Laboratory Evaluation of Moisture Performance of Weather Resistive Barriers

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ABSTRACT

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A prime function of a weather resistive barrier (WRB) is to shed the water, which may penetrate the cladding. WRB also functions to reduce airflow and control transport of water vapour through the wall. This means that the moisture balance of the adjacent materials could be strongly affected by a thermally driven water vapour, which is influenced by the outdoor temperature and solar radiation. In other words, moisture performance of WRB products must be evaluated within a context of adjacent wall components, and service conditions.

Since a number of shortcomings have been identified in the current methods used for testing of WRB, a basis enabling evaluation of a wide range of traditional and new WRB products had to be developed. The objective of this thesis aimed (1) to evaluate the effectiveness of the existing test methods used in characterizing moisture performance of WRB products, and (2) to provide a benchmark for assessment of different boundary conditions. The test materials were placed between a layer of water and various types of hygroscopic sinks including vacuum cast gypsum, oriented strand board (OSB), thick adsorbing paper (blotter) and a desiccant (anhydrous calcium chloride). The WRB were either placed directly in contact with the hygroscopic sink or were separated from it by an air gap. These tests indicated that moisture transport was highly dependent on the conditions introduced on the upper and the lower surfaces of the WRB.

This thesis reports the results of a series of experimental studies, which examined moisture transport to characterize WRB for input into material standards. The new test methods developed in the thesis include: *modified inverted cup (MIC)* test for measuring the maximum possible total moisture transmission, *moisture flux (MF)* test for measuring moisture flow to an OSB or plywood substrate, and *liquid penetration resistance (LPR)* test for measuring onset and the rate of the liquid phase transport.

The test methods were used to examine moisture transport through new WRB. The test were also used to evaluate effect of penetrations, outdoor weathering, and contribution of detergent dissolved in the interstitial water. Subsequent to the material testing, an assembly testing provided a comparative evaluation of such effects as penetrations or additives in a stucco layer. Proposed in this thesis are new laboratory test methods and the acceptance criteria to be incorporated in the next edition of North American material standards.

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NOMENCLATURE

A	Cross sectional area of flow path, [m^2]
d_{pore}	Pore diameter, [m]
d_{fiber}	Fiber diameter, [m]
G	Weight change, [kg]
q_v	Vapour diffusion flux density, [kg/m^2s]
q_w	Liquid flux density, [kg/m^2s]
ε	Void fraction, [-]
δ	Water vapour permeability, [kg/smPa]
t	Time, [s], [h]
ρ_w	Density of water, [kg/m^3]
ρ_s	Bulk density of a dry building material, [kg/m^3]
σ	Surface tension, [N/m]
φ	Relative humidity, [-]
ϑ	Temperature, [°C]
ν_k	Kinematic viscosity, [mm^2/s]
P_L	Partial pressure of water vapour, [Pa]
P_H	Hydrostatic pressure [Pa]
WVT	Water vapour transmission rate, [kg/sm^2]
w	Water content, [kg/m^3]
l	Length of flow path, [m]
Z_a	Still air layer resistance, [$Pasm^2/kg$]
Z_1, Z_2	Resistance at the material surface, [$Pasm^2/kg$]
Z_p	Bulk material resistance, [$Pasm^2/kg$]
Z_m	Combined resistance, [$Pasm^2/kg$]
S	Standard deviation, [-]

N	Number of test conducted, [-]

D	Difference between effects [-]

Δ	Difference operator [-]

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

It has been postulated that of all environmental conditions, moisture constitutes the greatest threat to the durability of building envelopes, and has been reported to be a contributing factor in 80% of cases involving damage (Trechsel, 2001). In recent years, there has been an alarming increase in moisture-originated envelope failures in coastal areas of United States, and Canada. Reported problems in Vancouver and coastal British Columbia (MHL, 1996); Alberta (BEE, 2000); Seattle, Washington (Desjarlais, 2001); Wilmington, North Carolina (Cheple and Huelman, 2000), Nova Scotia and Ontario (Chouinard and Lawton, 2001) revealed the widespread occurrence. While the frequency and the extent of failures varied, time and again the cause of the problems was attributed to the inadequate control of moisture entry from the exterior of the building. Data obtained from these field studies and surveys indicated that problems were attributed to the penetration of rain through the cladding, specifically through the inadequately designed and constructed details. Failures occurred in all types of cladding systems such as wood siding, vinyl siding, and external insulation finish system (EIFS). In British Columbia, the most visible failures were observed in stucco-clad walls. In the late 90's, the estimated reconstruction cost of the so-called "leaky condo", or "rotten condo" phenomenon was estimated to be in a range of a billion dollars, and involved structural deterioration of wood frame components, loss of integrity in exterior sheathing board; present was also evidence of mould growth, cracked cladding, and stained stucco. The Barrett Commission (1998 & 2000) reported that the subsequent financial failure of New Home Warranty of British Columbia Corporation had a significant impact on the homeowners, affecting both local and provincial sectors of economy.

In a seminal paper on functional requirements for walls, Hutcheon (1963) included heat, air, and moisture as critical factors, which must be controlled to achieve long-term performance of walls. While the fundamental requirements for walls have not changed, many aspects in construction practice have.

These changes included increased levels of airtightness of the building envelope (introduced with the use of air/vapour barriers), increased levels of thermal insulation (caused by the energy crises of the 70s), and changes in ventilation patterns introduced by the use of flue less electrical heaters, humidifiers, and mechanical ventilation. The tighter wall construction shifted the moisture balance, offset the drying and the wetting capability of the wall, and significantly reduced the drying potential of moisture.

With the advent of these changes in construction, the significance of external moisture management as a key element of environmental control in building envelopes became even more evident. The concept of environmental control in wood frame walls included a primary, and a secondary lines of defense (Bomberg and Brown, 1993), with the combination of four principles which included deflection, drainage, drying, and durability (Hazleden and Morris, 1999).

This approach recognized that during the service life of any building, water could penetrate the first line of defence, that is the cladding. The significance of this strategy focused on (1) reduced incidence of rainwater on the building envelope, and (2) an allowance of sufficient capability to balance the rain load i.e., balanced wetting and drying of the wall. This approach acknowledged the use of architectural detailing and cladding to deflect and shed the water from the building envelope. Figure 1.1 illustrates the significance of overhangs in relation to the observed failures in B.C. The increased width of the overhangs reduced the frequency of moisture-originated wall problems.

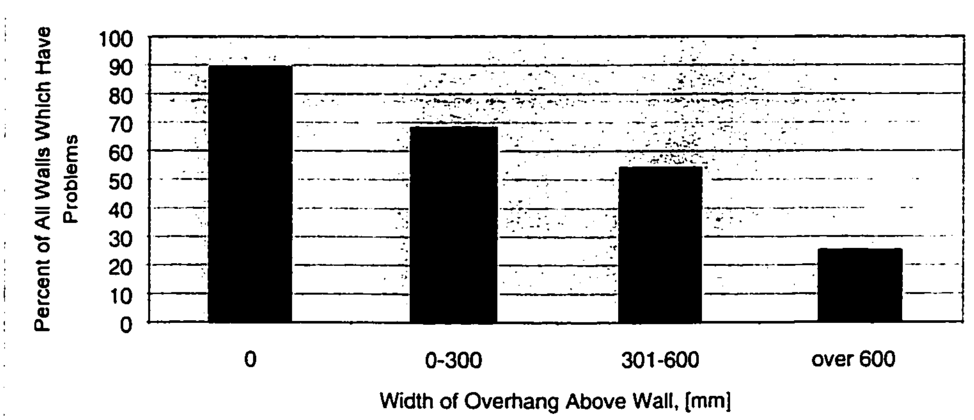

Figure 1.1 The width of the overhangs related to the performance of BC walls (from *Survey of Building Envelope Failures in the Coastal British Columbia (1996)* prepared by Morrison Hershfield Limited Consulting Engineers)

According to building science principles, a water management strategy must be integrated into the design of walls. However, most architects and designers are not aware of the significance of a second line of defense in which WRB is a critical component.

Building paper, first introduced in 1920s, was one of the earliest elements of environmental control in a building envelope. It contributed significantly towards an improved quality of indoor space through reduced heat losses, minimized air leakage, and improved thermal comfort of indoor space (Bomberg & Onysko, 2002). Understanding the material characteristics and function of WRB is one but, nevertheless, critical component in the design of durable building envelopes.

1.2 FACTORS AFFECTING THE PERFORMANCE OF WRB

The performance of the WRB membrane is affected by the adjacent elements within the wall. Burnett (2001) noted that field surveys indicated that the location of the membrane, its method of installation, and the type of cladding significantly influenced its contribution to the overall performance of a building envelope. The occurrence of recent failures reinforced the need for a holistic approach to the design of building envelopes, which requires that the interaction of various components comprising the building envelope be considered within a context of climatic and service conditions. In field conditions, WRB is subjected to environmental and mechanical loads, which occur during construction and a subsequent service life. Prior to the installation of the cladding, WRB is exposed to thermal and moisture loads, solar radiation, effects of atmospheric pollutants, as well as mechanical loads i.e., tensile forces generated by wind loads. In service, there exists a potential for mechanical and chemical interactions of WRB with adjacent components i.e., stucco or oriented strand board (OSB). These could affect the constituent materials of WRB products such as the fibers making up the base material or additives used in their manufacturing i.e., asphalts, hydrophobic agents, or ultraviolet stabilizers in polymeric materials. These interactions could significantly influence the field performance of WRB.

In evaluating WRB all aspects require equal recognition, even though the duration of direct exposure to weather prior to the installation of the cladding could be relatively short in comparison to the service life. In a traditional face-seal system such as stucco, the incidence for interaction between the various components including sheathing board (OSB or plywood), WRB, stucco cladding, and the fasteners is inevitable. The relative contribution of various factors to the overall performance has yet to be understood. In recent years, in view of a higher frequency of problems encountered in residential wood-frame construction, some questioned the performance of WRB products. Concerns related to the effect of penetrations, significance of contact between WRB and the substrate, effects of leached extractives from wood based sheathing and chemical additives from stucco have been expressed. Weston et al., (2001) conducted a laboratory evaluation of WRB used in combination with cedar siding. Burnett (2001) evaluated the effect of WRB location and method of attachment in relation to the type of cladding. Fissette (1998) performed a laboratory demonstration, indicating that leaching of extractives could affect moisture transmission properties of WRB. The studies conducted indicated that WRB could be subjected to continuous stresses in a number of complex interactions. Furthermore, they showed that interests are being expressed to broaden the knowledge base on numerous aspects of system interaction, and its impacts on the field performance of WRB. However, an examination of currently utilized approaches in determining hygric response of WRB products revealed a lack of proper testing methodology.

1.3 RESEARCH OBJECTIVES

A comprehensive research program addressing several aspects of WRB moisture performance was developed in a context of material and system level studies. At the material level, the research approach was focused on development of a methodology for characterization of WRB products for input into material standard. The system level evaluation addressed the issue of WRB interaction with adjacent components.

The following research needs were identified and became the objective in this thesis:

1. Defining WRB from a viewpoint of the cladding system requirements and included:
    - Examining of effect of various substrates on moisture transfer through selected WRB products,

- Evaluating of effects of boundary conditions i.e., varied water head on moisture transfer through WRB,
- Determining of effects of outdoor weathering on moisture transport through WRB,
- Examining of influence of various additives such as detergent and Bentonite® on moisture transport through WRB, and
- Assessing of effect of penetrations on moisture transmission to OSB and plywood substrates.

2. Reviewing of methods and laboratory characterization of WRB products, specifically evaluating the validity and merits of currently used moisture flow test methods.
3. Developing performance oriented test methodology for characterization of moisture flow through WRB for input into material standards.
4. Examining of the interactive effect between WRB and adjacent components in small-scale stucco assemblies.

CHAPTER 2

LITERATURE REVIEW

2.1 WRB DEFINED

A WRB is a layer, located on the outer surface of the load bearing assembly, and provides control of rain ingress, water vapour diffusion and airflow. The use of this term eliminates current ambiguity and confusion related with terminology. The terms in the current use include housewrap or wrap, building paper, water resistive membrane, weather resistive barrier, and sheathing membrane as referred to by the National Building Code of Canada (NBC, 1995). To focus the attention on the function of the material rather than on its location, the abbreviated term WRB (representing either water resistive barriers or weather resistive barriers) is used in this thesis. The exclusion of the word "membrane" is also appropriate as some products, which fulfill functions of WRB, are applied in a liquid form.

In a face seal system, such as stucco, WRB comprises an element of the second line of defence. Figure 2.1 illustrates that WRB and the supporting substrate (sheathing board), belonging to (1) the elements, which control penetration of rain, and (2) the elements controlling heat, air, and moisture.

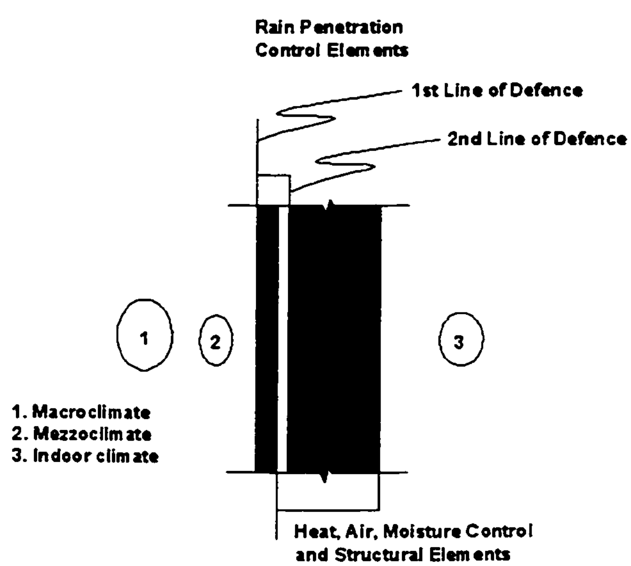

Figure 2.1 Rain, and heat, air, and moisture control elements inside a wall (Bomberg, 2001).

The WRB protects the structural elements of the wall, and fulfills the following three functions:

- Restricts ingress of rainwater, through the cladding from reaching moisture sensitive materials i.e., sheathing board, and wood frame
- Controls flow of vapour, allowing moisture within the wall to diffuse to the exterior and,
- Controls flow of air in either direction.

To fulfil these three functions, WRB must have sufficient resistance to the transfer of water, air, and vapour. With vapour flow being optimised with regard to climate, and moisture sensitivity of the wall.

2.2 CLASSIFICATION OF WRB

The members of the steering committee in the External Moisture Control consortium have proposed the following WRB classification. **The following section will review previous and current WRB classification.**

2.2.1. Existing WRB classifications

Initially, building paper comprised the only category of WRB. This term denoted a general category of paper-based materials used in walls, floors, ceilings, and roofs that provided resistance to dust, draft (airflow), water, and water vapour (ASTM, 1963). These products were composed of various raw materials that included waste papers, old rags, and chemical wood pulps, which were additionally treated (saturated or coated) with asphalt to provide extra resistance against environmental elements. The ASTM Committee D-6 on paper and paper-based products published a classification subdividing and defining each of the four categories of building papers (ASTM, 1963):

- Dry or unsaturated papers,
- Saturated papers,
- Saturated and coated papers,
- Duplexed papers.

This classification was based on the type of manufacturing process used. Materials, which belonged to the dry or unsaturated group of papers, remained untreated. Saturated papers were impregnated with asphalt or tar. In the third group, the saturated papers were additionally covered on both sides with an asphalt coating for increased resistance to the flow of air, water and vapour. The last group represented materials fabricated from two sheets of Kraft paper adhered together with asphalt coating. Since the requirements for the control of air, water and vapour flow through WRB were not yet established, materials from the above four classes were employed as WRB. The materials from the dry or unsaturated (untreated) class offered the lowest resistance to air, water and vapour, and while saturated and coated materials provided the highest resistance to the above-mentioned environmental factors. The United States Federal Specification UU-B-790a (1968) on Building Fiber, and Vegetable Fiber, introduced a classification for sulphate pulp fiber building papers. Table 2.2 presents a list, which groups the building papers into 4 types, 7 grades, and 11 styles, and covered various aspects of application in the construction industry. From this list only type I (Grade D water vapour permeable) building paper were sufficiently vapour permeable to be utilized in a cold climate.

The classification scheme presented above was based on material composition, and was dependent on the treatment of the pulp fibers, and the manufacturing process. The classification was limited in its scope as it only referred to a single group of materials that is the cellulose (sulphate pulp fiber) based products. Currently, there is a wide variety of WRB products available including; cellulose fibrous membranes, polymeric fibrous membranes, mechanically perforated membranes, micro-porous films, and liquid applied WRB. There is a need for a classification, which incorporates all available WRB materials, and not just cellulose based products.

Table 2.1 Classification of building papers specified in the UU-B-790a US Federal Specification (1968).

Types, grades, styles	Material name
Type I	Barrier paper
Grade A	High water-vapour resistance
Grade B	Moderate water-vapour resistance
Grade C	Water resistant
Grade D	Water-vapour permeable
Style 1a	Uncreped, not reinforced
Style 1b	Uncreped, not reinforced, red rosin size
Style 2	Uncreped, not reinforced, saturated
Style 3	Creped one direction, not reinforced
Style 4	Uncreped, reinforced
Style 5	Creped one direction, reinforced
Style 6	Creped two directions, not reinforced
Style 7	Creped two directions, reinforced
Type II	Concrete-curing paper
Grade E	Moisture retentive
Style 8	Regular colour, reinforced
Style 9	White, reinforced
Type III	Fire-resistant paper
Grade F	Water repellent
Style 10	56-pound paper
Type IV	Insulation tape paper
Grade G	High tensile strength-water resistant
Style 11	Reinforced

2.2.2 Proposed WRB classification

Raw materials and the manufacturing process have been the current basis for WRB classification. The use of such an approach does not permit the development of a matrix of performance factors into which various WRB products would eventually fit. Therefore, Weston (2003) proposed the following classification schemes based on:

1. Material composition and structure, and
2. In a case of multi-layer WRB, the layer that provides main resistance to the flow of water and air is used to classify the WRB.

The following five types of WRB have been identified (Weston, 2003):

- **Type C: Asphalt-impregnated cellulose fiber based WRB,**
- **Type M: Micro-porous film WRB,**
- **Type P: Polymeric fibrous WRB,**
- **Type PP: Perforated polymeric film,**
- **Type LA: Liquid-applied (trowel) WRB.**

Presented below is a detailed description of each class of products.

Type C: Asphalt-impregnated cellulose fiber WRB products:

Type C WRB is manufactured by impregnating or saturating base paper or felt with asphalt to impart water resistance. The main raw material utilized in the manufacturing of the base paper are recycled waste paper i.e., newspapers, old rags and chemical pulp. Depending on the selection of the manufacturing process, the saturation is performed in a form of water emulsion concurrent or subsequent to the process of manufacturing paper. The degree of saturation ranges from 50 percent to 175 percent, based on the weight of the fibers. The asphalt/cellulose ratio is higher in felts than in papers. Since the rags are softer and more porous than the paper, asphalt penetrates deeper into the rags (ASTM, 1963). The barrier properties of the finished WRB product are a function of the physical properties of the dry fiber matrix (pore size), and possibly the source of the cellulose fiber, the properties of the asphalt, and the asphalt/cellulose ratio. Figures 2.2, and 2.3 illustrate the structure of Grade D building paper. Figure 2.4 shows the structure of felt.

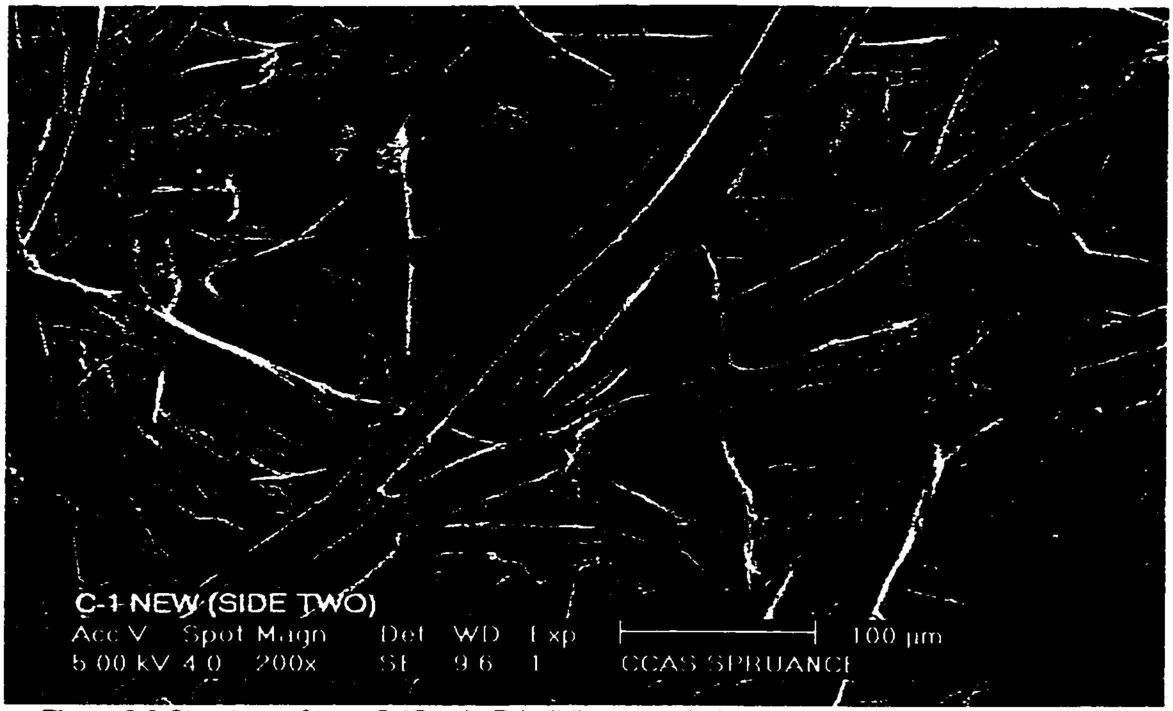

Figure 2.2 Structure of type C (Grade D building paper) viewed with a Scanning Electron Microscope (SEM), magnified 200 times (Weston, 2003).

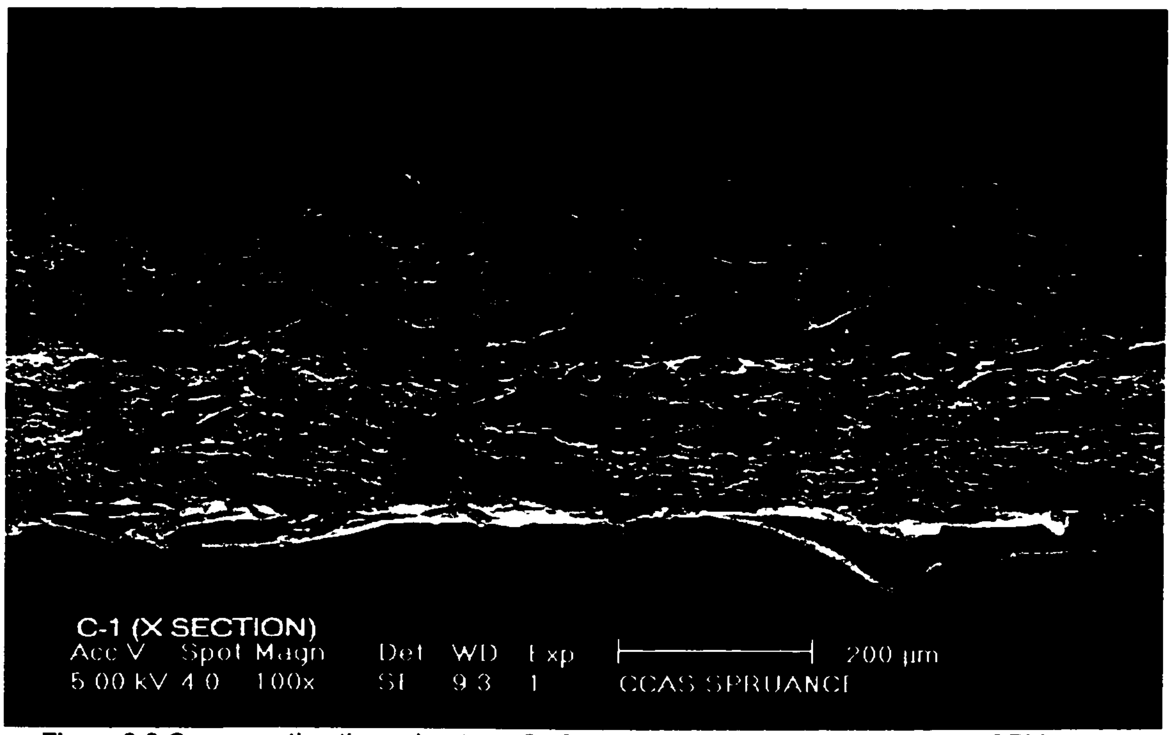

Figure 2.3 Cross section through a type C (Grade D building paper) viewed with SEM, magnified 100 times (Weston, 2003).

