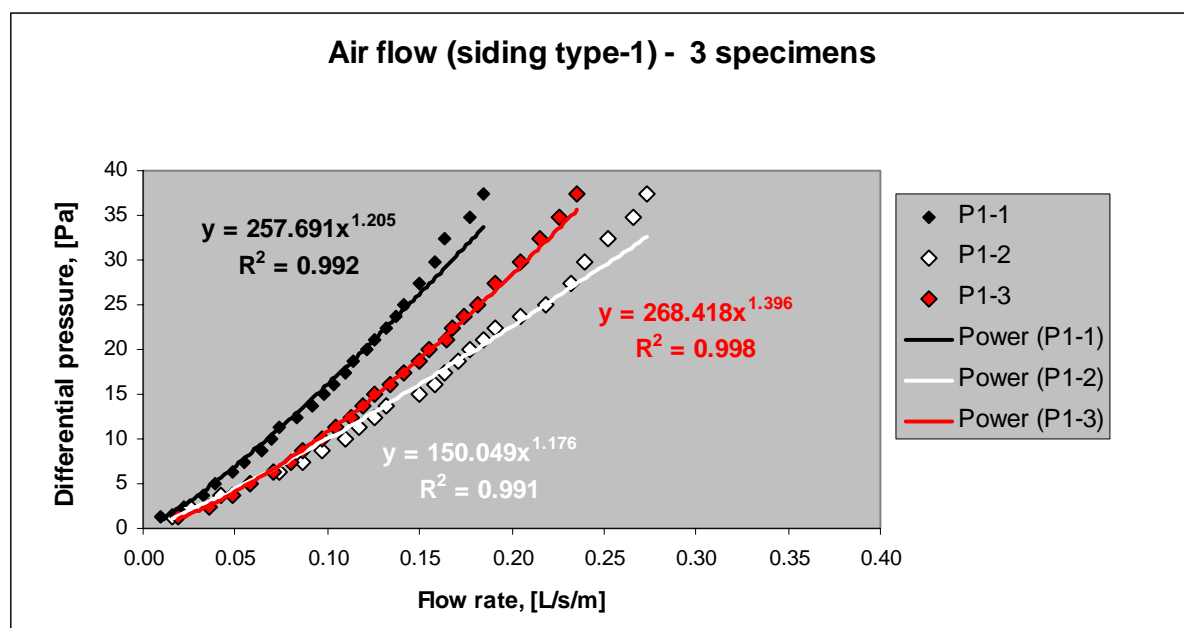


Figure 8 Air flow plots for product 1 siding (Vinyl - Profile #1).

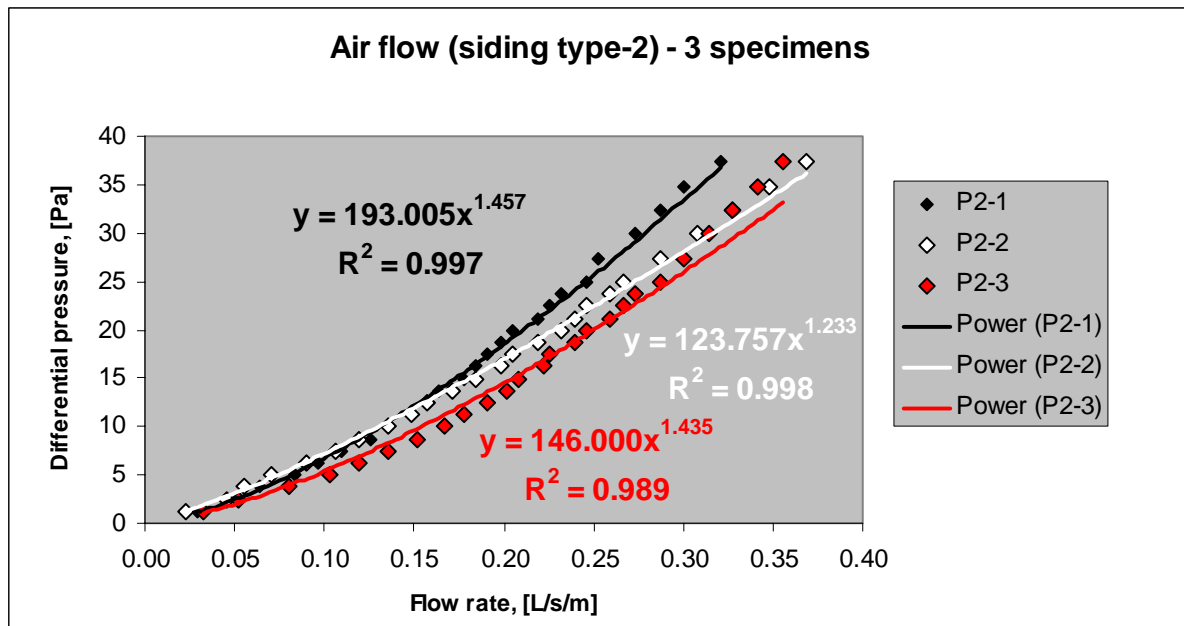


Figure 9 Air flow plots for product 2 siding (Vinyl - Profile #2).

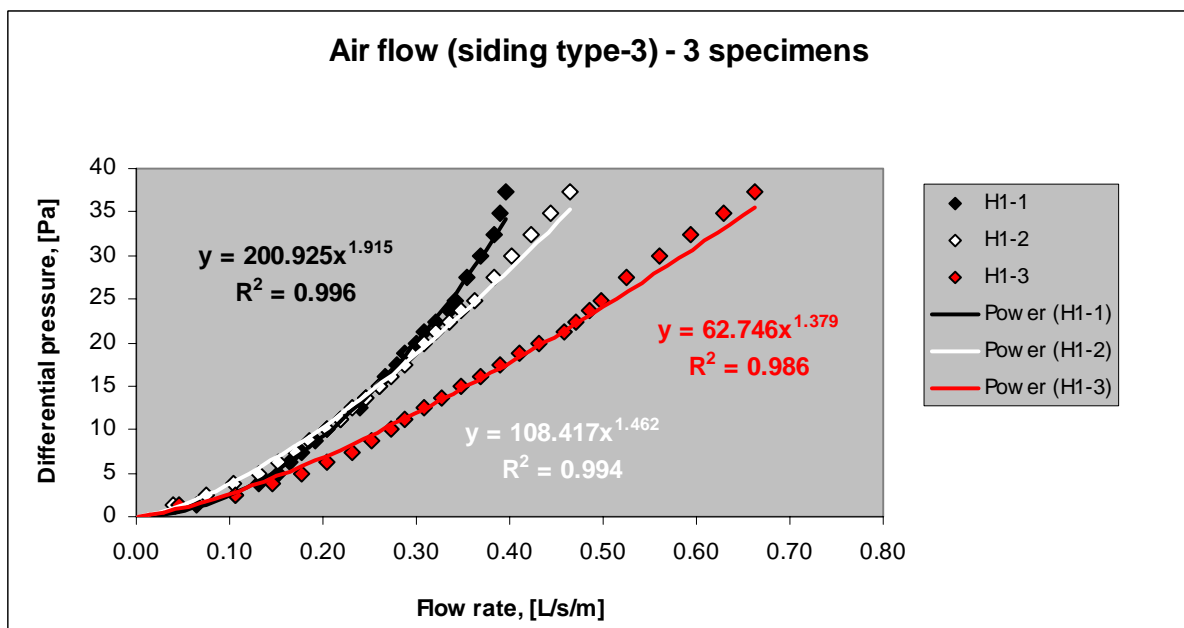


Figure 10 Air flow plots for product 3 siding (Hardboard profile H1).

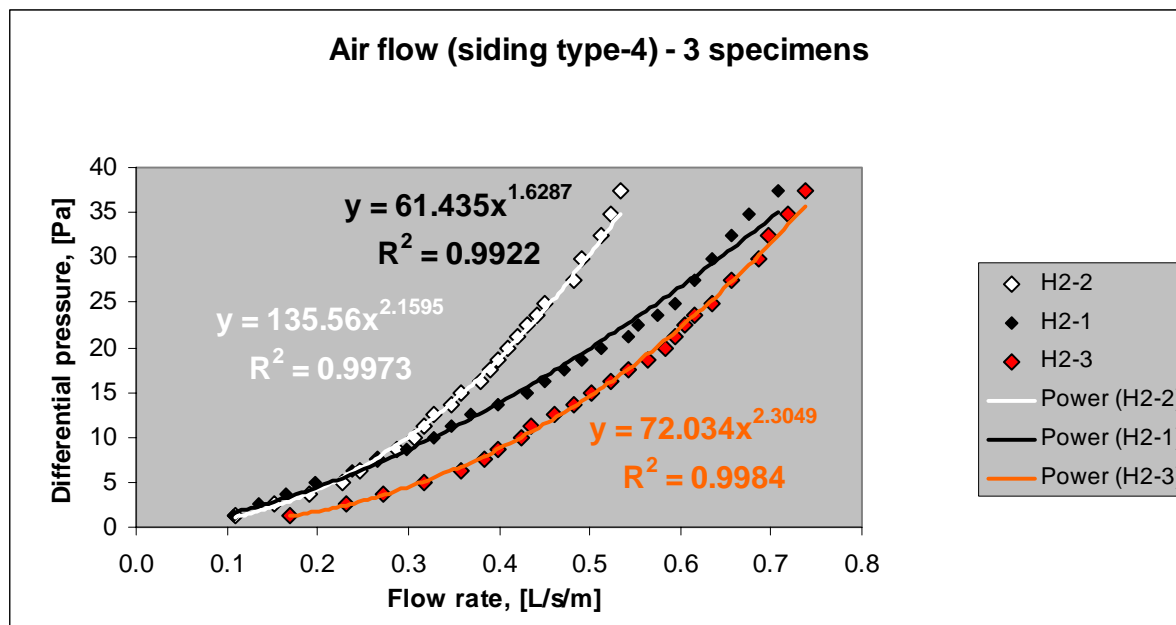


Figure 11 Air flow plots for product 4 siding (Hardboard profile H2).

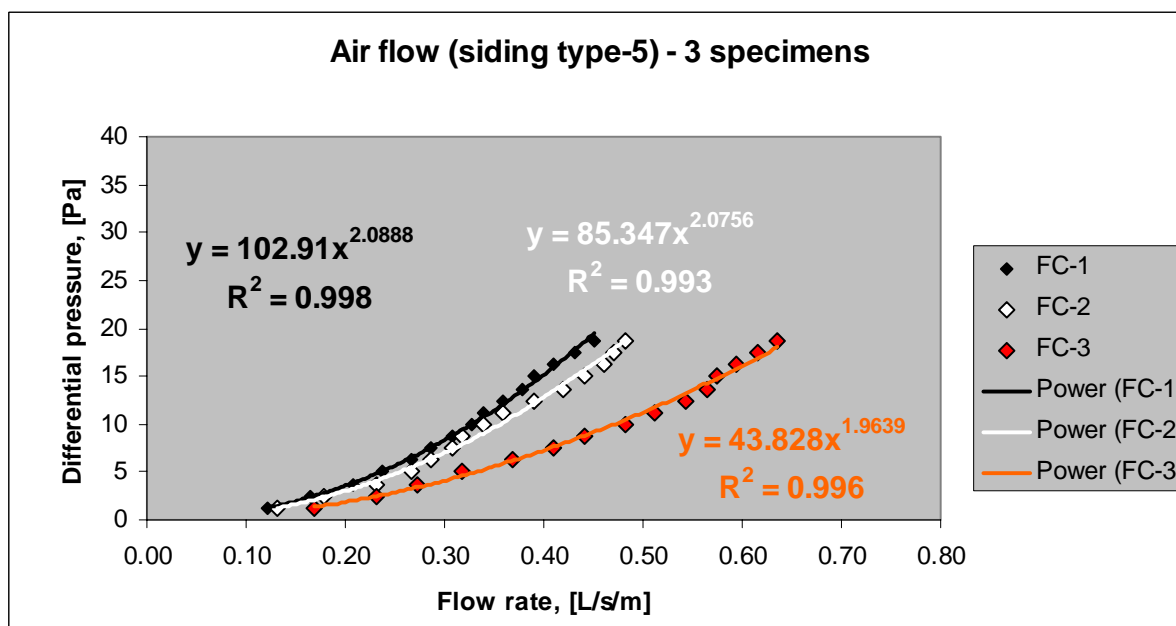


Figure 12 Air flow plots for product 5 siding (Fibre-cement board).

The air flow plots in Figures 8 through 12 show that a simple power function fit is appropriate to describe the relationships. The R^2 statistic values are all greater than 0.99. Several observations may be made about these results. Each plot represents the average for each assembly. Given the variability from one assembly to another of the same type, this implies that the individual joint flow characteristics are even more variable. The flow characteristics of manufactured joints in vinyl siding appear to be more uniform than those for other siding types.

Figure 13 compares plots for the two vinyl siding products. Vinyl siding product 2 has higher flow rates than product 1. The results for the three replicate tests show that even though these products have manufactured interlocking joints, there is still considerable variability in the installed samples. Despite the good fit to the data, deviation occurred at differential pressures higher than 27 Pa for product 1. This is attributed to the more flexible nature of this profile (#1) compared with the other profile. At higher pressures there is a greater tendency for the less stiff profiles to bow outward under pressure. The interlocking joints appear to become tighter at higher differential pressures.

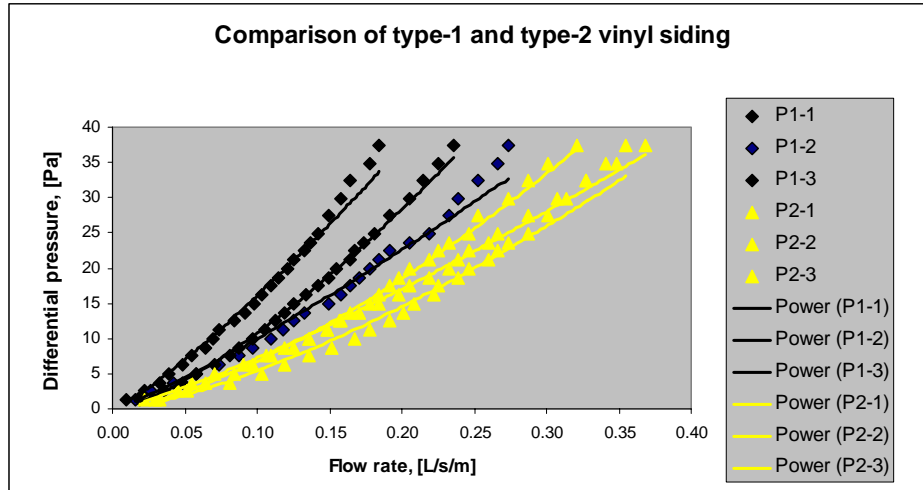


Figure 13 Air flow plots for vinyl siding products 1 and 2 (Profiles #1 and #2).

Similar comparisons were made for the hardboard siding (Types 3 and 4, H1 and H2) in Figure 14. With the exception of a single specimen (product 3), the remainder of the plots shows comparable results for both products. The regression fit (R^2 values) was excellent for all plots. The deviation from the fit at higher pressures is not as pronounced as that observed for Profile #1 (product type 1) vinyl siding. The hardboard siding products are much more rigid and do not deflect significantly so the joint characteristics remain constant.

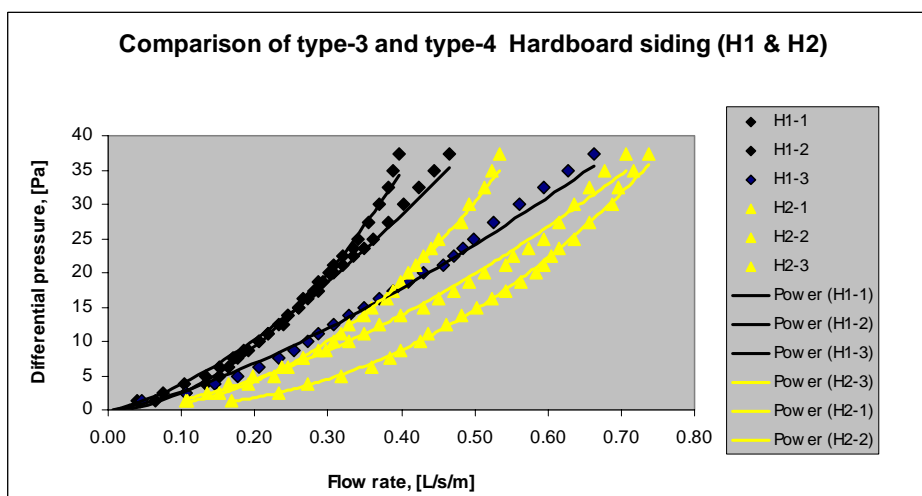


Figure 14 Air flow plots for hardboard siding, product 3 and 4 (H1 and H2).

Finally, Figure 15 is provided below to show all tests relative to each other on the same scale. The differences between and within groups are a function of their design as well as the manner they have been constructed with respect to tightness and fastening. Investigation of different installation techniques is better accomplished on full-sized wall specimens. However, in this case, the scope of the investigation was to determine if there was a relationship between air flow characteristics and vapour transmission of joints. The latter capability controlled the size of assemblies that could be handled.

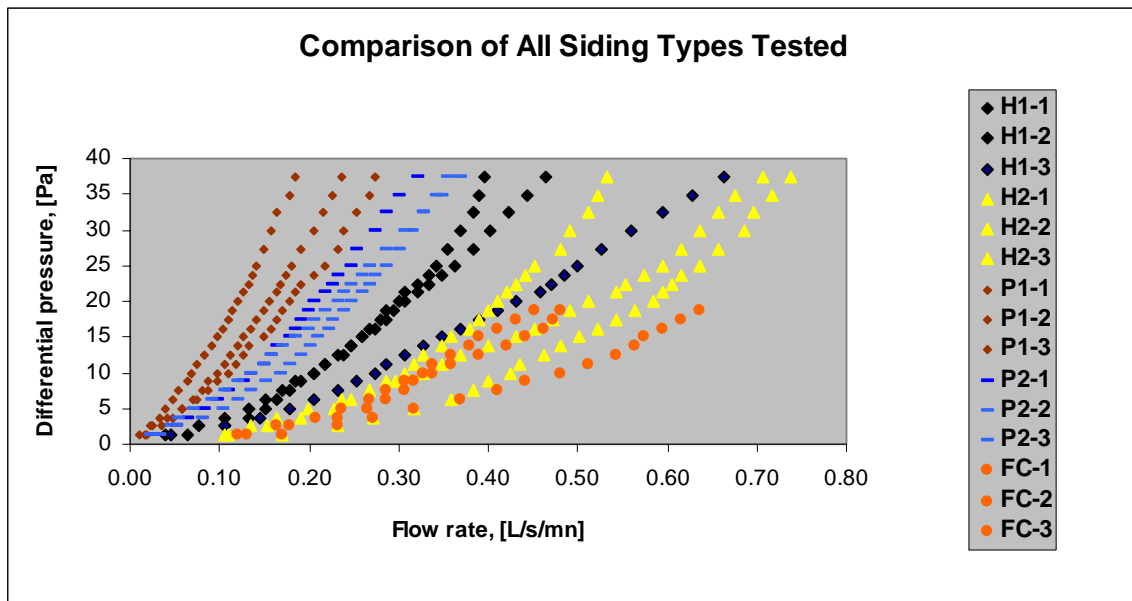


Figure 15 Comparison of air flow plots for all siding assemblies tested

4 WVT MEASUREMENTS OF SIDING JOINTS

Prior to performing the water vapour permeability tests the specimens were modified to include a port for placement of a sensor to measure RH and Temperature close to the underside of the specimens when they were mounted over the water bath in the pans. (Figure 4) A 2-inch diameter opening was drilled through the siding to receive a rubber stopper in which the RH and T sensor was inserted.

4.1 Experimental set-up

The experimental set-up consisted of three (3) aluminium pans, including the one used for the air flow measurements; a chamber supplied with conditioned air (controlled temperature and RH), and temperature/RH data logging capability. Figure 16 shows a schematic of the system utilized for these tests.

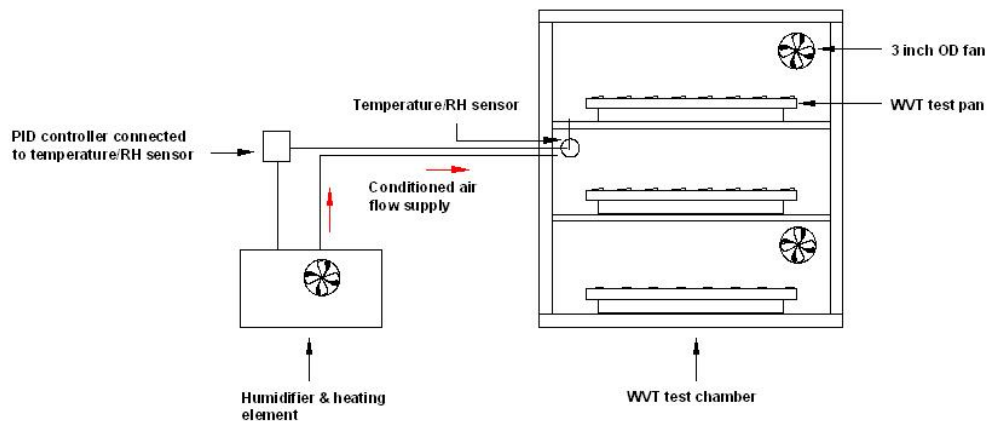


Figure 16 Schematic of the water vapour transmission test set-up

The pans for mounting the test assemblies were the same configuration as that utilized for the air permeability tests. Each pan contained three 1.5 inch high aluminium baffle plates to reduce the risk of water splashing the underside of the specimen during gravimetric weighing. A fitting port was installed on the side of the pan for filling and drainage purposes. The pan was filled with water at the beginning of the test with a known quantity of water. Gravimetric readings of the pan containing water and mounted specimen were obtained periodically. The resolution of measurement was 0.5 g. The weight loss of the system was equivalent to the quantity of moisture transported through the joints and siding. The WVT rate per unit length of laps for each type of siding was then calculated.

The maximum weight limit of 30 kg was imposed on the WVT test pan (combined test assembly with specimen and water in the pan). This was because that was the load limit for the accurate scale available for this work. The quantity of water that could be poured into the pan was limited to a depth of 1.5 inches. The air space available inside the pan was 4.5 inches deep. A comparative test was performed to examine the effect of water level inside the pan on the measured relative humidity (RH) near the bottom surface of the specimen. It was observed that there was no difference whether the water depth was 1.5 inches or 4 inches.

All tests were performed in a chamber built for this purpose that measured 4 ft by 4 ft by 5 ft in size. The chamber was constructed using lumber framing, and was clad with oriented strand board (OSB) and plywood. A 1.5-inch diameter opening was cut out of a side panel of the chamber which functioned as an access port for conditioned air. A 12-inch diameter flexible vinyl duct was mounted to this opening. The connection was sealed using polyurethane spray foam. The opposite end of the duct was mounted to a humidifier. Pre-heated air was ducted to the inlet in the humidifier.

The chamber had a certain degree of air leakage which required the humidifier to run continuously. This resulted in relatively steady temperature and RH conditions inside the chamber except when the pans were removed for weighing. Temperature and RH inside the chamber were monitored continuously throughout each test using a Vaisala INTERCAP sensor (model HMP50). The accuracy in temperature for the range experienced in this study was $\pm 0.6^{\circ}\text{C}$ ($\pm 1.2^{\circ}\text{F}$). The accuracy of the RH measurement was $\pm 3\%$ RH up to 90% RH, and $\pm 5\%$ RH between 95 and 98% RH. Average conditions measured in the chamber fell within the higher accuracy of the instrument.

Conditions were also monitored inside each pan. However, due to resource limitations which restricted the number of channels that could be monitored continuously these were only monitored for a 24-hour duration at the beginning and at the end of the test period. The sensors used were Vaisala RHT INTERCAP sensors that had a screw on sintered stainless steel cap for protection of the sensor against contact with liquid. For all tests performed, the measured temperatures and RH inside the pan were comparable at the beginning and at the end of the test which provided assurance that the conditions inside the pans remained stable throughout the WVT tests.

4.2 Boundary Conditions and Data Logging

For accurate determination of water vapour transmission rates it is critical to know what the water vapour pressures is on both boundaries of the specimen being tested. Actual (real time) water vapour pressure were calculated by multiplying the saturation vapour pressure by the relative humidity. The saturation vapour pressure is dependant on the temperature and can be calculated using thermodynamic equations of state such as those found in ASHRAE Book of Fundamentals. Thus, to be able to calculate water vapour pressure at both surfaces the temperature and the relative humidity must be known throughout the test period. Monitoring and data logging of temperature and RH in the chamber was performed using the Vaisala HMP50 temperature and RH sensor. The sensor was mounted in the center of the chamber. Since a fan mounted in the humidifier forced pre-conditioned air to the chamber, mixing inside the chamber was found adequate. Based on the recorded data, it was assumed that conditions were uniform throughout the tests. The velocity of the air flow entering the chamber inlet was measured to be (2 m/s or approximately 6 ft/s). The Vaisala sensor was connected to a PID controller which enabled communication with a desktop computer. The data was stored in text files and later imported into Excel worksheets for processing. Plots of the measured and calculated environmental conditions are provided in Appendix V.

4.3 Description of Test Protocol

Prior to start of the testing the specimens were stored in room conditions ($23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ & $50\% \pm 10\%$ RH) for a period of at least a week. The specimens were placed on the ledge of the pans. The outer edges of the specimen frames were aligned with the mouth of the frame providing a 0.25-inch wide and 1.5 inches deep space for pouring in a hot wax seal. The specimen was clamped to the frame and a predetermined quantity of hot wax mixture was poured in to fill the joint to the required depth. Upon setting, the wax provided an impervious (air and water tight) seal. The seal was a mixture of microcrystalline and refined paraffin wax in a respective 3:2 ratio by mass, and was prepared in accordance with the recommendations outlined in the ASTM E-96 (2000) standard. When the wax was cool the clamps were removed and the set-up was weighed. The pan remained on the balance, and water was poured into the pan using a funnel through the predrilled port for the sensor assembly. The quantity of water poured into the pans varied between 8 kg and 10 kg. The predrilled sensor opening in the surface of the siding was capped off with a rubber stopper and the set-up was weighted and the value recorded as the initial (test start) value. Each pan was then placed in the conditioned chamber and the test was started. Periodically (approximately) every 2 to 3 days the pans were removed and gravimetric readings were obtained. The time required for weighing and movement of pans in and out of the chamber was less than 5 minutes. The date, time, and weight of each pan were recorded at each reading. The interval at which the readings were taken and thus the overall duration of test for different types of siding materials depended on the rate of transmission through the joints and siding.

4.4 WVT Test Results

The results for each WVT test are presented in Appendix IV. The data and the corresponding plots therein represent the mass loss versus time, i.e., the WVT plots per meter of joint. On the basis of that information the permeance plots for each specimen were prepared giving the mass loss per unit length of joint and unit vapour pressure across the specimen. The mass loss was attributed to that passing through the joints presuming that the rate of transmission through the siding materials was insignificant in comparison.

Figures 17 through Figure 21 show the calculated permeance of the joints as a function of time. The plots indicate that initially a period of time elapses before stable transport rates are obtained. Calculated results for vinyl siding (profile #2) show a relatively uniform transmission from the onset of the test. However, for the other type (profile #1) there was a decrease in the calculated joint permeance over the first 180 hours of test for all three specimens. For tests performed on all the other siding products (Figures 19 through 21) there was a period during which, the transmission rate gradually increased before stable transport was reached. This suggests that part of the mass loss took place by diffusion through the siding material as well as through the joints.