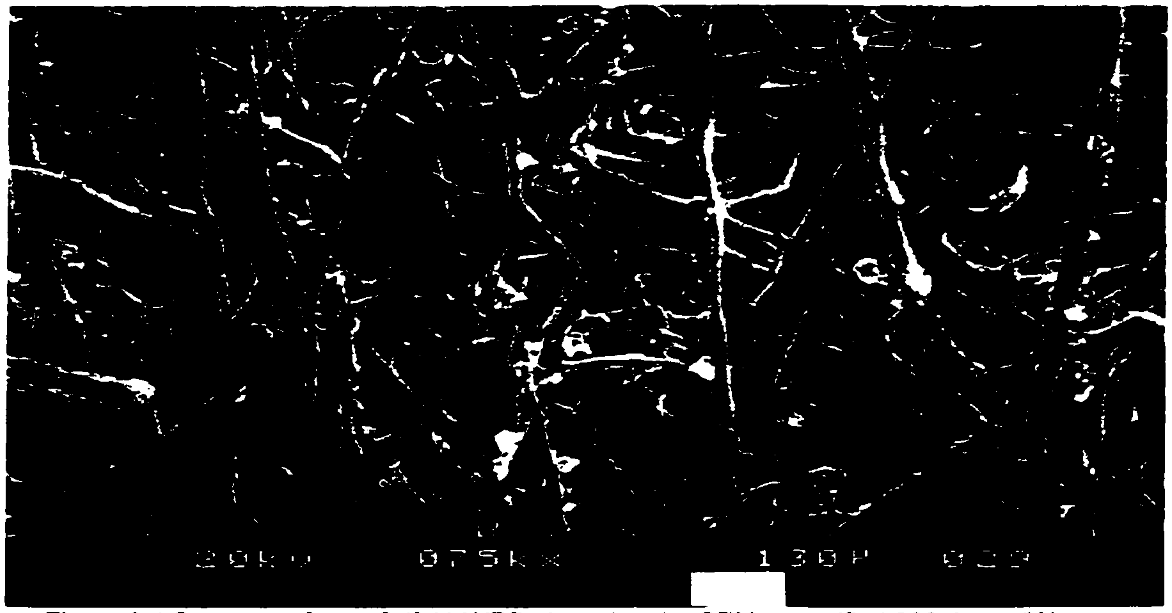

Figure 2.4 Structure of type C (felt) WRB viewed under SEM, magnified 200 times (Weston, 2003).

Type M: Micro-porous films:

These products incorporate a micro-porous film as a barrier material. They are manufactured by stretching monolithic films filled with particles. The stretching action creates pores around or at the particles as shown in Figure 2.5. Typically, the pore size and particle distribution determine WRB properties. As a result of fragile characteristic of the micro-porous, the products are always reinforced by woven or non-woven scrims.

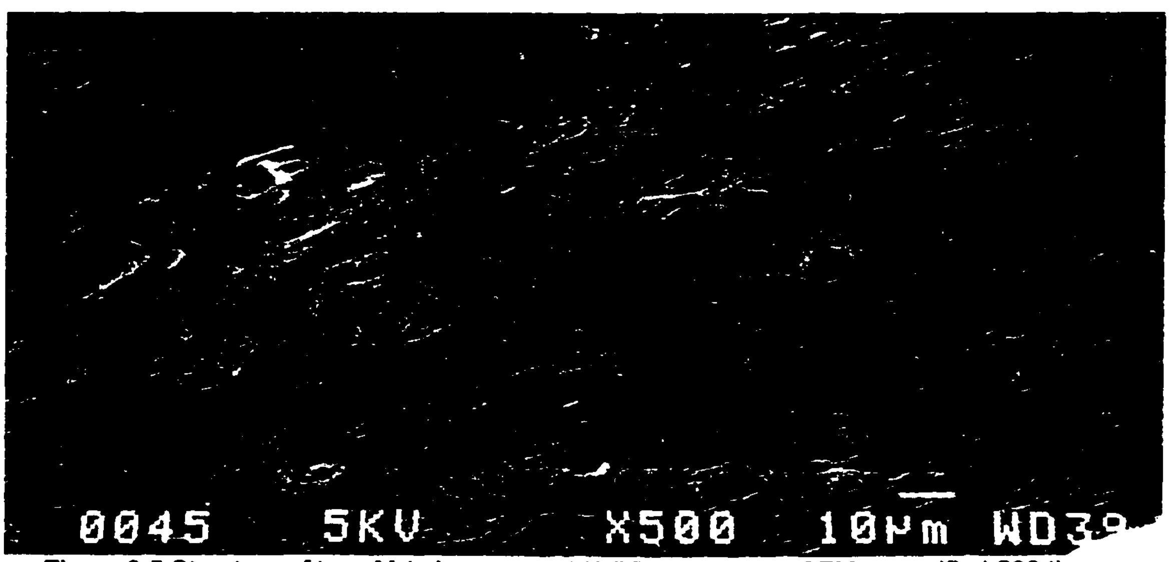

Figure 2.5 Structure of type M (micro-porous) WRB viewed with SEM, magnified 500 times (Weston, 2003).

Type P: Polymeric fibrous WRB products:

These products are composed of compressed fibrous mats in which the fibers and pores are small enough to provide a barrier to water. The fibers are made of hydrophobic polymers such as polyethylene or polypropylene. The barriers properties are a function of the pore size and volume. The pore diameter (d_{pore}) is related to the fiber diameter (d_{fiber}) and the void fraction (ε) as described in equation (2.1). Figures 2.6 and 2.7 show the structure of type P WRB.

$$d_{pore} \propto \frac{d_{fiber}}{(1-\varepsilon)} \tag{2.1}$$

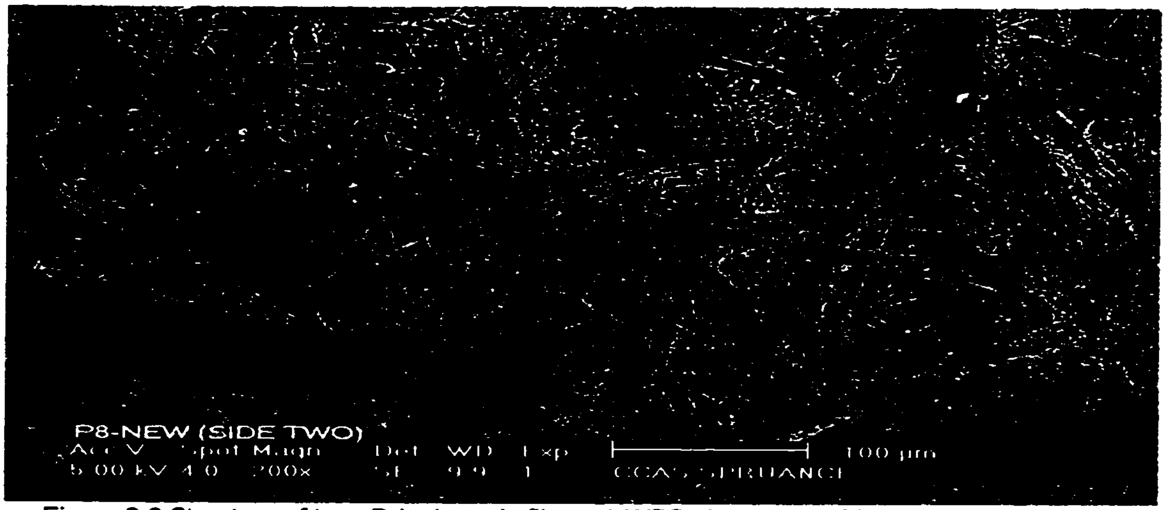

Figure 2.6 Structure of type P (polymeric fibrous) WRB viewed with SEM, magnified 200 times (Weston, 2003).

Figure 2.7 Cross section through type P WRB viewed with SEM, magnified 100 times (Weston, 2003).

Type PP: Perforated polymeric films:

The type PP WRB constitutes monolithic polymeric films that have been mechanically punctured. Material properties depend on the size and the number of penetrations. These materials might be supported by woven or non-woven scrims. The structure of these materials is illustrated in Figures 2.8 and 2.9.

Figure 2.8 Structure of type PP (perforated polymeric fibrous) WRB viewed with SEM, magnified 50 times (Weston, 2003).

Figure 2.9 Cross section through type PP WRB viewed with a SEM, magnified 100 times (Weston 2003).

Type LA: Liquid applied (trowel) WRB:

Liquid applied WRB are either manufactured in plant or in a field application of wood-based, composite sheathing. These composite products are typically used as the substrate in EIFS. The structure of type LA WRB is illustrated in Figures 2.10, and 2.11.

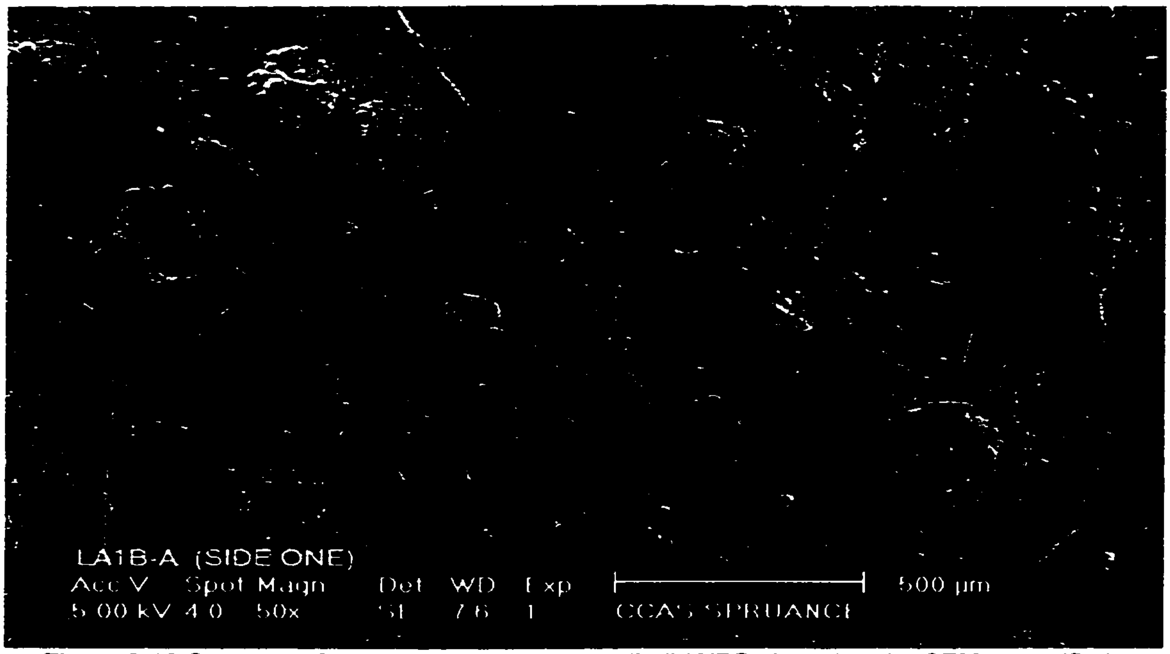

Figure 2.10 Structure of type LA (liquid/trowel applied) WRB viewed under SEM, magnified 50 times (Weston, 2003).

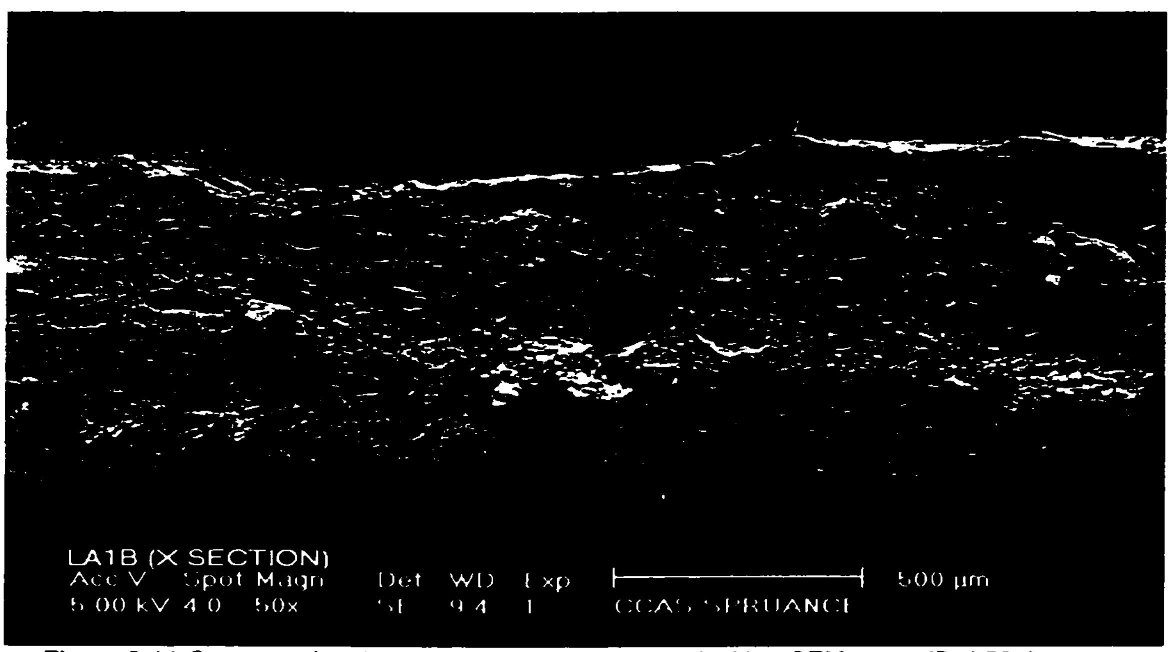

Figure 2.11 Cross section through type LA WRB viewed with a SEM, magnified 50 times (Weston, 2003).

2.3 REQUIREMENTS FOR WRB IN THE CURRENT MATERIAL STANDARDS

In Canada, the requirements for WRB have been under the jurisdiction of CGSB 51.32-M77 "Sheathing, Membrane, Breather Type" standard. First introduced in 1977 by the Canadian General Standards Board (formerly, the Canadian Government Specifications Board-CGSB), the standard describes WRB as "a secondary protective covering against the entry of wind and moisture, which are to provide moisture-resistant and draught (air flow) resistant barriers that do not impede the passage of water vapour and therefore minimize the condensation of such vapour (CAN 2-51.32-M77)." The standard goes on to describe WRB as "a single ply or laminated material, which might be coated, impregnated or perforated or a combination of these (CAN 2-51.32-M77)." Table 2.2 outlines water vapour transmission (WVT) criteria for both fresh and aged WRB as specified by the standard.

Table 2.2 Water vapour permeance requirements for WRB as specified in the CGSB 51.32M-77 (1977) standard.

Specimen condition	Water vapour permeability, ng/sm^2Pa
Fresh (virgin) material	$170<W_V<1400$
After accelerated aging	$W_V<2900$

The standard specifies a required limit on measured water vapour permeance for (1) fresh materials, and (2) material subjected to accelerated aging. These requirements are also referenced in Part 9, sub-section 9.23.17 of the National Building Code of Canada (NBC, 1995). The standard describes the WRB as a protective material, which imparts resistance to air, liquid, and vapour flow. However, the quantification of vapour with the ASTM E 96 dry cup test method is the only requirement to characterize moisture performance as specified in current material standard. In the revised draft of the CGSB 51.32 (2000) additional test methods i.e., ponding test, were proposed for evaluation of WRB resistance to water penetration. However, it has to be noted that the revised document has yet to be adopted.

2.4 REVIEW OF TEST METHODS

The following section examines existing water penetration test methods used in evaluation of WRB.

2.4.1. Water penetration

A number of test methods are currently used by the WRB industry to test the resistance of products to water penetration. They include; boat, dry indicator, water ponding, hydrostatic head and hydrostatic pressure test methods. These methods may be classified into three categories:

1) Test methods that do not employ hydrostatic pressure i.e., the boat test, and the dry indicator test,
2) Test methods that use low hydrostatic head, typically a 25 mm water head. This test is often referred to as a ponding tests, and
3) Tests used to characterize the on-set of liquid flow, and are conducted with high hydrostatic pressures generated by a column of water (as high as 2 meters).

The methods utilized in the evaluation of water penetration are listed in Table 2.3.

Table 2.3 Test methods currently employed in testing moisture penetration through WRB products.

Test number	Title and standard reference
1	'Boat test'(Method 181) in the US Federal Specification UU-P-31b
2	'Dry indicator test'(ASTM D779-94)
3	'Ponding test'-Canadian Construction Material Center (CCMC 12857-R)
4	'Hydrostatic pressure test'-American Association of Textile Chemists and Colourists (AATCC-127)
5	'Hydrostatic head test'-American Association of Textile Chemists and Colourists (AATCC-127)

2.4.1.1 Boat test

The boat test method is used to determine the resistance of the cellulose based WRB against penetration of moisture. The method referred to as 'Method 181' in the Federal US Specification UU-P-31b comprises section 4, Part 5 of the Federal US Stock Catalogue. Developed in 1949 for the approval process of a Grade D building paper, the procedure required WRB specimens to be fabricated into a small boat (measuring 2.5 $inch^2$). With a small amount of sprinkled moisture indicator inside it, the boat was floated in a petri dish. The time for the dry indicator to change colour served as a measure of the material's resistance to water (moisture) penetration. Table II in the US Federal Specification UU-B-790a (1968) required the grade D building paper to resist water penetration for 10-minute duration. The operator conducting the test determined the onset of colour change visually. The test was then terminated and the material was given a pass or fail rating based on the colour change of the moisture sensitive indicator. The moisture indicator used in testing consisted of pure sugar cane, pure soluble starch, and methyl violet dye prepared in a respective dry weight ratio of 45:5:1. The sugar had a dual purpose (1) it masked the colour of the methyl violet dye particles, and (2) absorbed the transmitted moisture and held it in a close proximity to the dye (ASTM D 779, 1994). The use of starch increased the stability of the mixture.

While the objective of the test aimed to determine the resistance of WRB to water penetration, the highly hygroscopic moisture indicator captured both liquid and vapour. The relative contribution of both vapour and liquid phase was unknown. Since the measured effect related to the combined transmission of both phases, the test method could not have been used for the determination of liquid flow. Furthermore, the test was imprecise, and several poorly controlled parameters were identified as sources of error. The layer of the moisture indicator was exposed to undefined laboratory conditions, and caused the absorption of the atmospheric vapour. Unspecified thickness of the moisture indicator layer, and variability introduced by manual means of its distribution affected the rate of colour change. The process of boat fabrication was also highly operator dependent.

Over the years, numerous improvements were instituted; the test was conducted on undisturbed specimens. The use of a watch glass sealed with an asphalt seal over the moisture indicator was instituted to eliminate the effects of atmospheric water vapour, as a means of better defining the boundary conditions. Despite these improvements, the errors caused by the presence of entrapped air bubbles at the specimen/water interface, and unevenly distributed indicator, remained unresolved.

2.4.1.2 Dry indicator test

A more recent variant of the boat test method, the ASTM D 779 (1994) dry indicator method was similar in approach to the boat test. The test method required exposing specimen's lower surface to a layer of water. The time for the moisture sensitive powder to change colour served as a rating criterion for resistance to penetration of water. The colour change was determined from visual inspection performed by the operator conducting the test. The composition of the indicator was the same as that in the boat test. The experimental set-up consisted of an aluminium float or a hollow cylinder with an attached wire frame clamp for mounting of the specimen and a watch glass. The test method still determined a combined effect of liquid and vapour transport, with the liquid flow dominant during the initial 30 seconds of the test (ASTM D 779, 1994).

2.4.1.3 Water Ponding test

This test method was developed by the roofing industry, and simulated the performance of roofing membranes exposed to stagnant rainwater. The Canadian Construction Material Center (CCMC, 1993) adopted the test method for routine product evaluation tests. The water ponding test required subjecting the upper surface of the specimen to a 25 mm water head during a two-hour test. During this time, the operator monitored the formation of three distinct droplets on the underside of the specimen. Following a two-hour period, with no physical indication of moisture transmission the test was terminated, and the material was given a passing mark. On the other hand, the appearance of three or more droplets on the lower surface resulted in a failing mark. While the test had well defined conditions on the upper surface, the conditions on the underside of the specimen remained unspecified. Use of visual observations in detecting the passage of three water droplets, and the short test duration could have influenced the results. Since the boundary conditions on the underside of the specimen were not well defined, instances could have occurred when the rate of transmission to the surface was below the rate of evaporation from the surface. Consequently, the drops could not have formed, or could have been small and remained undetected. In addition, the test method failed to address the proper handling and treatment of effects at edges of the specimen. In fibrous materials, the flow of water is multi directional, penetrating through the material as well as flowing perpendicularly along the fibres of the material. So while the concept appeared to be correct, the control of boundary conditions on the underside of the material as well as method of detecting water transmission required further improvements.

2.4.1.4 Water penetration under hydrostatic head

In a hydrostatic head test, the specimen was subjected to high columns of water. Developed by the American Association of Textile Chemists and Colourists, the test method designated as AATCC-127 (1998), measured water transmission through various textile products. The method was adapted to test the resistance to water penetration of polymer based WRB at various hydrostatic pressure. The test method outlined two procedures, which utilized (1) hydrostatic pressure tester or (2) hydrostatic head tester. With the use of hydrostatic pressure tester a column of water was introduced on the specimen's upper boundary, and the hydrostatic pressure corresponding to the height of the water head was the driving force. The device consisted of an inverted conical well equipped with a coaxial ring clamp used to fasten the specimen on the underside of the well. Water was introduced automatically at a rate of 10 mm (100 Pa) of hydrostatic pressure per second to the upper surface of the specimen, which measured 114 mm in diameter. The test was conducted with a desired column of water, for duration of 5 hours. Depending on the WRB tested, higher hydrostatic pressures in the range of up to 2.8 m (corresponding to 28kPa) were employed in testing different type P WRB. The appearance of three water droplets during the 5-hour test duration marked the failure of the material. Both the hydrostatic pressure and the time at the appearance of the drops were recorded. The test method specified that the formation of the droplets must have occurred in distinct places on the specimen's surface. The test method further specified that droplets formed within 3 mm proximity of the coaxial ring were discounted. This accounted for the compressive stresses created by the use of the ring, which modified the characteristics of water transmission at the edges of the material. Again, the use of operator's judgement in determining the formation of three droplets could have propagated errors.

The hydrostatic head tester applied hydraulically compressed layer of water to the underside of the material. This method used an electronically controlled pump and applied a hydrostatic pressure at the rate of 60 mbar/min (600 mm of water head per minute). The same procedure was used to obtain results as in the procedure described above. Alternatively, the time for water to penetrate at a specified static pressure could be measured. The methods examined are employed in determining moisture penetration through WRB. Depending on the test method used, liquid or vapour could be the dominant phase in the transmission process. To this end, test methods used in determining WVT through WRB were also evaluated.

2.4.2 WATER VAPOUR TRANSMISSION

The following section presents the overview of test methods used to measure WVT through the WRB, which includes the dry cup, wet cup, inverted cup and double cup. In addition to the description of the test methods, sources of errors that influence the results are also examined.

2.4.2.1 The cup methods

The following relation derived from Fick's law governs the process of isothermal vapour diffusion under the gradient of partial vapour pressure (gradient of concentration):

$$G = -\delta \bullet \frac{\Delta p}{\Delta \ell} \tag{2.2}$$

where;

G = mass of vapour diffusing through unit area in unit time, kg/s•m^2
p = partial vapour pressure, Pa
ℓ = length of the flow path, m
δ = permeability, kg/smPa

The equation could be integrated for an average value of μ over the pressure range involved to obtain the following equation:

$$G = \bar{\delta} A t \frac{(p_1 - p_2)}{\ell} \qquad (2.3)$$

where;

G = total mass of vapour transmitted, kg
A = cross sectional area of the flow path, m^2
t = time of flow, s
ℓ = length of flow path, m
$(p_1 - p_2)$ = difference in vapour pressure, Pa
$\bar{\delta}$ = average permeability, kg/smPa

In 1953, under the E 96 designation, the ASTM standardized the dry cup and the wet cup test methods. The two procedures specified a gravimetric method for determining WVT under steady state conditions through materials less than 32 mm thick. The dry cup, and the wet cup both utilized single containers fabricated from impervious, non-reactive materials i.e., stainless steel, aluminium, or polyvinylchoride (PVC). The following materials were placed in the cups (1) desiccant (moisture sink), a highly hygroscopic absorbent was placed in the dry cup container, and (2) water or saturated salt solution (moisture source) was placed in the wet cup. Inside the cup, a layer of air separated the source or sink of vapour from the specimen's surface. The specimen was sealed airtight to the mouth of the container. The sealed set-up was placed in an environment with a constant temperature, and relative humidity (RH). While the conditions inside the cups were maintained as described above, the conditions in the surrounding air space were controlled with either the use of mechanical equipment or saturated salt solutions. Figure 2.12 illustrates schematically, the dry and the wet cup test set-ups.

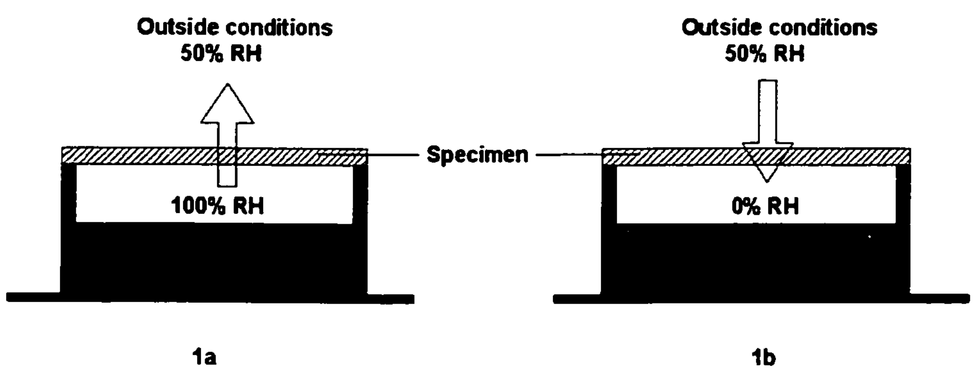

Figure 2.12 Schematic illustrating different boundary conditions in (1a) wet-cup, and (1b) dry-cup set-ups.

During the test, periodic changes in cup weights were measured gravimetrically. The WVT was determined from the measured data following the onset of steady state. Steady state was achieved when weight gain or mass loss became stable over time, and was represented by a curve having a constant slope. The rate of WVT was related to the mass of vapour transmitted during a specified duration of time and through a given flow path area. The area of the flow path was represented by the specimen's surface area. WVT related to the difference in vapour pressure yielded permeability coefficient (δ) in kg/sm^{2}Pa illustrated in equation (3).

The ASTM E 96 (2000) standard outlined different boundary conditions. While the RH in the space surrounding the dry-cup and the wet-cup were required to be maintained at 50%, the temperatures could have been varied. Table 2.4 indicates corresponding temperatures for each procedure as outlined in the ASTM E 96 standard.

Table 2.4 Procedures specified for measuring WVT as outlined in the ASTM E 96 (2000).

Procedure	**Conditions**
Procedure A	Dry cup conducted with desiccant at 23 C
Procedure B	Wet cup conducted with water at 23 C
Procedure BW	Inverted cup conducted with water at 23 C
Procedure C	Dry cup conducted with desiccant at 32.2 C
Procedure D	Wet cup conducted with water at 32.2 C
Procedure E	Dry cup conducted with desiccant at 37.8 C

In addition to the dry cup and wet cup procedures, the ASTM standard specified a modified version of the wet cup test referred to as the inverted cup test, which was designated as a procedure BW. In the inverted water method the wet cup was reversed, and the layer of water was in direct contact with the specimen's upper surface. Figure 2.13 shows a schematic of the inverted cup test method.

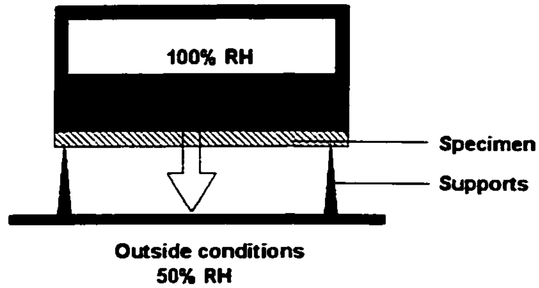

Figure 2.13 Schematic of an inverted cup test set-up.

This test varied from the traditional wet-cup procedure in two respects: (1) the specimen was subjected to additional, and undefined, hydrostatic pressure generated by the layer of water, and (2) the still air layer, which separated the specimen from the water or salt solution, was excluded. Further modifications led to the development of the double cup test method, which combined the dry-cup and the wet-cup as illustrated in Figure 2.14. The test set-up employed two cups; (1) water or salt solution was contained in the bottom cup, and (2) desiccant was contained in the top cup. The specimen was mounted horizontally between two rings and, properly sealed with a wax mixture. O-ring gaskets were inserted in the machined grooves at the container's edges. The two cups with the specimen mounted in between were clamped together between two aluminum plates. During testing, the set-up was periodically disassembled and weights of dry cup, wet cup, and the specimens were measured. In the double cup the weight increase in the dry cup corresponded to the weight of water vapour absorbed by the desiccant. On the other hand, the weight decrease in the wet cup corresponded to the weight of the water or salt solution that evaporated inside the wet cup. The weight loss in the dry cup was equal to the weight gain in the dry cup and in the specimen. The amount of quantity of moisture that accumulated in the material under isothermal conditions was largely dependent on its moisture content at equilibrium.

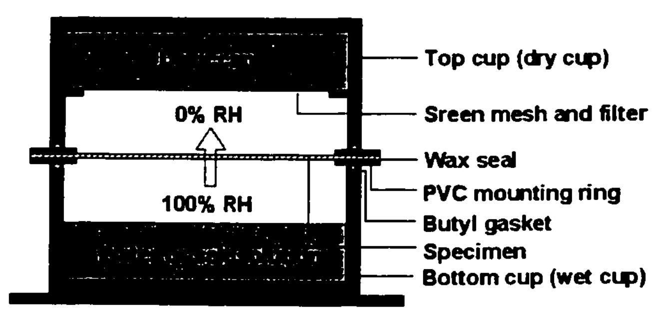

Figure 2.14 Schematic of a double cup test set-up.

Schwartz et al., (1989) conducted WVT with modified cup test and proposed that in isothermal tests, the use of this test method was preferred for two reasons. First, only the temperature of the chamber or the desiccator needed to be controlled, whereas in dry and wet cup tests both the temperature and RH were required to be controlled. Second, the information on moisture accumulation in the specimen was determined since the set-up was periodically disassembled and the weights of the specimen as well as the two cups were obtained. This was not possible with the dry, wet, or the inverted wet cup. The following section examines the sources of errors in WVT testing and their influence on the measured results.

2.4.3 Sources of errors in WVT tests

Although the tests appeared simple, poorly controlled parameters could significantly contribute to error propagation. Toas (1989) demonstrated that WVT test significantly depended on the skill of the operator conducting the test. Hansen and Bertelsen (1989) reported uncertainty in measurement related to material variability, and variations in test conditions. Particularly for permeable materials such as WRB products, measurement errors could cause the apparent measurements to be much higher than the resistance offered by the material. Several sources of error were identified in steady state cup measurements and included:

- Cup design and sealing techniques,
- Effect of a masked edge,
- Determination of the onset of the steady state,
- Frequency of data collection,
- Resistance offered by the still air layer and the material's surface,
- Changes in vapour diffusion rates due to fluctuating barometric pressures,
- Changes in the hygroscopic nature of the moisture sink.

2.4.3.1 Cup design and sealing system

Joy and Wilson (1965), noted that the selection of materials used in fabrication of test cups for WVT, the design, the sealing technique, and the properties of sealing materials all played an inherent role in error propagation. A number of noncorroding and nonreactive materials were found to be suitable for the construction of the cups i.e., glass, certain plastics, and anodized or epoxy resin covered metals. The ASTM E 96 (2000) required the sealing materials to possess the following characteristics; no weight loss or gain due to evaporation, oxidation, hygroscopicity, and water solubility, and be as impervious to moisture as possible. Good adhesion to the specimen and the dish, and conformance to rough surfaces and non-regular shapes, as well as strength, pliability, and desirable viscosity were also required.

2.4.3.2 Masked edge effects

The difference between the surface areas exposed to the vapour flux and the total cross sectional area of a homogenous specimen introduced significant error in WVT measurements for materials in excess of 1-inch thick. Joy and Wilson (1965) noted that the increased masked edge introduced errors in the range of up to 20%, and demonstrated that an increased masked edge from 0.125 inch to 0.625 inch increased the vapour transmission by 10%.

2.4.3.3 Onset of the steady state

Permeability of a given material was determined from the steady state, and results measured before the onset of the steady state were excluded from calculations. Two methods were utilized to ascertain whether the steady state was reached. In one instance, the mass increase of the cup was plotted as a function of time. When the initial transient conditions stabilized, a linear relationship with a constant slope was obtained. This indicated that the water vapour diffused at a constant rate through the specimen. In the second instance, the rate of vapour transmitted was plotted as a function of time, and a horizontal plot denoted a steady state. The time to reach this varied and depended on the material's thickness, hygroscopic character, and initial moisture content (Joy and Wilson, 1965). Babbitt (1939) reported that for thin and highly non-hygroscopic materials, steady state was reached relatively quickly. However, hygroscopic materials thicker than 25 mm, required a period of 6 to 12 weeks for onset of steady state.

2.4.3.4 Resistance at the material's surface

Hansen and Lund (1990) reported that the resistance of water vapour in a dry or wet cup was a combination of resistances. These included, (1) resistance provided by the bulk of the material (Z_p), (2) resistance offered at the material and air layer interface on the specimen's upper and lower surfaces (Z_1, Z_2, respectively), and (3) resistance imparted by the air layer inside the cup (Z_a). This could be expressed by the following equation:

$$q = \frac{\Delta p}{Z_p + Z_1 + Z_2 + Z_a} = \frac{\Delta p}{Z_m} \qquad (2.4)$$

where;

Z_m = Combined resistance, $Pasm^2/kg$
Z_p = Resistance provided by the bulk of the material, $Pasm^2/kg$
Z_1 = Resistance offered by the material/air interface (upper boundary), $Pasm^2/kg$
Z_2 = Resistance offered by the material/air interface (lower boundary), $Pasm^2/kg$
Z_a = Resistance imparted by the still air layer, $Pasm^2/kg$
q = Moisture flux, kg/sm^2
p = Pressure, Pa

2.4.3.5 Resistance offered by the still air layer

The resistance offered by the stagnant air layer, and its influence on measured apparent resistance required consideration. Babbitt (1939) conducted experiments, and measured diffusion resistance for various materials including kraft paper with 1to 5, 7, and 8 layers of material. The obtained resistance (Z_m), reciprocal of water vapour permeability $\left(\frac{1}{\delta}\right)$, was plotted as a function of layers. The obtained linear curve did not pass through the origin but slightly above it, and indicated that additional resistance existed across the air space between the specimen and the moisture source. The diffusion resistance offered by the stagnant air layer (Z_a) could be determined by multiplying the air layer thickness (ℓ) by the inverse of water vapour permeability in air $\left(\frac{1}{\delta_a}\right)$:

$$Z_a = \frac{l}{\delta_a} \qquad (2.5)$$

Tveit (1966), used the diffusion theory, and predicted the resistance offered by the stagnant air layer in relation to the overall resistance, and corrected the measured values. Hansen and Lund (1990) demonstrated that an increased stagnant air layer from 5 mm to 25 mm in a wet cup test reduced the vapour pressure at the specimen's boundary. Burch et al. (1992) conducted an experimental analysis, and revealed that the rate of WVT became increasingly inaccurate for highly permeable materials with an error of more than 20%.

2.4.3.6. Effect of changes in barometric pressure

Bomberg (1989), and Hansen and Lund (1990) reported that the buoyancy effect due to the fluctuations in barometric pressure had a more significant effect on the weight change during WVT testing. Wilkins and Pullan (1988) observed the effect of barometric pressure on the WVT for low permeance materials, as illustrated in Figure 2.15.

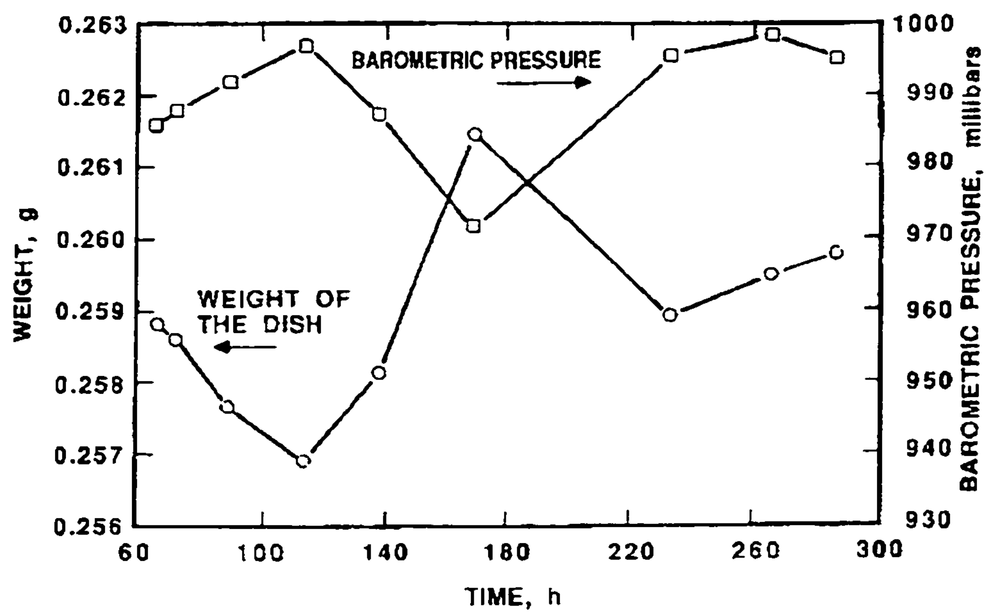

Figure 2.15 Effect of barometric pressure on weight change in WVT tests (Wilkins and Pullan, 1988).

The barometric pressure was inversely related to the weight changes of the dish. Thus, correction accounting for the buoyancy effect was needed for low permeance materials below 2.9 ng/sm^{2}Pa (Bomberg, 1989).

2.4.3.7 Conditions at the surface of the moisture source

Changes in the nature of the moisture source greatly influenced the conditions generated at its surface. Errors could be propagated by improperly prepared saturated salt solution, or inadequately regenerated desiccant. Chemical purity of salt, water and sorbent solution as well as the method of preparation and presence of air borne contaminants could offset the equilibrium balance (Labuza, 2000). In addition, the temperature dependence, and the time of preparation could significantly affect the generated partial vapour pressures. Several researchers have noted the significance of proper desiccant regeneration (drying) and cooling prior to conducting the WVT tests. Chang and Hutcheon (1953) demonstrated that for a 6 mm air space, pre-drying the desiccant at 200°C decreased the relative humidity inside the dry-cup to about 3%. Desiccant not regenerated for extended durations of time (approximately 3 days), increased the vapour pressure at the surface of the desiccant in the double cup tests conducted with WRB.

2.5 CONCLUSIONS

The above discussion presented limitations of existing WRB classification. The new classification encompassing various types of WRB products was proposed. The current approaches employed in testing water penetration, and WVT through WRB products was reviewed. Water penetration testing was performed through numerous variants from the three groups; (1) tests, which do not utilize hydrostatic pressure, (2) tests, which use low hydrostatic pressures, and (3) tests, which utilize high hydrostatic pressures in excess of bubbling point to determine the onset of liquid flow through WRB. Since tests in groups (1) and (3) are arbitrary, they are restricted to quality control of the cellulose and polymeric WRB products. The tests relate to combined effects of liquid and vapour phase transmission, and determine different material characteristics. Thus, materials tested with different test methods could be compared. Experimental factors, which could propagate errors, were discussed in detail. These included the use of visual observation in detecting moisture transmission, short test duration, and inadequately defined boundary conditions on the surface of the material during testing. The tests in-group (1) did not appear precise enough for further analysis, the ponding test group (2) as proposed by CCMC for inclusion to the revised Canadian standard is worth further analysis and improvement.

The review of WVT tests listed many sources of uncertainty. The simple nature of these test methods appeared misleading, and various procedural difficulties, which could significantly reduce reproducibility, were identified. Shortcomings related to the method of cup sealing, attachment of the specimen, obtaining complete airtightness of the system, and regeneration of the desiccant were encountered in the ASTM E 96 WVT standard. A brief overview was provided to introduce concepts in test method utilized in the laboratory examination of moisture transfer through WRB products. The current test methods could be sufficient for quality control of WRB products. Better relation to field performance and improved control of test parameters is required for tests used by codes and standards.

CHAPTER 3

MEASURING TOTAL MOISTURE FLOW THROUGH WRB

3.1 MOISTURE FLOW TO A HYGROSCOPIC SINK

To place a test method development in the context of WRB field performance, a clear understanding of the moisture transfer through WRB was needed. The WRB specimen was placed between a 25 mm layer of water (on the upper surface) and a layer of hygroscopic material, called a moisture sink (on the lower surface). The moisture sinks, selected for examination, included thick adsorbing paper (blotter), vacuum cast gypsum (fabricated at Concordia University), OSB, desiccant (anhydrous calcium chloride), and an empty container. With the exception of the desiccant, which was separated from the lower surface of the WRB with a 10 mm air gap, the remaining substrates were placed in a direct contact with the WRB. A 25 mm layer of water was introduced on the top surface, to reproduce the water layer employed in the CCMC ponding test (see chapter 2). Figure 3.1 illustrates the experimental set-ups used in measuring moisture flux with selected moisture sinks. The test was conducted under controlled laboratory conditions (20±2 °C, and 40±10% RH). The water was removed periodically, the upper surface of the WRB was blotted with a pre-wetted paper towel, and the whole set-up was weighed on an analytical balance, with a precision to ±0.001 g. Following the weighing, the water was refilled to a 25±1 mm level and the test was continued. When the moisture flux was stabilized i.e., a steady state condition was established and at least 4 more readings were taken prior to terminating the test. The incremental weight increase of the set-up was plotted in relation to time with several type C, and type P WRB as illustrated in Figure 3.2.

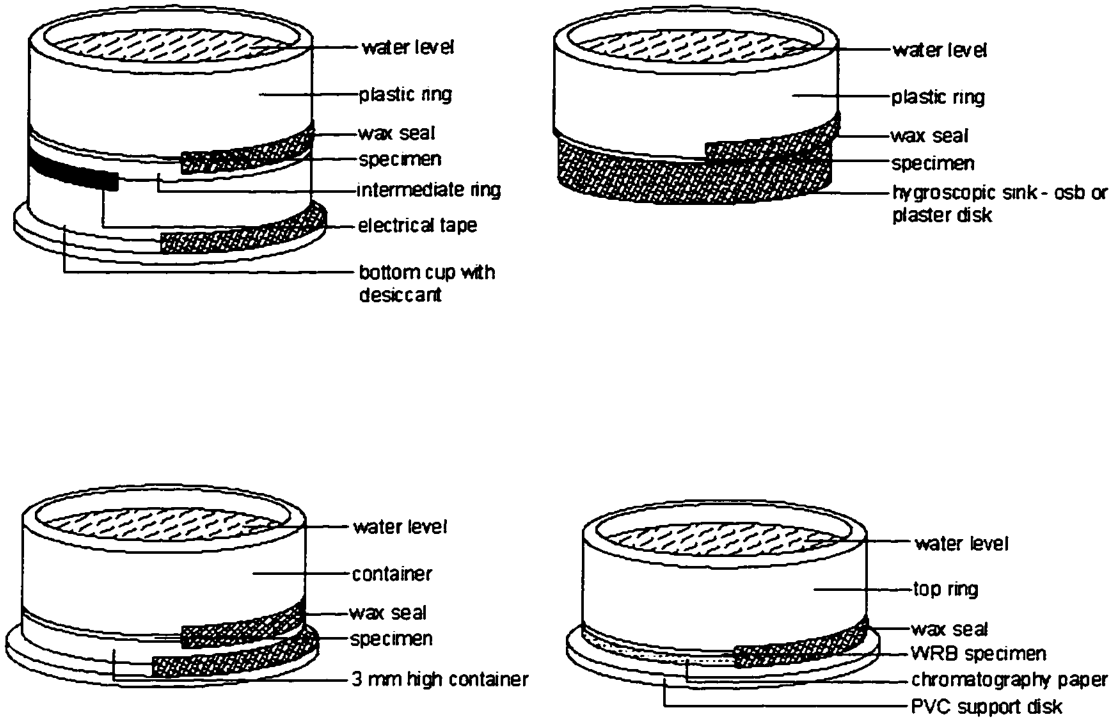

Figure 3.1 Moisture flux set-ups that included various hygroscopic sinks.

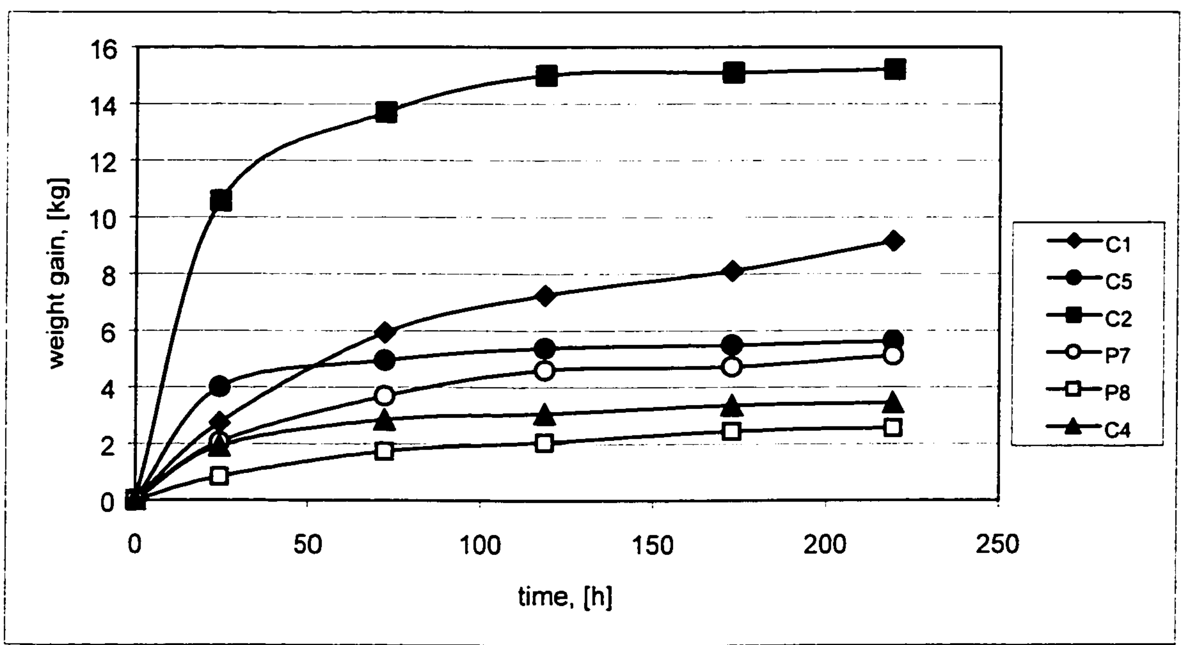

Figure 3.2 Weight increases, measured with 4 type C and 2 type P WRB products and blotting paper as a hygroscopic sink.