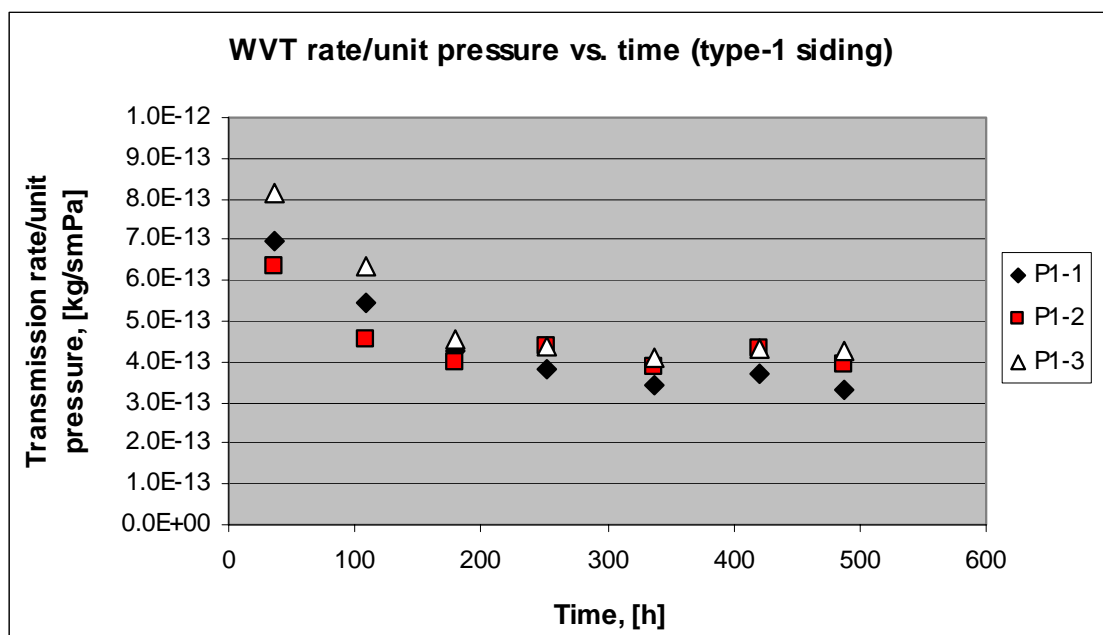


Figure 17 Calculated joint permeance for siding product 1(Vinyl – Profile #1).

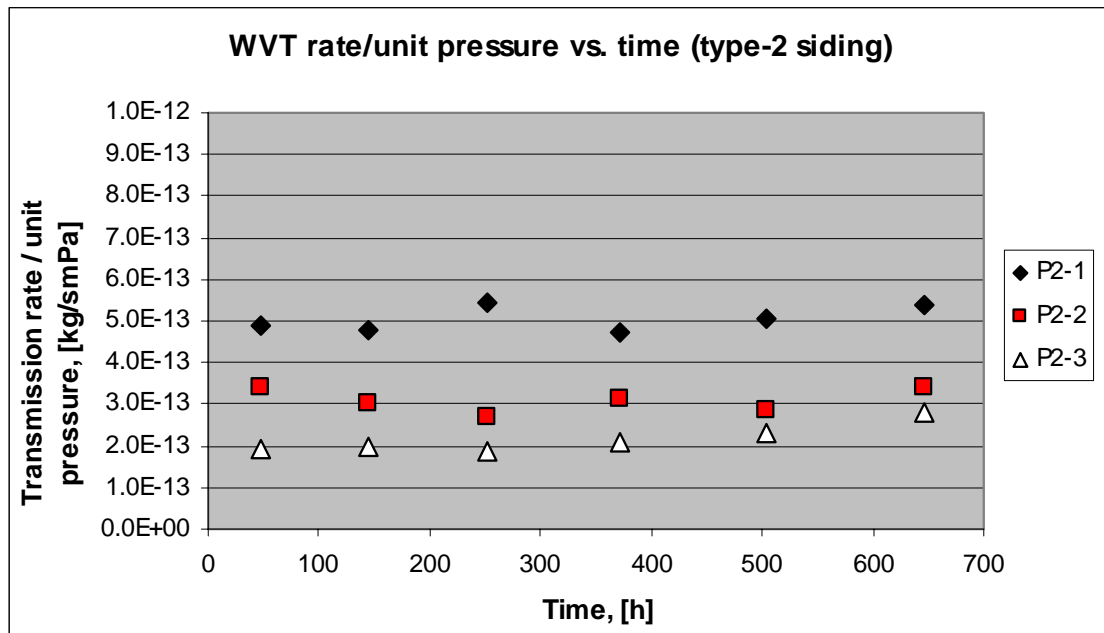


Figure 18 Calculated joint permeance for siding product 2 (Vinyl – Profile #2).

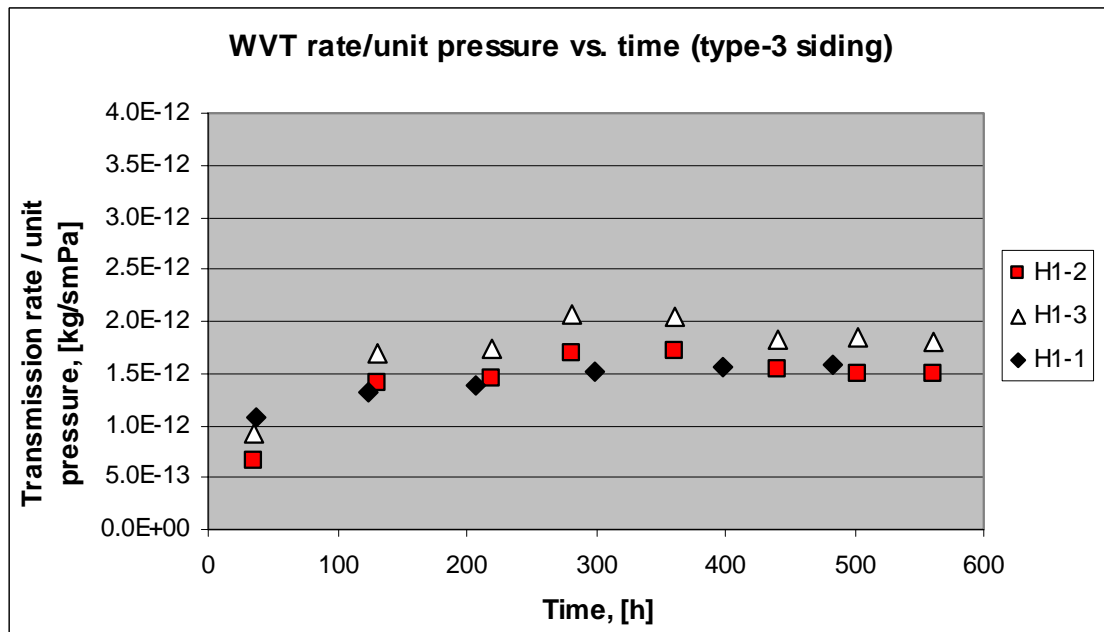


Figure 19 Calculated joint permeance for siding product 3(Hardboard – H1).

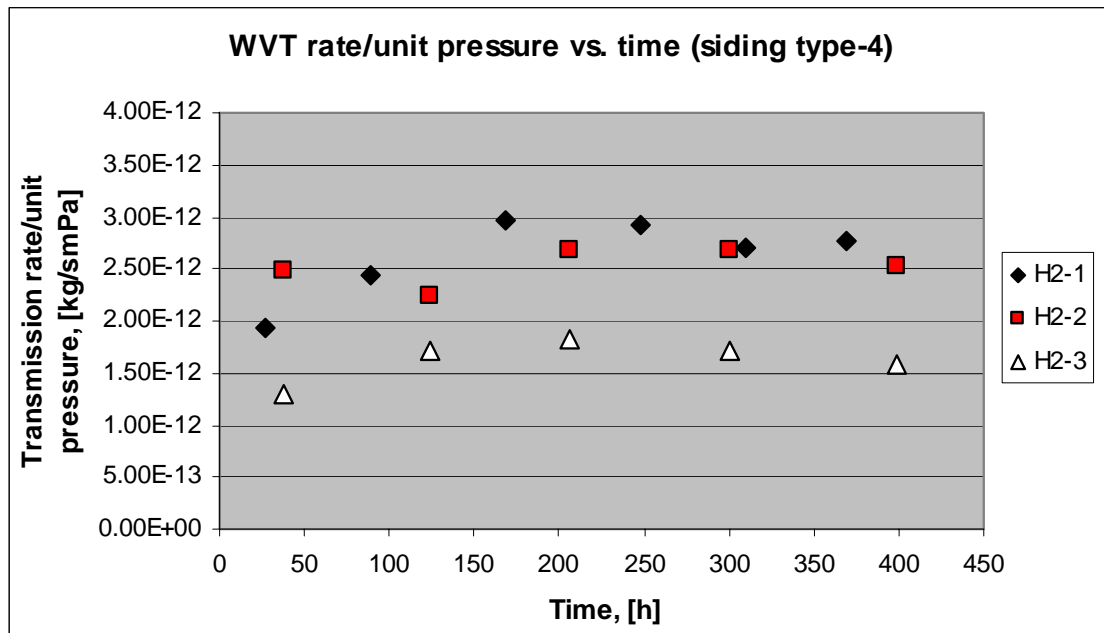


Figure 20 Calculated joint permeance for siding product 4 (Hardboard – H2).

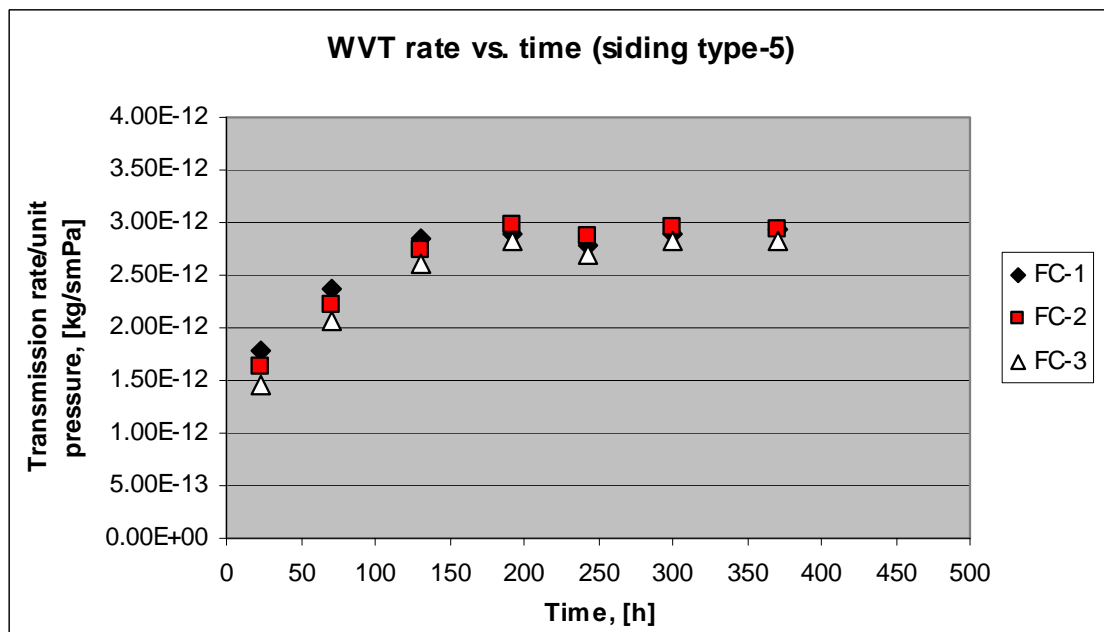


Figure 21 Calculated joint permeance for siding product 5 (Fibre-Cement Board).

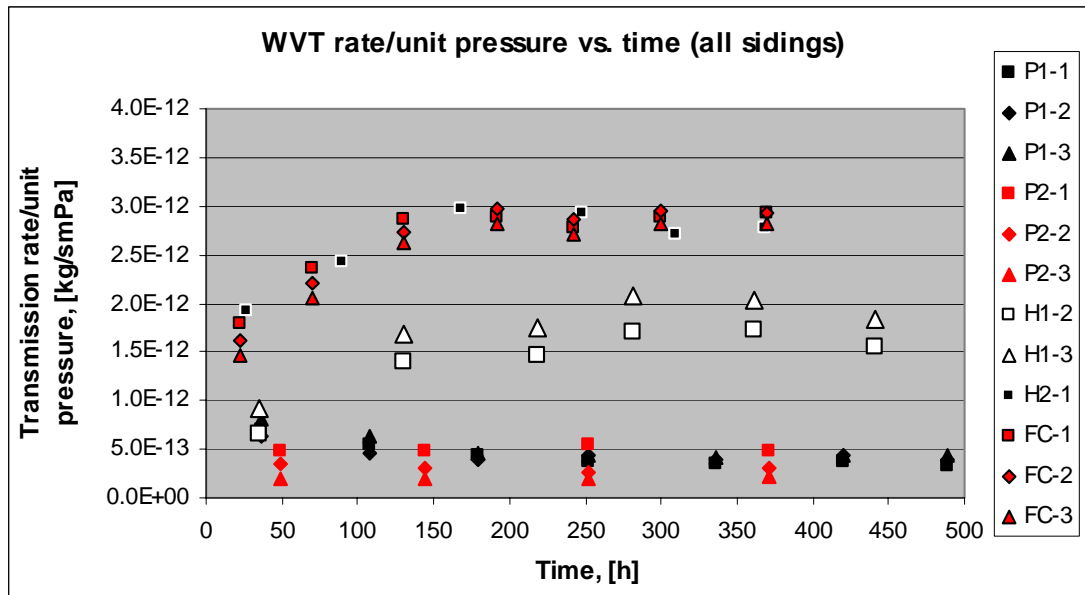


Figure 22 Comparison of joint permeance values for all 5 siding products tested.

A comparison of calculated joint permeance for all tested products (Figure 22 above) shows distinctly that transmission through the joints in vinyl siding was nearly one order of magnitude (8 times) lower in comparison to transmission rates of hardboard siding (product 4 – profile H2) and fibre reinforced cement siding (product 5). The joint permeance was also 5 times lower than that calculated for the other hardboard siding tested in this program (product 3 – profile H1).

Table 2 shows the average joint permeance and the corresponding standard deviations calculated from the steady state portion of each test. In this instance, the average joint permeance rate represents the mean value calculated from the last four (4) data points. Table 3 provides the joint permeance as an average value for each of the three replicate specimens.

Table 2 Average joint permeance for each tested specimen

Specimen Number	Designation Code	Joint Permeance [kg/smPa]	Standard deviation [kg/smPa]	COV [%]
S1-1	P1-1	3.56E-13	2.40E-14	6.8
S1-2	P1-2	4.14E-13	2.53E-14	6.2
S1-3	P1-3	4.28E-13	1.21E-14	2.8
S2-1	P2-1	5.15E-13	3.26E-14	6.3
S2-2	P2-2	3.03E-13	3.05E-14	10.1
S2-3	P2-3	2.27E-13	3.80E-14	17.1
S3-1	H1-1	1.57E-12	2.27E-13	1.4
S3-2	H1-2	1.56E-12	1.09E-13	7.0
S3-3	H1-3	1.88E-12	1.12E-13	5.9
S4-1	H2-1	2.84E-12	1.22E-13	4.3
S4-2	H2-2	2.63E-12	7.16E-14	2.7
S4-3	H2-3	1.70E-12	9.74E-14	5.7
S5-1	FC-1	2.88E-12	6.53E-14	2.3
S5-2	FC-2	2.93E-12	4.89E-14	1.7
S5-3	FC-3	2.79E-12	6.16E-14	2.2

Table 3 Joint permeance for each product (average of 3 replicate specimens)

Product Number	Designation Code	Average Joint Permeance [kg/smPa]	Permeance STDEV [kg/smPa]	COV [%]
1	P1	3.99E-13	3.79E-14	9.5
2	P2	3.48E-13	1.30E-13	37.7
3	H1	1.54E-12	1.94E-13	12.6
4	H2	2.39E-12	5.26E-13	22.0
5	FC	2.87E-12	9.95E-14	3.5

Table 4 lists the WVT rates and the joint permeance as averaged values for each product (average values calculated from 3 replicate specimens). The values in the third and in the fifth column indicate the rank of the WVT rate and permeance relative to the lowest measurement of all products.

Table 4 Comparison of mean WVT rates and Joint Permeance for 5 siding products.

Product Number	Designation Code	WVT [kg/sm]	WVT Rank	Joint Permeance [kg/smPa]	Permeance Rank
1	P1	4.35E-10	1.1	3.99E-13	1.1
2	P2	4.03E-10	1.0	3.48E-13	1.0
3	H1	1.37E-09	3.8	1.54E-12	4.4
4	H2	2.17E-09	5.4	2.39E-12	6.9
5	FC	2.54E-09	6.3	2.89E-12	8.2

5 CORRELATION ANALYSIS

One of the objectives of this investigation was to determine if there was a relationship between the air permeance and vapour permeance of joints in siding. While the air flow characteristics of joints, whether collectively or individually, can be determined quickly, obtaining the vapour permeance of joints is very time consuming. A reader may have noted that up to 488 hours of test time were taken to obtain the vapour permeance of the more impermeable sidings. One has to deal with relatively few large samples at a time and using a very accurate scale to be able to detect the change in mass.

To examine the potential relationship noted above, both air and vapour permeance have to be cast in terms of their respective driving potentials. That was already done for the vapour permeance of joints reported in Section 4. The air flow characteristic of joints reported in Section 3 need to be recast in the inverse form from that already reported.

The air flow characteristics were provided in the following power equation form:

$$P = C Q^N$$

where P= the differential pressure in Pa; Q is the resulting flow in Litres per second per meter of joint; and C and N are coefficients.

The inverse of that equation is:

$$Q = c P^n \\ = (1/C)^{1/N} P^{1/N}$$

Thus $n = 1/N$ and $c = (1/C)^n$.

The summary of the coefficients of power law regressions for the air flow tests and their conversion as noted above are provided in Table 5.

Table 5 Recasting the coefficients describing the air flow characteristics of the joints tested

Siding Type	Designation Code	Specimen Number	P = C Q ^N		Q = c P ⁿ	
			Coefficient C	Exponent N	Coefficient c	Exponent n
1	P1	1	257.69	1.205	0.010	0.830
		2	150.05	1.176	0.014	0.850
		3	268.42	1.396	0.018	0.716
2	P2	1	193.42	1.457	0.027	0.686
		2	123.76	1.233	0.020	0.811
		3	146.00	1.435	0.031	0.697
3	H1	1	200.93	1.915	0.063	0.522
		2	108.42	1.462	0.041	0.684
		3	62.75	1.379	0.050	0.725
4	H2	1	61.44	1.629	0.080	0.614
		2	135.56	2.160	0.103	0.463
		3	72.03	2.305	0.156	0.434
5	FC	1	102.91	2.089	0.109	0.479
		2	85.35	2.076	0.117	0.482
		3	43.83	1.964	0.146	0.509

The data for both vapour and air flow tests were then aligned in Table 6, and the air flow at 1 Pa was chosen to compare with the vapour permeability. At this differential pressure, the flow rate equals the value of the coefficient “c”.

Table 6 Summary of air flow characteristics and vapour permeability of assemblies tested.

Siding Type	Designation Name	Specimen Number	Q = c P ⁿ		Vapour Permeance kg/smPa	Air Flow at 1 Pa L/s/m
			Coefficient c	Exponent n		
1	P1	1	0.0100	0.830	3.56E-13	0.010
		2	0.0141	0.850	4.14E-13	0.014
		3	0.0182	0.716	4.28E-13	0.018
2	P2	1	0.0270	0.686	5.15E-13	0.027
		2	0.0201	0.811	3.03E-13	0.020
		3	0.0310	0.697	2.27E-13	0.031
3	H1	1	0.0627	0.522	1.57E-12	0.063
		2	0.0406	0.684	1.56E-12	0.041
		3	0.0497	0.725	1.88E-12	0.050
4	H2	1	0.0798	0.614	2.84E-12	0.080
		2	0.1030	0.463	2.63E-12	0.103
		3	0.1564	0.434	1.7E-12	0.156
5	FC	1	0.1088	0.479	2.88E-12	0.109
		2	0.1174	0.482	2.93E-12	0.117
		3	0.1459	0.509	2.79E-12	0.146

Plots of the two characteristics of joints being examined are provided in Figures 24 and 25.

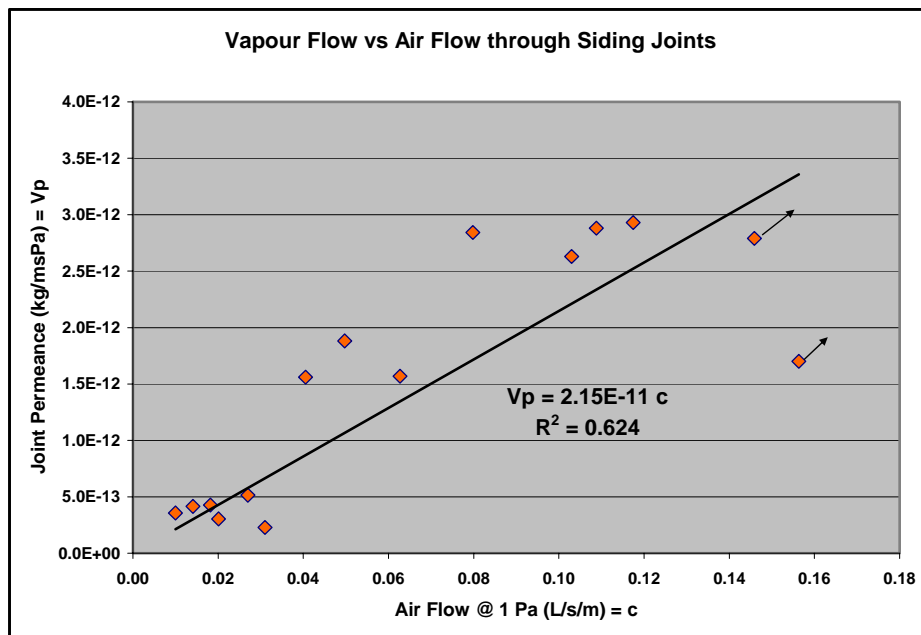


Figure 23 Plot of vapour joint permeance and air flow characteristics (at 1 Pa)

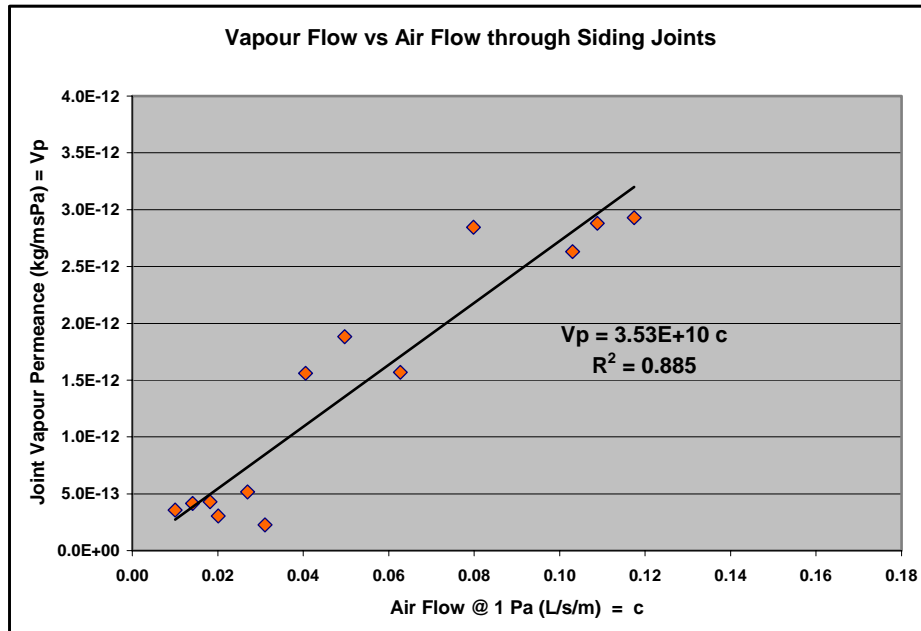


Figure 24 Plot of vapour joint permeance and air flow characteristics (at 1 Pa) excluding two outlier values noted in Figure 23.

The plot in Figure 23 includes two outliers, specimens H2-3 and FC-3, both of which are highlighted in Table 6. Examination of the air flow plots (Figure 11 and 12) reveals that the fitted curves for both specimens are relatively flat at low differential pressures and also do not seem to converge with others in the same group, whereas plots for all other specimens of all types converge. If they are treated as outliers

and eliminated from consideration, the plot shown in Figure 24 shows a more consistent relationship between the two joint properties. This is also reflected in the R^2 reported for the linear regressions shown on each plot. For the present, this comparison supports the contention that within the experimental error achieved, there is a correlation between the two measures of joint performance. We have no explanation for the low pressure behaviour of the two outlier specimens.

6 DISCUSSION AND CONCLUSIONS

Part of the variability noted in these plots shown in Figure 24 may be related to effects that impact on the repeatability of weight measurements of the pans for the WVT tests. Due to the difficulty in handling, and the potential effect that handling had on convective flow within and through joints, as well as on the conditions experienced, unaccounted for effects were present compared with assumed boundary conditions. Continuous undisturbed weighing would have been a more desirable approach. However, given the limitations in both time and financial resources, this was the only approach that could be taken at the time.

In the same vein, the air flow measurements had to be limited to only some of the joints available for products 4 and 5 due to a limitation in the range of flow measurements possible. Due to the low flow rates, calibration flow measurements of each assembly should also have been determined in the event that leakage, other than through the assumed joints occurred, such as at edge seals and other sealed joints.

Quite apart from the impact of experimental procedures on the results, there is the fundamental issue of moisture buoyancy. It has been assumed that the weight loss from a pan through a siding assembly has all occurred as a result of the difference in vapour pressure across the assembly. However, it should be noted that the density of moist air inside the pan beneath the assembly is less dense than in the chamber or room. The joints in the siding can allow some moist air to escape directly by air movement in addition to that escaping by diffusion. Any air movement through the joints invites the movement of makeup air from the chamber or room back into the pan air space where it would dilute the moisture content of the air exposed to the free water in the pan. By measuring the RH and T of the air just under the specimen and using that to calculate the vapour pressure difference across the specimen, this only partially accounts for the moisture lost by stack effect across the test specimen. The actual moisture exchange across the test specimens is a very complex matter.

Measurement of air flow characteristics of individual joints in full scale walls by Onysko and Jones [3] on a siding product similar to Type 3 (H1) has shown that how the wall is assembled has an effect on the air tightness of joints in siding. For example, it was shown that flat-headed nails were more difficult to overdrive than round-headed nails, and this helped assure a more uniform spacing at ship lapped joints. Joints were more airtight where over-driven nails were applied. Average air leakage was about 15 times that obtained on smaller sample walls by others at that time.

Given these findings, it is likely that only an approximate relationship between air flow and vapour flow characteristics of siding systems can be considered for field applied siding systems. Vinyl siding, with its manufactured interlocking joints and small drain holes, can be considered tightest for both vapour and air flow. This is followed in leakiness by hardboard siding with a spline system which registers each siding course relative to the course below. Contact mismatch leads to some air and vapour transmission. Greater transmission resulted for the second hardboard product that had an in-line interlocking shiplap joint, which had moderately higher leakiness than the first product. The leakiest siding was the fibre-cement product (as constructed) because of the greater mismatch provided between the adjacent courses of siding. Each system, by design and by assembly, results in a unique range of tightness that may be translated to equivalent vapour permeance, but only in a somewhat general way given all of the factors influencing air tightness and vapour exchange.

7 REFERENCES

- [1] ASTM (2000). ASTM E96-00. “Standard Test Methods for Water Vapour Transmission of Materials”, American Society for Testing and Materials, Vol. 04.06.
- [2] ASTM. C1498-04a Standard Test Method for Hygroscopic Sorption Isotherms of Building Materials
- [3] Onysko D.M. and S.K. Jones. 1988. Air tightness of one type of hardboard siding. Forintek Canada Corp. report to Canadian Forestry Service. Project No. FCC-43-10-016. Also presented at CIB-W40 Meeting, September 11-14, 1989 Victoria, BC.

APPENDIX I

Scheduling of Air and Vapour Transmission Tests

Table I-1 Summary of air flow test program

Summary of Air Flow Tests							
Test number	Type of siding tested	Number of specimen tested	Test start date	Test finish date	Test duration [h]	Number of lapped joints	Total length of joints/specimen [m]
1	Vinyl siding (type 1)	1	Nov 30/ 05	Nov 30/ 05	8	3	2.48
		1	Dec 2/ 05	Dec 2/ 05	8		
		1	Dec 3/05	Dec 3/05	8		
2	Vinyl siding (type 2)	1	Dec 5/05	Dec 5/05	8	3	2.48
		1	Dec 7/05	Dec 7/05	8		
		1	Dec 9/05	Dec 9/05	8		
3	Wood based siding (type 3)	1	Jan 10/06	Jan 10/06	8	3	2.48
		1	Jan 11/06	Jan 11/06	8		
		1	Jan 12/06	Jan 12/06	8		
4	Wood based siding (type 4)	1	Mar 26/06	Mar 26/06	8	2	1.65
		1	Mar 28/06	Mar 28/06	8		
		1	Jan 30/06	Jan 30/06	8		
5	Cement board siding (type 5)	1	Feb 25/06	Feb 25/06	8	2	1.65
		1	Feb 26/06	Feb 26/06	8		
		1	Feb 27/06	Feb 27/06	8		

Table I-2 Summary of water vapour transmission tests

Summary of Water Vapour Transmission Tests								
Test number	Type of siding tested	Number of specimen tested	Test start date	Test finish date	Test duration [days]	Test duration [h]	Number of lap joints	Total length of joints/specimen [m]
1	Vinyl siding (type 1)	3	10-Nov-05	2-Dec-05	21.7	521.3	3	2.48
2	Vinyl siding (type 2)	3	4-Jan-06	3-Feb-06	29.7	711.9	3	2.48
3	Wood based siding (type 3)	2	9-Feb-06	6-Mar-06	24.8	593.9	3	2.48
4	Wood based siding (type 4)	1	9-Feb-06	6-Mar-06	16.7	401.9	2	1.65
5	Cement board siding (type 5)	3	6-Mar-06	17-Mar-06	17.0	408.9	2	1.65

APPENDIX II

Fabrication of Test Specimens

Fabrication Procedure

The following describes the fabrication sequence for siding assemblies for the air flow and water vapour transmission tests:

1. All siding specimens included in this test program were fabricated on supporting wooden frames.
2. Nominal 2 x 4 dimension lumber was planed for good contact for construction of the frames. The actual measurements of the finished members were 1.25 inch by 3.25 inch.
3. Each square frame was constructed using three studs spaced 16-inch on centres as well as single top and bottom plates. The spacing between the studs was representative of typical stud spacing in residential construction.
4. The stud members were connected at each end using two 4-inch long galvanized deck screws.
5. The constructed frames were coated with three coats of low vapour permeable paint, followed by 3 coats of polyurethane lacquer to impart water vapour resistance of the frames. **Figure II-1** shows a fully constructed and coated frame.