Figure 3.2 indicates that a two-stage process characterizes moisture flux through a WRB into a blotter. Prior to the onset of the steady state, all tested materials showed an initial higher transmission rate. This could be explained by a superposition of two processes (1) the contribution from the moisture storage in the WRB and moisture sink, and (2) a change in the driving force for the moisture flux as a result of increased moisture content in the hygroscopic sink. The magnitude of changes and the duration of the initial period varied depending on the type of WRB used. Moisture flux to a moisture sink was calculated by relating the weight increase of the set-up with the flow path area, and the time between readings:

$$q = \frac{G}{t \bullet A} \tag{3.1}$$

where:

q = Moisture flux, $kg/s{\bullet}m^2$
G = Weight increase of the set-up, kg
t = Time between readings, s
A = Area of the flow path, m^2

The specimen's diameter was measured using Mitutoyo absolute digimatic callipers with accuracy to ±0.01 mm. The time was measured using a digital Cole-Parmer stopwatch with accuracy to ±0.01 s. The difference between the initial and stabilized moisture flux was higher for type C than for type P WRB, and could be attributed to a higher contribution of moisture storage offered by the cellulose based products.

3.2 EFFECT OF VARIED TEST PARAMETERS – RUGGEDNESS STUDY

A test method under development should undergo an evaluation process to determine the significance of changes levels of selected parameters on measured results. A ruggedness study based on the Plackett-Burman design (P-B design) (1987) was developed. This approach involved selecting a probable number of parameters for evaluation, and then selecting two extreme levels denoted as high and low settings for each factor under evaluation. The ASTM E1169 (1987) requires that N must be an integer and a multiple of 4 i.e., 4, 8, 12, 16, etc. It further recommends that for purposes of practicality and ease of calculations, 8-test set-up be utilized in evaluation. Conducting 8 tests allowed for the evaluation of seven main effects (seven factors) as given by the formula below:

$$\textit{Number of main effects evaluated} = (N-1) \tag{3.2}$$

where;
N = Number of tests conducted

The factors selected for evaluation included:

- Type of hygroscopic sink,
- Frequency of readings,
- Masked edge effect,
- Capacity of hygroscopic sink,
- Contact between the WRB and the substrate,
- Height of the water head,
- Use of desiccant.

3.2.1 Description of selected factors and settings

The test parameters selected for an evaluation in the Ruggedness Test are described below:

- **Hygroscopic sink:** Two types of hygroscopic sinks were used (1) vacuum cast gypsum disks, and (2) blotter.
- **Frequency of measurements:** The interval between data collection was varied. At a low setting, measurements were taken every two days. At a high setting, measurements were taken once a day.
- **Specimen size:** The effective surface area of the tested specimen was varied. Two options were used (1) a fully exposed specimen (100±1 mm in diameter), and (2) a partially sealed specimen with half of its effective area exposed, (50±1 mm in diameter).
- **Size of hygroscopic sink:** The thickness of hygroscopic sink was varied. The vacuum plaster disks were cast in two different thicknesses. The two groups of disks had different volumetric dimensions, and weight. At a low setting, the thinner gypsum disk and one layer of blotter were used respectively. At a high setting, the thickness of the gypsum disk and the blotter was doubled.

- **Contact vs. no contact:** The quality of the interface between the specimen and the hygroscopic sink was varied. At a low setting, separation was provided with a double layer of galvanized steel screening mesh. The small separation provided a capillary break at the specimen/hygroscopic sink interface. At a high setting, the specimen and the hygroscopic sink were placed in contact with each other.
- **Water head:** The thickness of the water layer present in the cup on the upper surface of the specimen was controlled. Varied water level allowed the control of hydrostatic pressures to which the material was subjected. At a low setting, a 5±1 mm layer of water was used, and at a high setting the water layer was increased to 25±1 mm. These corresponded to 50±10 Pa and 250±10 Pa of hydrostatic pressure, respectively.
- **Use of desiccant:** The use of desiccant decreased and maintained a constant RH in the cup, and thus maximized the vapour drive through the material. An anhydrous calcium chloride was used. At a low setting, the desiccant was not used. At a high setting the desiccant was used in combination with gypsum disk, or blotter.

The range of variation denoted as low and high setting for each parameter under evaluation was established. Table 3.1 lists the seven parameters selected for evaluation and the corresponding low and high settings.

Table 3.1 Variables and their settings selected for examination of moisture flux in the ruggedness test.

No.	Evaluated parameters	Settings	
		Low (-)	High (+)
A	Type hygroscopic sink used	Blotter	Gypsum
B	Frequency of readings	1/2 days	1 per day
C	Size of specimen (diameter)	50±1 mm	100±1 mm
D	Size of hygroscopic sink	Small	Large
E	Contact	No	Yes
F	Height of water head	5±1 mm	25±1 mm
G	Use of desiccant	No	Yes

In the P-B design, the settings for each factor were distributed so that half of the test set-ups were conducted at a high setting and the other half at a low setting. The arrangement of low and high settings for the first row of the P-B design was obtained from the ASTM E 1169 (1987). The orthogonal arrangement in each consecutive row is shown in Table 3.2. Table 3.3 lists the setting distribution for each test set-up.

Table 3.2 Distribution of settings in a Plackett-Burman design for N=8.

	Factors						
Test set-up	A	B	C	D	E	F	G
1	+	+	+	-	+	-	-
2	-	+	+	+	-	+	-
3	-	-	+	+	+	-	+
4	+	-	-	+	+	+	-
5	-	+	-	-	+	+	+
6	+	-	+	-	-	+	+
7	+	+	-	+	-	-	+
8	-	-	-	-	-	-	-

Note: (+) corresponds to the high setting of the variable
(-) corresponds to the low setting of the variable

Table 3.3 Arrangement of parameter in each test set- up.

	Factors						
Test set-up	Type of sink (A)	Reading frequency (B)	Specimen diameter (C)	Capacity of moisture sink (D)	Contact b/w WRB and substrate (E)	Height of water head (F)	Use of desiccant (G)
1	Gypsum	1/day	100 mm	Small	yes	5mm	no
2	Blotter	1/day	100 mm	Large	no	25 mm	no
3	Blotter	1-2 days	100 mm	Large	yes	5mm	yes
4	Gypsum	1-2 days	50 mm	Large	yes	25 mm	no
5	Blotter	1/day	50 mm	Small	yes	25 mm	yes
6	Gypsum	1-2 days	100 mm	Small	no	25 mm	yes
7	Gypsum	1/day	50 mm	Large	no	5 mm	yes
8	Blotter	1-2 days	50 mm	Small	no	5 mm	no

The schematic below illustrates set-ups 4, and 6 used in the ruggedness study.

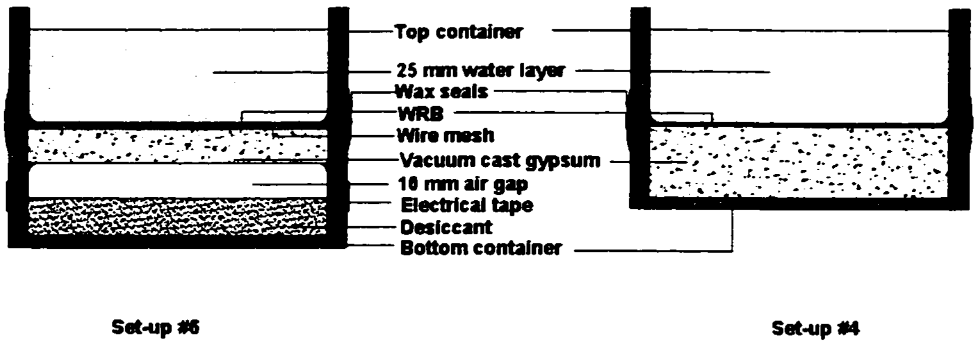

Figure 3.3 Test set-ups 4 and 6 used in the ruggedness study.

3.2.2 Design calculations

The effect of a factor is calculated as the average of measurements made at a high level minus the average of measurements made at a low level, and is given by the following equation:

$$Effect\ of\ a\ factor = \frac{\left[\sum Factors\,(+)\right]}{N[+]} - \frac{\left[\sum Factor\,(-)\right]}{N[-]} \qquad (3.3)$$

where:

Factor (+) = results of the experiment with high setting for a given factor
Factor (-) = results of the experiment with low setting for a given factor
N (+) = Number of experiments with high setting for a given factor
N (-) = Number of experiments with low setting for a given factor

Since two sets of test were conducted, each having eight set-ups the t-value for each factor was calculated from the average of the two t-values obtained for each effect using the following formula:

$$t_{N-1} = \frac{average\ effect\ of\ a\ factor}{2\sqrt{\left[\sum d^2/(N-1)\right]\times(N/8)}\ /\ \sqrt{2N}} \qquad (3.4)$$

where:

N = number of test conducted
d = difference between effect values calculated from two sets of data

The data for the test conducted with type C (C4) WRB is reported in Table 3.4. The average rate of moisture flux obtained following the onset of steady state and the corresponding standard deviation (S) are included.

Table 3.4. Moisture flux and the corresponding standard deviation measured in the Ruggedness study.

Factors								Moisture flux, kg/s.m²			
Setup	A	B	C	D	E	F	G	Data set 1	Standard deviation	Data set 2	Standard Deviation
1	G	1/day	100 mm	S	yes	5mm	no	4.2 E-06	4.7 E-07	4.5 E-06	1.2 E-06
2	B	1/day	100 mm	L	no	25 mm	no	1.4 E-06	9.5 E-07	1.0 E-06	7.5 E-07
3	B	1-2 days	100 mm	L	yes	5mm	yes	6.2 E-07	5.6 E-08	5.7 E-07	5.7 E-08
4	G	1-2days	50 mm	L	yes	25 mm	no	8.9 E-06	1.9 E-07	6.4 E-06	2.0 E-07
5	B	l /day	50 mm	S	yes	25 mm	yes	9.7 E-07	5.8 E-07	2.6 E-06	1.1 E-06
6	G	1-2 days	100 mm	S	no	25 mm	yes	2.4 E-06	9.5 E-07	1.8 E-06	8.2 E-07
7	G	1/day	50 mm	L	no	5 mm	yes	7.2 E-06	1.9 E-07	2.7 E-06	2.6 E-07
8	B	1-2 days	50 mm	S	no	5 mm	no	2.9 E-06	3.8 E-06	3.5 E-06	1.7 E-06
							Ave.	3.6 E-06		2.8 E-06	

The data below shows the calculated *t-value* using formula (2) for the average effect obtained from the two sets of results.

Table 3.5 Calculated *t-value* for the averaged effect of each factor under evaluation.

		First data set		Second data set		Difference in	Average		|t-value|
Factor	Level	Average	Effect	Average	Effect	effects (d)	effect	(d)²	(t-test)
A	G	5.7E-06		3.8 E-06					
A	B	1.5 E-06	4.2 E-06	1.9 E-06	1.9 E-06	-2.3 E-06	3.1 E-06	5.3 E-12	4.4
B	1/d	3.4 E-06		2.7 E-06					
B	1-2 d	3.7 E-06	-2.6 E-07	3.1 E-06	-3.8 E-07	-1.1 E-07	-3.2 E-07	1.3 E-14	0.5
C	100	2.1 E-06		2.0 E-06					
C	50	5.0 E-06	-2.9 E-06	3.8 E-06	-1.8 E-06	1.0 E-06	-2.4 E-06	1.1 E-12	3.4
D	L	4.5 E-06		2.7 E-06					
D	S	2.6 E-06	1.9 E-06	3.1 E-06	-4.0 E-07	-2.3 E-06	7.6 E-07	5.4 E-12	1.1
E	Y	3.7 E-06		3.5 E-06					
E	N	3.5 E-06	1.9 E-07	2.2 E-06	1.3 E-06	1.1 E-06	7.2 E-07	1.1 E-12	1.1
F	25	3.4 E-06		2.9 E-06					
F	5	3.7 E-06	-3.4 E-07	2.8 E-06	1.3 E-07	4.7 E-07	-1.0 E-07	2.3 E-13	0.2
G	Y	2.8 E-06		1.9 E-06					
G	N	4.3 E-06	-1.5 E-06	3.9 E-06	-2.0 E-06	-4.3 E-07	-1.7 E-06	1.9 E-13	2.5
							Ave.	1.3 E-11	
		Variance of (d) = Expected value of d2 = Sd2/(N-1)						1.9 E-12	

To determine a statistical significance of each main effect under evaluation, the calculated t-value was compared with the reference t-value. For 95% probability and seven degrees of freedom, the t-value was determined at 1.9 (Moore and McCabe, 1993). The effect of any factor was considered significant when the calculated t-value was above the reference *t-value*. The following parameters in Table 3.5 did not have a significant effect on the test results:

- Frequency of readings,
- Capacity of hygroscopic sink,
- Degree of contact between the WRB and the substrate,
- Height of the water head.

With the *t-value* above the reference value, the following three factors were considered to have a statistical significance on moisture flux within the tested range:

- Type of hygroscopic sink used,
- Masked edge effect,
- Use of desiccant.

Assuming that liquid transport was dominant, the increase in moisture flux results would be directly proportional to the height of the water head. An increase in transmitted moisture would correspond to an increase in water head levels. In addition, the condition of no contact between the WRB and the substrate would be expected to influence the rate of liquid flow. In the instance of no contact, the discontinuity of pores would eliminate the capillary driving forces. The height of water head and the degree of contact between the WRB and the substrate were expected to have a significant effect; however, the results of the ruggedness test showed an opposite effect. This can only be explained by the fact that water vapour transport was the dominant phase of moisture flux. This was confirmed by the fact that the use of desiccant had a significant effect on the measured results. The desiccant was placed on the lower side of the substrate and was separated by a 10±1 mm air layer. The highly hygroscopic nature of the desiccant indicated that water vapour flow dominated over liquid flow. All parameters and conditions listed, which had a significant effect on moisture flux, were related to WVT. While changes in the parameter settings that would affect the liquid phase transport were not significant. The effect of boundary conditions on moisture flux was examined further by changing the type of the substrate used, and the thickness of the water layer.

3.3 EFFECT OF A SUBSTRATE

To examine the effect of a substrate, moisture flux was measured with OSB, plywood, blotter, regularly regenerated desiccant and vacuum cast gypsum (fabricated at the Concordia University). To establish the same boundary conditions at the onset of the experiment, the substrate materials were pre-conditioned in an air-circulating oven at a temperature of 65±5 °C until a steady weight was obtained. The pre-dried moisture sink was placed in contact with the lower surface of the WRB or in the case of the desiccant, a 10±1 mm air gap separated the moisture sink from the specimen's lower surface. The upper surface of the WRB was subjected to a 25±1 mm water head as illustrated in Figure 3.3. The weight increase of the set-up, which was the combined weight change of the moisture sink and the WRB, were periodically measured. Figures 3.4 and 3.5 illustrate the effect of a substrate on moisture flux performed with a single type C and type P WRB.

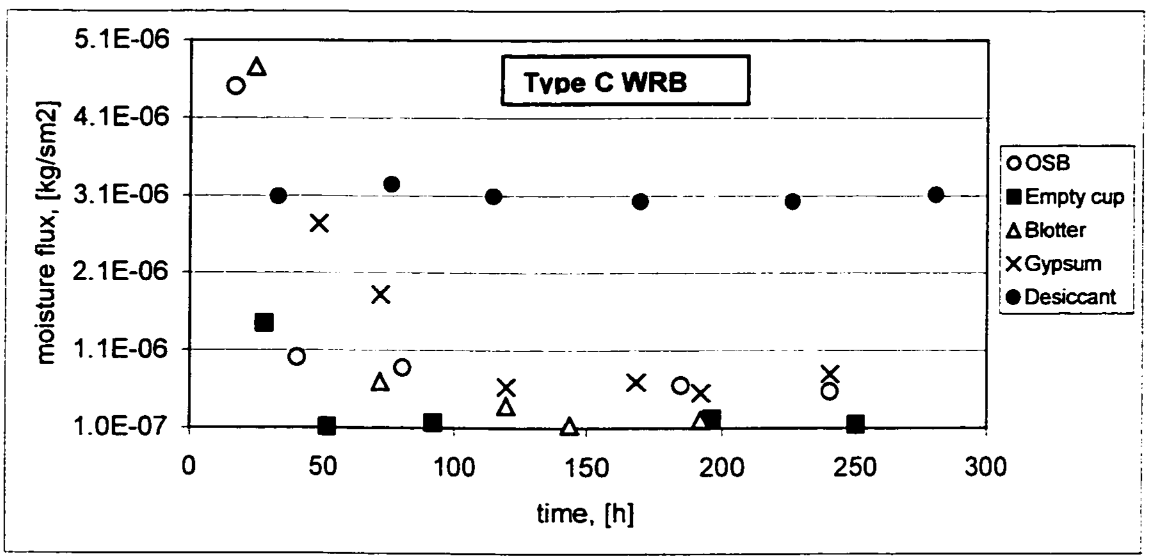

Figure 3.4 Moisture flux measured with type C (C4) WRB and various hygroscopic sinks.

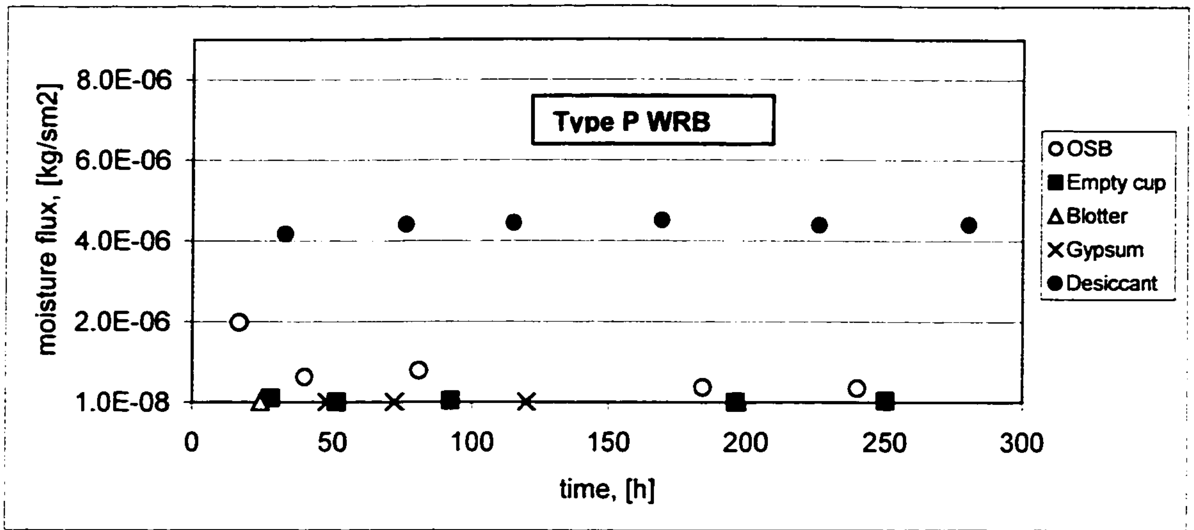

Figure 3.5 Moisture flux measured with type P (P6) WRB and various hygroscopic sinks

Figure 3.4 shows that moisture flux was dependent on the type of moisture sink used, and with exception of regularly regenerated desiccant it decreased over time. The results indicated that tests performed with the desiccant showed the highest and most constant moisture flux. Figure 3.5 illustrates moisture flux measured with type P WRB. A difference in time required to reach the steady state was observed between type C and type P WRB. For type P material this period was shorter, below 50 hours in comparison to the 150 hours required for type C material. To provide a better understanding of this phenomenon, better knowledge of the nature of the hygroscopic sinks were required. The sorption isotherm as illustrates in Figure 3.6 provides more insight about the boundary conditions generated during testing.

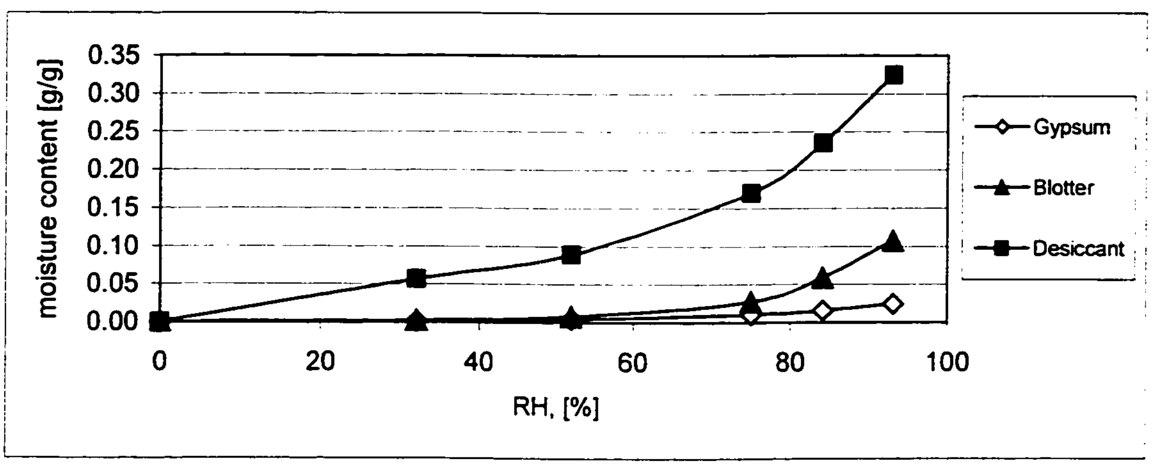

Figure 3.6 Adsorption isotherm for desiccant, vacuum cast gypsum, and blotter measured at 21±1 °C temperature.

It is clear that moisture storage and conditions at the surface of the moisture sink strongly affected both the evaporation and vapour diffusion away from the water meniscus. The desiccant proved to be the strongest hygroscopic sink with moisture storage several times higher than the vacuum cast gypsum or the blotting paper. The use of desiccant in comparison with other moisture sink generated conditions of optimum vapour diffusion. In the next step, the effects of varied boundary conditions on the top surface of WRB were examined.

3.4 EFFECT OF WATER HEAD

To determine the effect of water head, the height of water head introduced on the top surface of the WRB was varied. The WRB was subjected to 25±1 mm, 50±1 mm, and 100±1 mm water heads. To eliminate the effect of a moisture sink, an empty 30±0.1 mm deep container was used to collect the transmitted moisture. Figure 3.8 shows the measured moisture flux with a single type C, and type P WRB.