Figure II-1 Typical wooden frame to which siding panels were mounted.

6. The siding was cut so that each piece overlapped the edge studs in the frame by at least 0.25 inch.
7. The siding courses were laid out one at a time, starting from the bottom of the frame, and nailed at 16 inch on center using 1.5 inches long nails with a 5/16 inches diameter flat head. Figures II-2 through II-6 show the sequence of assembly for a vinyl siding specimen.



Figure II-2 First siding panel mounted onto the supporting frame.



Figure II-3 Close-up of the nail connection.



Figure II-4 Fully mounted siding panels.

8. High density polyurethane spray foam was then applied at the siding/frame interface (on both sides) to impart air tightness at that interface.



Figure II-5 Spray polyurethane foam applied on the perimeter to attain an air seal.



Figure II-6 Back side with spray polyurethane foam applied on the perimeter.

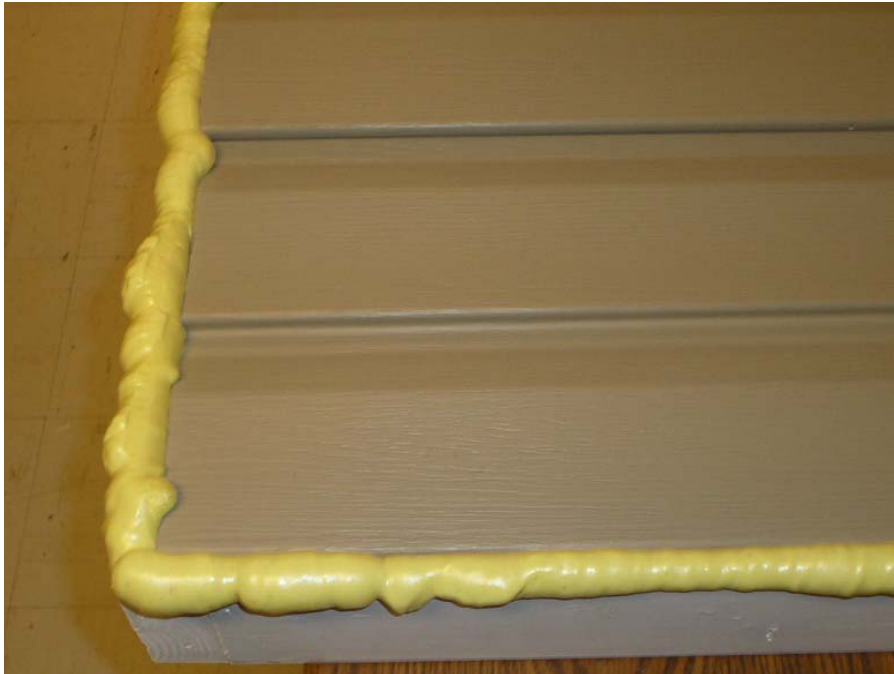


Figure II-7 Close up of the spray polyurethane foam applied at a corner.

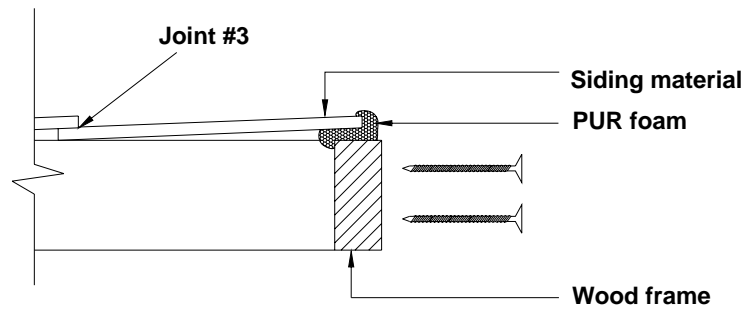


Figure II-8 Cross section of polyurethane spray foam seal at the siding/wood frame interface at the top of the specimen assembly.

9. Upon mounting the siding on the frame, an opening for a temperature/RH sensor assembly was drilled in the surface of the siding.

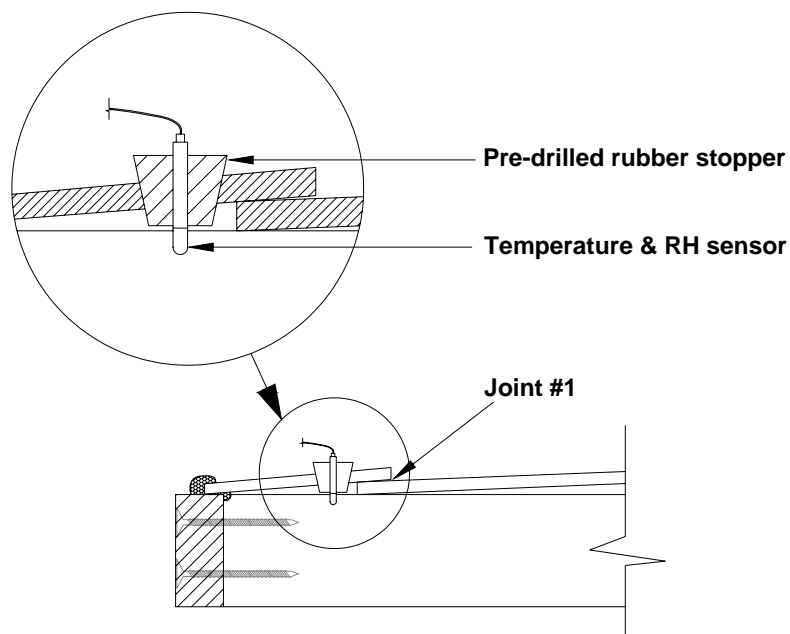


Figure II-9 Detail showing the sensor and rubber stopper assembly.

APPENDIX III

Air Flow Test Results

The following tables contain the measured and converted raw data. The differential pressure versus the measured total flow plots are provided immediately under each table.

Table III-1 Measurements for product Type-1 assembly 1 (Vinyl siding, Profile #1, 3 joints)

Measured diff. pressure Inch of H ₂ O	Converted diff. pressure [Pa]	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	3	1.4
0.01	2.5	7	3.3
0.015	3.7	10	4.7
0.02	5.0	12	5.7
0.025	6.2	15	7.1
0.03	7.5	17	8.0
0.035	8.7	20	9.4
0.04	10.0	21.5	10.1
0.045	11.2	23	10.9
0.05	12.5	26	12.3
0.055	13.7	28.5	13.5
0.06	14.9	30.5	14.4
0.065	16.2	32	15.1
0.07	17.4	34	16.0
0.075	18.7	35.5	16.8
0.08	19.9	37.5	17.7
0.085	21.2	39	18.4
0.09	22.4	41	19.3
0.095	23.7	42.5	20.1
0.1	24.9	44	20.8
0.11	27.4	46.5	21.9
0.12	29.9	49	23.1
0.13	32.4		24
0.14	34.9		26
0.15	37.4		27

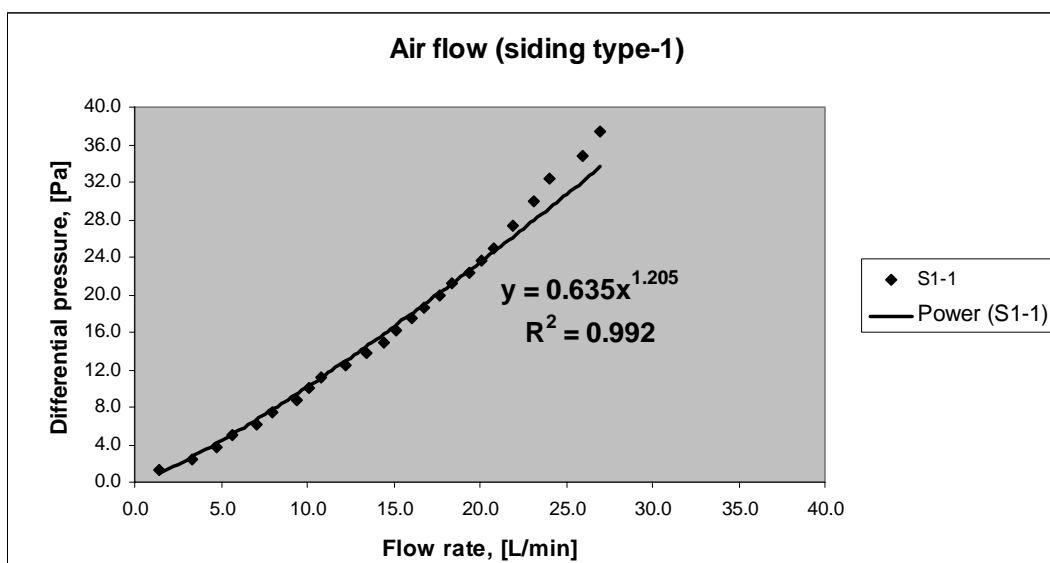


Table III-2 Measurements for product Type-1, assembly 2 (Vinyl siding, Profile #1, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	5	2
0.01	2.5	8	4
0.015	3.7	13	6
0.02	5.0	18	8
0.025	6.2	23	11
0.03	7.5	27	13
0.035	8.7	30	14
0.04	10.0	34	16
0.045	11.2	36.5	17
0.05	12.5	39	18
0.055	13.7	41	19
0.06	14.9	46.5	22
0.065	16.2	49	23
0.07	17.4		24
0.075	18.7		25
0.08	19.9		26
0.085	21.2		27
0.09	22.4		28
0.095	23.7		30
0.1	24.9		32
0.11	27.4		34
0.12	29.9		35
0.13	32.4		37
0.14	34.9		39
0.15	37.4		40

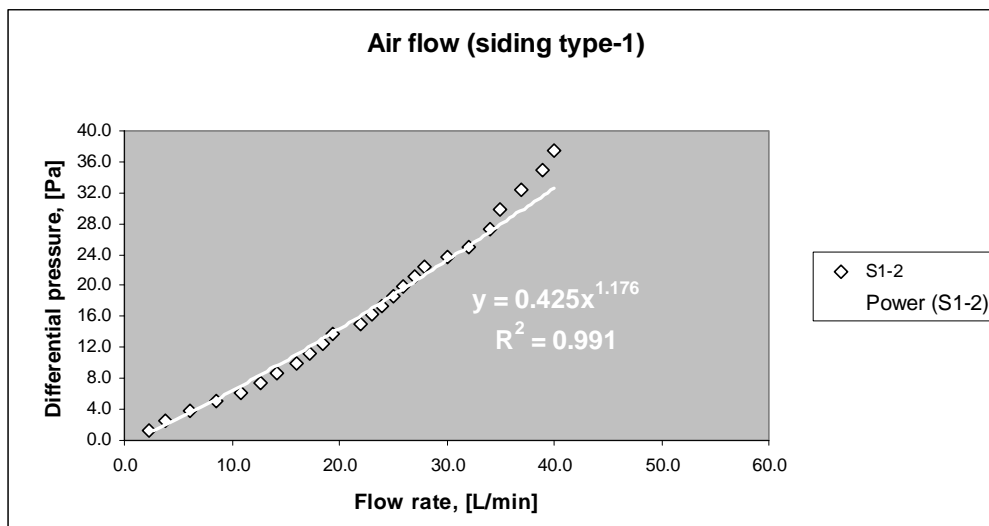


Table III-3 Measurements for product Type-1, assembly 3 (Vinyl siding, Profile #1, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	6	3
0.01	2.5	11	5
0.015	3.7	15	7
0.02	5.0	18	8
0.025	6.2	22	10
0.03	7.5	25	12
0.035	8.7	27	13
0.04	10.0	30	14
0.045	11.2	32.5	15
0.05	12.5	35	17
0.055	13.7	37	17
0.06	14.9	39	18
0.065	16.2	41.5	20
0.07	17.4	44	21
0.075	18.7	46.5	22
0.08	19.9	48	23
0.085	21.2	51	24
0.09	22.4		25
0.095	23.7		26
0.1	24.9		27
0.11	27.4		28
0.12	29.9		30
0.13	32.4		32
0.14	34.9		33
0.15	37.4		35

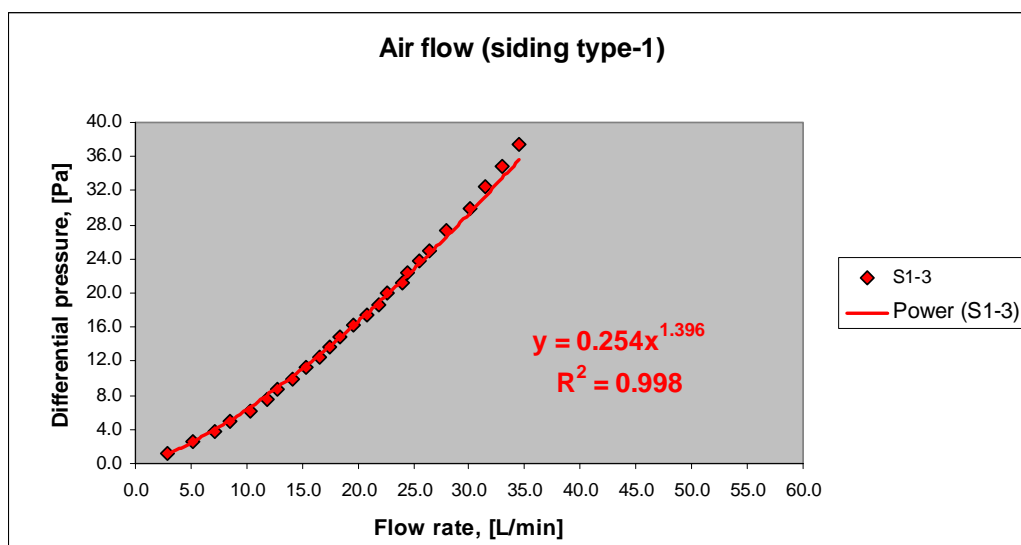


Table III-4 Measurements for product Type-2, assembly 1 (Vinyl siding, Profile #2, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	9	4
0.01	2.5	16	8
0.015	3.7	20	9
0.02	5.0	26	12
0.025	6.2	30	14
0.03	7.5	34	16
0.035	8.7	39	18
0.04	10.0	42	20
0.045	11.2	46	22
0.05	12.5	49	23
0.055	13.7		24
0.06	14.9		26
0.065	16.2		27
0.07	17.4		28
0.075	18.7		29
0.08	19.9		30
0.085	21.2		32
0.09	22.4		33
0.095	23.7		34
0.1	24.9		36
0.11	27.4		37
0.12	29.9		40
0.13	32.4		42
0.14	34.9		44
0.15	37.4		47

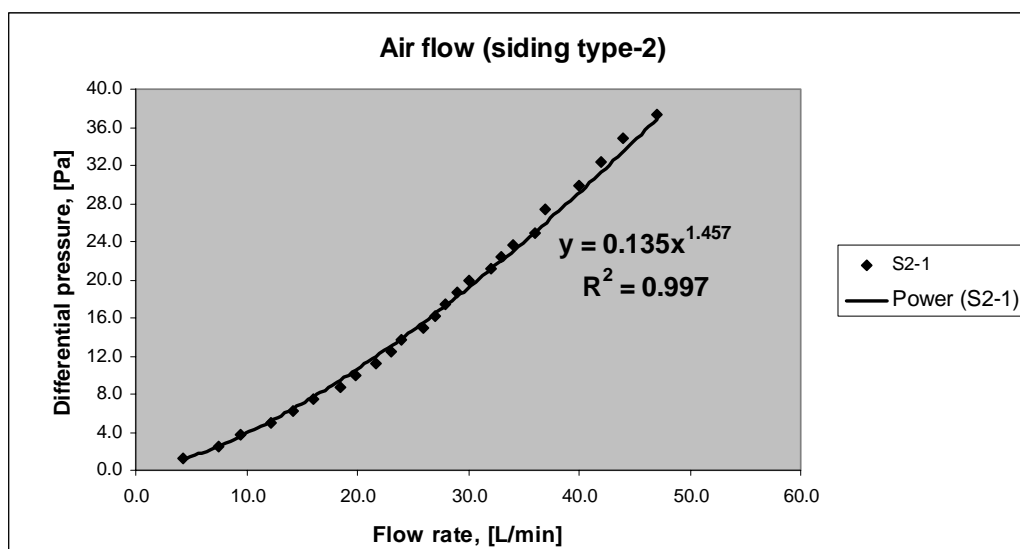


Table III-5 Measurements for product Type-2, assembly 2 (Vinyl siding, Profile #2, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	7	3
0.01	2.5	14	7
0.015	3.7	17	8
0.02	5.0	22	10
0.025	6.2	28	13
0.03	7.5	33	16
0.035	8.7	37	17
0.04	10.0	42	20
0.045	11.2	46	22
0.05	12.5		23
0.055	13.7		25
0.06	14.9		27
0.065	16.2		29
0.07	17.4		30
0.075	18.7		32
0.08	19.9		34
0.085	21.2		35
0.09	22.4		36
0.095	23.7		38
0.1	24.9		39
0.11	27.4		42
0.12	29.9		45
0.13	32.4		48
0.14	34.9		51
0.15	37.4		54

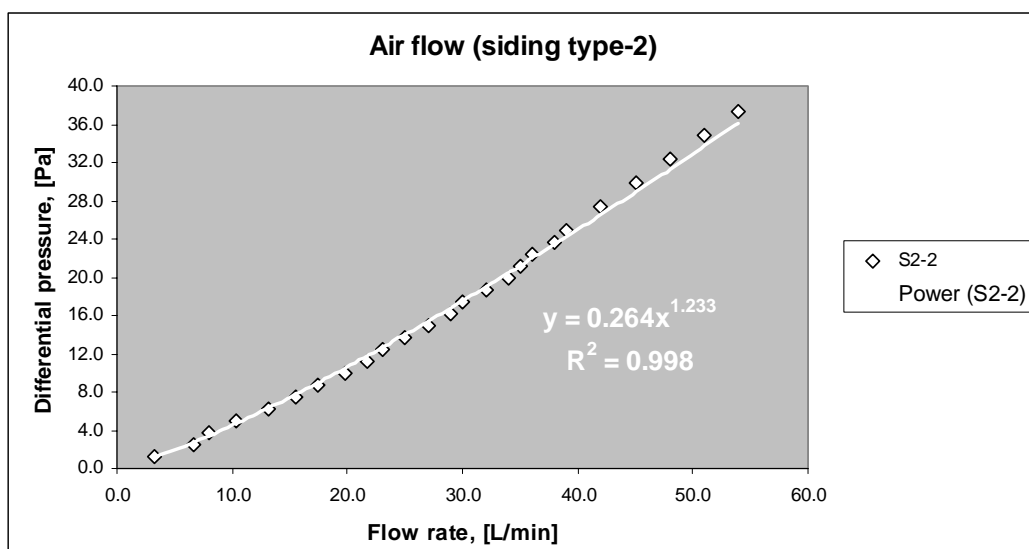


Table III-6 Measurements for product Type-2, assembly 3 (Vinyl siding, Profile #2, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	10	5
0.01	2.5	16	8
0.015	3.7	25	12
0.02	5.0	32	15
0.025	6.2	37	17
0.03	7.5	42	20
0.035	8.7	47	22
0.04	10.0		25
0.045	11.2		26
0.05	12.5		28
0.055	13.7		30
0.06	14.9		31
0.065	16.2		33
0.07	17.4		33
0.075	18.7		35
0.08	19.9		36
0.085	21.2		38
0.09	22.4		39
0.095	23.7		40
0.1	24.9		42
0.11	27.4		44
0.12	29.9		46
0.13	32.4		48
0.14	34.9		50
0.15	37.4		52

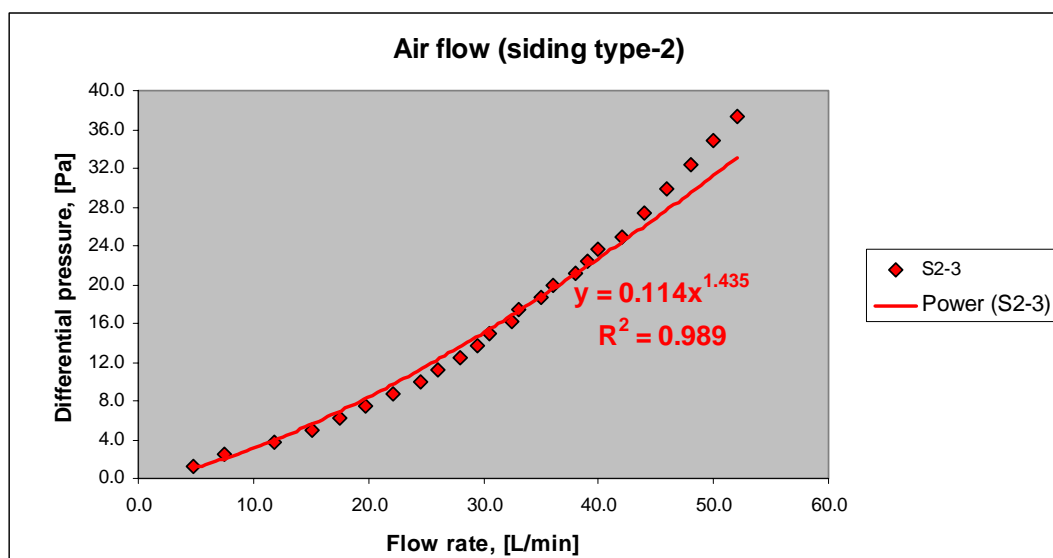


Table III-7 Measurements for product Type-3, assembly 1 (Hardboard siding, Profile H1, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	20	9
0.01	2.5	33	16
0.015	3.7	41	19
0.02	5.0	47	22
0.025	6.2		24
0.03	7.5		26
0.035	8.7		28
0.04	10.0		30
0.045	11.2		32
0.05	12.5		35
0.055	13.7		36
0.06	14.9		38
0.065	16.2		39
0.07	17.4		41
0.075	18.7		42
0.08	19.9		44
0.085	21.2		45
0.09	22.4		47
0.095	23.7		49
0.1	24.9		50
0.11	27.4		52
0.12	29.9		54
0.13	32.4		56
0.14	34.9		57
0.15	37.4		58

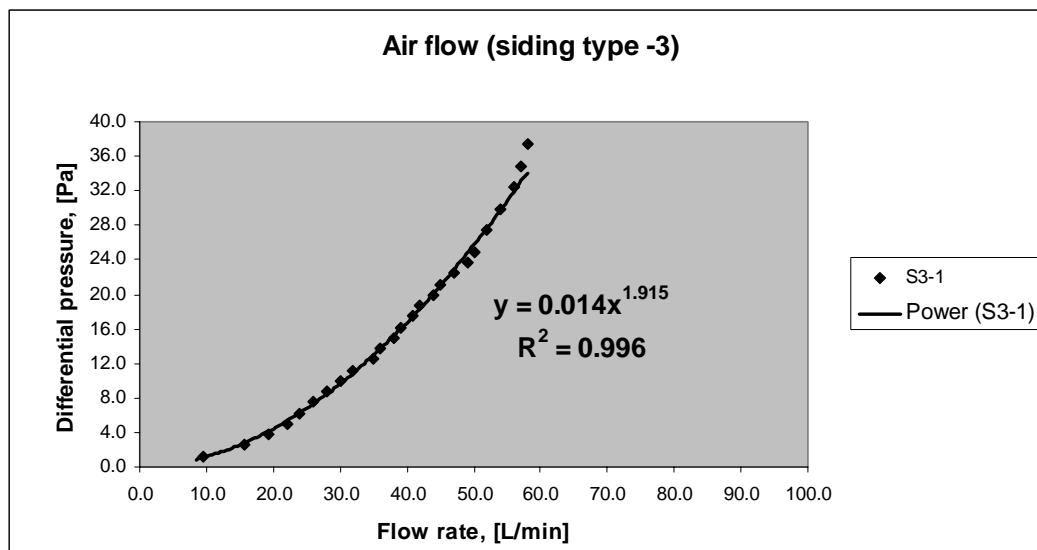


Table III-8 Measurements for product Type-3, assembly 2 (Hardboard siding, Profile H1, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/minute
0.005	1.2	12.5	6
0.01	2.5	23.5	11
0.015	3.7	32.5	15
0.02	5.0	41	19
0.025	6.2	47	22
0.03	7.5		25
0.035	8.7		27
0.04	10.0		30
0.045	11.2		32
0.05	12.5		34
0.055	13.7		36
0.06	14.9		38
0.065	16.2		40
0.07	17.4		42
0.075	18.7		43
0.08	19.9		45
0.085	21.2		47
0.09	22.4		49
0.095	23.7		51
0.1	24.9		53
0.11	27.4		56
0.12	29.9		59
0.13	32.4		62
0.14	34.9		65
0.15	37.4		68

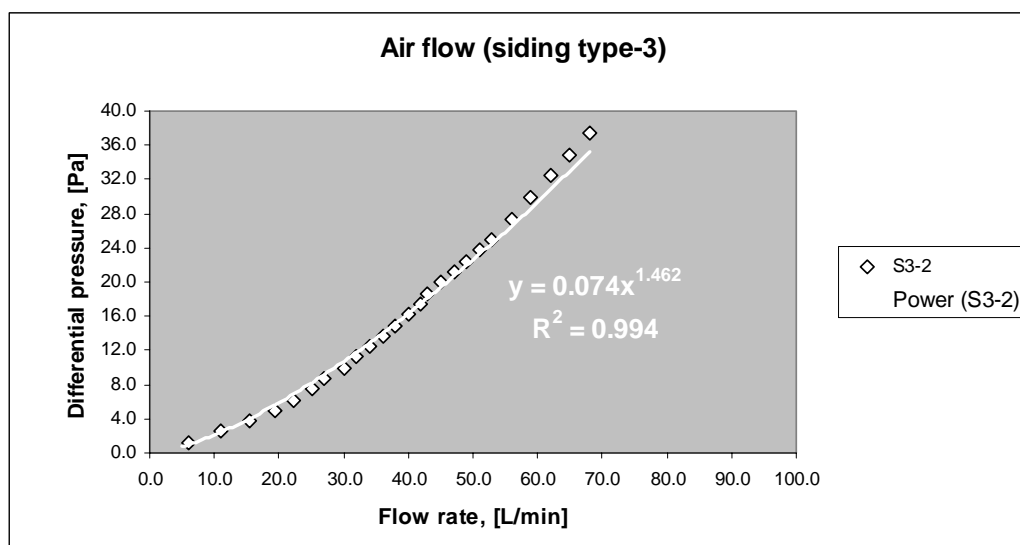


Table III-9 Measurements for product Type-3, assembly 3 (Hardboard siding, Profile H1, 3 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	14	7
0.01	2.5	33	16
0.015	3.7	45	21
0.02	5.0		26
0.025	6.2		30
0.03	7.5		34
0.035	8.7		37
0.04	10.0		40
0.045	11.2		42
0.05	12.5		45
0.055	13.7		48
0.06	14.9		51
0.065	16.2		54
0.07	17.4		57
0.075	18.7		60
0.08	19.9		63
0.085	21.2		67
0.09	22.4		69
0.095	23.7		71
0.1	24.9		73
0.11	27.4		77
0.12	29.9		82
0.13	32.4		87
0.14	34.9		92
0.15	37.4		97