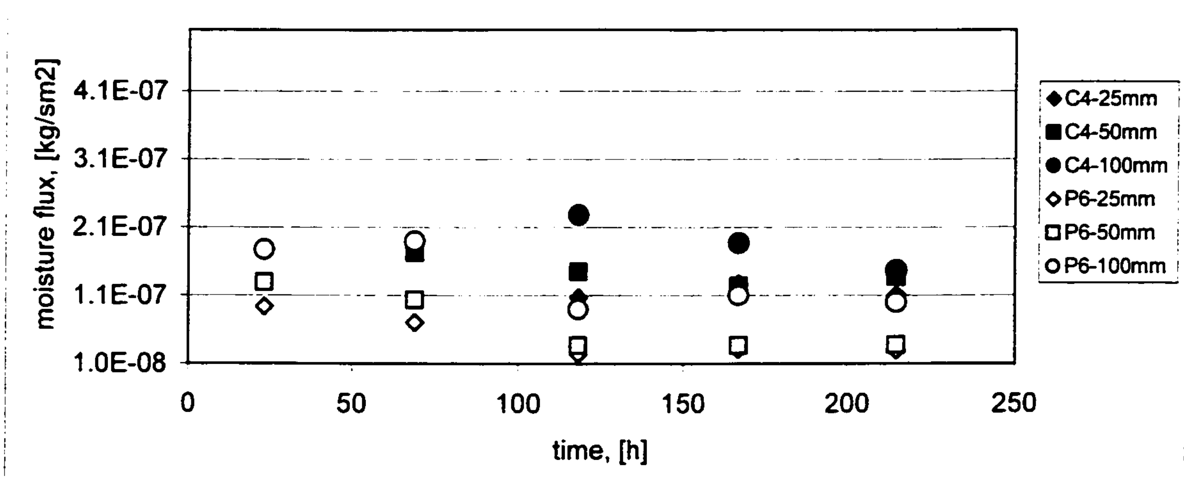

Figure 3.7 Measured moisture flux to a 30 mm deep bottom container with type C, and the type P with 25 mm, 50 mm, and 100 mm water head.

Figure 3.7 shows the lack of linear dependence in moisture flux measured in test with varied water head. Although the moisture flux for type P WRB was higher when conducted with a 100 mm water head, no difference was observed when the test was conducted with 25 mm and 50 mm water heads. Another test was conducted with a 250 ± 1 mm water head. The measured moisture flux was compared in Figure 3.8 to a series of tests conducted with 25 mm water head.

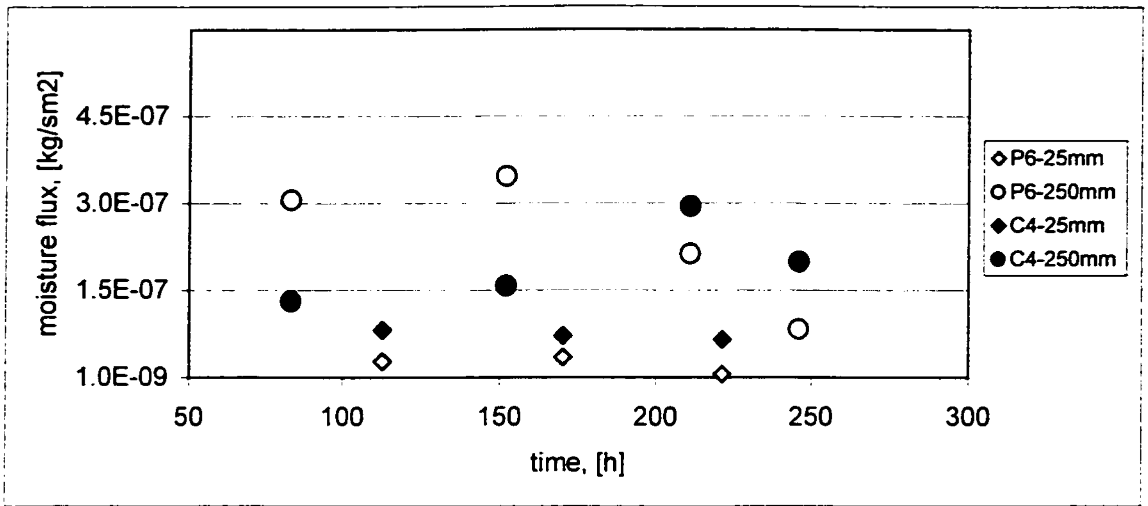

Figure 3.8 Moisture flux measured to a 30 mm deep bottom container through type C, and type P WRB with 25 mm and 250 mm water head.

The result showed that increasing the water head may have increased the variability of the results flux but had a minor effect on the measured moisture flux. The results were stable when tested with a 25 mm layer of water. Next, the effect of the volume change of the bottom container was examined. Since a reduction in the container's volume would equilibrate the partial water vapour pressure much faster, a 30 mm deep container was replaced with a 3±0.1 mm deep container. Figure 3.9 shows measured moisture flux with type P and type C products.

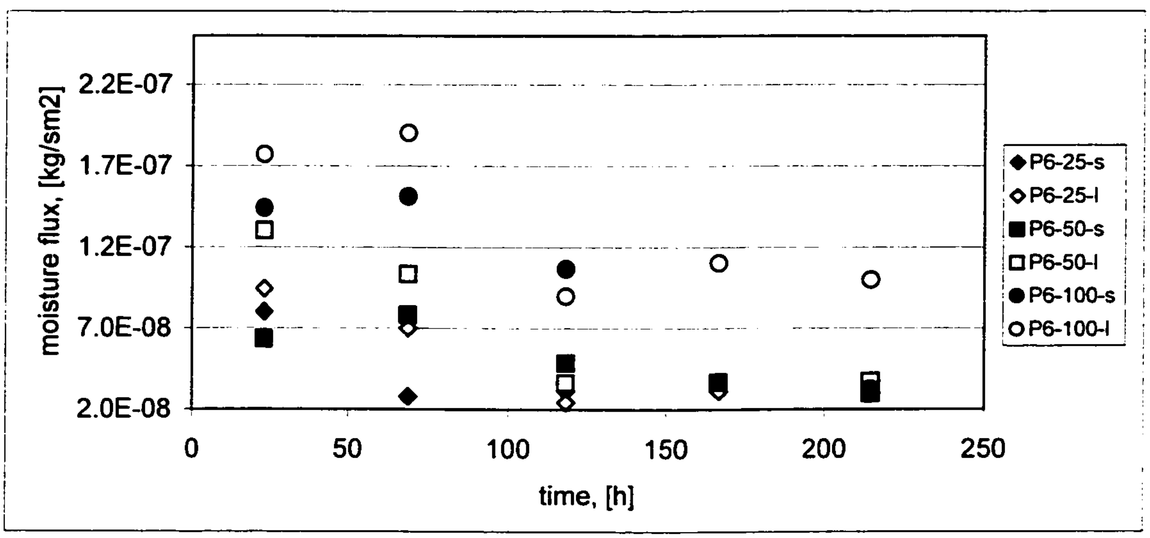

Figure 3.9 Moisture flux rate tested with 3mm deep bottom container for type C and type P WRB with 25 mm, 50 mm, and 100 mm water heads.

In general, reducing the volume in the bottom container had a minor effect on the moisture flux, which reinforces the hypothesis that water dominant total moisture transport occurred. To confirm this, the transmission coefficient was calculated as a function of one of the two driving forces (1) vapour diffusion, and (2) liquid flow. In the instance of vapour diffusion, the (P_L) partial vapour pressure was used as the driving force. Under the assumption of a liquid flow, the (P_H) hydrostatic pressure generated by the water head was used as the driving force. The recalculated apparent transmission coefficients and the corresponding standard deviation are listed in Tables 3.6, and 3.7. The name apparent highlighted the fact that the measured moisture flux could not be recalculated into transmission coefficient, since the moisture transport was a combination of liquid and vapour phase in an undefined ratio. The data indicated that tests conducted with an increased water head on the top surface of the WRB, and a collection containers on the opposite side were not precise. The standard deviation showed that the error was sometimes as high or nearly as high as the calculated transmission coefficients.

Table 3.6 Apparent transmission coefficients recalculated from moisture flux tests conducted with type C WRB with 25mm, 50 mm, 100 mm, and 250 mm water heads, and with a 3 mm, and a 30 mm deep water collection containers.

Transmission coefficient, (kg/sm^{2}Pa)					
Water head height, mm	Recalculated with hydrostatic pressure	Standard deviation	Recalculated with partial water vapour pressure	Standard deviation	Size of water collection container
C4-25	4.3 E-10	5.2 E-11	3.8 E-11	4.6 E-12	[30 mm] deep
C4-50	2.2 E-10	9.8 E-11	3.9 E-11	1.7 E-11	
C4-100	1.3 E-10	6.3 E-11	4.5 E-11	2.2 E-11	
C4-25	2.9 E-10	3.3 E-11	2.6 E-11	2.9 E-12	[30 mm] deep Repeated test
C4-100	1.3 E-10	5.3 E-11	4.5 E-11	1.9 E-11	
C4-250	8.7 E-11	2.8 E-11	7.8 E-11	2.5 E-11	
C4-25	2.9 E-10	4.2 E-11	4.8 E-11	1.4 E-11	[3 mm] deep
C4-50	1.9 E-10	3.3 E-11	5.2 E-11	7.4 E-12	
C4-100	4.8 E-11	1.4 E-11	6.7 E-11	1.2 E-11	

Table 3.7 Apparent transmission coefficients recalculated from moisture flux tests conducted with type P WRB with 25 mm, 50 mm, 100 mm, and 250 mm water heads with 3 mm, and 30 mm deep water collection containers.

Transmission coefficient, (kg/sm^{2}Pa)					
Water head height, mm	Recalculated with hydrostatic pressure	Standard deviation	Recalculated with partial water vapour pressure	Standard Deviation	Size of water collection container
P6-25	1.3 E-10	1.6 E-11	1.1 E-11	1.4 E-12	30 [mm] deep
P6-50	9.7 E-11	4.3 E-11	1.7 E-11	7.6 E-12	
P6-100	8.2 E-11	5.7 E-11	2.9 E-11	2.0 E-11	
P6-25	9.5 E-10	6.1 E-10	8.4 E-12	5.4 E-12	30 [mm] deep Repeated test
P6-100	7.3 E-10	1.1 E-10	2.8 E-11	4.0 E-12	
P6-250	8.6 E-10	5.3 E-10	7.6 E-11	4.7 E-11	
P6-25	1.6 E-10	8.4 E-11	1.8 E-11	7.6 E-12	3 [mm] deep
P6-50	1.1 E-10	6.7 E-11	1.9 E-11	1.2 E-11	
P6-100	1.2 E-10	4.6 E-11	4.4 E-11	1.6 E-11	

The remaining results were reported as moisture fluxes kg/sm^2 rather than transmission coefficients kg/s•m^2•Pa, and were calculated using Equation (3.1), because the driving force was a combination of partial vapour pressure, and a hydrostatic pressure in an unknown ratio.

All tests performed with moisture sinks other than the desiccant indicated that minor changes in moisture content of the moisture sink highly influenced moisture flux to the surface of the sink. Increasing water head on the upper surface of the WRB had no effect on measured moisture flux. The test performed with varied water heads indicated that measuring moisture flux to an empty collection generated variable results. The test performed with desiccant as moisture sinks indicated highest and most stable moisture flux.

3.5 DEVELOPMENT OF MODIFIED INVERTED CUP (MIC) TEST

It was demonstrated that to achieve a repeatable laboratory test, the boundary conditions on both sides of the WRB had to be well defined. The following boundary conditions were found acceptable for characterization of WRB in laboratory testing:

- A 25 mm water head on the upper surface of the WRB, which was similar to the inverted wet cup test described in the ASTM E 96 (2000),
- Use of periodically regenerated desiccant or a layer of water on the opposite side of the WRB separated by a 10 mm air layer on the underside of the WRB.

Having selected the boundary conditions, tests were conducted to determine, within laboratory repeatability, precision between replicate specimens, and two different operators. Figure 3.10 shows the moisture flux measured with various types of WRB products. The results indicate the stability of moisture flux measured in the MIC test method with five type C and three type P WRB.

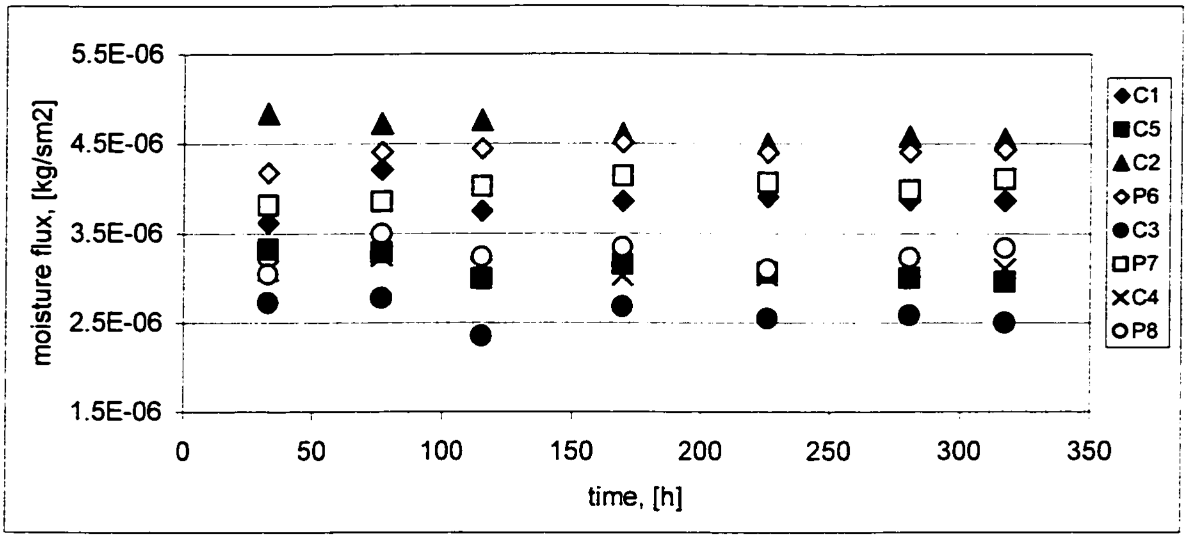

Figure 3.10 Moisture flux measured in MIC test with five type C, and three type P WRB.

Figures 3.10 and 3.11 show the repeatability of the results between tested replicate specimens for type C and type P products. The data indicates stability and repeatability of the results for the tested replicate specimens.

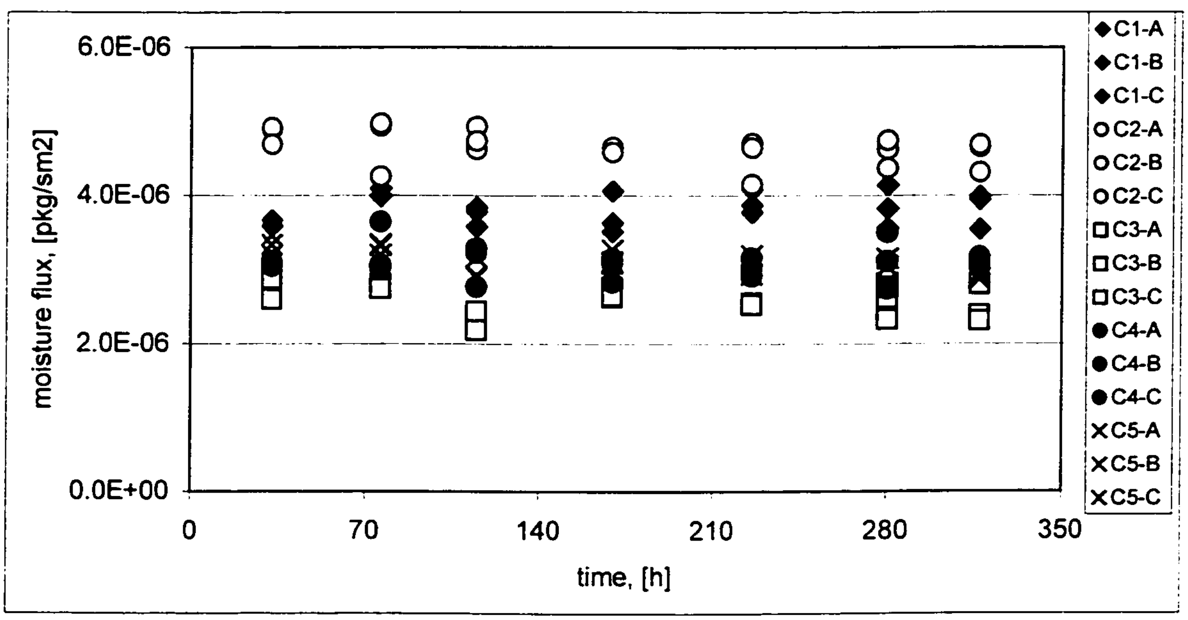

Figure 3.11 Moisture flux measured with MIC test and three replicate specimens for five type C WRB products.

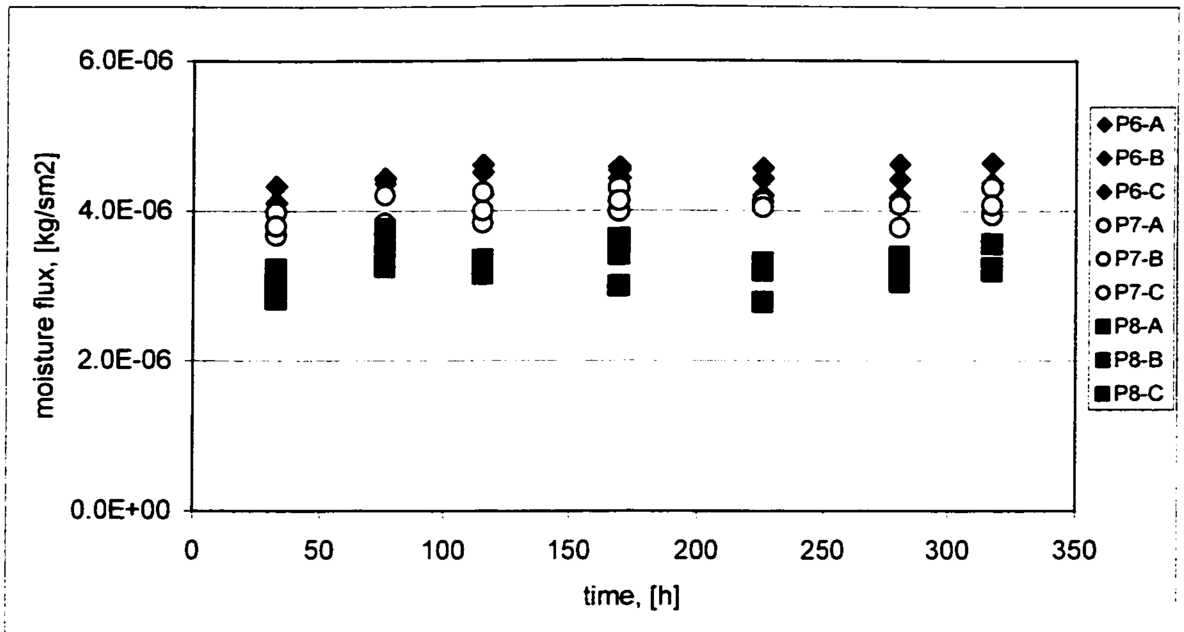

Figure 3.12 Moisture flux measured with MIC test for three replicate specimens for three type P WRB products.

Table 3.7 lists the calculated moisture flux and the corresponding standard deviation for the specimens in Figure 3.12. It represents an average from 6 points measured at various time intervals throughout the test duration.

Table 3.8 Moisture flux and standard deviation calculated on replicate specimens for 8 WRB products.

Specimens	Moisture flux, [kg/sm^2]	Standard deviation
C1-A	3.80E-06	4.48E-07
C1-B	3.79E-06	5.93E-07
C1-C	4.14E-06	6.54E-07
C2-A	4.66E-06	2.88E-07
C2-B	4.60E-06	1.77E-07
C2-C	4.60E-06	2.43E-07
C3-A	2.46E-06	2.86E-07
C3-B	2.52E-06	2.81E-07
C3-C	2.73E-06	2.49E-07
C4-A	3.26E-06	2.67E-07
C4-B	2.95E-06	1.77E-07
C4-C	3.08E-06	1.41E-07
C5-A	3.13E-06	1.16E-07
C5-B	3.10E-06	1.46E-07
C5-C	2.99E-06	1.88E-07
P6-A	4.46E-06	1.05E-07
P6-B	4.53E-06	9.09E-08
P6-C	4.30E-06	1.44E-07
P7-A	3.85E-06	1.82E-07
P7-B	4.10E-06	1.85E-07
P7-C	4.13E-06	7.77E-08
P8-A	3.11E-06	2.10E-07
P8-B	3.36E-06	1.64E-07
P8-C	3.39E-06	2.33E-07

The results indicated a good agreement between replicate specimens, with the standard deviation being an order of magnitude lower than the measured moisture flux. The MIC tests performed with periodically regenerated desiccant indicated high repeatability precision. However, the test method could not be used to examine all of the effects i.e., the effect of penetrations because the fasteners (nails or staples) needed to be fastened securely into the substrate. In this instance, secondary wood based moisture sinks i.e., OSB and plywood were selected for laboratory testing. Tests performed with OSB and plywood as moisture sinks were denoted as a moisture flux (MF) tests.

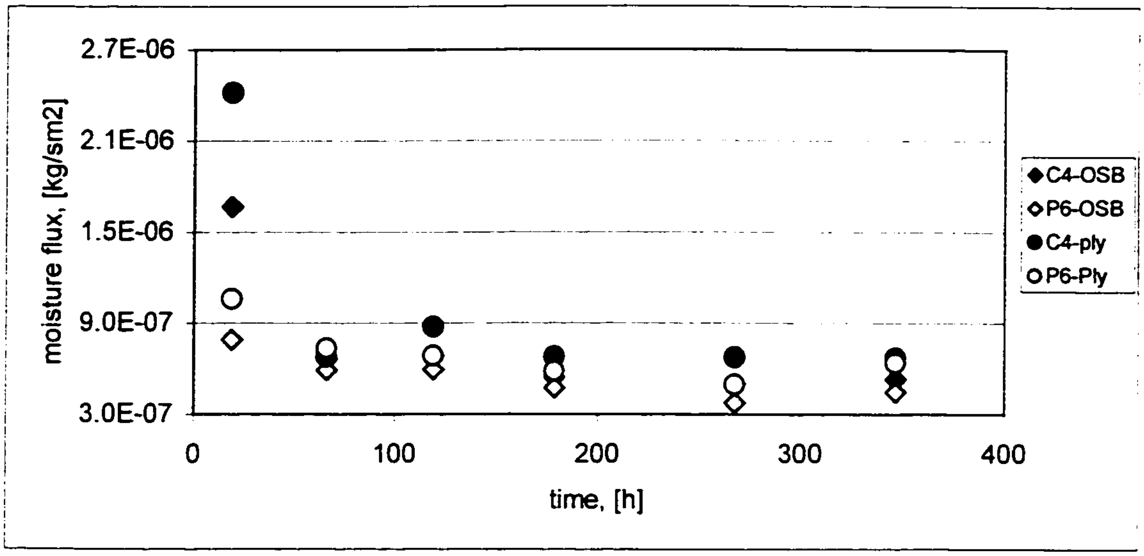

Figure 3.13 Moisture flux measured with the MF test, and OSB and plywood as moisture sink.

Figure 3.13 shows repeatability of the measured moisture flux when the tests were performed with OSB and plywood as moisture sinks. The calculated moisture flux was an order of magnitude lower than that measured with the MIC test method in Figure 3.4 and 3.5.

3.6 CONCLUSIONS

The MIC test method performed with 25 mm water layer on the surface, and use of frequently regenerated desiccant on the lower surface separated with a 10 mm air gap had well defined boundary conditions. The test method measured optimum vapour dominant total moisture transmission, and was found acceptable and is recommended for use in the evaluation of WRB products. The MF test, which measured moisture flux to an OSB substrate, was necessary to examine the effect of penetrations, to evaluate liquid applied WRB products in order to relate the moisture performance of different WRB products.