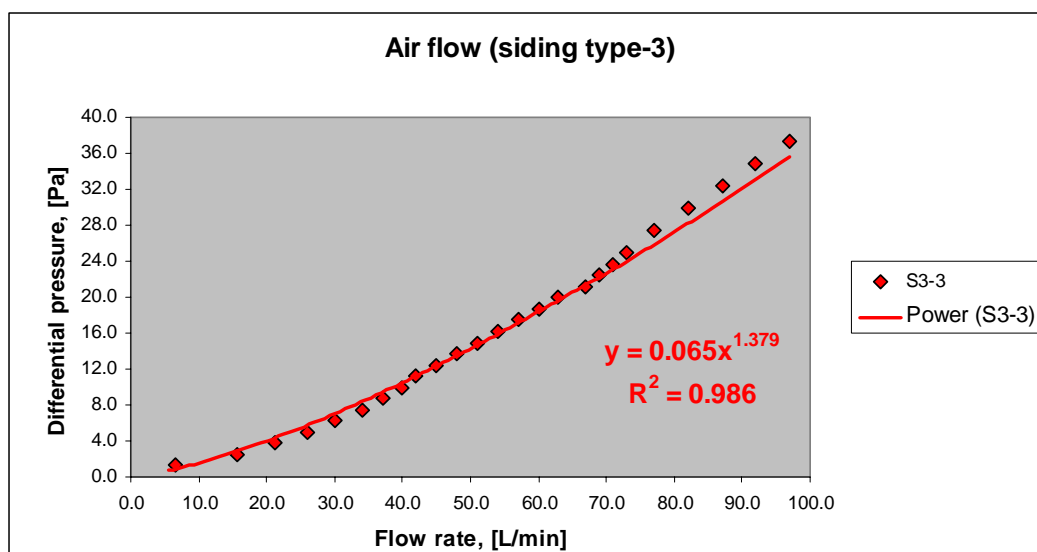


Table III-10 Measurements for product Type-4, assembly 1 (Hardboard siding, Profile H2, 2 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	22	10
0.01	2.5	28	13
0.015	3.7	34	16
0.02	5.0	41	19
0.025	6.2	49	23
0.03	7.5		26
0.035	8.7		29
0.04	10.0		32
0.045	11.2		34
0.05	12.5		36
0.055	13.7		39
0.06	14.9		42
0.065	16.2		44
0.07	17.4		46
0.075	18.7		48
0.08	19.9		50
0.085	21.2		53
0.09	22.4		54
0.095	23.7		56
0.1	24.9		58
0.11	27.4		60
0.12	29.9		62
0.13	32.4		64
0.14	34.9		66
0.15	37.4		69

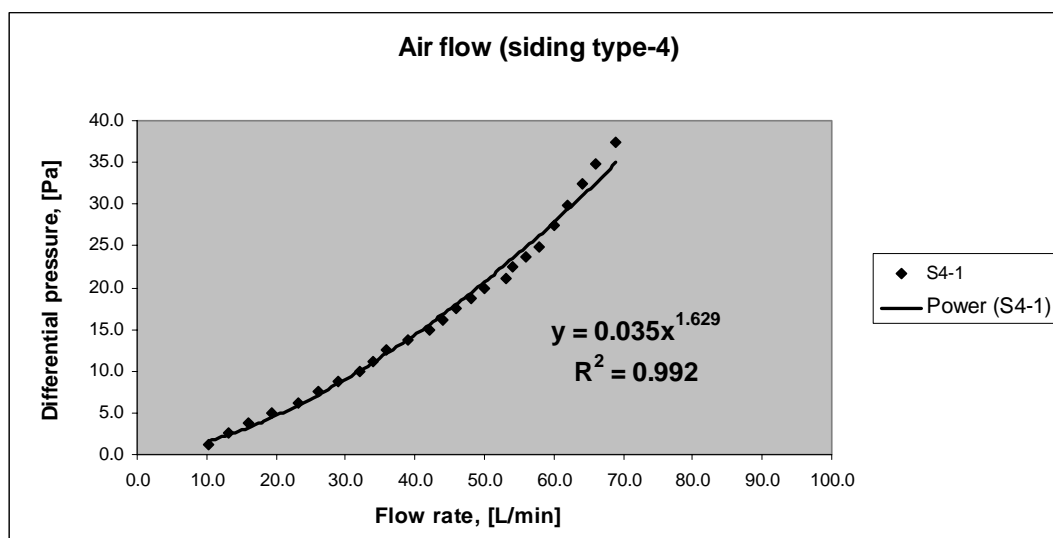


Table III-11 Measurements for product Type-4, assembly 2 (Hardboard siding, Profile H2, 2 joints)

Measured diff. pressure Inches of water	Converted diff. pressure [Pa]	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	22.5	11
0.01	2.5	31.5	15
0.015	3.7	39.5	19
0.02	5.0	47	22
0.025	6.2		24
0.03	7.5		26
0.035	8.7		28
0.04	10.0		30
0.045	11.2		31
0.05	12.5		32
0.055	13.7		34
0.06	14.9		35
0.065	16.2		37
0.07	17.4		38
0.075	18.7		39
0.08	19.9		40
0.085	21.2		41
0.09	22.4		42
0.095	23.7		43
0.1	24.9		44
0.11	27.4		47
0.12	29.9		48
0.13	32.4		50
0.14	34.9		51
0.15	37.4		52

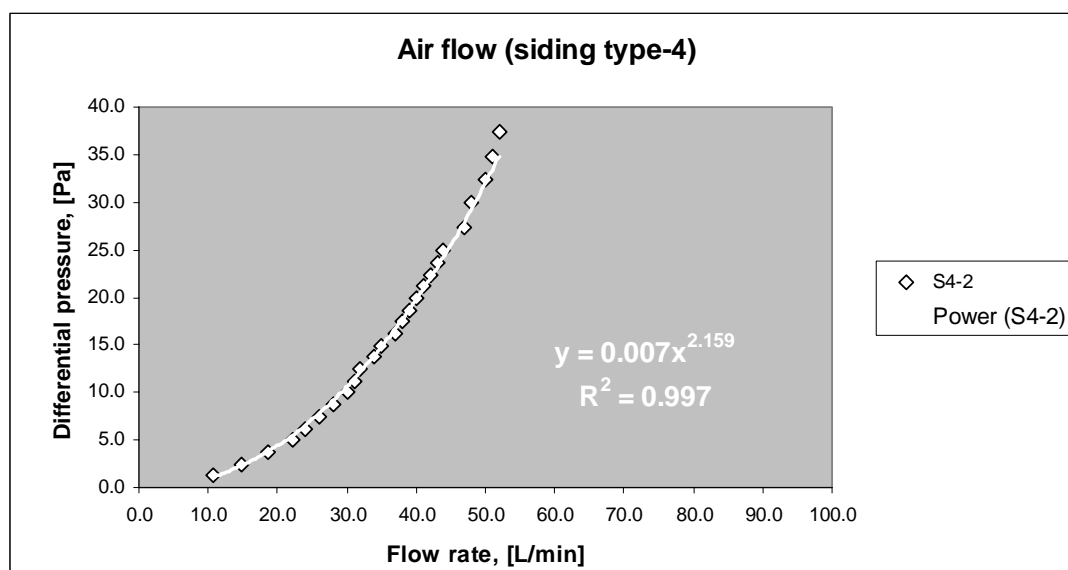


Table III-12 Measurements for product Type-4, assembly 3 (Hardboard siding, Profile H2, 2 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	35	17
0.01	2.5	48	23
0.015	3.7		27
0.02	5.0		31
0.025	6.2		35
0.03	7.5		38
0.035	8.7		39
0.04	10.0		42
0.045	11.2		43
0.05	12.5		45
0.055	13.7		47
0.06	14.9		49
0.065	16.2		51
0.07	17.4		53
0.075	18.7		55
0.08	19.9		57
0.085	21.2		58
0.09	22.4		59
0.095	23.7		60
0.1	24.9		62
0.11	27.4		64
0.12	29.9		67
0.13	32.4		68
0.14	34.9		70
0.15	37.4		72

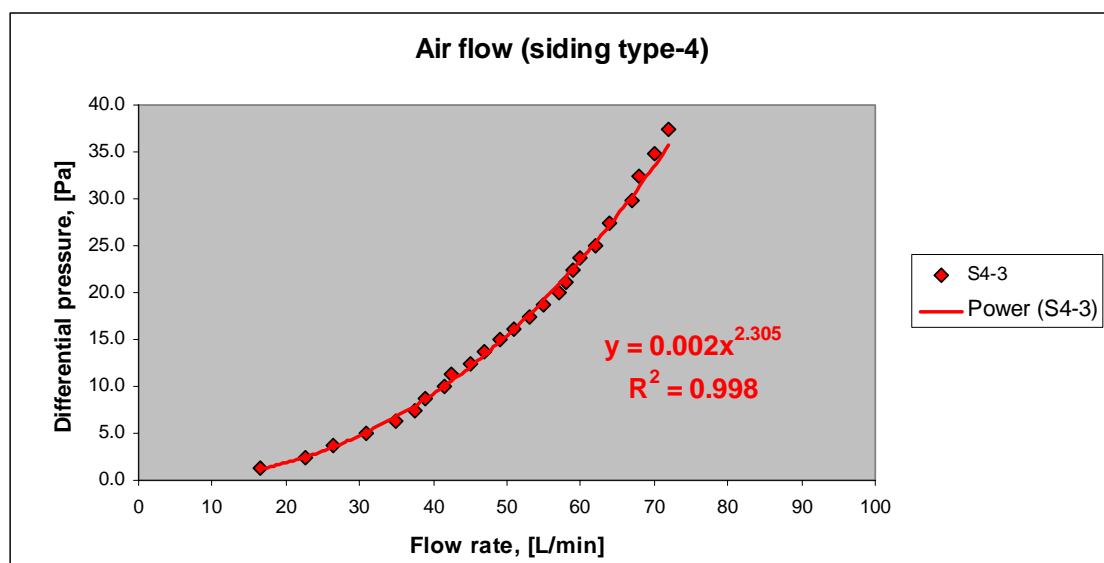


Table III-13 Measurements for product Type-5, assembly 1 (Fibre-cement siding, 2 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	25	12
0.01	2.5	34	16
0.015	3.7	43	20
0.02	5.0	49	23
0.025	6.2		26
0.03	7.5		28
0.035	8.7		30
0.04	10.0		32
0.045	11.2		33
0.05	12.5		35
0.055	13.7		37
0.06	14.9		38
0.065	16.2		40
0.07	17.4		42
0.075	18.7		44
0.08	19.9		-
0.085	21.2		-
0.09	22.4		-
0.095	23.7		-
0.1	24.9		-
0.11	27.4		-
0.12	29.9		-
0.13	32.4		-
0.14	34.9		-
0.15	37.4		-

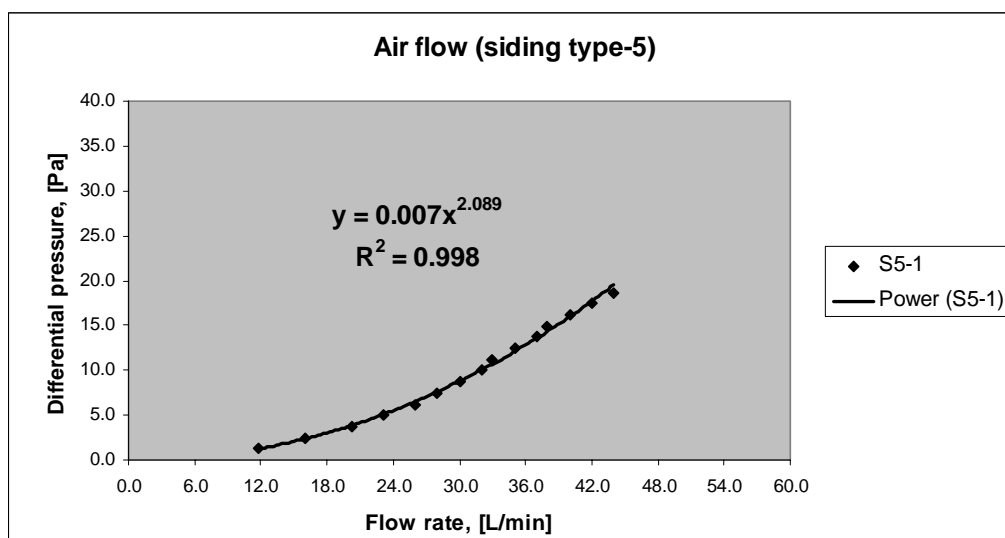


Table III-14 Measurements for product Type-5, assembly 2 (Fibre-cement siding, 2 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	27	13
0.01	2.5	37	17
0.015	3.7	48	23
0.02	5.0	55	26
0.025	6.2		28
0.03	7.5		30
0.035	8.7		31
0.04	10.0		33
0.045	11.2		35
0.05	12.5		38
0.055	13.7		41
0.06	14.9		43
0.065	16.2		45
0.07	17.4		46
0.075	18.7		47
0.08	19.9		-
0.085	21.2		-
0.09	22.4		-
0.095	23.7		-
0.1	24.9		-
0.11	27.4		-
0.12	29.9		-
0.13	32.4		-
0.14	34.9		-
0.15	37.4		-

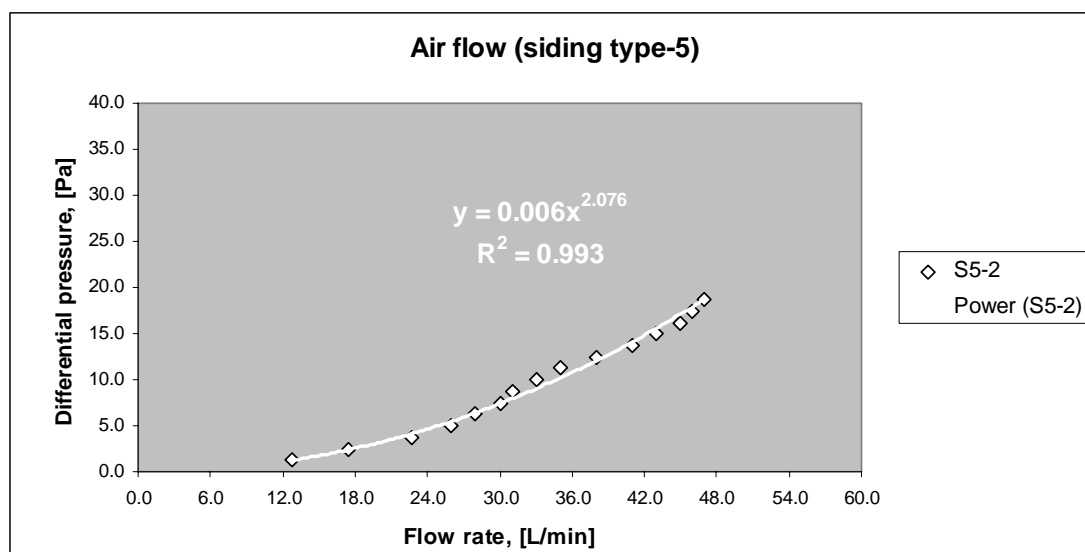
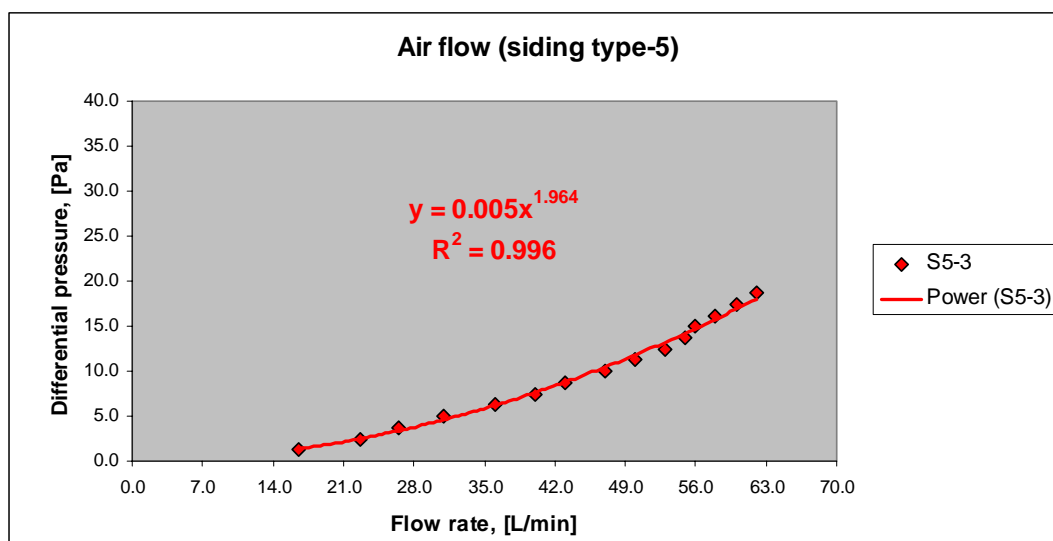


Table III-15 Measurements for product Type-5, assembly 3 (Fibre-cement siding, 2 joints)

Measured diff. pressure Inches of water	Converted diff. pressure Pascal	Measured flow rate Flow rate [SCFH]	Converted flow rate Litres/hour
0.005	1.2	35	17
0.01	2.5	48	23
0.015	3.7	53	27
0.02	5.0	62	31
0.025	6.2		36
0.03	7.5		40
0.035	8.7		43
0.04	10.0		47
0.045	11.2		50
0.05	12.5		53
0.055	13.7		55
0.06	14.9		56
0.065	16.2		58
0.07	17.4		60
0.075	18.7		62
0.08	19.9		-
0.085	21.2		-
0.09	22.4		-
0.095	23.7		-
0.1	24.9		-
0.11	27.4		-
0.12	29.9		-
0.13	32.4		-
0.14	34.9		-
0.15	37.4		-



APPENDIX IV

Water Vapour Transmission Data

Table IV-1 Data sheet for WVT tests on three Type 1 assemblies (Vinyl siding Profile #1).

Date & time	Time diff.	Time diff.	Time diff.	Time increase cumulative,	Time interval	Weight, [kg]			Weight loss, [g]		
	[d]	[h]	[s]	[h]	[h]	1	2	3	1	2	3
11/10/05 20:25	0.00	0.00	0.00E+00	0.00	0.00	27.2625	27.2890	27.8040	0.0	0.0	0.0
11/13/05 20:25	3.00	72.00	6.22E+06	72.00	36.00	27.2510	27.2785	27.7905	11.5	10.5	13.5
11/16/05 20:25	3.00	72.00	6.22E+06	144.00	108.00	27.2420	27.2710	27.7800	9.0	7.5	10.5
11/19/05 19:40	2.97	71.25	6.16E+06	215.25	179.63	27.2350	27.2645	27.7725	7.0	6.5	7.5
11/22/05 21:40	3.08	74.00	6.39E+06	289.25	252.25	27.2285	27.2570	27.7650	6.5	7.5	7.5
11/26/05 20:43	3.96	95.05	8.21E+06	384.30	336.77	27.2210	27.2485	27.7560	7.5	8.5	9.0
11/29/05 19:43	2.96	71.00	6.13E+06	455.30	419.80	27.2150	27.2415	27.7490	6.0	7.0	7.0
12/2/05 13:40	2.75	65.95	5.70E+06	521.25	488.27	27.2100	27.2355	27.7425	5.0	6.0	6.5

Date & time	Rate of transmission (kg/sm) ⁽¹⁾			Rate of transmission/unit pressure (kg/smPa)		
	1	2	3	1	2	3
11/10/05 20:25	-	-	-	-	-	-
11/13/05 20:25	7.5E-10	6.8E-10	8.8E-10	6.8E-13	6.2E-13	8.0E-13
11/16/05 20:25	5.8E-10	4.9E-10	6.9E-10	5.3E-13	4.5E-13	6.2E-13
11/19/05 19:40	4.6E-10	4.3E-10	4.9E-10	4.2E-13	3.9E-13	4.5E-13
11/22/05 21:40	4.1E-10	4.7E-10	4.8E-10	3.8E-13	4.3E-13	4.3E-13
11/26/05 20:43	3.7E-10	4.2E-10	4.4E-10	3.4E-13	3.8E-13	4.0E-13
11/29/05 19:43	3.9E-10	4.6E-10	4.6E-10	3.6E-13	4.2E-13	4.2E-13
12/2/05 13:40	3.5E-10	4.3E-10	4.6E-10	3.2E-13	3.9E-13	4.2E-13
Average	3.8E-10	4.4E-10	4.6E-10	3.5E-13	4.1E-13	4.2E-13
Stdev	2.5E-11	2.7E-11	1.3E-11	2.4E-14	2.5E-14	1.2E-14
COV (%)	6.6	6.1	2.8	6.8	6.2	2.8

Table IV-2 Data sheet for WVT tests on three Type 2 assemblies (Vinyl siding Profile #2).

Date & time	Time diff. [d]	Time diff. [h]	Time diff. [s]	Time increase cumulative, [h]	Time interval [h]	Weight, [kg]			Weight decrease, [g]		
						1	2	3	1	2	3
1/4/06 19:23	0.00	0.00	0.00E+00	0.00	0.00	26.4035	25.7390	26.5085	0.0	0.0	0.0
1/8/06 20:25	4.04	97.03	8.38E+06	97.03	48.52	26.3920	25.7310	26.5040	11.5	8.0	4.5
1/12/06 19:43	3.97	95.30	8.23E+06	192.33	144.68	26.3810	25.7240	26.4995	11.0	7.0	4.5
1/17/06 19:48	5.00	120.08	1.04E+07	312.42	252.38	26.3650	25.7160	26.4940	16.0	8.0	5.5
1/22/06 16:22	4.86	116.57	1.01E+07	428.98	370.70	26.3515	25.7070	26.4880	13.5	9.0	6.0
1/28/06 22:34	6.26	150.20	1.30E+07	579.18	504.08	26.3330	25.6965	26.4795	18.5	10.5	8.5
2/3/06 11:14	5.53	132.67	1.15E+07	711.85	645.52	26.3155	25.6855	26.4705	17.5	11.0	9.0

Date & time	Rate of transmission (kg/sm) ⁽¹⁾			Rate of transmission/unit pressure (kg/smPa)		
	1	2	3	1	2	3
1/4/06 19:23	-	-	-	-	-	-
1/8/06 20:25	5.5E-10	3.9E-10	2.2E-10	4.81E-13	3.35E-13	1.88E-13
1/12/06 19:43	5.4E-10	3.4E-10	2.2E-10	4.70E-13	2.99E-13	1.92E-13
1/17/06 19:48	6.2E-10	3.1E-10	2.1E-10	5.34E-13	2.67E-13	1.83E-13
1/22/06 16:22	5.4E-10	3.6E-10	2.4E-10	4.66E-13	3.11E-13	2.07E-13
1/28/06 22:34	5.8E-10	3.3E-10	2.6E-10	4.96E-13	2.82E-13	2.28E-13
2/3/06 11:14	6.2E-10	3.9E-10	3.2E-10	5.32E-13	3.34E-13	2.73E-13
Average	5.9E-10	3.5E-10	2.6E-10	5.1E-13	3.0E-13	2.2E-13
Stdev	3.8E-11	3.4E-11	4.4E-11	3.2E-14	3.0E-14	3.8E-14
COV (%)	6.5	9.9	16.9	6.3	10.1	17.1

Table IV-3 Data sheet for WVT tests on three Type 3 assemblies (Hardboard siding Profile H1).

Date & time	Time diff.	Time diff.	Time diff.	Time increase cumulative,	Time interval	Weight, [kg]			Weight decrease, [g]		
	[d]	[h]	[s]	[h]	[h]	1	2	3	1	2	3
2/9/06 15:50	0.00	0.00	0.00E+00	0.00	0.00	-	29.5910	29.6425	-	-	-
2/12/06 13:43	2.91	69.88	6.04E+06	69.88	34.94		29.5825	29.6305		8.5	12.0
2/17/06 15:43	5.08	122.00	1.05E+07	191.88	130.88		29.5525	29.5945		30.0	36.0
2/19/06 21:50	2.25	54.12	4.68E+06	246.00	218.94		29.5370	29.5760		15.5	18.5
2/22/06 19:55	2.92	70.08	6.06E+06	316.08	281.04		29.5165	29.5510		20.5	25.0
2/26/06 13:15	3.72	89.33	7.72E+06	405.42	360.75		29.4895	29.5190		27.0	32.0
3/1/06 13:15	3.00	72.00	6.22E+06	477.42	441.42		29.4675	29.4930		22.0	26.0
3/3/06 15:45	2.10	50.50	4.36E+06	527.92	502.67		29.4525	29.4745		15.0	18.5
3/6/06 9:45	2.75	66.00	5.70E+06	593.92	560.92		29.4330	29.4510		19.5	23.5

Date & time	Rate of transmission (kg/sm) ⁽¹⁾			Rate of transmission/unit pressure (kg/smPa)		
	1	2	3	1	2	3
2/9/06 15:50	-	-	-	-	-	-
2/12/06 13:43		5.7E-10	8.0E-10		6.47E-13	9.14E-13
2/17/06 15:43		1.1E-09	1.4E-09		1.39E-12	1.66E-12
2/19/06 21:50		1.3E-09	1.6E-09		1.44E-12	1.72E-12
2/22/06 19:55		1.4E-09	1.7E-09		1.67E-12	2.04E-12
2/26/06 13:15		1.4E-09	1.7E-09		1.70E-12	2.01E-12
3/1/06 13:15		1.4E-09	1.7E-09		1.52E-12	1.80E-12
3/3/06 15:45		1.4E-09	1.7E-09		1.47E-12	1.82E-12
3/6/06 9:45		1.4E-09	1.7E-09		1.47E-12	1.77E-12
Average		1.4E-09	1.7E-09		1.5E-12	1.8E-12
Stdev		2.2E-11	2.1E-11		1.1E-13	1.1E-13
COV (%)		1.6	1.2		7.0	5.9

Table IV-4a Data sheet for WVT tests on one (1) Type 4 assembly (Hardboard siding Profile H2).

Date & time	Time diff.	Time diff.	Time diff.	Time increase cumulative,	Time interval	Weight, [kg]			Weight decrease, [g]		
	[d]	[h]	[s]	[h]	[h]	1	2	3	1	2	3
2/17/06 15:50	0.00	0.00	0.00E+00	0.00	0.00	29.2835			-	-	-
2/19/06 21:50	2.25	54.00	4.67E+06	54.00	27.00	29.2695			14.0		
2/22/06 19:51	2.92	70.02	6.05E+06	124.02	89.01	29.2460			23.5		
2/26/06 13:15	3.73	89.40	7.72E+06	213.42	168.72	29.2140			32.0		
3/1/06 11:15	2.92	70.00	6.05E+06	283.42	248.42	29.1890			25.0		
3/3/06 15:45	2.19	52.50	4.54E+06	335.92	309.67	29.1695			19.5		
3/6/06 9:45	2.75	66.00	5.70E+06	401.92	368.92	29.1455			24.0		

Date & time	Rate of transmission (kg/sm) ⁽¹⁾			Rate of transmission/unit pressure (kg/smPa)		
	1	2	3	1	2	3
2/17/06 15:50	-	-	-	-	-	-
2/19/06 21:50	1.8E-09			1.9E-12		
2/22/06 19:51	2.4E-09			2.4E-12		
2/26/06 13:15	2.5E-09			2.9E-12		
3/1/06 11:15	2.5E-09			2.9E-12		
3/3/06 15:45	2.6E-09			2.7E-12		
3/6/06 9:45	2.5E-09			2.7E-12		
Average	2.5E-09			2.8E-12		
Stdev	4.6E-11			1.2E-13		
COV (%)	1.8			4.3		

Table IV-4b Data sheet for WVT tests on two (2) additional Type 4 assemblies (Hardboard siding Profile H2).

Date & time	Time diff. [d]	Time diff. [h]	Time diff. [s]	Time increase cumulative, [h]	Time interval [h]	Weight, [kg]			Weight decrease, [g]		
						1	2	3	1	2	3
4-7-06 13:50	0.00	0.00	0.00E+00	0.00	0.00		28.9785	29.1250	0.0	0.0	0.0
4-10-06 16:33	3.11	74.72	6.46E+06	74.72	37.36		28.9535	29.1120	0.0	25.0	13.0
4-14-06 18:07	4.07	97.57	8.43E+06	172.28	123.50		28.9235	29.0890	0.0	30.0	23.0
4-17-06 14:15	2.84	68.13	5.89E+06	240.42	206.35		28.9015	29.0740	0.0	22.0	15.0
4-22-06 13:17	4.96	119.03	1.03E+07	359.45	299.93		28.8625	29.0490	0.0	39.0	25.0
4-25-06 19:03	3.24	77.77	6.72E+06	437.22	398.33		28.8355	29.0320	0.0	27.0	17.0
4-29-06 16:42	3.90	93.65	8.09E+06	530.87	484.04		28.8030	29.0115	0.0	32.5	20.5

Date & time	Rate of transmission (kg/sm) ⁽¹⁾			Rate of transmission/unit pressure (kg/smPa)		
	1	2	3	1	2	3
4-7-06 13:50	-	0.0E+00	0.0E+00		0.0E+00	0.0E+00
4-10-06 16:33		2.4E-09	1.2E-09		2.5E-12	1.3E-12
4-14-06 18:07		2.2E-09	1.7E-09		2.2E-12	1.7E-12
4-17-06 14:15		2.3E-09	1.6E-09		2.7E-12	1.8E-12
4-22-06 13:17		2.3E-09	1.5E-09		2.7E-12	1.7E-12
4-25-06 19:03		2.5E-09	1.6E-09		2.5E-12	1.6E-12
4-29-06 16:42		2.5E-09	1.6E-09		2.6E-12	1.7E-12
Average		2.4E-09	1.5E-09		2.6E-12	1.7E-12
Stdev		9.1E-11	3.3E-11		7.2E-14	9.7E-14
COV (%)		3.8	2.1		2.7	5.7

Table IV-5 Data sheet for WVT tests on three Type 5 assemblies (Fibre-cement siding, FC).

Date & time	Time diff.	Time diff.	Time diff.	Time increase cumulative,	Time interval	Weight, [kg]			Weight decrease, [g]		
	[d]	[h]	[s]	[h]	[h]	1	2	3	1	2	3
3/6/06 14:30	0.00	0.00	0.00E+00	0.00	0.00	28.9375	29.1050	29.2700	0.0	0.0	0.0
3/8/06 11:46	1.89	45.27	3.91E+06	45.27	22.63	28.9265	29.0950	29.2610	11.0	10.0	9.0
3/10/06 13:45	2.08	49.98	4.32E+06	95.25	70.26	28.9110	29.0805	29.2475	15.5	14.5	13.5
3/13/06 11:50	2.92	70.08	6.06E+06	165.33	130.29	28.8870	29.0575	29.2255	24.0	23.0	22.0
3/15/06 16:20	2.19	52.50	4.54E+06	217.83	191.58	28.8685	29.0385	29.2075	18.5	19.0	18.0
3/17/06 18:05	2.07	49.75	4.30E+06	267.58	242.71	28.8510	29.0205	29.1905	17.5	18.0	17.0
3/20/06 10:20	2.68	64.25	5.55E+06	331.83	299.71	28.8275	28.9965	29.1675	23.5	24.0	23.0
3/23/06 15:25	3.21	77.08	6.66E+06	408.92	370.38	28.7995	28.9685	29.1405	28.0	28.0	27.0

Date & time	Rate of transmission (kg/sm) ⁽¹⁾			Rate of transmission/unit pressure (kg/smPa)		
	1	2	3	1	2	3
3/6/06 14:30	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
3/8/06 11:46	1.7E-09	1.5E-09	1.4E-09	1.8E-12	1.6E-12	1.4E-12
3/10/06 13:45	2.2E-09	2.0E-09	1.9E-09	2.3E-12	2.2E-12	2.0E-12
3/13/06 11:50	2.4E-09	2.3E-09	2.2E-09	2.8E-12	2.7E-12	2.6E-12
3/15/06 16:20	2.5E-09	2.5E-09	2.4E-09	2.9E-12	2.9E-12	2.8E-12
3/17/06 18:05	2.5E-09	2.5E-09	2.4E-09	2.7E-12	2.8E-12	2.7E-12
3/20/06 10:20	2.6E-09	2.6E-09	2.5E-09	2.8E-12	2.9E-12	2.8E-12
3/23/06 15:25	2.5E-09	2.5E-09	2.5E-09	2.9E-12	2.9E-12	2.8E-12
Average	2.5E-09	2.6E-09	2.4E-09	2.8E-12	2.9E-12	2.8E-12
Stdev	5.1E-11	4.0E-11	5.3E-11	6.4E-14	4.8E-14	6.1E-14
COV (%)	2.0	1.5	2.2	2.3	1.7	2.2

APPENDIX V

Environmental Conditions for Water Vapour Transmission Tests

APPENDIX V – BOUNDARY CONDITION PLOTS

The following appendix contains plots of boundary conditions including: temperature, relative humidity, saturation vapour pressure and actual vapour pressure, monitored during conduct of the WVT tests.

Appendix V-1a: Boundary Conditions inside the Chamber for WVT Tests Performed with Type-1 Siding.

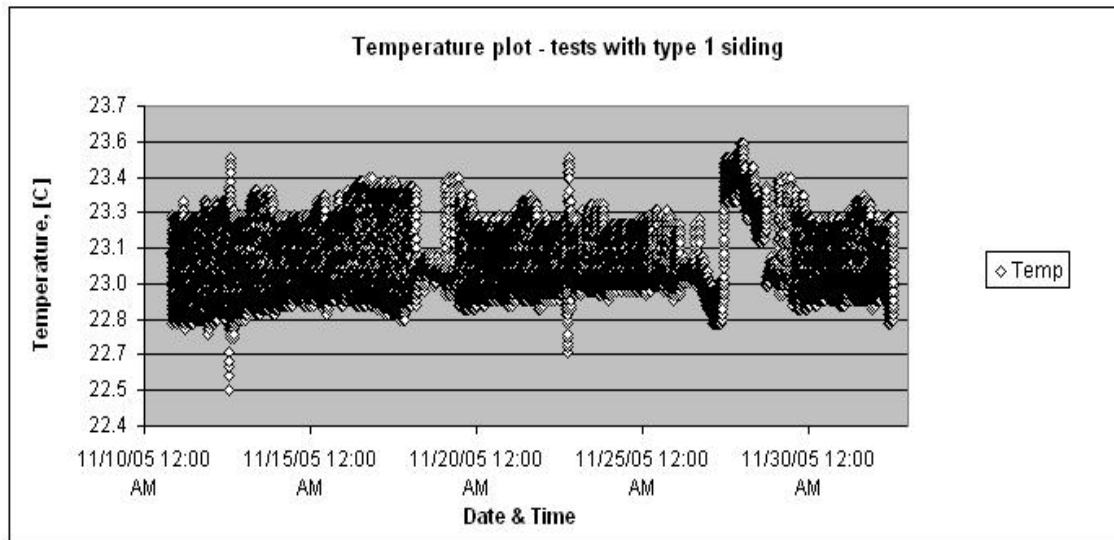


Figure V1a-1

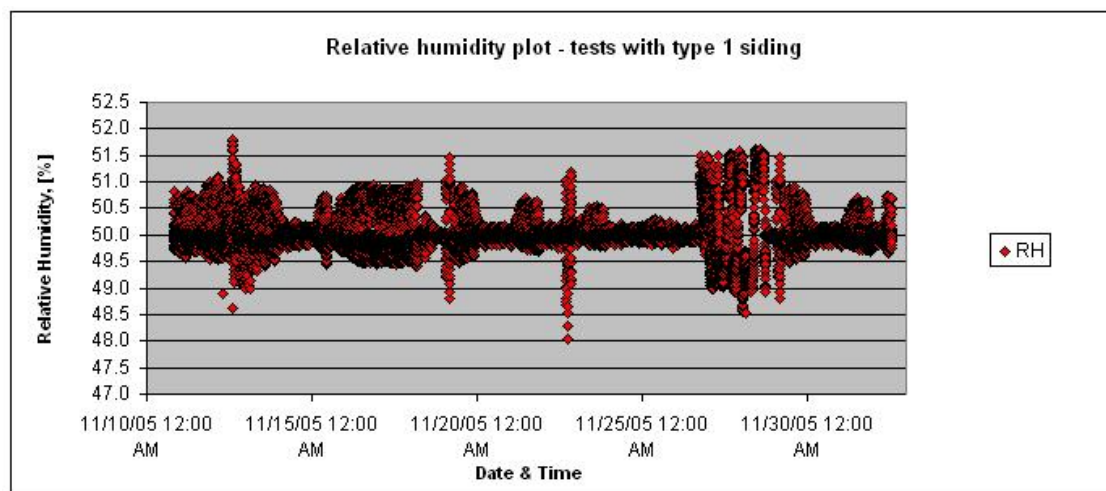


Figure V1a-2

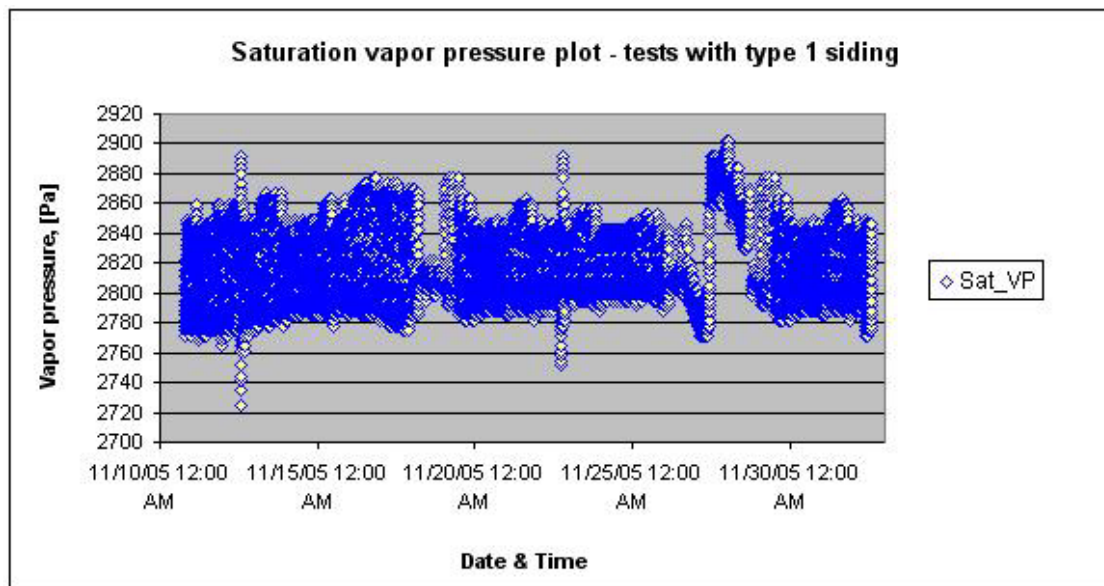


Figure VIa-3

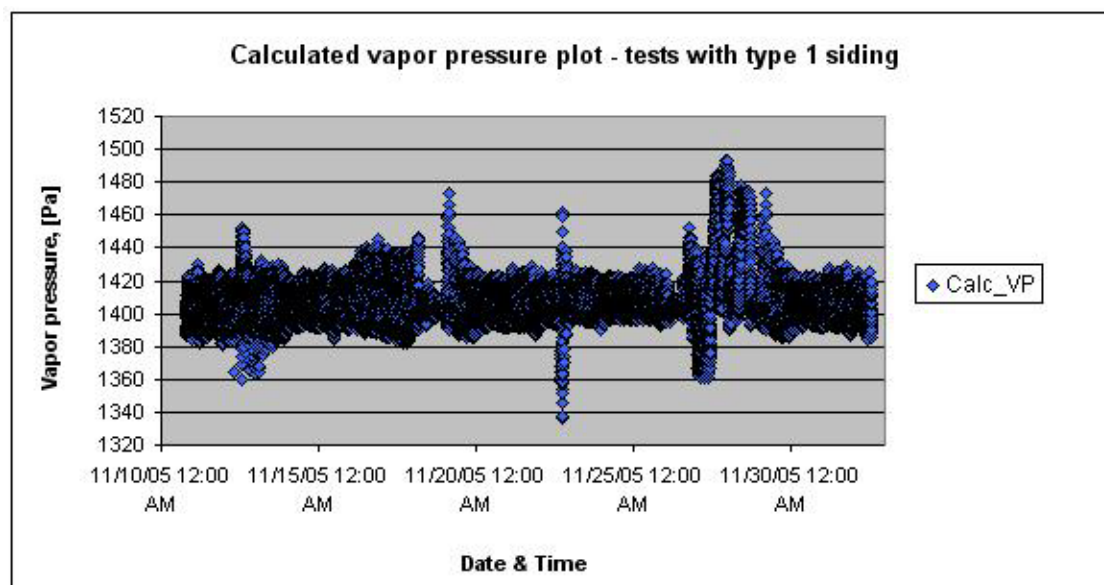


Figure VIa-4

Appendix V-1b: Boundary conditions measured inside the pan for WVT tests performed with type-1 siding (measurements performed at the beginning of the test)

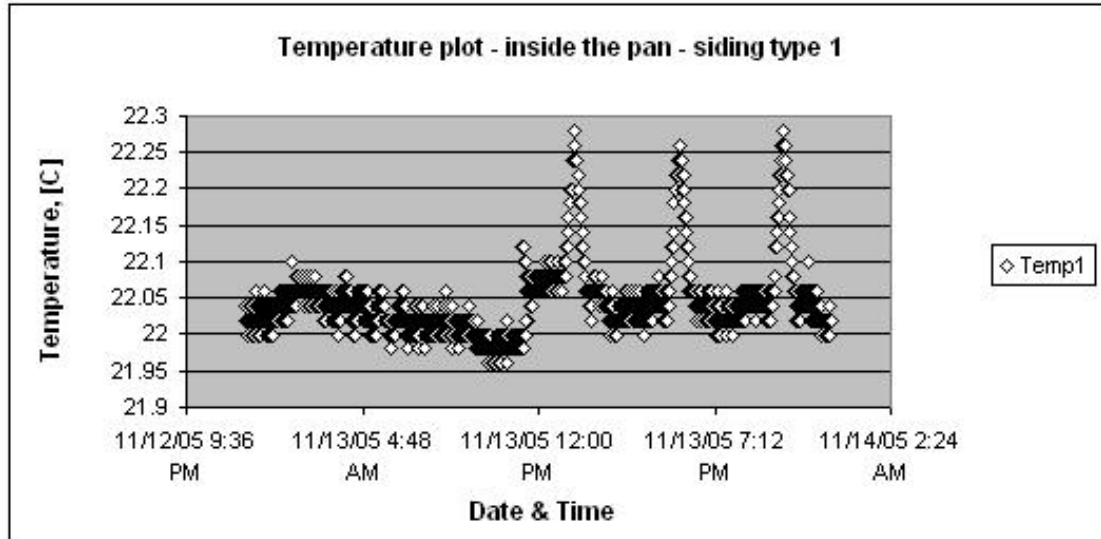


Figure V1b-1

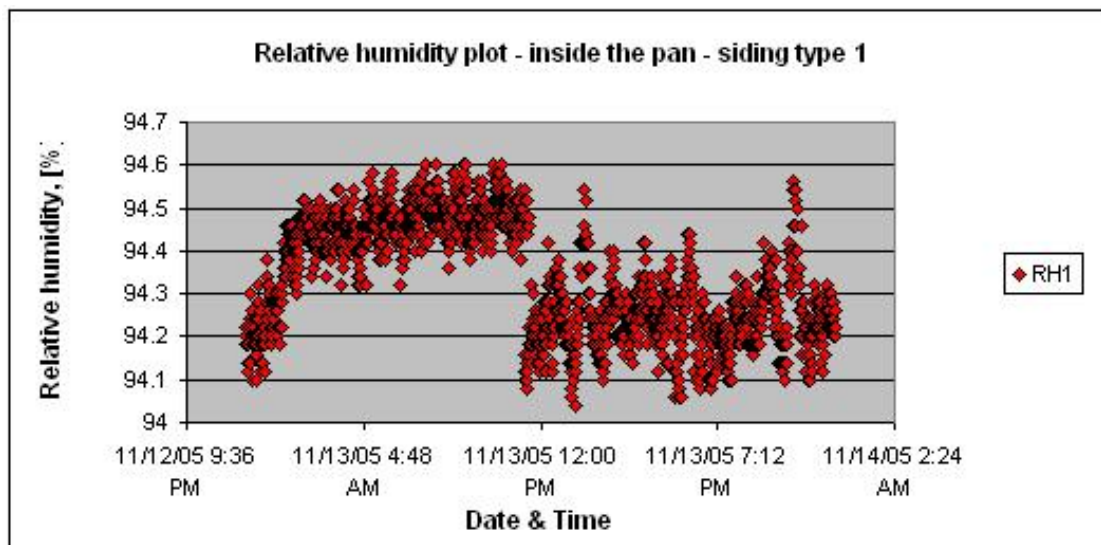


Figure V1b-2

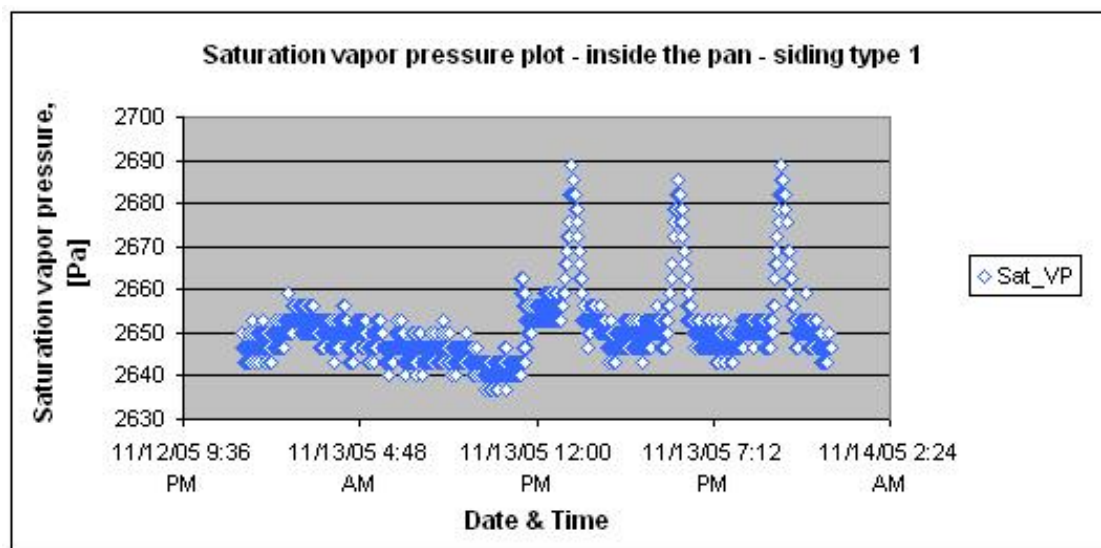


Figure V1b-3

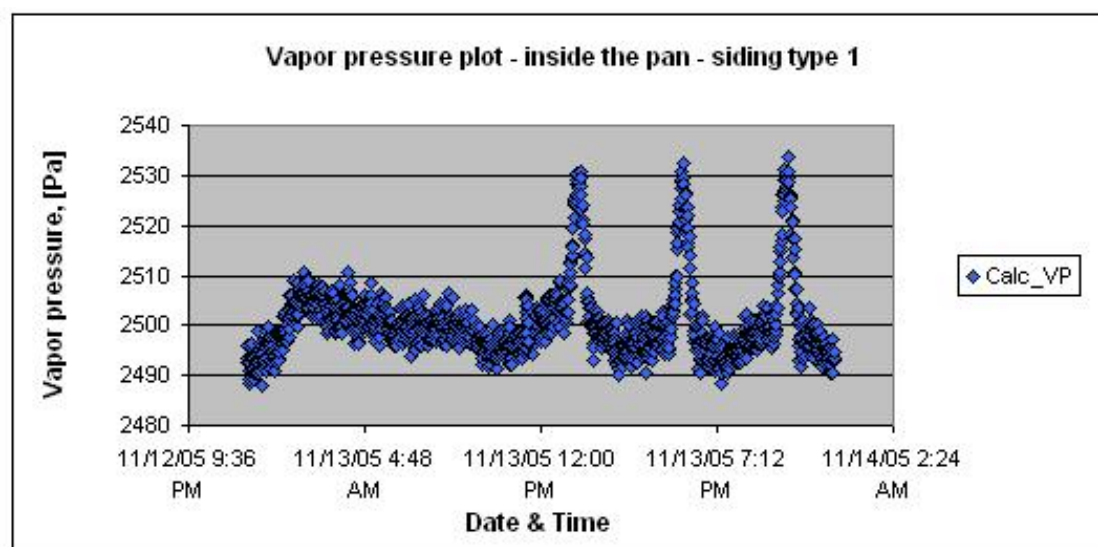


Figure V1b-4

Appendix V-1c: Boundary conditions measured inside the pan for WVT tests performed with type-1 siding (measurements performed at the end of the test)

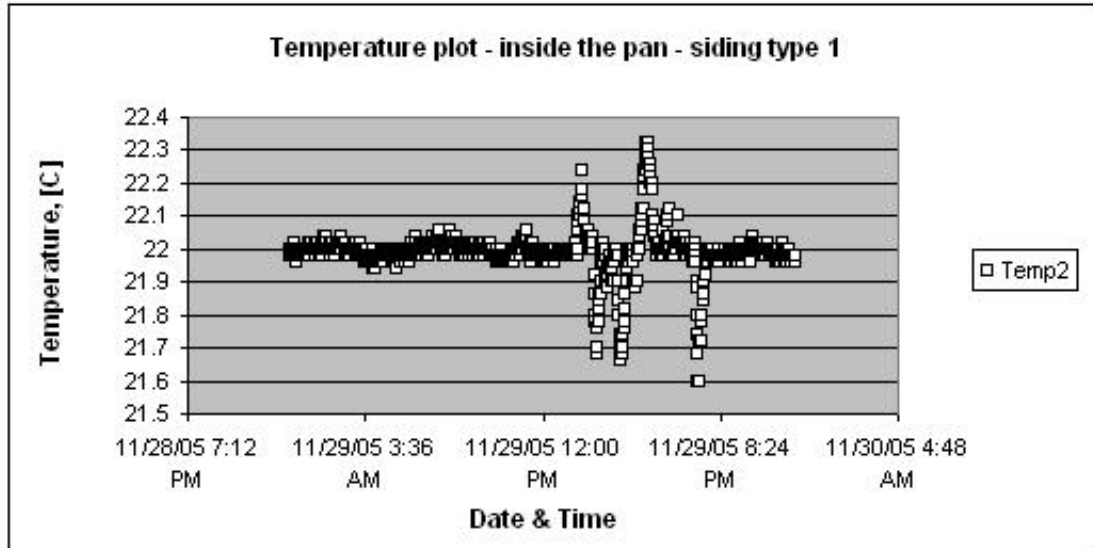


Figure V1c-1

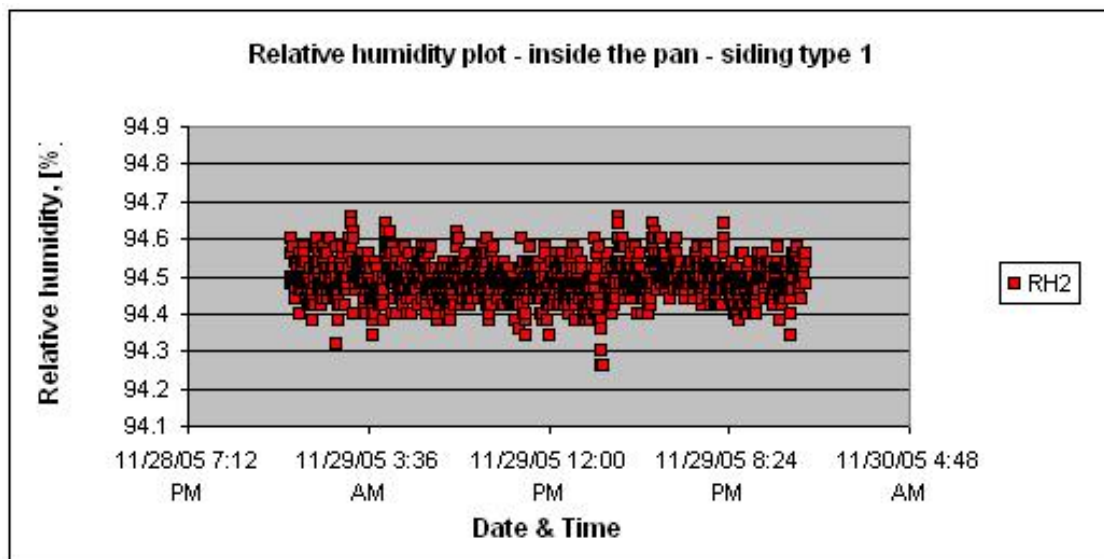


Figure V1c-2

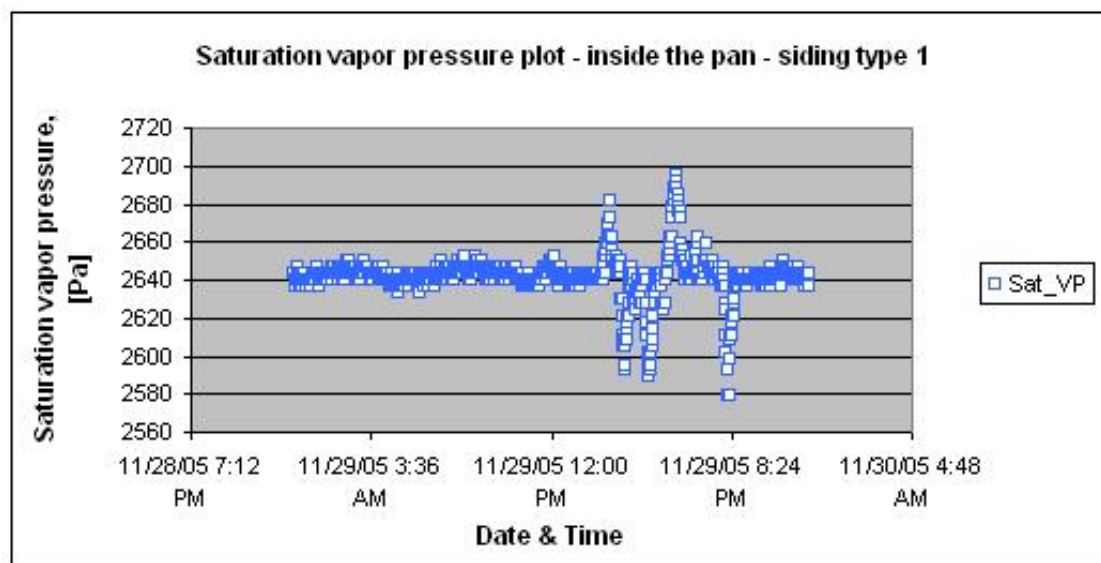


Figure VIc-3

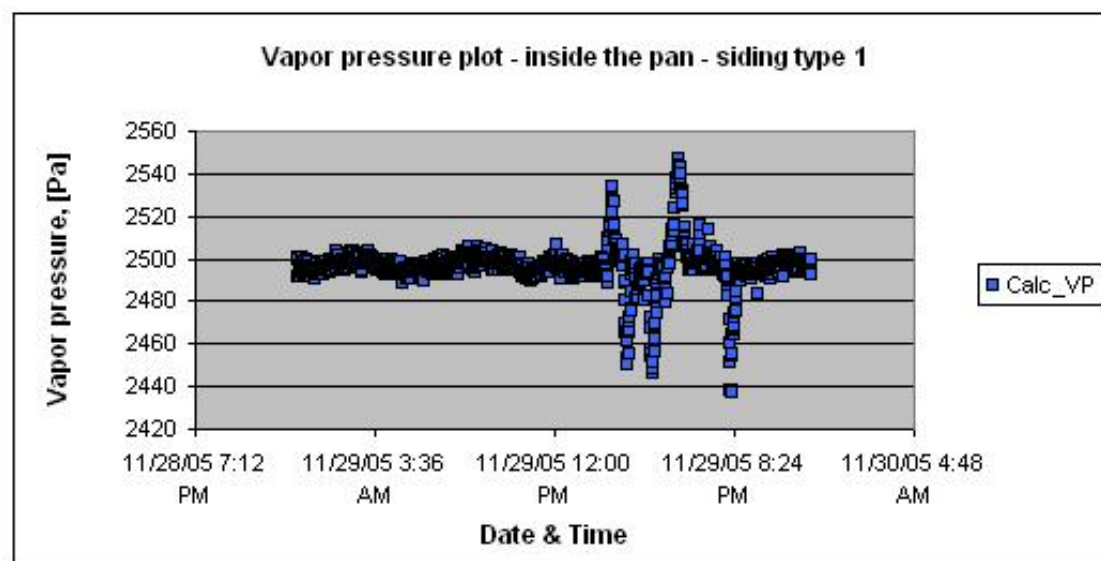


Figure VIc-4

Table VIc-1

Start date & time	Finish date & time	Time duration [h]	Average vapour pressure [Pa]	Standard deviation
1/11/06 9:00 AM	1/12/06 10:00 AM	25	2498	67
1/28/06 10:30 AM	1/29/06 11:30 AM	25	2496	10
1/11/06 9:00 AM	1/29/06 11:30 AM	50	2497	49

Appendix V-2a: Boundary Conditions inside the Chamber for WVT Tests Performed with Type-2 Siding.