CHAPTER 4

MEASURING LIQUID FLOW THROUGH WRB

4.1 PENETRATION AND FILTRATION OF LIQUID

The previous chapter dealt with the development of MIC, a test method utilized to quantify vapour dominant total moisture transport. However, instances could arise when a more specific knowledge of liquid flow through WRB could be required i.e., for input into advanced HAM models. The following issues will be discussed in this chapter:

- The time to the onset of liquid flow when different heights of water head were applied to one surface of WRB,
- The time to the onset of liquid flow when water is applied to both surfaces of WRB,
- The rate of liquid flow once a continuous flow is established and,
- Comparison of measured results with re-calculated flow from the intrinsic permeability measurements (porosity component only).

So far, moisture transport through WRB was considered when a layer of water was introduced on its top surface and a moisture sink was placed on its lower surface. Under such conditions, all three phases; liquid water, water vapour and air were contained in the pores of the WRB, while the transport phenomena was dominated by vapour diffusion. Thorsen (1987) noted that for hydrophobic membranes, the inverted cup test method (similar to MIC performed in this research) could be used to measure water vapour permeability but could prove difficult in obtaining liquid permeability. In fact, this has been the case with the tested WRB. It was shown in chapter 3 that increasing water head to 250 mm had no effect on moisture flux. Therefore, another approach was employed to measure penetration and filtration of liquid through WRB. In this approach, water was introduced on both sides of the WRB. The lower surface was subjected to 500±10 Pa of hydrostatic pressure, and the top surface to 250±10 Pa of hydrostatic pressure. The resultant 250±20 Pa pressure difference forced the liquid to flow upwards through the material. The test was denoted as a *liquid penetration resistance (LPR)* test. During the initial stages of the test, entrapped air in the pore matrix prevented the liquid from moving through the entire volume of the pores and moisture was transported predominantly in the vapour phase driven by diffusion. With time, the water pushed out some of the air bubbles, while others dissolved in the water and diffused towards the region of lower pressure i.e., diffused outwards, and the so called liquid break through condition occurred. Hall and Hoff (2002) noted that for unsaturated materials, a percolating network connected the majority of the air filled pores to the boundary; the air pockets being at the atmospheric pressure rapidly diffused to the surface. This was a time dependent phenomena, and varied for different WRB products. The penetration of liquid through WRB was marked by an onset of liquid filtration (a visible increase of water level inside a container). The time in days to the onset of liquid flow was determined from a visual inspection performed twice a day. Following the liquid breakthrough, the liquid was collected, and its weight was determined. The rate of liquid flux in (kg/sm^2) was calculated using Equation (3.1) by relating the weight of the liquid with respect to the area of the specimen, and the time recorded between readings.

4.2 EXPERIMENTAL SET-UP FOR LIQUID PENETRATION RESISTANCE (LPR) TEST

The experimental set-up included a sealed acrylic container with a 100±0.1 mm inside diameter. A plastic grid (mesh) was inserted at the bottom of the container and provided support for the WRB. On the containers' side, an opening was drilled and a stainless steel capillary outflow fitting, with an orifice measuring 0.79 mm, was inserted. The bottom of the fitting was located 25±0.1 mm above the top surface of the WRB. Polyamide capillary outflow tubing with a 0.25 mm inside diameter was attached to the fitting. A 10 cc syringe was used to extract the liquid that filtrated through the WRB following the onset of continuous liquid flow. A brass fitting with a 4 mm opening was installed in the cover of the container, and provided air pressure equalization at the onset of liquid flow. The WRB membrane was sealed to the bottom edges of the container with a wax mixture as illustrated in Figure 4.1. The specimen's upper surface was subjected to a hydrostatic pressure generated by a 25±1 mm thick layer of distilled water. The sealed set-up was then placed in a glass tank measuring 920 mm by 300 mm by 460 mm. The tank was large enough to provide constant water head during the second stage of the test during was the rate of filtration was measured. Water was added slowly until a 25±2 mm difference between water levels inside the container and inside the tank was reached. A total of 12 specimens, representing 4 types of WRB and 3 replicas for each type, were tested. During the experiment, the tank was covered with a polyethylene sheet to reduce water evaporation. The water level was monitored twice a day, and water was added accordingly to maintain the 250±20 Pa overpressure acting on the WRB.

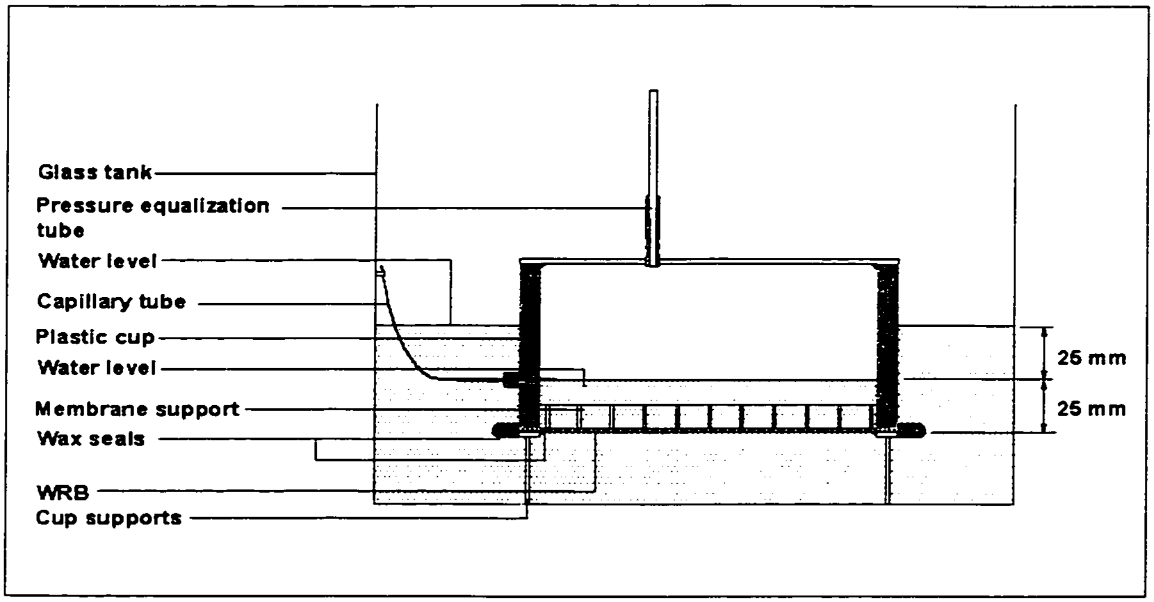

Figure 4.1 Set-up for a LPR test.

The test procedure included (1) determining the time in days to the onset of the liquid breakthrough, and (2) the rate of liquid filtration subsequent to the onset of continuous liquid penetration. Due to the variation in liquid flow through the different type of WRB, the frequency of data collection varied.

4.3 RESULTS AND DISCUSSION

In tests performed with types C, and P WRB, the readings were collected twice a day and in tests performed with type PP WRB the frequency of measurements was increased to several readings per hour. Table 4.1 lists the time in days to the onset of liquid breakthrough.

Table 4.1 Onset of liquid flow through WRB products and proposed classification.

WRB code	Time, [days]	Pass/fail criterion
C1	3	Pass
C2	2	Pass
C3	3	Pass
C4	4	Pass
C5	6	Pass
P6	>21	Pass
P7	>7	Pass
P8	>7	Pass
PP9	1 hour	Fail
PP11	Instant	Fail

Table 4.1 shows the onset of liquid flow and the proposed pass/fail criterion based on 1-day resistance to the liquid breakthrough as a minimum benchmark for WRB. When the flow of water was established in less than 1 day, the WRB failed the test. This occurred with tested type PP (PP9) and (PP11) WRB products. It was evident that under 250±20 Pa of hydrostatic pressure difference, 2 to 6 days were necessary to initiate a continuous flow of water through type C WRB. No visible liquid flow was observed through P7 and P8 WRB for seven days. For P6, the test was extended to three weeks and still no visible water penetration was recorded. It may be assumed that the period to the onset of continuous liquid flow depended on the removal or dissolution of entrapped air in the pore matrix of the material. Even though the water was in contact with the specimen's upper and lower surfaces, air remained entrapped in the pore structure of the WRB. The process of air dissolution and diffusion depended on the nature of the pores, and applied water pressure difference. For type PP products, the onset of liquid flow was instantenous and could have been attributed to the diameter and the distribution of mechanically induced penetrations. These penetrations extended throughout the WRB matrix and differed from the connectivity of the pores, (see SEM images in section 2.1.2). Table 4.2 lists the liquid flow rates and the corresponding standard deviation measured through various WRB products with 250±10 Pa of water pressure difference following the onset of liquid filtration.

Table 4.2 Liquid flow rates measured following the onset of liquid filtration.

WRB code	Liquid flow rate, kg/sm2	Standard deviation
C1	2.1 E-05	5.4 E-07
C2	1.8 E-05	4.6 E-07
C3	1.9 E-05	4.6 E-07
C4	2.1 E-05	9.1 E-07
C5	2.2 E-05	7.2 E-07
P6	-	-
P7	-	-
P8	-	-
PP9	2.2 E-04	1.1 E-05
PP11	9.3 E-02	8.7 E-03

Figure 4.2 illustrates the stability of liquid flow through type C WRB products during 80-hour test duration.

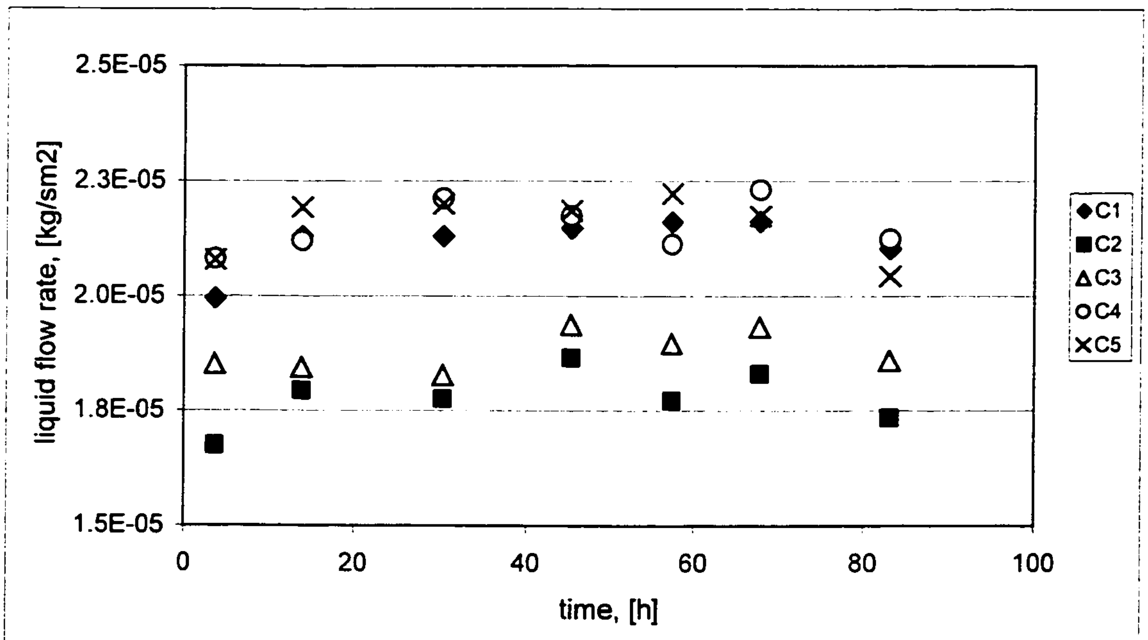

Figure 4.2 Liquid flow measured with five type C WRB products with 250 Pa hydrostatic pressure difference.

Figure 4.3 shows the stability and repeatability precision of the LPR test method tested with three replicate specimens. The results were in good agreement.

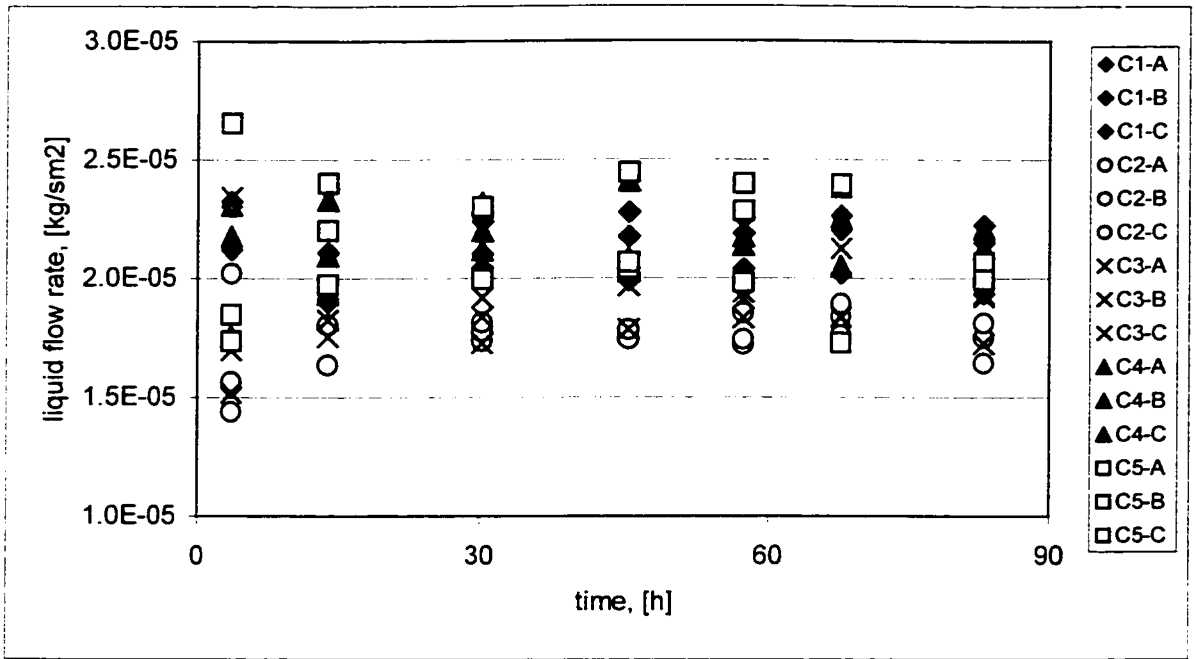

Figure 4.3 Liquid flow rates measured with three replicate specimens for five type C WRB.

The table below lists the average liquid flow rates and the corresponding S for five type C WRB products.

Table 4.3 Liquid flow rates measured following the onset of continuous flow.

WRB code	Liquid flow rate, kg/sm2	Standard deviation
C1-A	2.2 E-05	7.4 E-07
C1-B	2.2 E-05	2.0 E-06
C1-C	2.0 E-05	1.5 E-06
C2-A	1.7 E-05	5.3 E-07
C2-B	1.8 E-05	6.8 E-07
C2-C	1.9 E-05	9.7 E-07
C3-A	1.9 E-05	5.6 E-07
C3-B	1.9 E-05	1.6 E-06
C3-C	1.8 E-05	8.5 E-07
C4-A	2.2 E-05	1.9 E-06
C4-B	2.0 E-05	1.4 E-06
C4-C	2.1 E-05	1.1 E-06
C5-A	2.1 E-05	1.8 E-06
C5-B	2.2 E-05	1.8 E-06
C5-C	2.2 E-05	2.9 E-06
PP9-A	2.3 E-04	1.4 E-05
PP9-B	2.2 E-04	1.2 E-05
PP9-C	2.2 E-04	1.4 E-05
PP11-A	5.9 E-02	7.5 E-03
PP11-B	5.9 E-02	8.2 E-03
PP11-C	5.0 E-02	3.0 E-03

Figure 4.4 shows the rate of liquid flow measured on PP11 product. The rate of flow was between two and three orders of magnitude larger for PP11 WRB than for type C products.

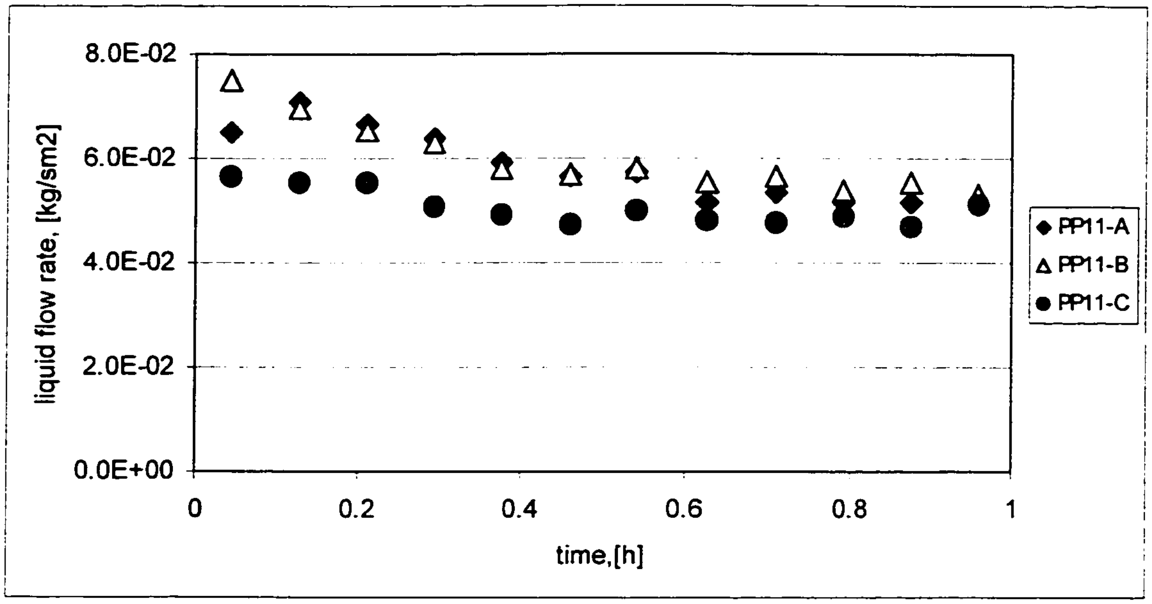

Figure 4.4 Liquid flow rates measured with three (◆) PP-11 specimens.

Water permeance can be calculated by dividing the rate of water flow by the corresponding hydrostatic pressure 250 Pa. To ascertain the validity of the measured data, the results were compared to water permeance kg/sm^{2}Pa recalculated from air permeance L/sm^{2}Pa measured at 25±0.1 °C. The volumetric airflow can be recalculated to the mass flow using the measured air permeance for the WRB products (see Table 4.4), and the corresponding density of air at 25 °C, which was 1.184 kg/m3. Assuming the same intrinsic permeance for the WRB, the ratio of kinematic viscosity (ν_W) of water at 20 °C, which was 1.0E-06 m^2/s could be related to that of air at 25 °C, which was 1.5E-05 m^2/s, and could be used to recalculate the (mass) of air permeance with respect to the mass of water permeance. The water permeance was obtained by multiplying the ratio of kinematic viscosity of air and water, which was 6.67E-02, by the intrinsic air permeance recalculated from the volumetric airflow to mass flow. A detailed presentation of the recalculation was included in Appendix A. Table 4.3 shows the measured air permeance, and water permeance calculated from liquid filtration measured with the LPR test method, and the water permeance recalculated from measured air permeance.

Table 4.4 Comparison of recalculated water permeance from the measured air permeance with the water permeance values obtained experimentally.

WRB code	Air permeance, L/(sm2Pa)[1]	Recalculated water permeance kg/sm2Pa	Measured water permeance kg/sm2Pa
C1	1.7 E-03	13 E-08	8.6 E-08
C2	8.9 E-04	7.0 E-08	7.2 E-08
C3	5.6 E-04	4.5 E-08	7.5 E-08
C4	2.6 E-03	22 E-08	8.4 E-08
C5	2.2 E-03	18 E-08	8.7 E-08

Note: (1) Air permeance measurements performed by (Zangh, 2003).

The measured water permeance was comparable with the water permeance values recalculated from the measured air permeance.

4.4 CONCLUSIONS

The test results indicated a good agreement between the replicate specimens with the standard deviation being one or two magnitudes lower than the measured liquid flow rates. The LPR test method, with water in contact with both WRB surfaces and a 250 Pa pressure difference, is found acceptable and is recommended for use in the evaluation of WRB products.

CHAPTER 5

APPLICATION OF DEVELOPED TEST METHODS IN THE EVALUATION OF WRB

This section is focused on the application of developed test methods in a laboratory evaluation of moisture performances of type C, and P WRB. To set an acceptance criterion, the WRB were tested at the material and at an assembly levels. At the material level MIC, MF and LPR tests were used to evaluate such effects as weathering, penetrations, and additives that might leach out of stucco. At the assembly level, the WRB was placed with stucco on one side and OSB substrate on the other. Moisture was driven under a constant thermal gradient, and the weight increase of an OSB disk was measured gravimetrically. The assembly tests were conducted to determine the effect of penetrations and additives in stucco on moisture transport through WRB.

5.1 EFFECT OF FASTENERS

A comparative study was conducted to examine the change in moisture flux in the presence of mechanical fasteners through WRB. To evaluate the effect of fasteners, MF test measuring moisture flux to an OSB substrate was performed as illustrated in Figure 5.1. In traditional stucco walls, two types of fasteners are often used (1) nails utilized to fasten the reinforcing metal mesh, and (2) staples used to attach WRB to the wood-based substrate. Standard galvanized 25 mm roofing nails with 11 mm in diameter head, and 10 mm Arrow Type T50 staples were fastened securely through WRB into the OSB and plywood substrates.

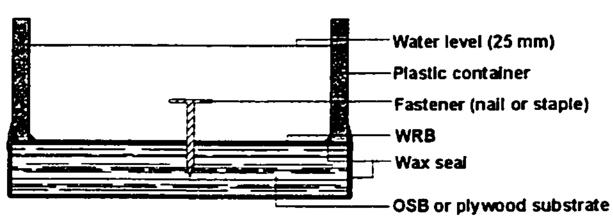

Figure 5.1 Schematic of MF experimental set-up with fastener.

First, the moisture flux was measured on OSB substrate alone without fasteners and results are reported in Figure 5.2. The data showed that moisture fluxes measured with either OSB or plywood substrate or type C, or P WRB were practically identical. The tests were repeated but nails, staples were used to penetrate the WRB and the data is reported in Figures 5.3 and 5.4.

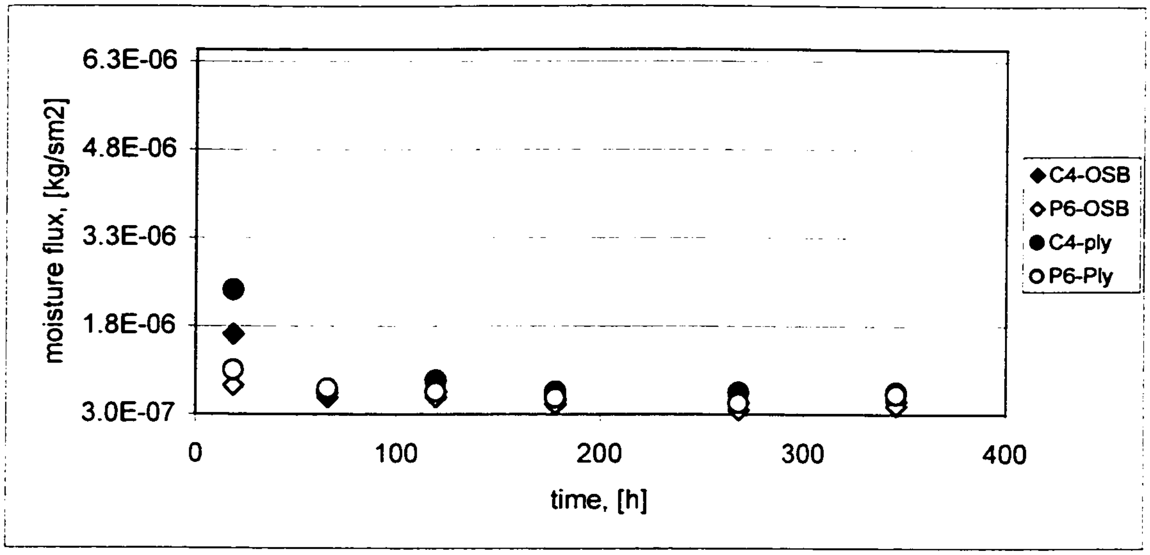

Figure 5.2 Moisture flux to OSB and plywood substrates with two type C, and two type P WRB products.