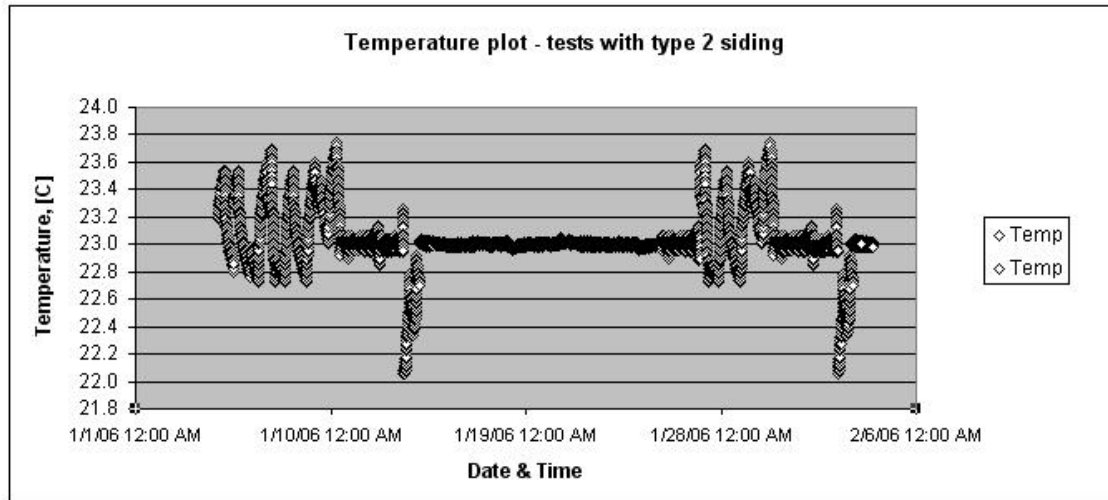


Figure V2a-1

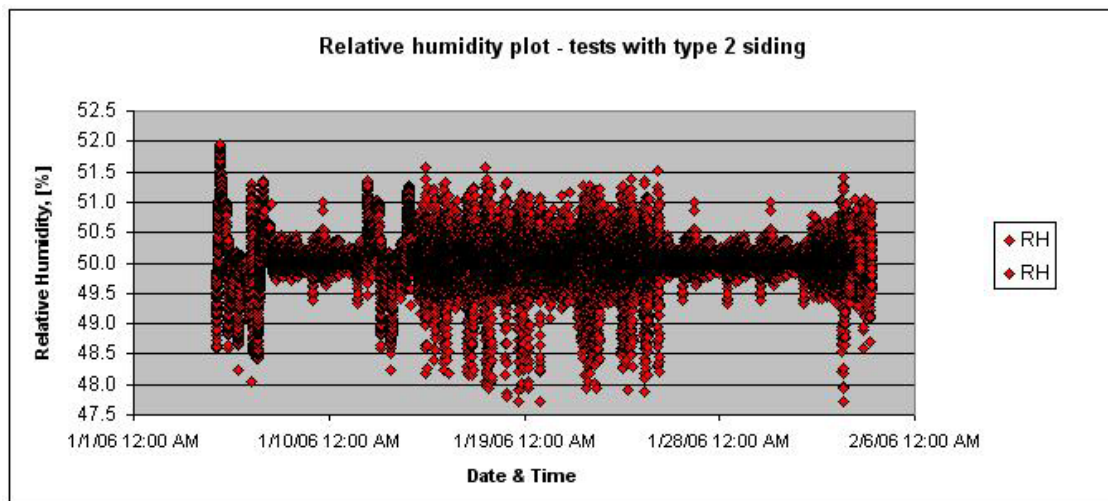


Figure V2a-2

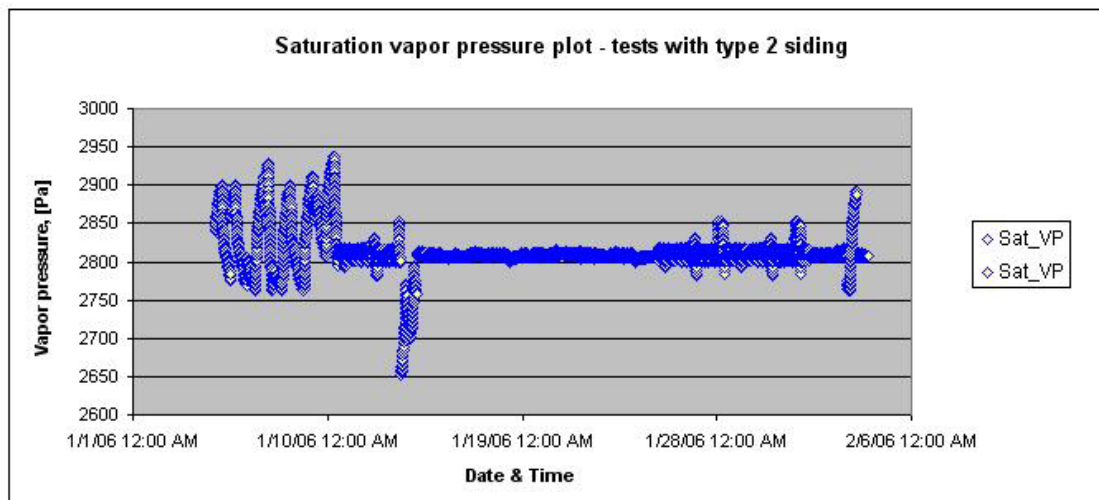


Figure V2a-3

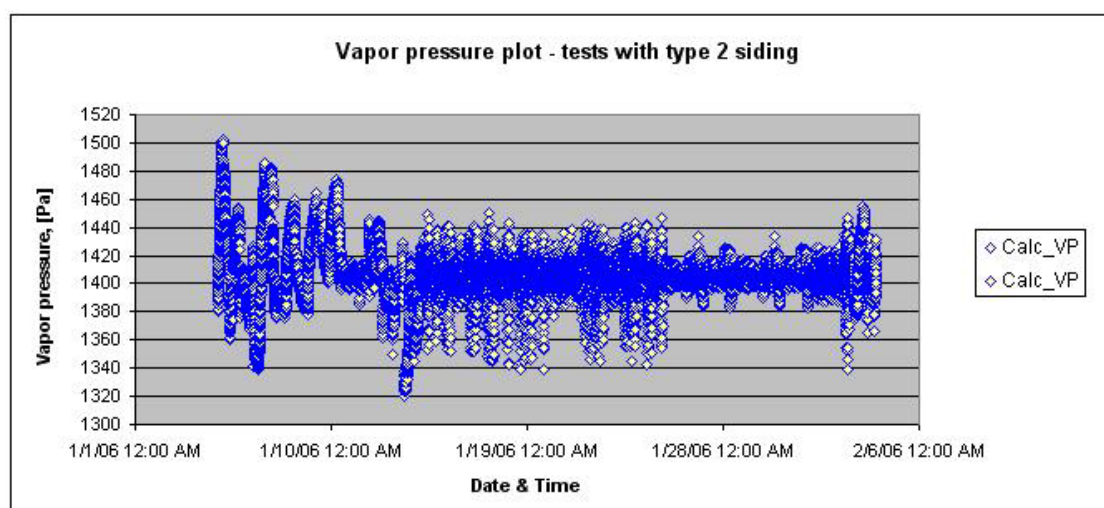


Figure V2a-4

Appendix V-2b: Boundary conditions measured inside the pan for WVT tests performed with type-2 siding (measurements performed at the beginning of the test)

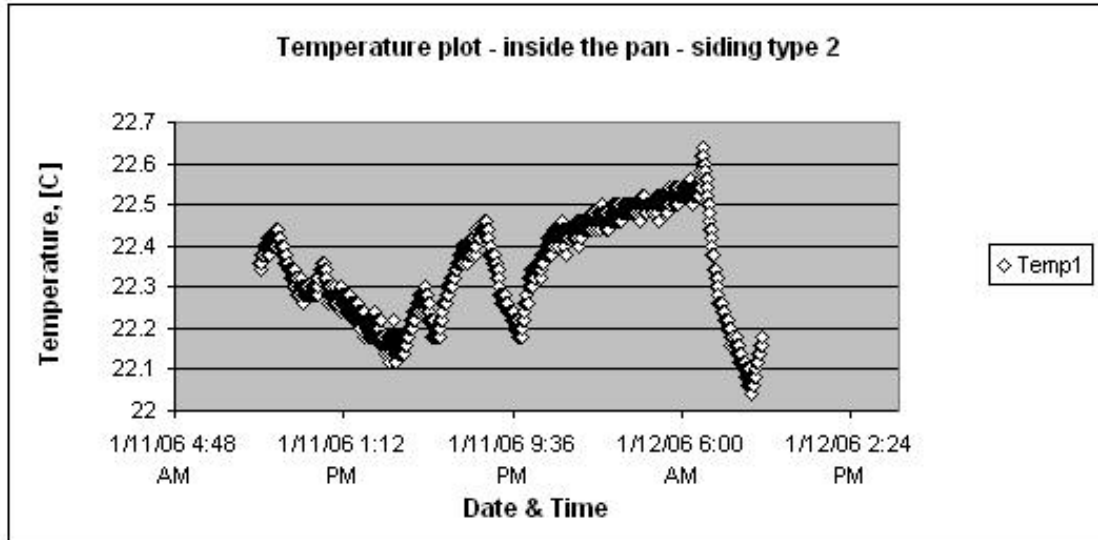


Figure V2b-1

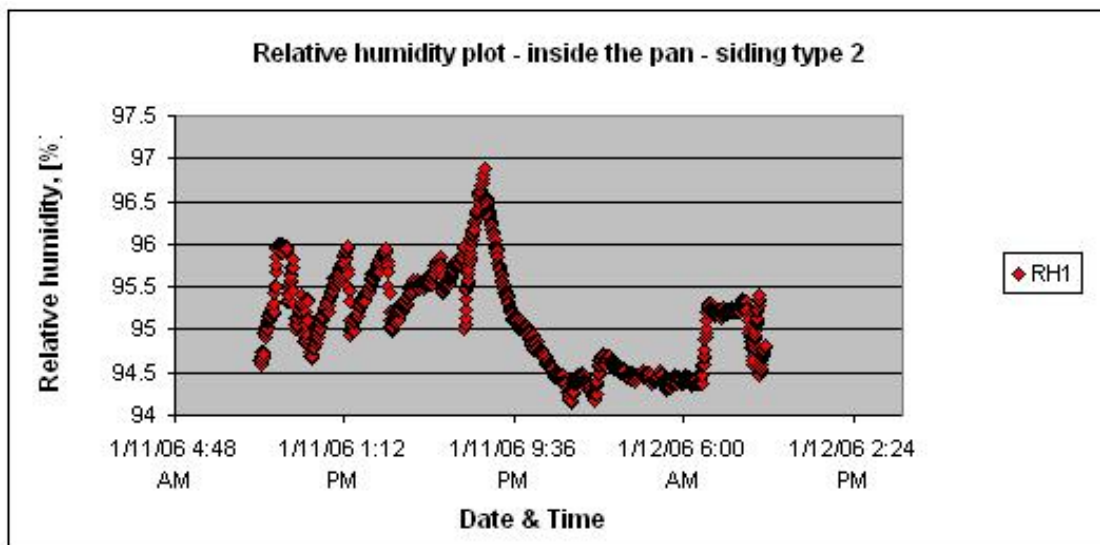


Figure V2b-2

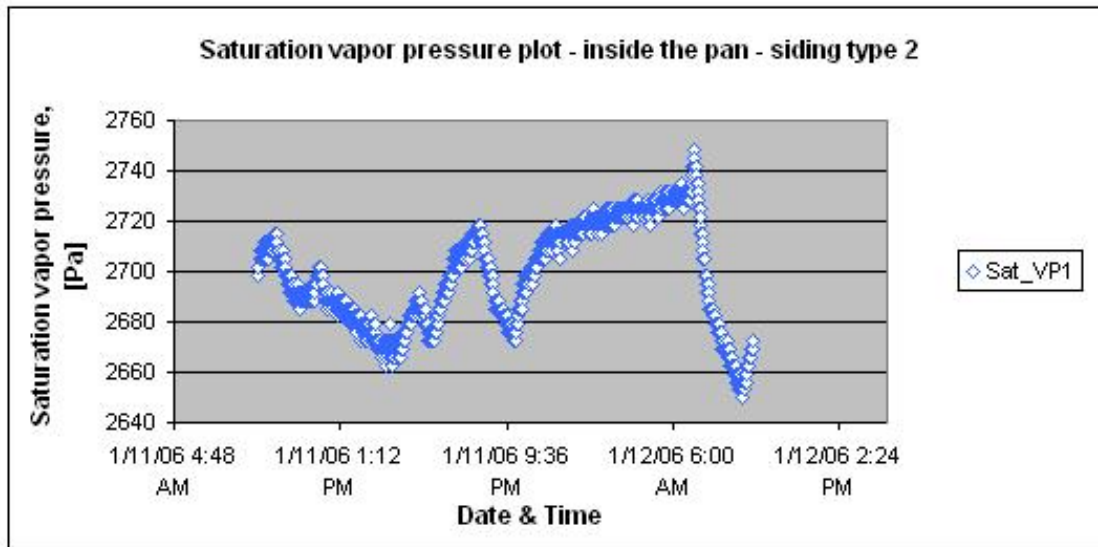


Figure V2b-3

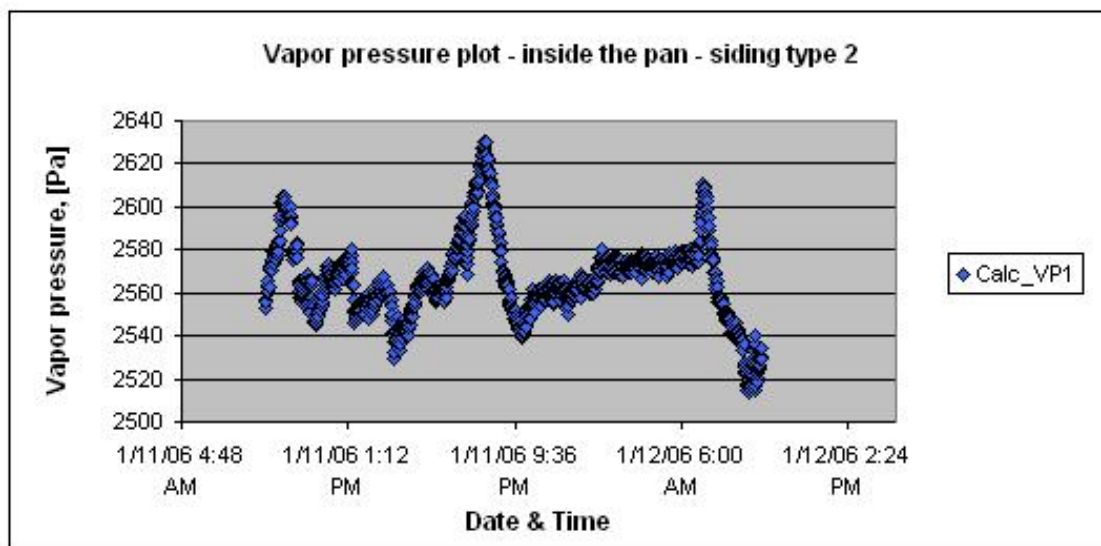


Figure V2b-4

Appendix V-2c: Boundary conditions measured inside the pan for WVT tests performed with type-2 siding (measurements performed at the end of the test)

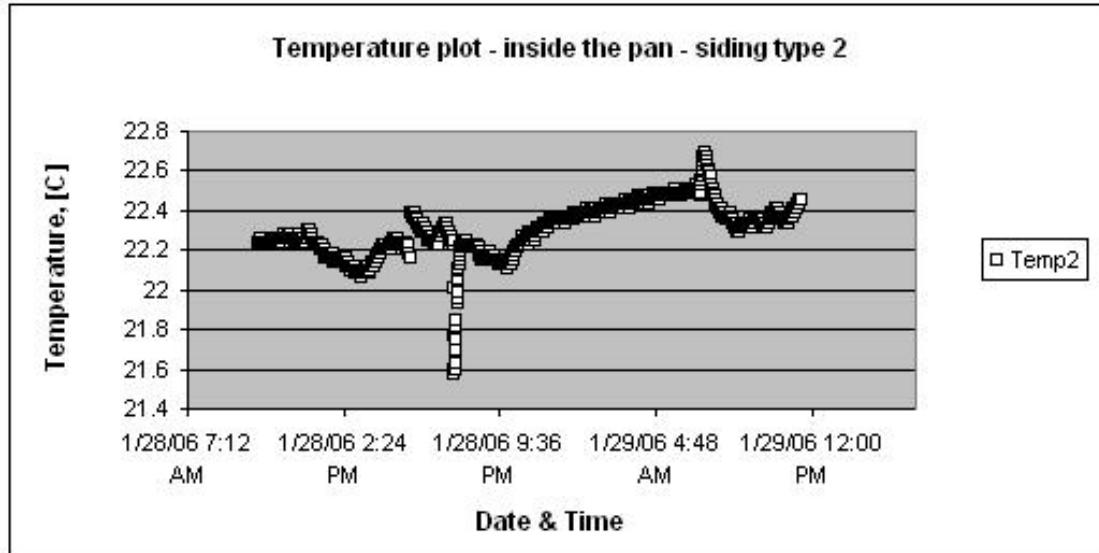


Figure V2c-1

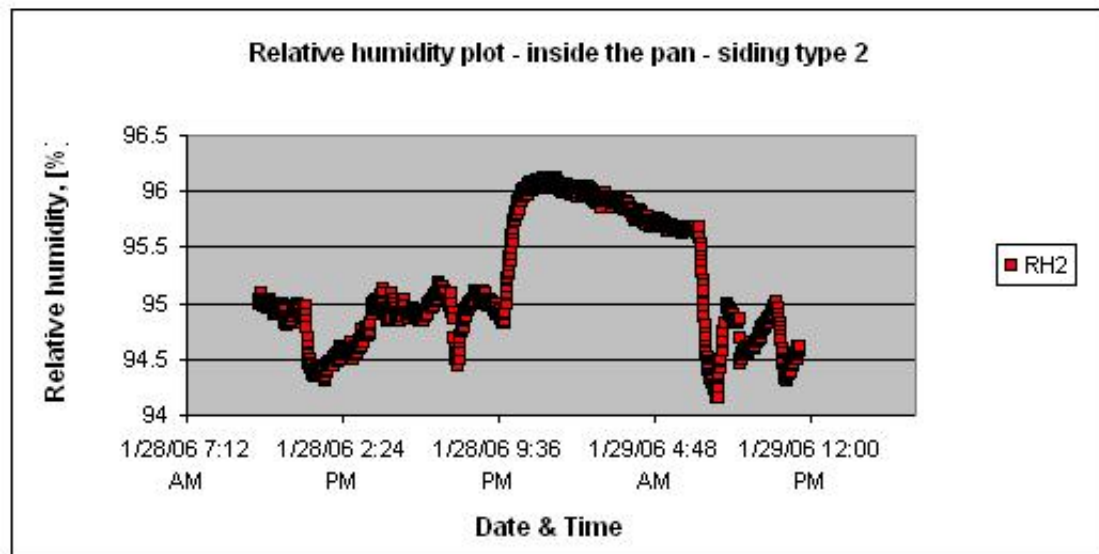


Figure F2c-2

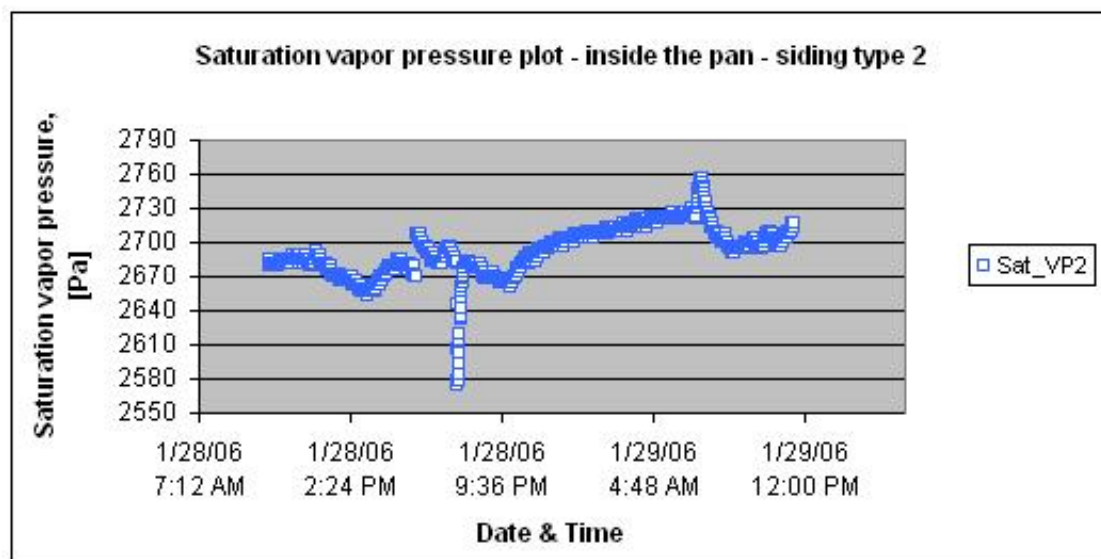


Figure V2c-3

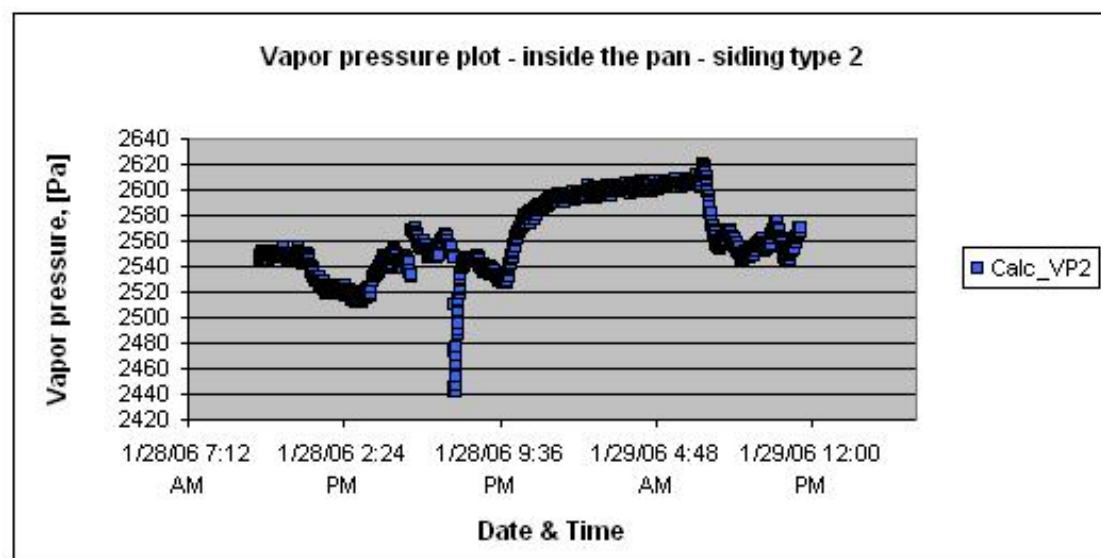


Figure V2c-4

Table V2c-1

Start date & time	Finish date & time	Time duration [h]	Average vapour pressure [Pa]	Standard deviation
1/11/06 9:00 AM	1/12/06 10:00 AM	25	2567	19
1/28/06 10:30 AM	1/29/06 11:30 AM	25	2563	30
1/11/06 9:00 AM	1/29/06 11:30 AM	50	2565	25

Appendix V-3a: Boundary conditions inside the chamber for WVT tests performed with type-3 and type-4 specimens.

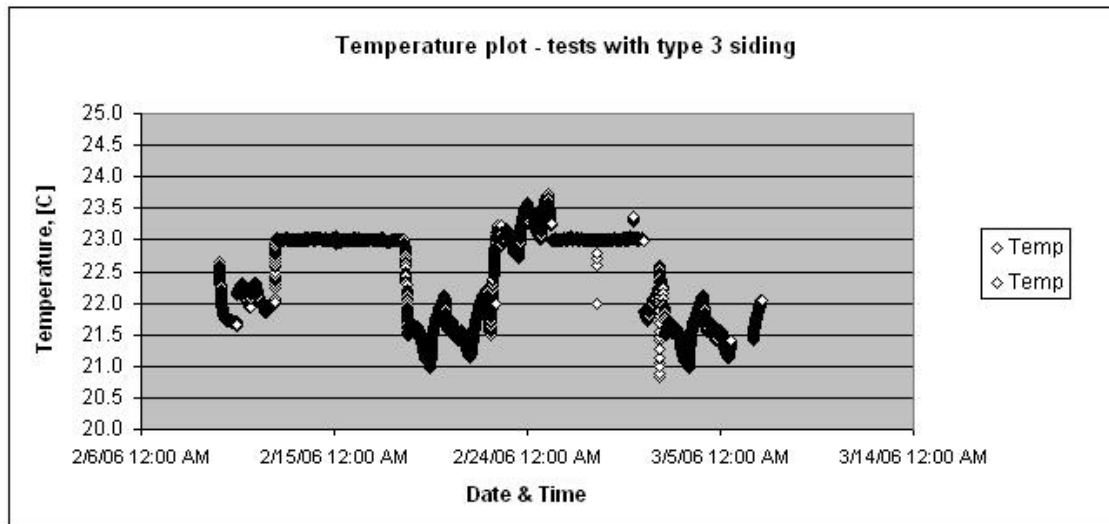


Figure V3a-1

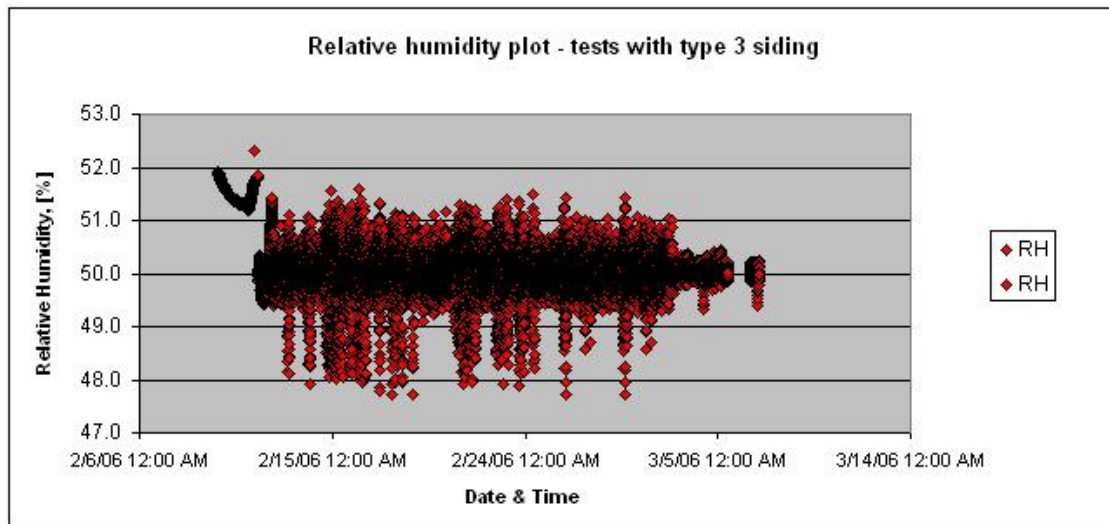


Figure V3a-2

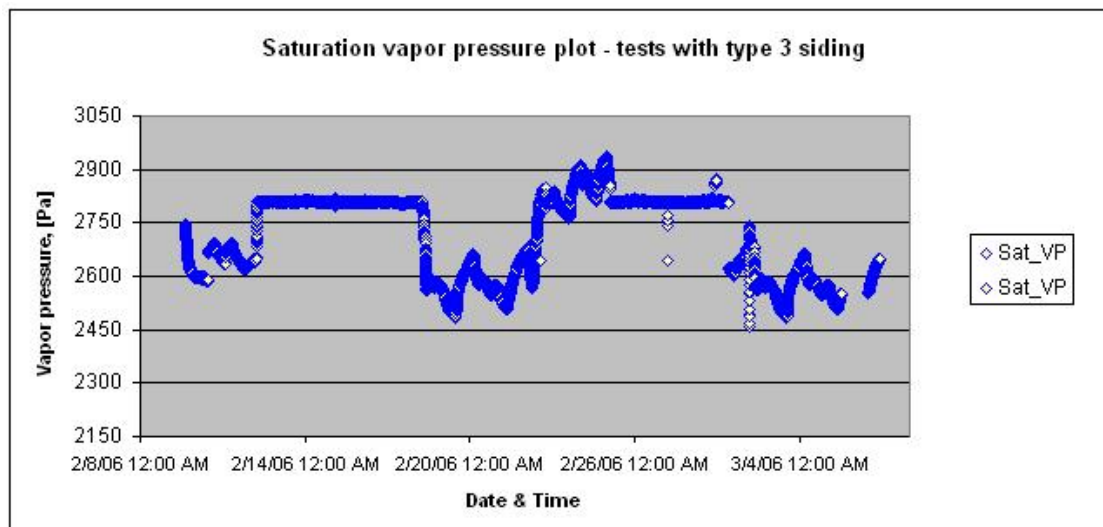


Figure V3a-3

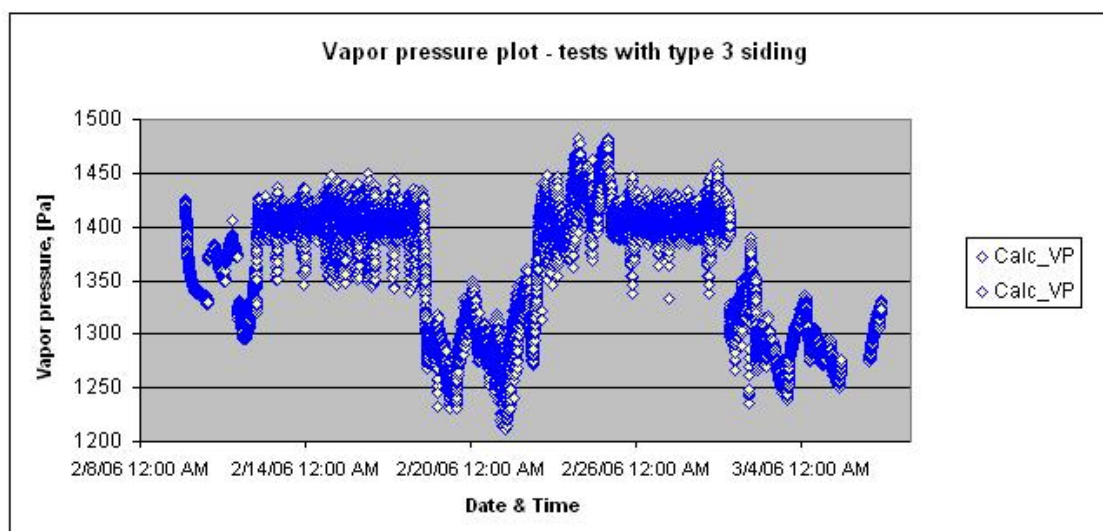


Figure V3a-4

Appendix V-3b: Boundary conditions measured inside the pan for WVT tests performed with type-3 siding (measurements performed at the beginning of the test)

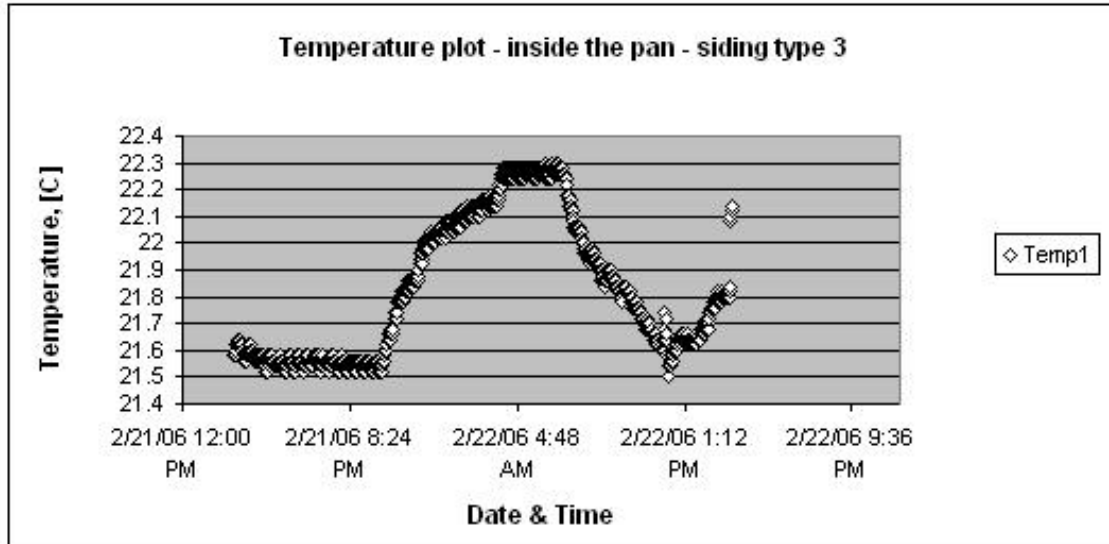


Figure V3b-1

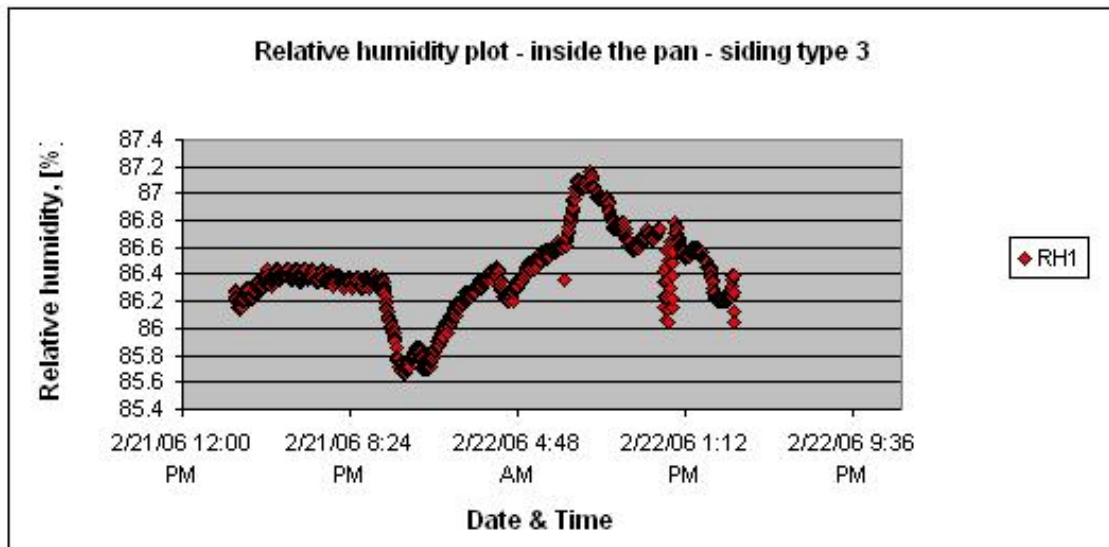


Figure V3b-2

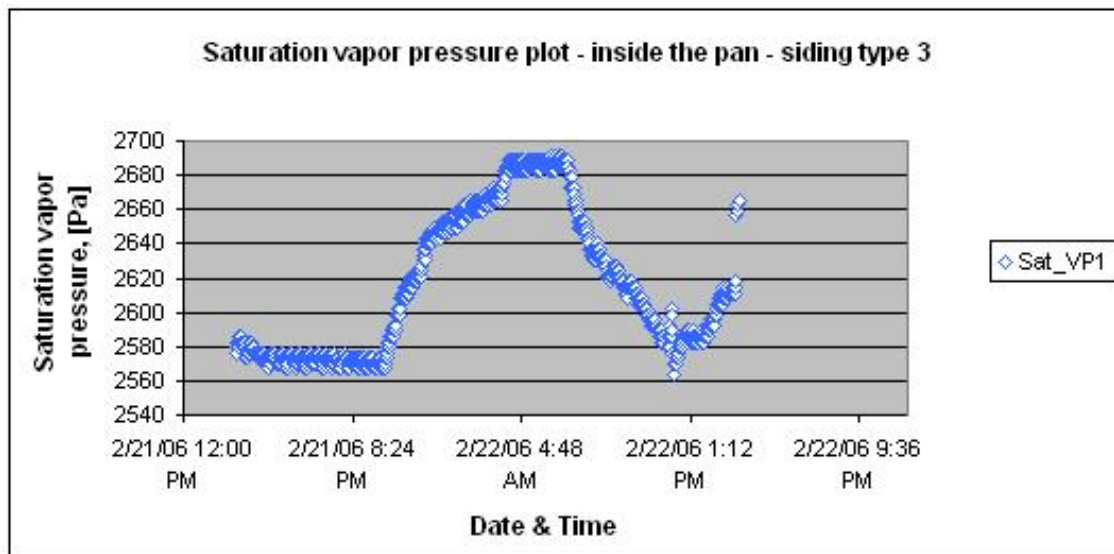


Figure V3b-3

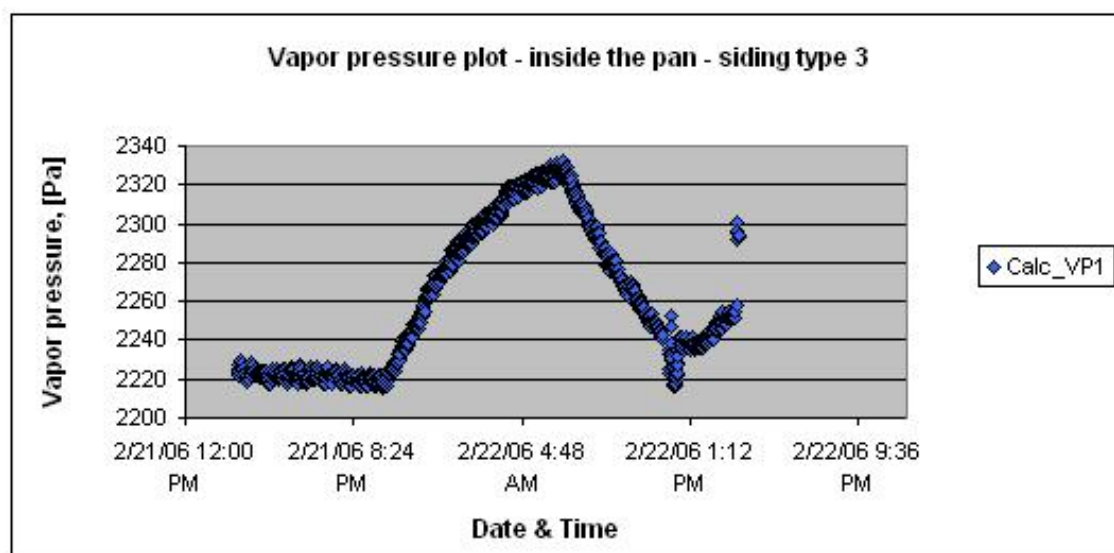


Figure V3b-4

Appendix V-3c: Boundary conditions measured inside the pan for WVT tests performed with type-3 siding (measurements performed at the end of the test)

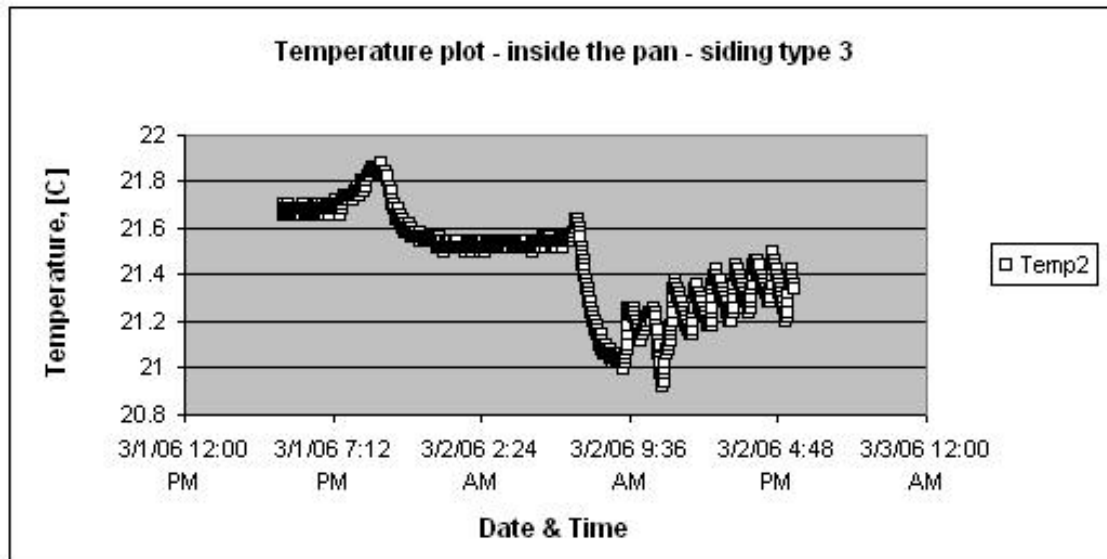


Figure V3c-1

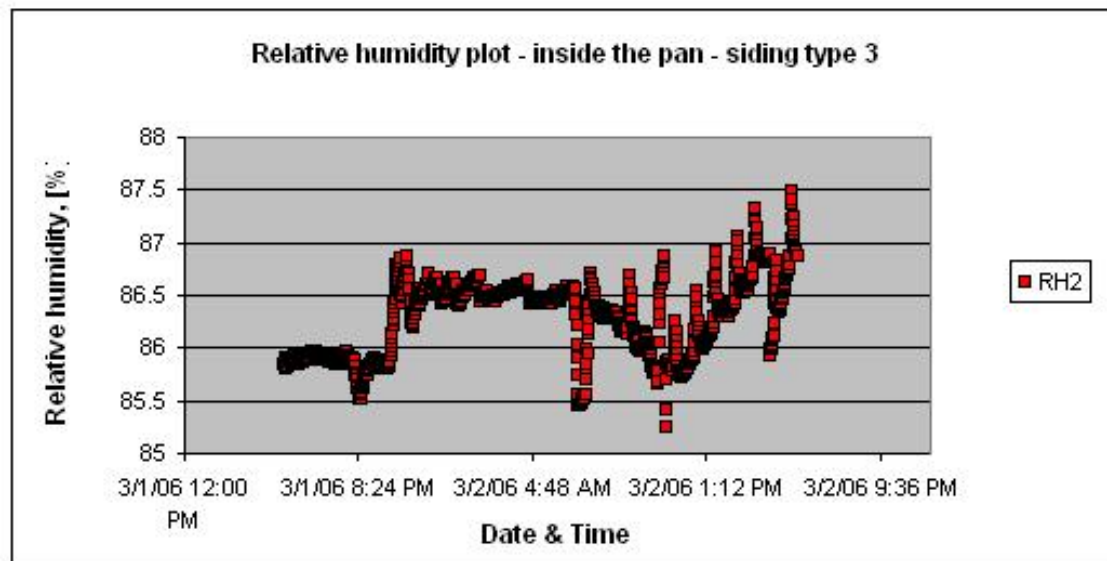


Figure V3c-2

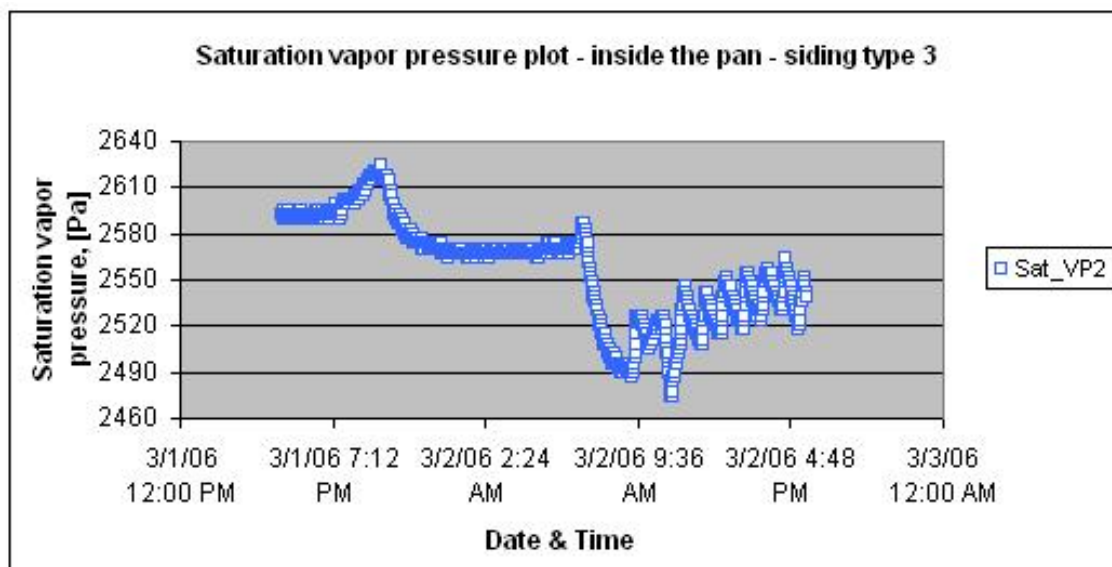


Figure V3c-3

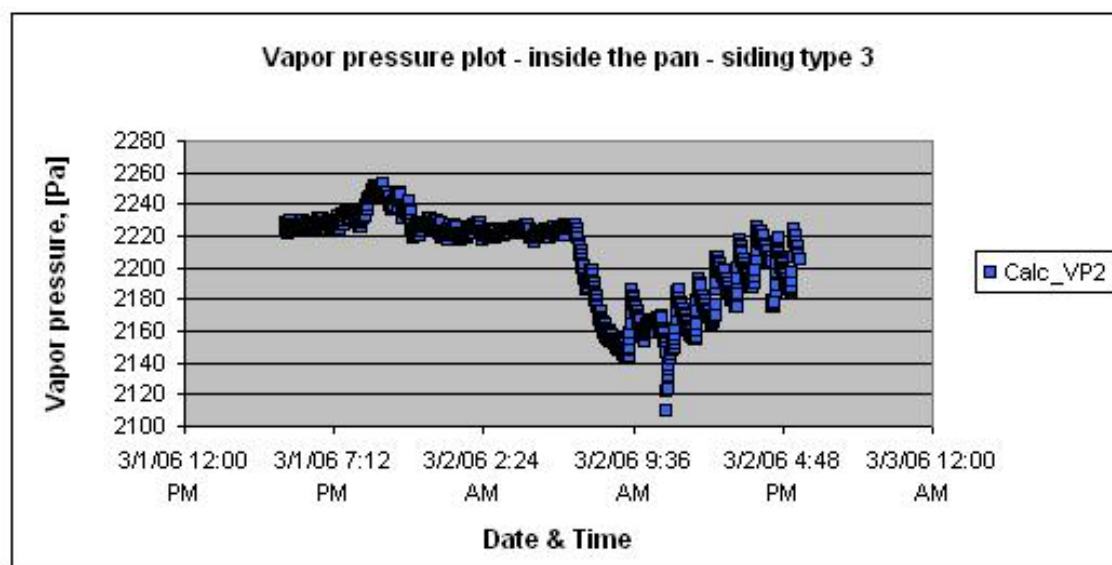


Figure V3c-4

Table V3c-1

Start date & time	Finish date & time	Time duration [h]	Average vapour pressure [Pa]	Standard deviation
2/21/06 2:36 PM	2/22/06 3:36 PM	25	2260	37
3/1/06 4:36 PM	3/2/06 5:36 PM	25	2207	28
2/21/06 2:36 PM	3/2/06 5:36 PM	50	2234	43

Appendix V-3d: Boundary conditions measured inside the pan for WVT tests performed with type-4 siding (measurements performed at the beginning of the test)

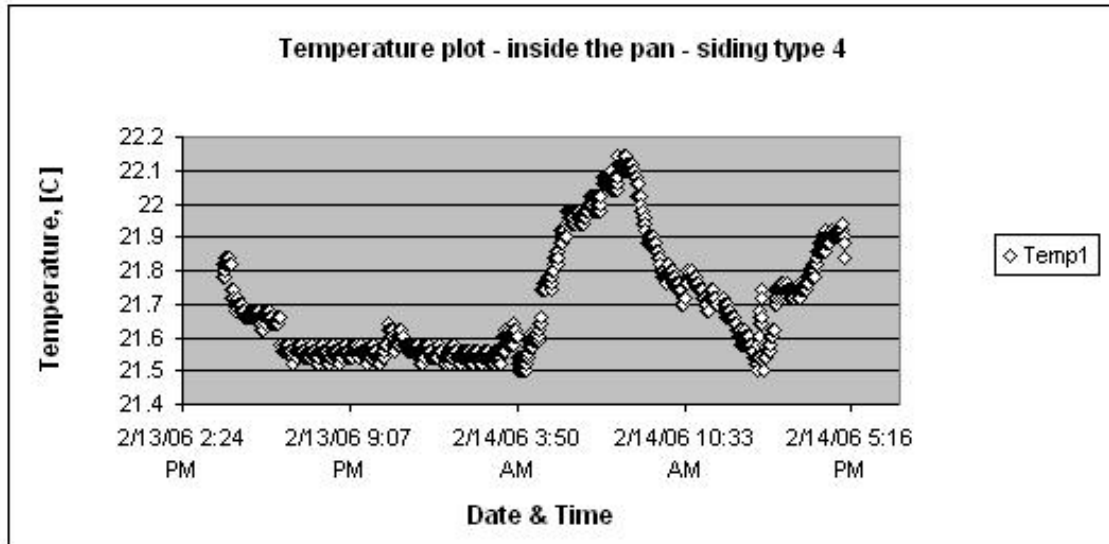


Figure V3d-1

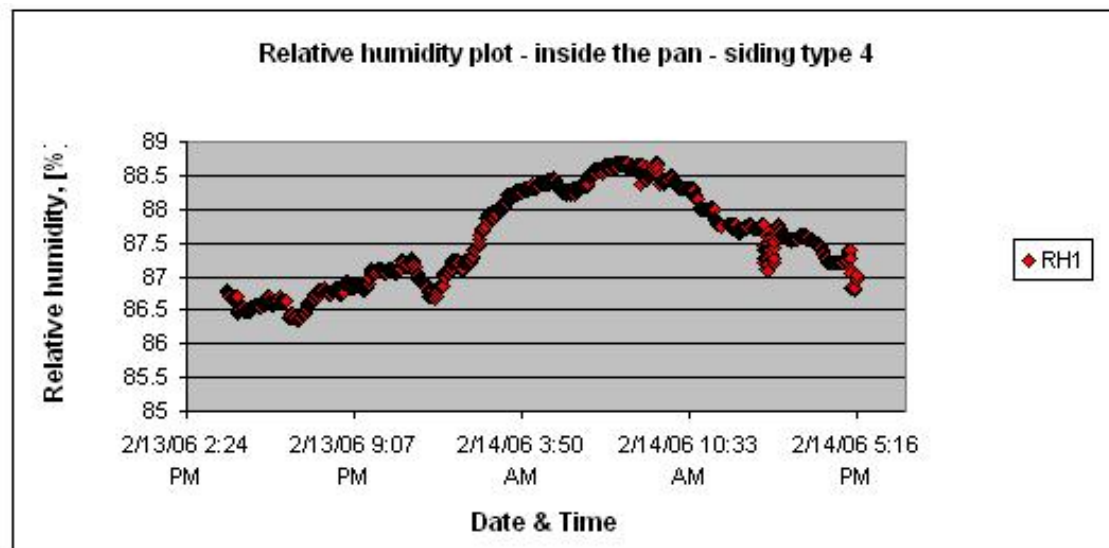


Figure V3d-2

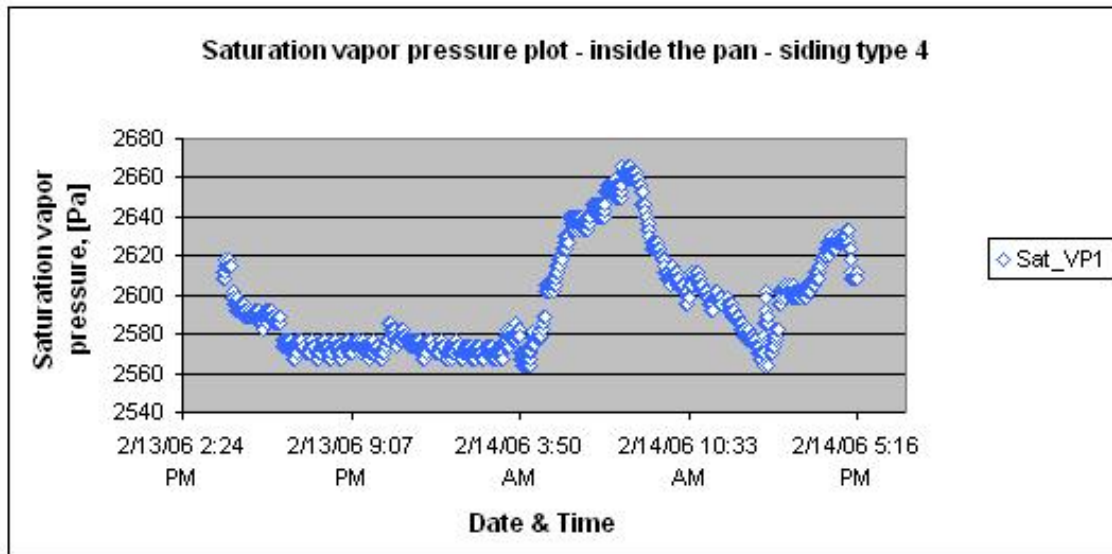


Figure V3d-3

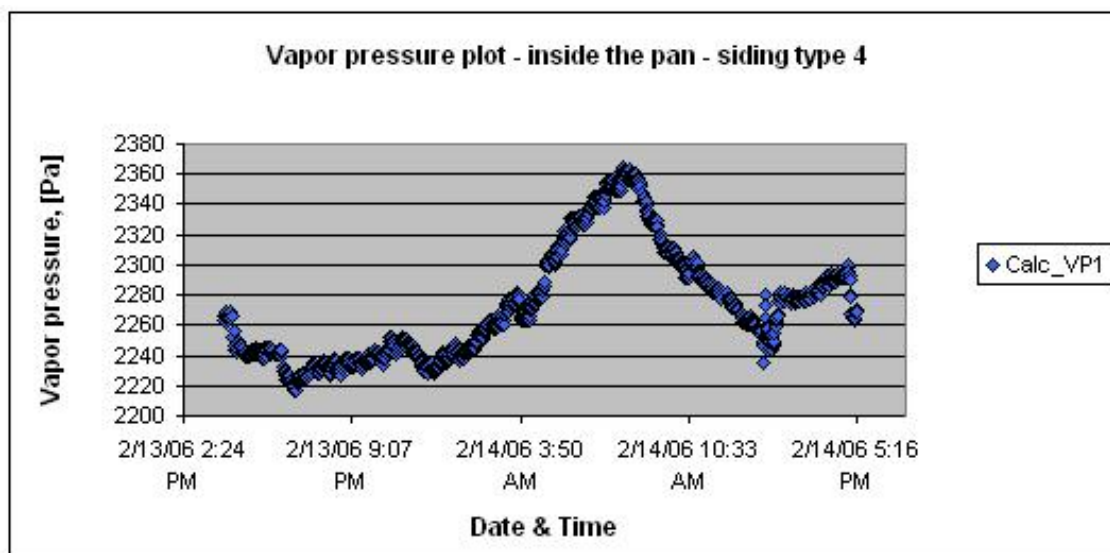


Figure V3d-4

Appendix V-3e: Boundary conditions measured inside the pan for WVT tests performed with type-4 siding (measurements performed at the end of the test)