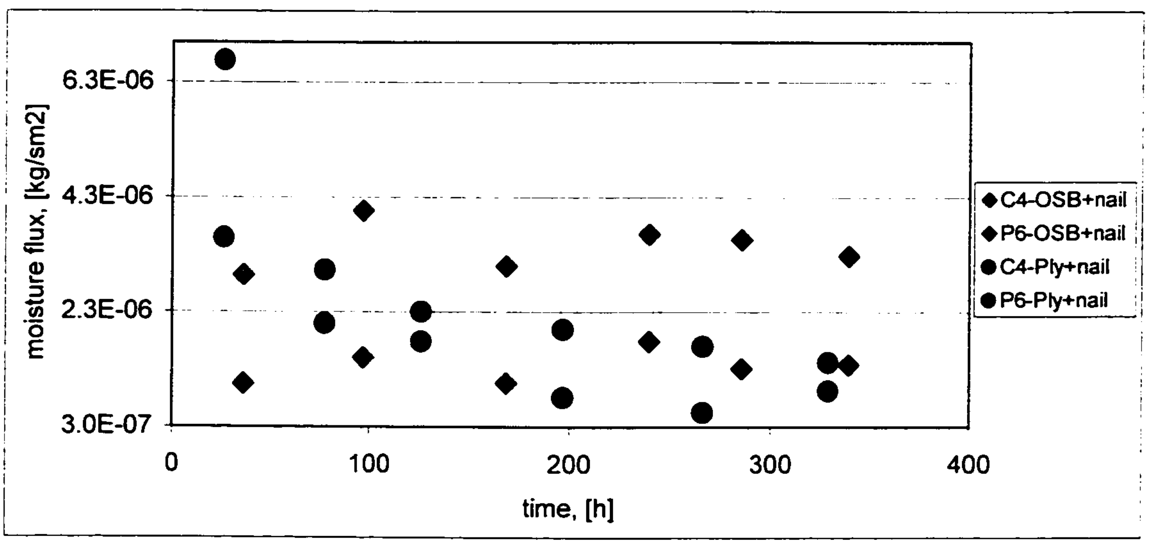

Figure 5.3 Moisture flux to OSB and plywood substrates with nails as penetrations, and two type C, and two type P WRB products.

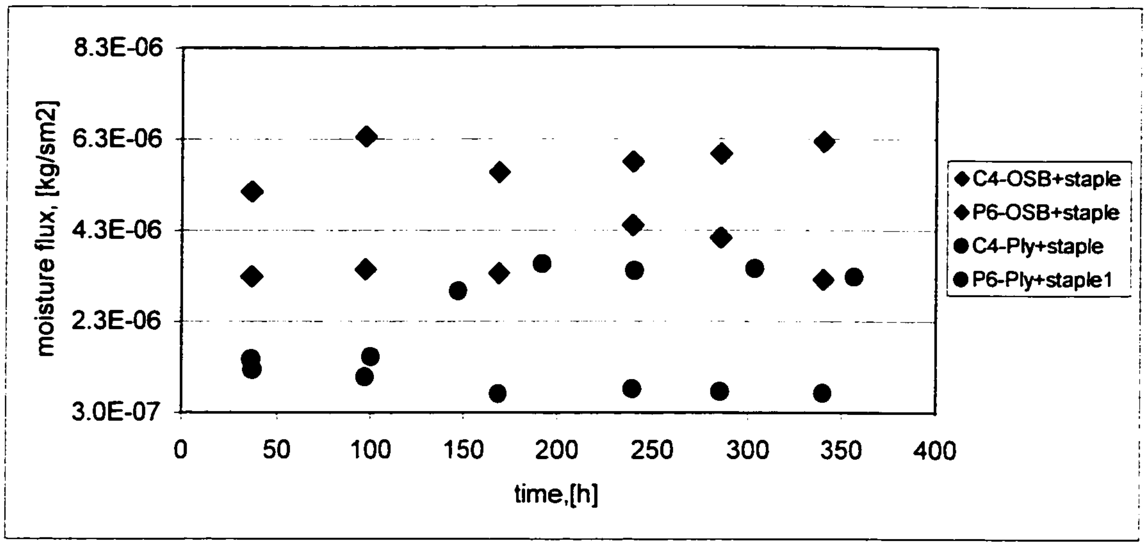

Figure 5.4 Moisture flux to OSB and plywood substrates with staples as penetrations, and two type C, and two type P WRB products.

Figures 5.3, and 5.4 indicate an increased moisture flux to OSB and plywood substrates when penetrations such as nails or staples were used. Three series of tests that incorporated fasteners were examined; one series with nails, and two series with staples. Tables 5.1 and 5.2 respectively list the measured moisture flux on WRB with OSB and plywood substrates with and without penetrations.

Table 5.1 Moisture flux to an OSB and plywood substrate without fasteners.

WRB code	Moisture flux, [kg/sm2]			
	OSB substrate	Standard deviation	Plywood substrate	Standard Deviation
C4	5.8 E-07	8.4 E-08	7.1 E-07	8.9 E-08
C5	4.8 E-07	9.9 E-08	6.2 E-07	8.1 E-08
P6	5.0 E-07	9.6 E-08	6.3 E-07	9.3 E-08
P8	3.6 E-07	5.1 E-08	5.0 E-07	9.2 E-08

Table 5.2 Moisture flux to an OSB and plywood substrate with fasteners.

WRB code	Moisture flux, [kg/sm2]			
	OSB substrate		Plywood substrate	
	Nail	Staple	Nail	Staple
C4	3.5 E-06	5.5 E-06	2.1E-06	1.2 E-06
C5	2.6 E-06	2.4 E-06	2.3 E-06	2.1 E-06
P6	1.4 E-06	3.5 E-06	1.2 E-06	3.5 E-06
P8	7.7 E-07	4.2 E-06	2.7 E-06	2.4 E-06

The results indicate that the moisture flux increased one order of magnitude in tests conducted with penetrations.

5.2 EFFECT OF WEATHERING

Prior to the installation of the cladding, WRB often remains exposed to the outdoor elements. To determine the effect of weathering on the moisture performance of WRB, the materials were subjected to outdoor exposure on the rooftop of the BCE engineering building at Concordia U. The weathering procedure involved mounting 0.6 m by 0.9 m WRB samples in racks, and exposing them to the outdoor elements that included wind loads, thermal fluctuations, rain, pollutants, and ultraviolet radiation (UV). Staples were utilized to fasten the perimeter edges of the WRB to the frame of the rack. To minimize the possibility of WRB tearing at the edges, additional plywood pieces were fastened over the stapled edges. Schematic in Figure 5.5 illustrates the racks with mounted WRB.

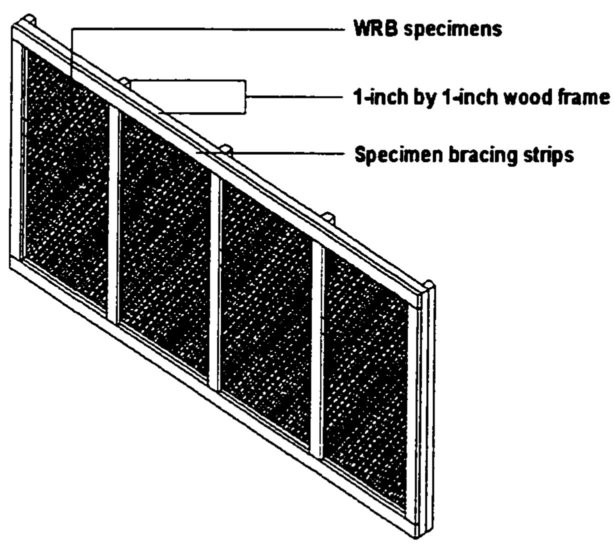

Figure 5.5 Schematic of roof racks utilized in outdoor exposure of WRB.

The two racks each with four WRB were mounted in a vertical position and were oriented in a southwest direction as illustrated in Figure 5.6.

Figure 5.6 Exposure racks located on the rooftop of Concordia University building.

Five type C and three type P WRB products were exposed in a two, four-month series of outdoor weathering. The first weathering series extended from July 27th 2001 to November 27th 2001(fall exposure). The second weathering series commenced on November 27th 2001, and lasted until March 27th 2002 (winter exposure). Following the exposures and prior to testing, the materials were removed and stored in dry laboratory conditions at 20±3°C, and 40±10% RH.

5.2.1 Weather data records

Weather data records for the city of Montreal were collected for the duration of the outdoor exposure. The data was obtained from Environment Canada and is included in Appendix B.

5.2.2 Conducting MIC and LPR tests on weathered WRB

The MIC and LPR test methods were performed to evaluate the significance of weathering on vapour and liquid phase flow through type C and type P WRB. Figure 5.7 relates the results of the MIC test performed with one series of fresh and two series of weathered materials.

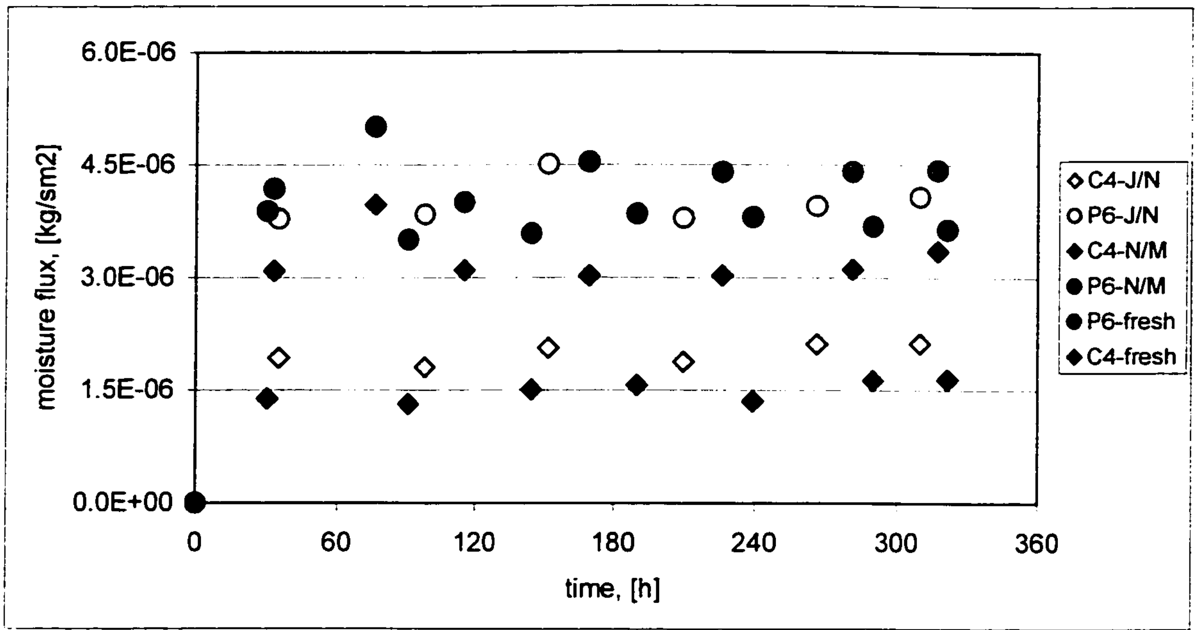

Figure 5.7 Moisture flux measured with MIC test on fresh and two series of materials exposed outdoors between July to November and November to March.

The measured moisture flux with the MIC test on fresh and weathered P6 WRB showed a small effect. For C4 WRB, a slightly higher reduction in transmission was observed following the rooftop exposure. The data in Table 5.3 suggests that the four-month weathering exposures slightly reduced transmission rates in MIC tests conducted with cellulose-based products. Varying the season at the start of weathering exposure i.e., July, November, indicated a minor change in the measured moisture flux.

Table 5.3 Moisture flux measured with MIC test on fresh and weathered WRB.

WRB code	Moisture flux, [kg/sm2]					
	July 27th- Nov 27th-	Standard deviation	Nov 27th- March 27th	Standard deviation	Fresh WRB	Standard deviation
C1	2.5 E-06	2.1 E-07	2.7 E-06	3.3 E-07	4.2 E-06	4.9 E-07
C2	4.4 E-06	4.0 E-07	4.2 E-06	8.5 E-07	5.4 E-06	7.7 E-07
C3	1.7 E-06	1.1 E-07	1.8 E-06	1.8 E-07	2.6 E-06	1.5 E-07
C4	2.0 E-06	1.5 E-07	1.6 E-06	1.5 E-07	3.3 E-06	3.6 E-07
C5	2.7 E-06	1.5 E-07	2.4 E-06	2.1 E-07	3.1 E-06	3.3 E-07
P6	4.0 E-06	2.9 E-07	3.8 E-06	7.3 E-07	4.5 E-06	3.2 E-07
P7	4.4 E-06	5.9 E-07	4.0 E-06	8.9 E-07	4.0 E-06	2.0 E-07
P8	3.5 E-06	3.0 E-07	3.3 E-06	4.6 E-07	3.3 E-06	2.1E-07

Generally, the weathering exposure had a minor effect on moisture flux through these products. The LPR test was performed to determine the effect of weathering on liquid phase flow through the WRB with respect to (1) the length of time to the onset of liquid flow, and (2) the rate of filtration. Since the data obtained with the MIC test method indicated comparable moisture flux for the fall and winter exposures, the LPR test was only performed on a single series of specimens exposed from July 27th 2001 to November 27th 2001. Table 5.4 lists the time to the onset of liquid flow, and the measured flow rates.

Table 5.4 Period of time from the start of the test to the onset of continuous liquid flow through weathered type C, and type P WRB.

WRB code	Time, days
C1	2.5
C2	1.5
C3	3
C4	3
C5	6
P6	>7
P7	>7
P8	>7

The weathering exposure had a minor effect on liquid transport through type C WRB. The results in Table 5.4 were compared with results from tests results performed on fresh type C WRB in Table 4.1. A small reduction in time to the onset of liquid breakthrough was observed for the weathered, single ply, type C WRB. The reduction in time to reach continuous flow was observed on single ply type C WRB. Tests with products C1 and C2 indicated half a day reduction; while for C4 products, a one-day reduction was observed. The rate of liquid flow through five type C weathered WRB products were also measured, and the results are shown in Figure 5.7. The liquid flow rates measured on weathered type C WRB in Figure 5.8 were compared with the rates measured on fresh WRB in Figure 4.2. A significant increase in liquid flow rate from 2.0E-5 kg/sm^2 to 5.0E-5 kg/sm^2 was measured with the LPR test. Type P products P6, P7, and P8 were also examined; however no visible liquid flow through these products was observed during the seven-day test.

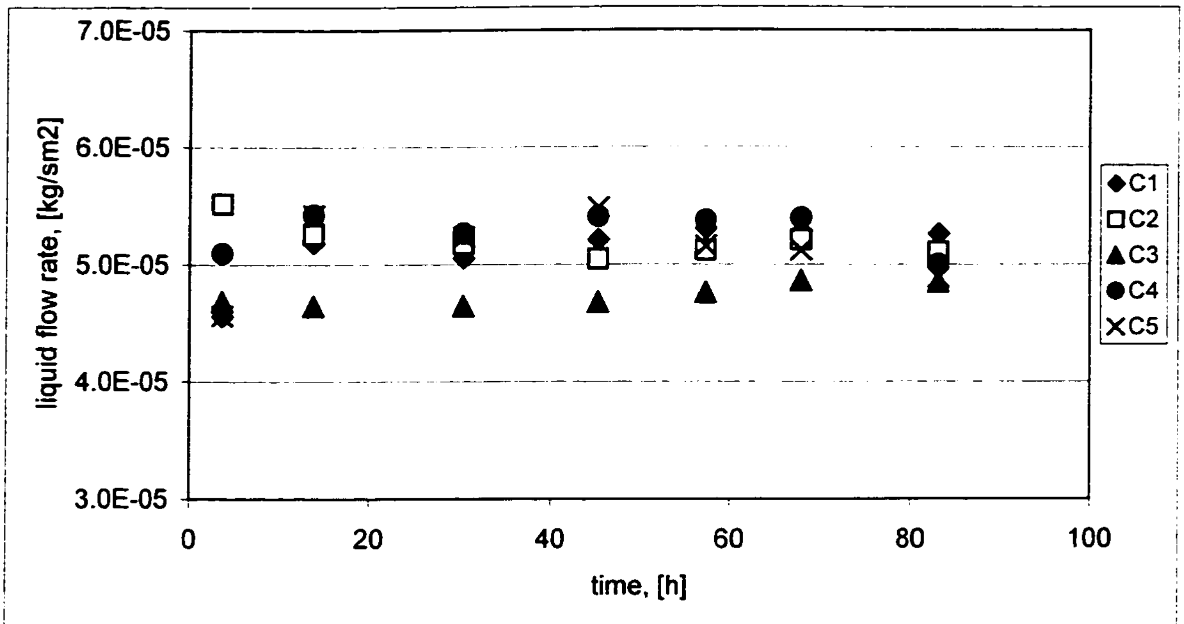

Figure 5.8 Liquid flow rates measured on five type C WRB following the outdoor exposure.

The MIC did not show an effect of outdoor exposure on measured moisture flux with WRB products. Since vapour phase dominated moisture transport in MIC test, changes to the surface characteristics of the WRB i.e., changes to the hydrophobic treatment in the WRB would not be detected. On the other hand the LPR test did show an increase in measured liquid flux indicating that the transport phenomena will vary depending on boundary conditions present on both sides WRB.

5.3 EFFECTS OF DETERGENT SOLUTION

In stucco walls, the WRB is in contact with OSB substrate on one side, and stucco cladding on the other. Under service conditions, it is possible for the additives in stucco to dissolve in the interstitial water, and to be transported to the WRB surface. A detergent solution (sometimes added instead of stucco plastisizers) was selected as the solution for laboratory evaluation. MIC and LPR tests were performed on the selected C4, C5, P6, and P8 WRB.

5.3.1 Preparation of solutions

The detergent solution was prepared at Concordia University. The detergent solution was prepared by adding Tide detergent to distilled water until all undissolved detergent remained deposited in the bottom of the container. The solution was maintained at 40±0.1 °C during preparation and represented a 100 % supersaturated detergent solution.

5.3.2 Characterization of solutions

Prior to testing, surface tension (σ) and kinematic viscosity (ν_K) were measured to characterize the detergent solution and determine an appropriate concentration for use in a laboratory evaluation. Fisher Tensiomat No.21, illustrated in Figure 5.9 was utilized to measure the surface tension of prepared solutions. The measurements were performed in accordance with the ASTM D 971 (1999) and D 1331 standards (2001).

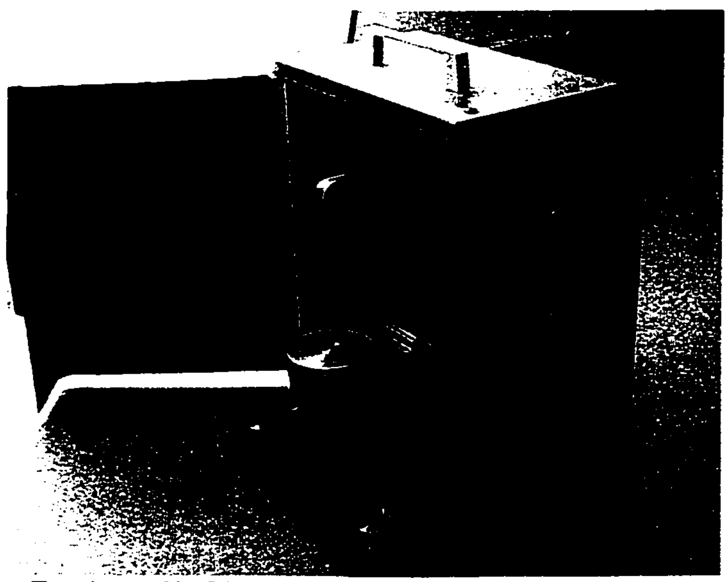

Figure 5.9 Fisher Tensiomat No.21.

The surface tension of the detergent solution is plotted as function of concentration in Figure 5.10.

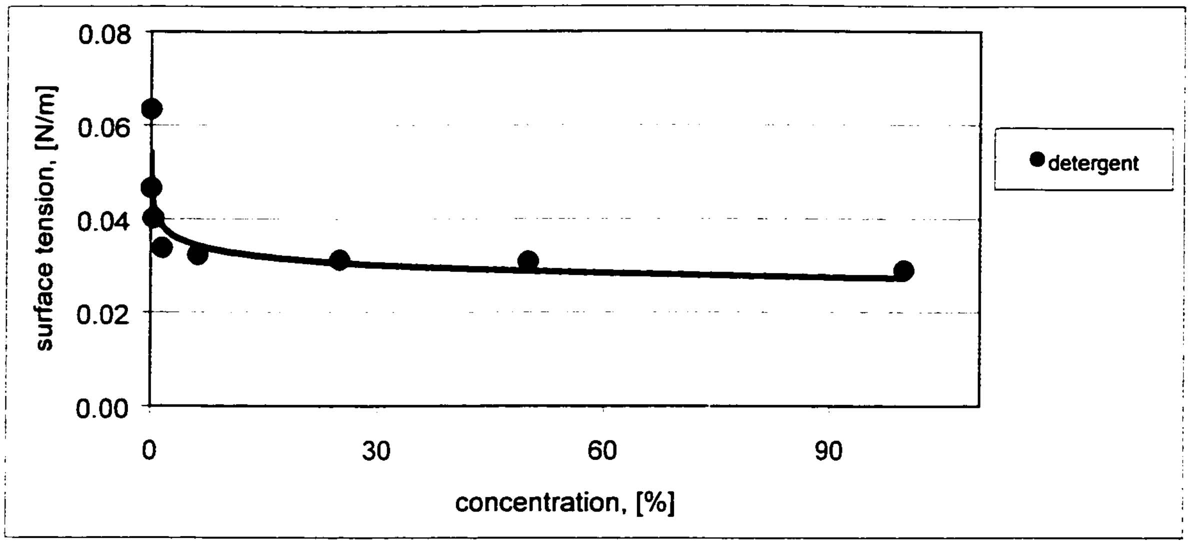

Figure 5.10 Surface tension of detergent solution measured at various concentrations.

The measured surface tension for water 0.069 N/m was compared with a referenced value of 0.072 N/m (Handbook of Chemistry and Physics, 1984), and showed a good agreement. The measured surface tension for the 1% detergent solution indicated a substantial reduction at concentrations less than 0.1%. The surface tension measured on the detergent solution at a concentration as low as 0.02 % was much lower in comparison to that of water.

Table 5.5 Surface tension values of detergent solution measured at various concentrations.

Concentration,[%]	Surface tension, [N/m]	
	Detergent solution	Standard deviation
0.02	0.063	5.4 E-04
0.09	0.047	2.3 E-04
0.39	0.040	3.0 E-04
1.56	0.034	3.3 E-04
6.25	0.032	7.5 E-04
25	0.031	5.0 E-04
50	0.031	4.8 E-04
100	0.029	4.6 E-04

A 1% detergent solution was selected for use in MIC and LPR test methods because it represented approximately a 50% reduction in surface tension. The selection of a detergent solution with a higher concentration proved difficult in testing and characterization because the readings were highly influenced by the foaming of the solution.