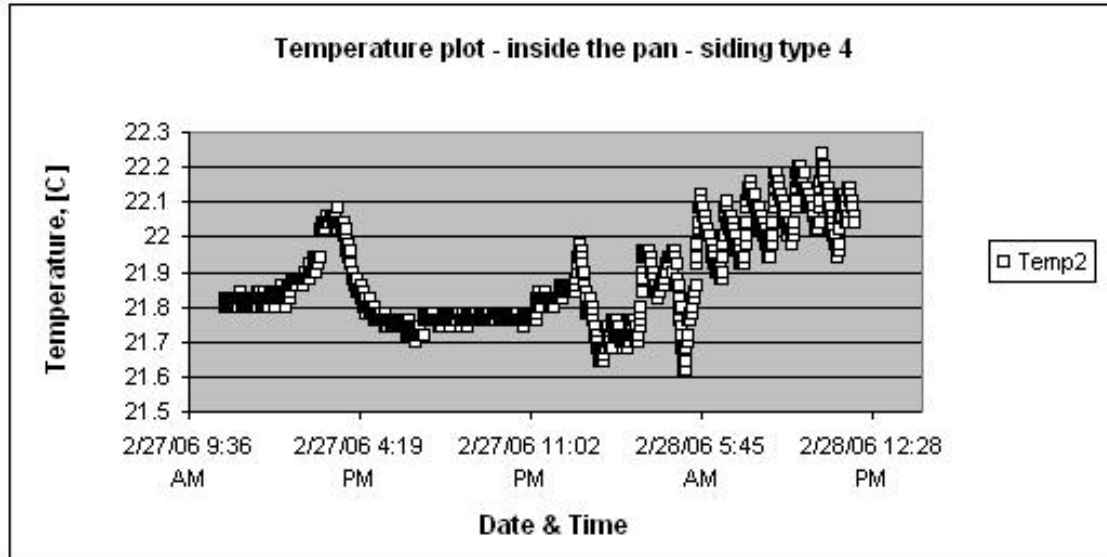


Figure V3e-1

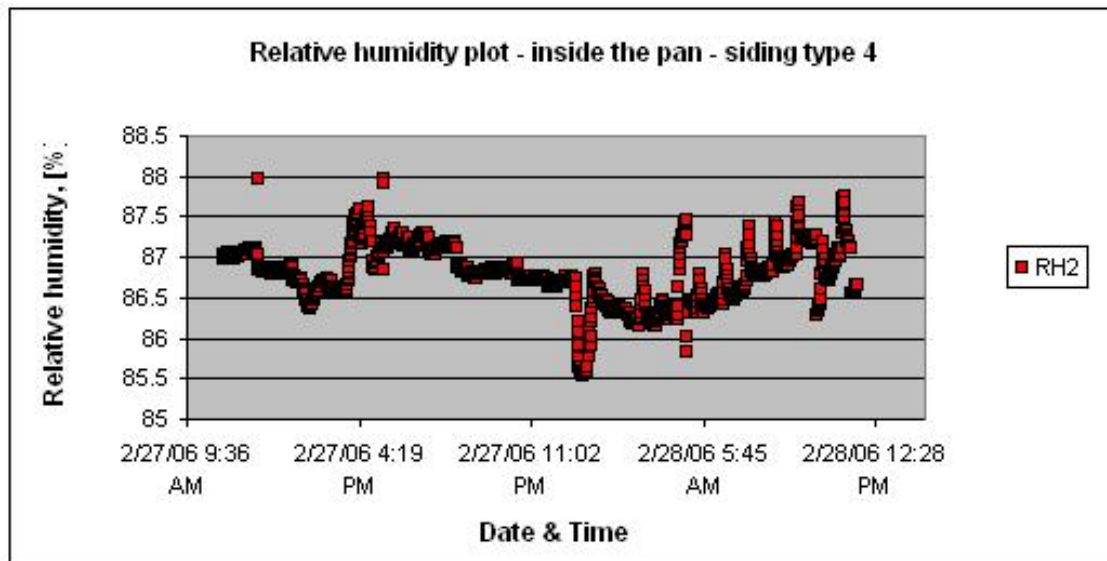


Figure V3e-2

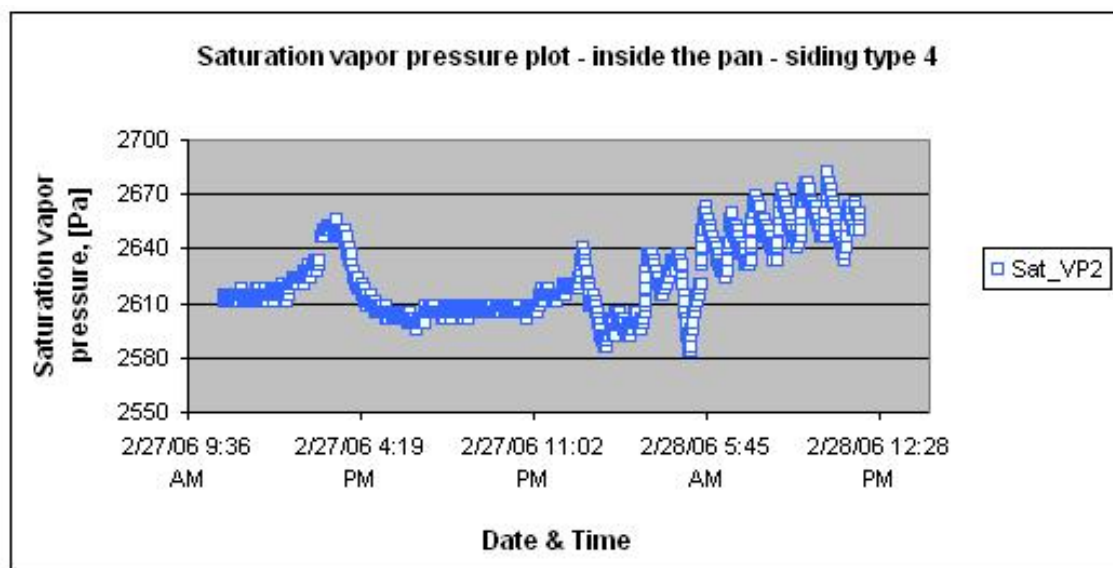


Figure V3e-3

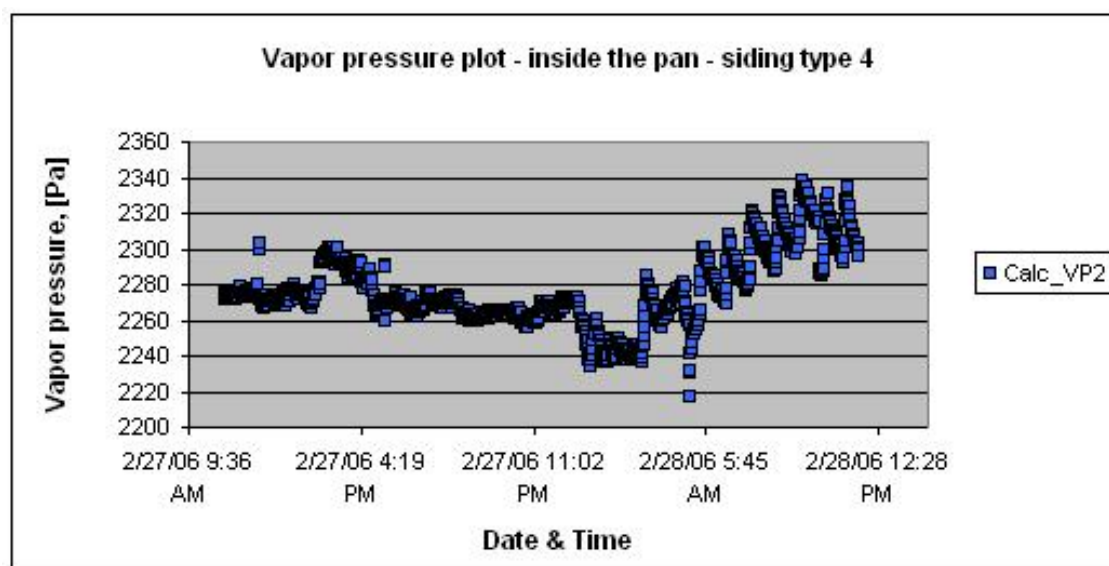


Figure V3e-4

Table V3e-1

Start date & time	Finish date & time	Time duration [h]	Average vapour pressure [Pa]	Standard deviation
2/13/06 4:00 PM	2/14/06 5:30 PM	25	2273	37
2/27/06 11:00 AM	2/28/06 11:50 AM	25	2276	20
2/13/06 4:00 PM	3/2/06 5:36 PM	50	2275	30

Appendix V-4a: Boundary conditions measured inside the pan for WVT tests performed with type-5 siding (specimens 1, 2 & 3).

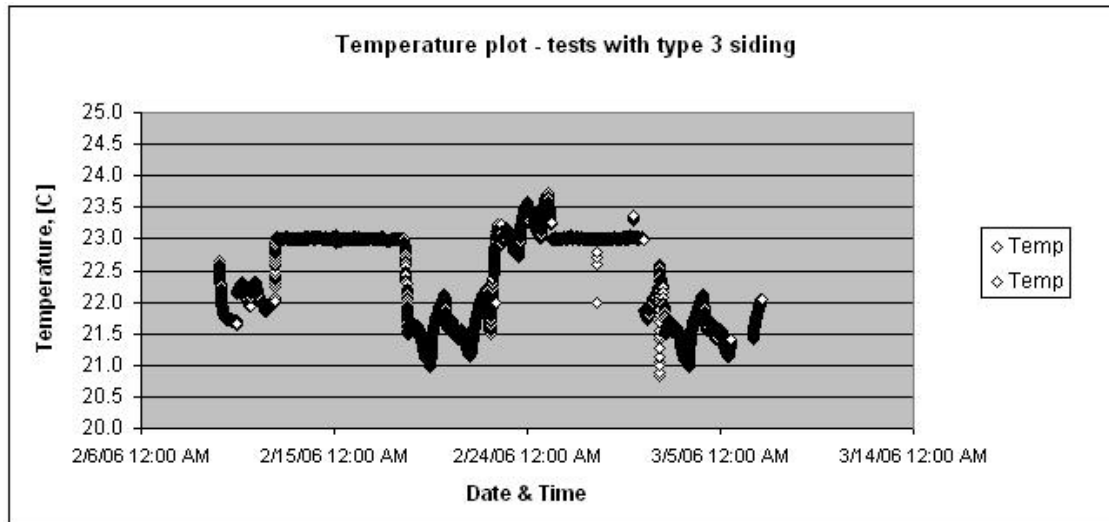


Figure V4a-1

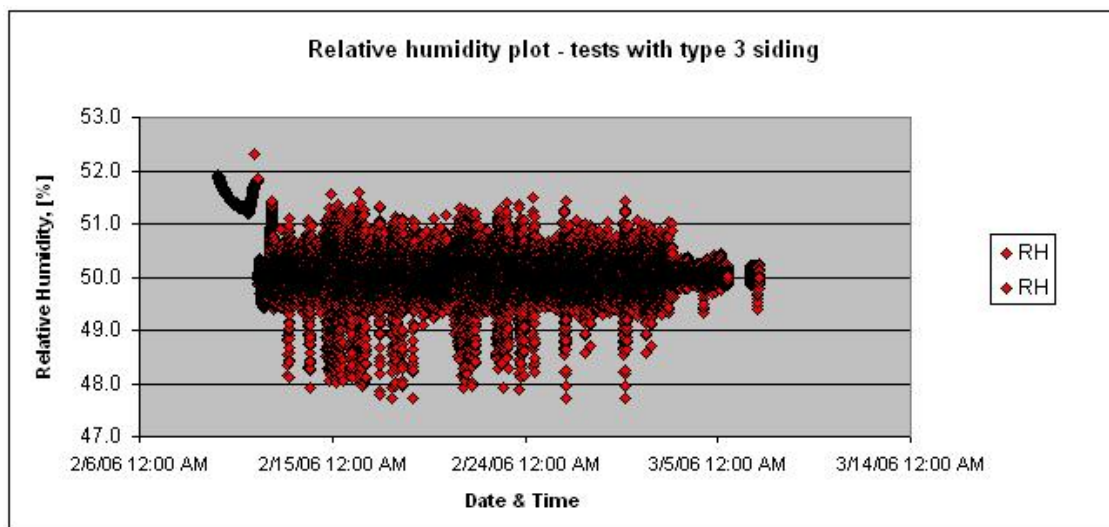


Figure V4a-2

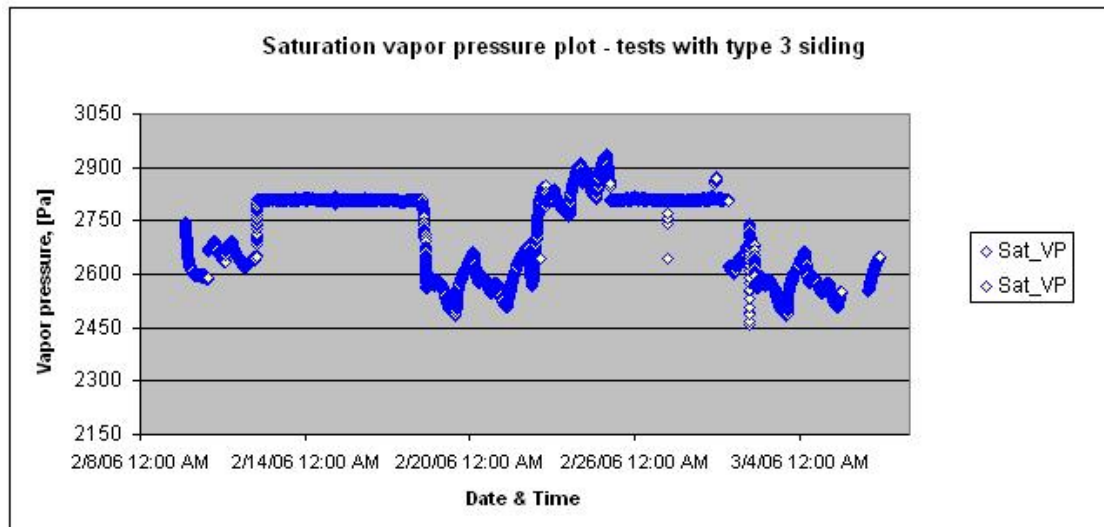


Figure V4a-3

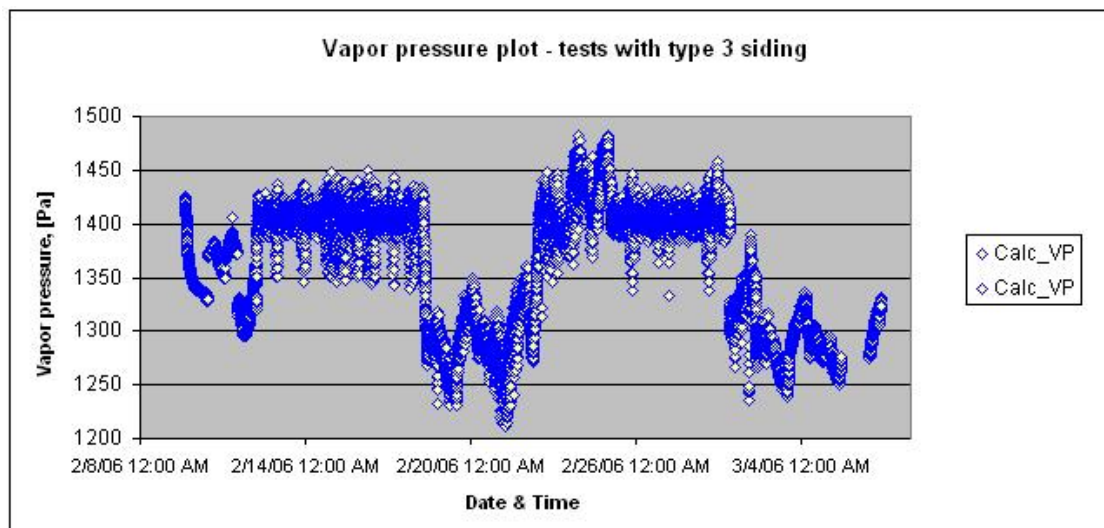


Figure V4a-4

Appendix V-4b: Boundary conditions measured inside the pan for WVT tests performed with type-5 siding (specimen 1, 2, and 3) (measurements performed at the beginning of the test).

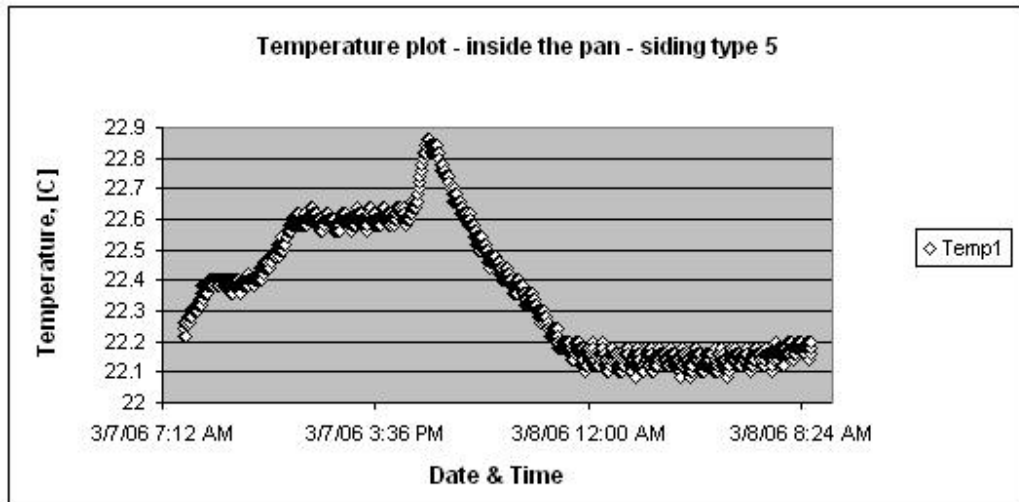


Figure V4b-1

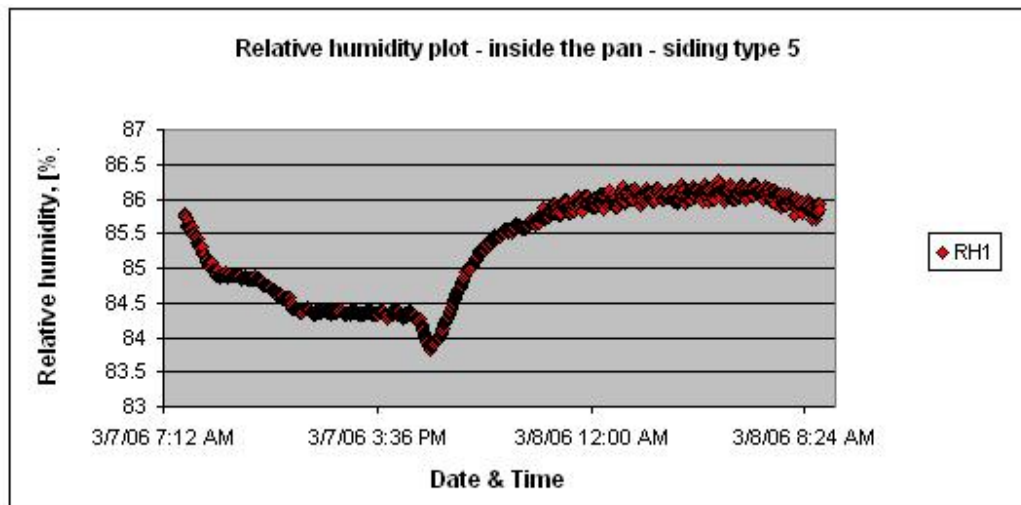


Figure V4b-2

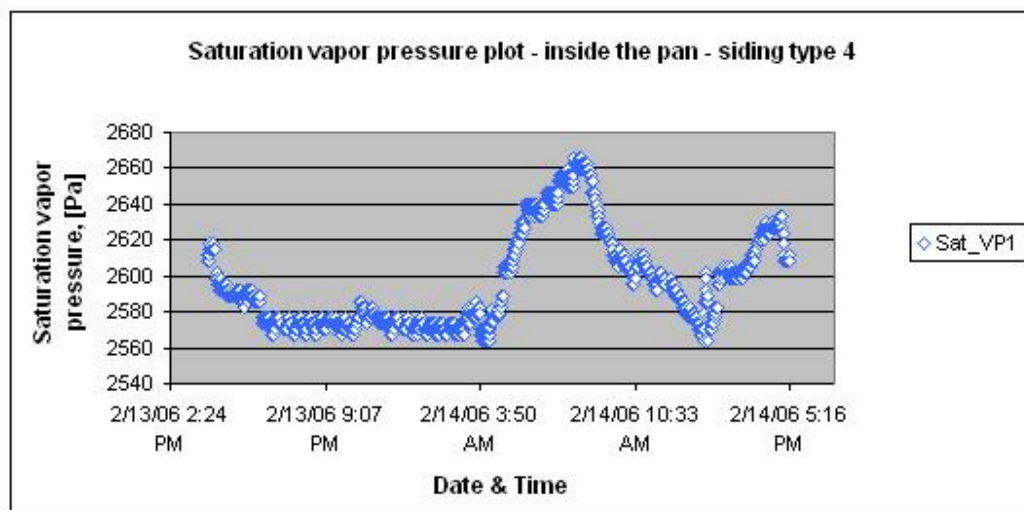


Figure V4b-3

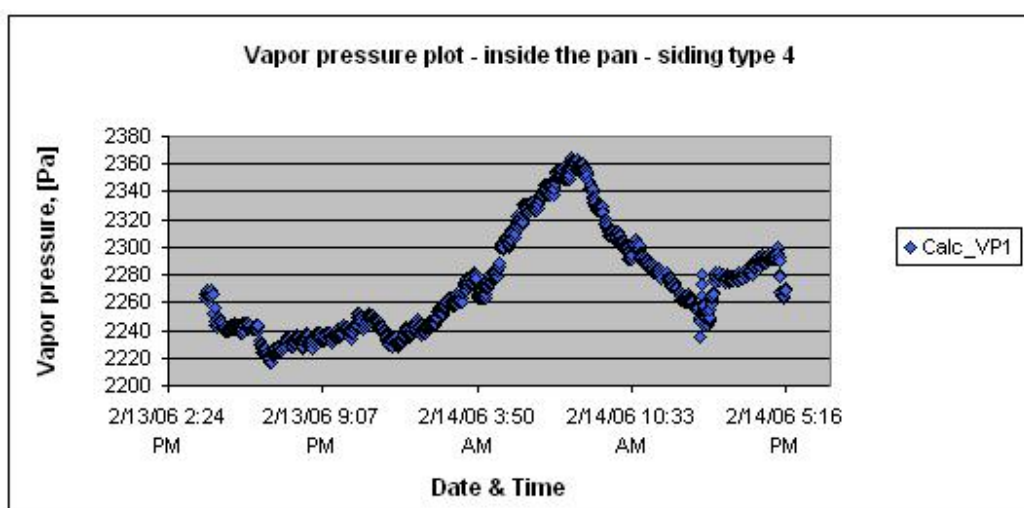


Figure V4b-4

Appendix V-4c: Boundary conditions measured inside the pan for WVT tests performed with type-5 siding (measurements performed at the end of the test)

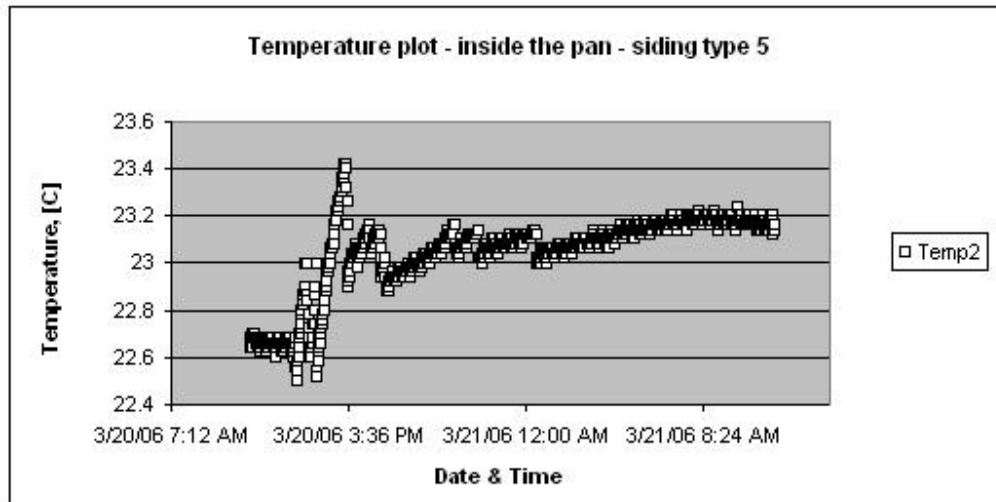


Figure V4c-1

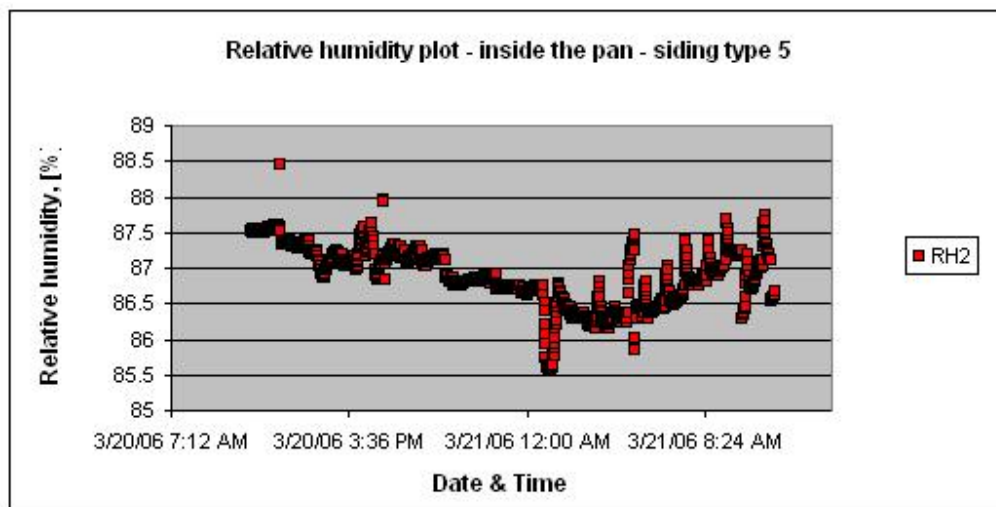


Figure V4c-2

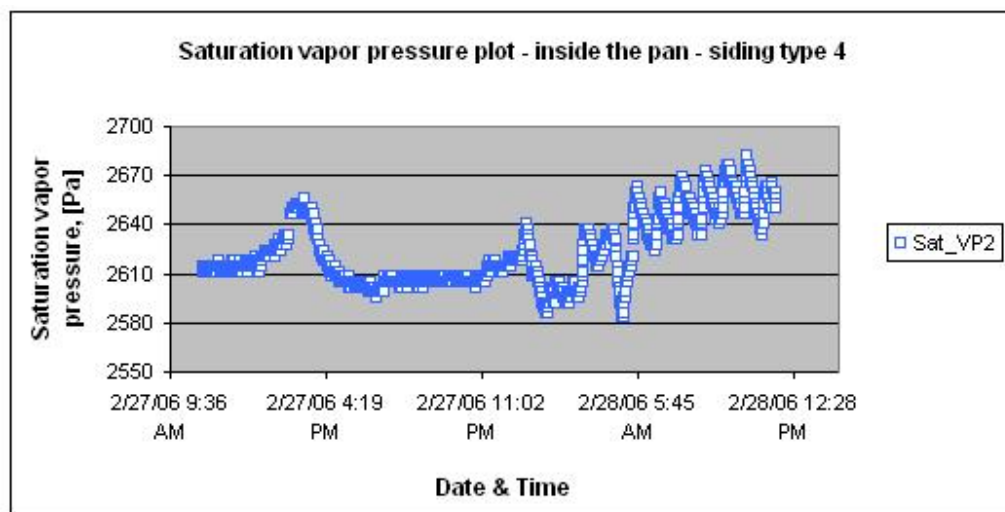


Figure V4c-3

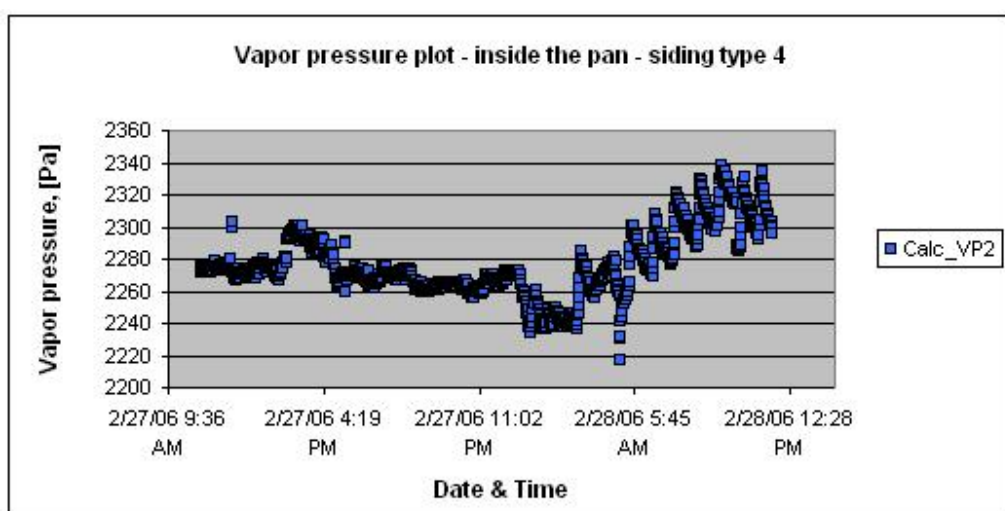


Figure V4c-4

Table V4c-1

Start date & time	Finish date & time	Time duration [h]	Average vapour pressure [Pa]	Standard deviation
3/8/06 8:00 AM	3/8/06 9:00 PM	25	2305	12
3/20/06 11:35 AM	3/21/06 11:50 AM	25	2446	25
3/8/06 8:00 AM	3/21/06 11:50 AM	50	2375	73