In addition to measuring surface tension, kinematic viscosity was also measured. The test was performed in accordance with the ASTM D-445 (2001) standard that used the Cannon-Fenske Routine Viscometer No. 25 as illustrated in Figure 5.11. The test involved measuring the flow rate of a fixed volume of fluid flowing from a point through a given size capillary.

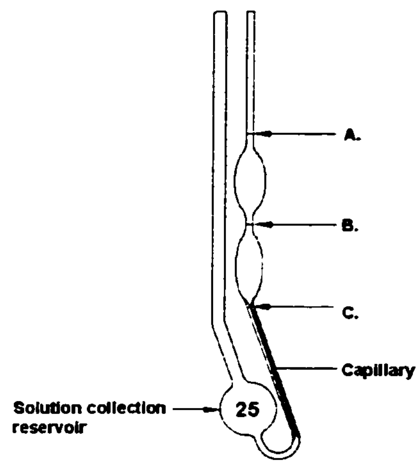

Figure 5.11 Schematic of a Cannon-Fenske Routine viscometer.

Prior to the commencement of testing, the viscometer was immersed in a sulphur-chromic acid solution to remove any organic compounds and hydrocarbons that could have offset the readings. The viscometer was then rinsed with distilled water and dried in an oven at 105°C overnight. The viscometer was filled with a 1% detergent solution to a point designated as A. The viscometer was then immersed in a beaker filled with water so that the level of the solution was below the beaker's water level. The beaker was placed in a constant temperature liquid bath maintained at 42.2±0.1°C. This maintained the temperature inside the beaker at 40±0.1°C. The viscometer remained immersed for half an hour prior to testing. This allowed the temperature of the detergent solution to equilibrate with the temperature inside the beaker. Kinematic viscosity was determined by multiplying the mean time required for the meniscus to move from point B to point C with the viscometer's calibration constant. The set-up used in the determination of kinematic viscosity is illustrated in Figure 5.12.

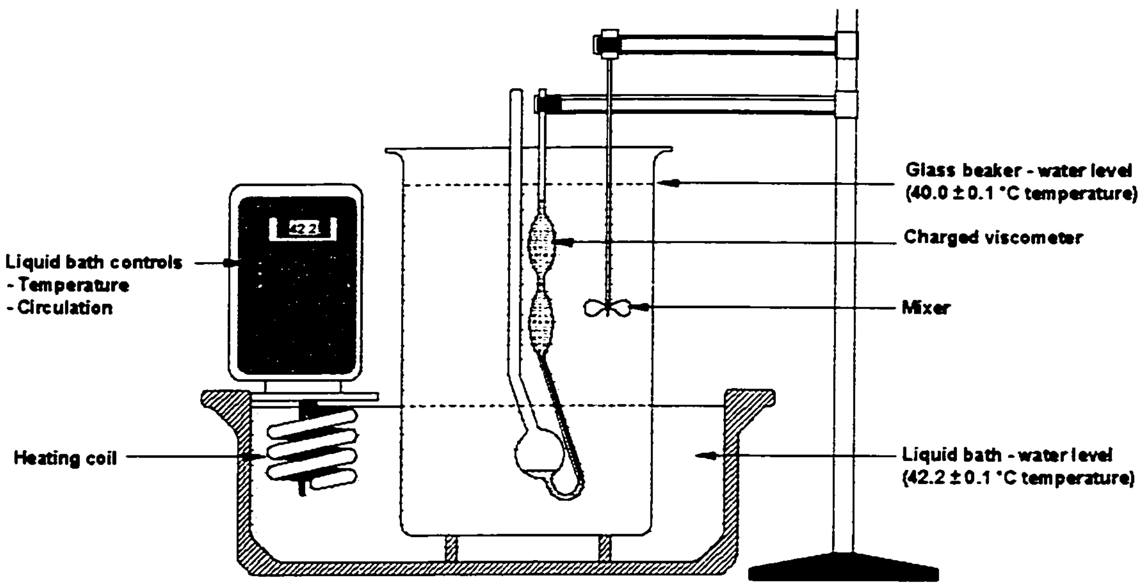

Figure 5.12 Schematic of set-up used in kinematic viscosity.

The kinematic viscosity measured on the detergent solution was compared with that of water in Table 5.6.

Table 5.6 Kinematic viscosity of tap water and 1% detergent solution.

Solutions tested	Kinematic viscosity, [mm2/s]	Standard deviation
Tap water	0.68	5.0 E-04
1% solution	1.22	3.1 E-02

The data in Table 5.6 showed a large difference between the kinematic viscosity of tap water and 1% detergent solution.

5.3.3 Conducting MIC and LPR tests with detergent solution

The prepared 1% detergent solution was used in MIC and LPR tests with C4, C5, P6, and P8 WRB. Cellulose based WRB (C4, and C5) showed a minor increase in moisture flux when performed with the detergent solution. On the other hand, a minor reduction in moisture flux was measured on polymeric (P6, and P8) WRB as shown in Figure 5.7. This was expected because vapour dominated moisture transport in MIC tests. However, since kinematic viscosity indicated a change to the resistance of flow between water and 1% detergent solution, a change in liquid phase transport through the WRB was expected. To test this hypothesis the LPR test was conducted. Table 5.8 lists the onset of liquid flow conducted with 1% detergent solution.

Table 5.7 Moisture flux measured with MIC test method.

WRB code	Moisture flux, [kg/sm2]			
	Tap water	Standard deviation	1 % detergent solution	Standard deviation
C4	3.3 E-06	3.6 E-07	3.9 E-06	7.8 E-07
C5	3.1 E-06	3.3 E-07	3.3 E-06	3.7 E-07
P6	4.5 E-06	3.2 E-07	3.0 E-06	4.6 E-07
P8	3.3 E-06	2.1 E-07	2.7 E-06	2.6 E-07

Table 5.8 Onset of liquid flow performed with LPR test and 1% detergent solution.

WRB code	Time, days
C4	1
C5	1.5
P6	3
P8	3

There was a significant difference between the results shown in Table 5.8 and those measured for water flow and reported in Table 4.1. The time to the onset of liquid flow was reduced by a factor of four (C4 from 4 days to 1 day and C5 from 6 days to 1.5). Type P membranes that did not show water breakthrough for a period of 7 or 21 days, indicated a breakthrough of the 1% detergent solution following the 3-day test duration. The rate of liquid filtration were measured and are listed in Table 5.9

Table 5.9 Liquid filtration performed with 1% detergent solution on three replicate specimens.

WRB code	Liquid flow rate, [kg/sm2]	Standard deviation
C4-A	5.9 E-04	5.4 E-06
C4-B	6.0 E-04	6.2 E-06
C4-C	6.1 E-04	1.3 E-05
C5-A	5.2 E-04	5.1 E-06
C5-B	5.0 E-04	7.8 E-06
C5-C	4.9 E-04	9.0 E-06
P6-A	4.4 E-06	3.1 E-07
P6-B	4.4 E-06	2.5 E-07
P6-C	4.4 E-06	2.0 E-07
P8-A	2.2 E-05	1.9 E-06
P8-B	2.0 E-05	1.4 E-06
P8-C	2.1 E-05	1.1 E-06

Although the rate of liquid filtration through type P products was previously not measured, there was one order of magnitude increase in the filtration rate performed with 1% detergent solution in comparison to the filtration with tap water. This was in agreement with the results shown by changes in the physical properties of the penetrating fluid i.e., surface tension and kinematic viscosity. While the change in the liquid flow rate was expected, the unexpected and the most significant observation were related to the reduction in time to reach liquid breakthrough as shown in Figure 5.8. The effect of 1% detergent solution had a significant effect on liquid flux through the WRB.

5.4 Assembly testing

To determine moisture flux in stucco assemblies, WRB was placed between the OSB sheathing board on one side, and stucco cladding on the other. The adjacent components could affect on the moisture performance of WRB. The following several effects were examined;

- Significance of penetrations on moisture transmission through WRB,
- Changes in moisture transmission with additives present in stucco,
- Effect of WRB type (C and P) on moisture transmission in an assembly testing,

5.4.1 Program description

A total of 36 wall assemblies 0.45 m by 0.23 m were prepared for testing. The assemblies, partially fabricated at Concordia University in Montreal were transported to Ottawa for completion.

Table 5.10 Description of specimen fabricated for testing.

Batch code	Stucco type	Contact vs no contact	Number of replicas	WRB code	Mechanical penetrations	Number of specimens
1	Standard type Lime/cement	Contact	3	3[1]	No fasteners	9
2	3 types Lime/cement with additives	Contact	3	3[2]	1 fastener	27
				Total specimens		36

Note: (1) The WRB included C1, C2, C4, P7, and P8.
(2) The WRB included C1, C4, P7.

5.4.2 Components of assemblies

The assemblies were constructed in a manner representative of a present day construction practices. The following sequence of materials from the inner most to the outer most components comprised the assemblies:

- 12.8 mm OSB sheathing board,
- WRB membrane,
- 25 mm by 25 mm galvanized metal mesh,
- Fasteners – nails and staples,
- Stucco cladding.

Schematic in Figure 5.13 illustrates the sequence of components in the assemblies.

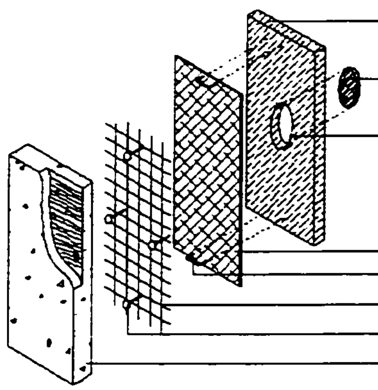

Figure 5.13 Components used in the fabrication of the stucco assemblies.

- **OSB:** The OSB sheathing board constituted the most interior layer of the assembly In construction, the OSB board is used as an exterior sheathing that provides rigidity, and serves as the anchoring surface for WRB. The OSB panels were cut from standard OSB boards that measured 1.2 m by 2.4 m by 0.12 m thick. The prepared OSB panels measured 0.45 m by 0.23 m, and had a removable central section (disk), which measured 0.12 m in diameter as shown in Figure 5.14.

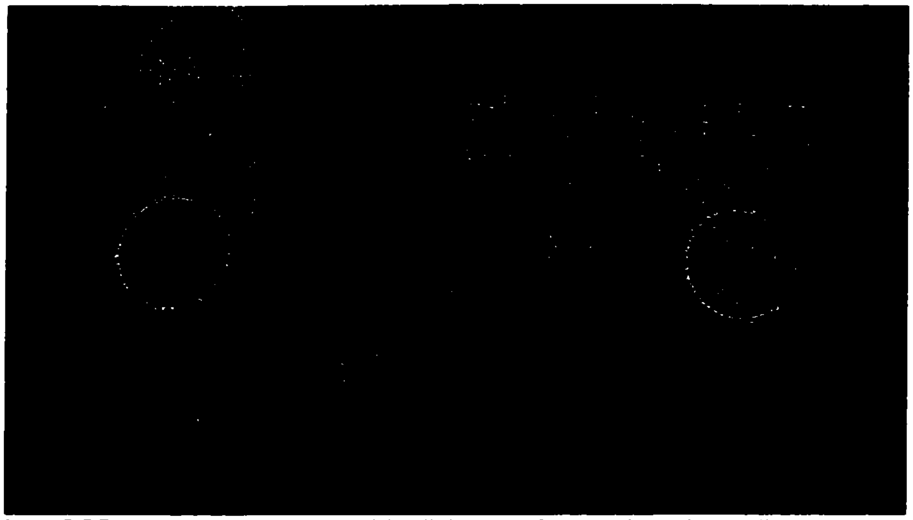

Figure 5.14 OSB panels with a removable disk used for gravimetric readings.

- **WRB:** The WRB comprised the next element in the assembly. Type C and P membranes were included. The cut materials measured 0.45 m by 0.23 m. A 10 mm Arrow Type T50 staples fastened the WRB to the OSB substrate at the top and the bottom of the assembly.
- **Reinforcing mesh:** Galvanized steel, 12 gage 0.03 m by 0.03 m wire mesh was utilized for reinforcement. The wire mesh was cut shorter to prevent it from protruding from the assembly and measured 0.22 m by 0.44 m. Standard 0.06 m galvanized steel roofing nails with an 11 mm diameter head were used to anchor the reinforcing wire mesh to the OSB substrate. The nails were fastened securely so that the head of the nail was not compressing the WRB. The excess nail length protruding through the opposite side of the OSB board was removed with a grinder.
- **Stucco lamina:** A two-coat stucco finish was applied to the assembly. The scratch coat was applied in an 11±1 mm thick layer and consisted of cement, lime, and sand in a ratio of $1{:}{}^{1}/_{2}{:}4{}^{1}/_{2}$. During the application the scratch coat was allowed to set for approximately one hour. The surface of the specimens was then scratched to impart roughness and increase the mechanical interlock between the scratch coat and the brown coat. The specimens were allowed to cure for duration of one week. Following the curing period, a 9±1 mm thick layer of brown coat, which consisted of cement, lime, and sand in a ratio of $1{:}{}^{1}/_{2}{:}5{}^{1}/_{2}$ was applied on top of the scratch coat.

The brown coat was allowed to cure for another week, and the finished specimens were transported back to Concordia University for testing. The composition of different mixes used in fabrication of the specimens is described in Table 5.11.

Table 5.11 Composition of stucco mixes and description of additives.

Coat	Mix ratio (C:L:S)	Additives	
		Bentonite®	Detergent
Scratch-I	$1:{}^{1}/_{2}:4{}^{1}/_{2}$	None	None
Scratch-II	$1:{}^{1}/_{2}:4{}^{1}/_{2}$	1 cup	None
Scratch-III	$1:{}^{1}/_{2}:4{}^{1}/_{2}$	1 cup	${}^{1}/_{2}$ cup
Brown	$1:{}^{1}/_{2}:5{}^{1}/_{2}$	None	None

Bentonite® and detergent were selected as additives and were incorporated in the scratch coat mixes. In present day construction practices, the Bentonite® and the detergent are often used as an economic alternative to plasticizers, which improve the workability of the stucco mix. The additives were incorporated into the scratch coat and none was added to the brown coat. Three batches of scratch coat were prepared. The first batch contained no additives. The second batch contained 1 cup (approximately 0.25 L) of Bentonite®. The final batch contained 1 cup (approximately 0.25 L) of Bentonite® and ${}^{1}/_{2}$ a cup (approximately 0.125 L) of 100% detergent solution. The amount of the Bentonite® accounted for approximately 0.3% of the scratch coat-II by weight. In the scratch coat-III, the weight of the Bentonite® and detergent respectively accounted for 0.3%, and 0.1% of the mix by weight. Figure 5.15 illustrates the application of stucco by a well-trained crew.

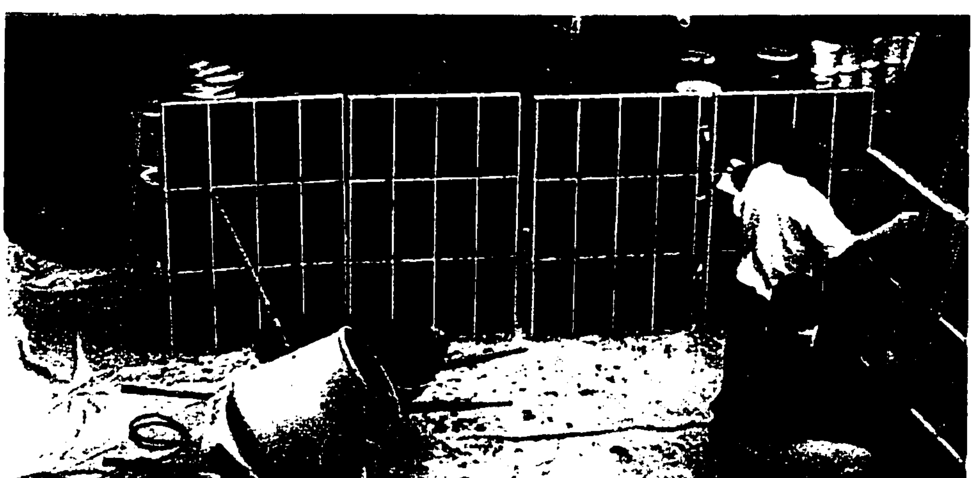

Figure 5.15 Application of stucco mix.

The delivered specimens were stored in dry room conditions, 20±3°C and 40±10% RH. The effect of the penetrations and additives on moisture transmission through the WRB was examined. The backside of the OSB and the edges of the assemblies were sealed with two coats of acrylic primer and two coats of acrylic latex exterior paint. During this process, the OSB disks were removed and the edges of both the OSB opening and the disks were treated as well. The edges received an additional coat of primer. The coats were allowed to cure fully. In addition to the paint, the backside and the edges of the disks were covered with a beeswax mixture to impart moisture accumulation in the disks. The disks were secured in the assemblies with a 3 mm backer rod as illustrated in Figure 5.16, and caulked with sealant to eliminate vapour diffusion at the joint.

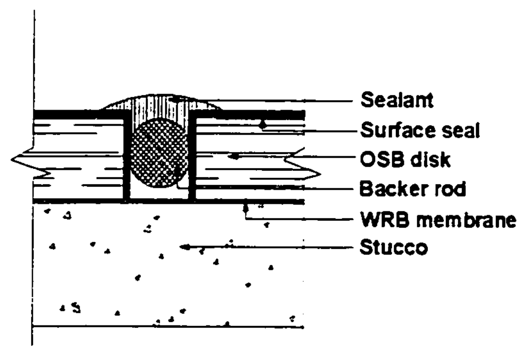

Figure 5.16 Joint seal of the removable OSB disk.

During testing, the sealant was peeled, the disk removed, and the weight of the disks was measured with an analytical balance. Following each reading the removable piece was reinserted into the assemblies. A backer rod was reinserted which secured the removable sections; the joint was resealed with fresh seal and peel sealant, and allowed to cure for a period of 4 hours. Following the curing period, the test was continued.

5.4.3 Environmental cycling chamber

Moisture was thermally driven through the specimens in an environmental cycling facility. The large chamber measured 4.9 m by 2.45 m by 2.45 m, and was constructed from a 38 mm by 38 mm wood-frame, and sheathed with plywood. The interior space was subdivided into three compartments, as illustrated in Figure 5.17. The central compartment was separated from the adjacent spaces with two test walls constructed from 38 mm by 89 mm wood frame. Test wall 1 and 2 respectively contained 22 and 14 specimen cavities. The walls were insulated with two, 25 mm layers of rigid expanded insulation. The bottom of the chamber was sloped and fitted with a custom fabricated PVC pan for the collection of condensate and runoff from the mechanical equipment. A heating/cooling coil was installed, and provided a maximum operating temperature in the range of (–15±3°C to 70±3°C). The coil was equipped with a fan measuring 0.35 m in diameter, which provided a continuous mixing of the air inside the compartment. A 5-ton compressor was used for the cooling of the chamber. The system's operation was controlled with a Paragon programmable electronic time controller, and a Honeywell and Johnson Control (A319) electronic temperature control with an operating temperature range between (–30±2°C to 107±2°C).

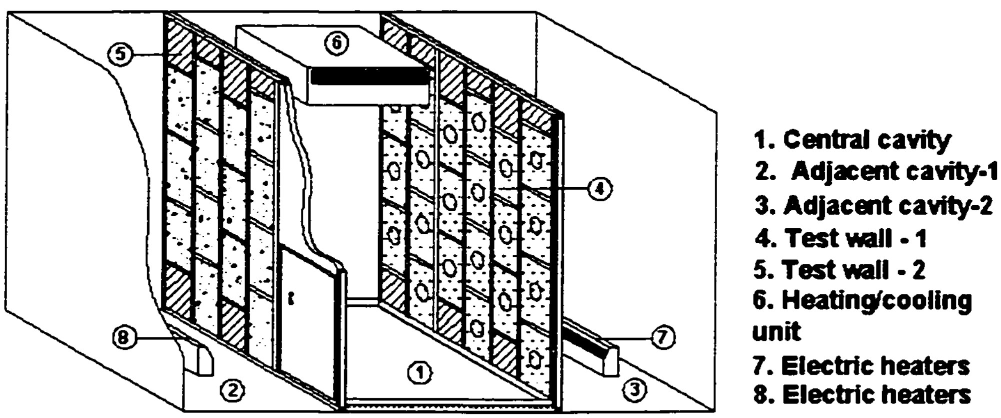

Figure 5.17 Schematic of the environmental cycling facility.

The adjacent compartments were each equipped with two 1000-watt electric heaters. Two 10 cm fans were installed and provided continuous mixing of the air. The heaters were connected to programmable time controllers and Honeywell temperature controls. The operating compartment temperatures ranged between (20±3°C to 70±3°C). The two compartments had a built in closed loop HVAC system, and Eurotherm-847 controllers. However, due to the high airflow generated by the system inside the chambers, and the need to minimize evaporation from the surface of the assemblies, the 1000-watt heaters provided heating in place of the HVAC system. Figure 5.18 illustrates the layout of the mechanical equipment.

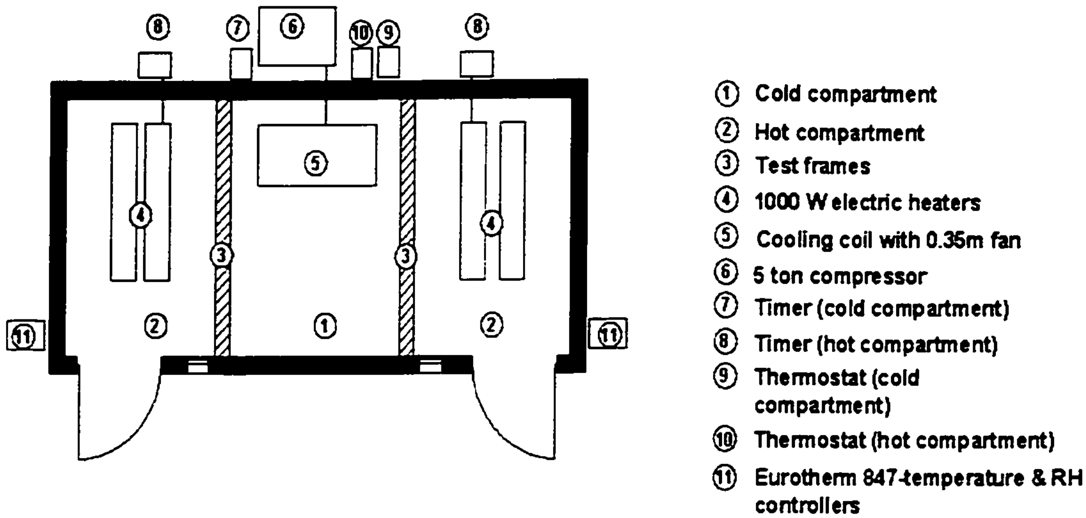

Figure 5.18 Schematic of mechanical components and controls.

5.4.4 Selection of conditions

The assembly tests were conducted to examine the significance of the effect of fasteners and additives in stucco on moisture transport through WRB. The selection of the assembly components, size as well as test conditions was governed by this objective. Thus, the test conditions were selected to impart the maximum accumulation of moisture in the OSB substrate. This occurred when high thermal and vapour pressure gradients were generated. With a thermal gradient, moisture always moves to the cold side. The specimens were subjected to a (60±5°C) thermal gradient. The specimens were mounted in the test frame with the OSB side facing the central compartment (cold side) with a temperature of (−10±3°C); while, the stucco side was subjected to high temperatures in range of (50±5°C). The assemblies were subjected to 60°C temperature gradient to maximize the moisture accumulation in the OSB substrate.

During testing, spraying onto the stucco was administered manually, and 6.8 L and 4 L of water per hour, were deposited respectively onto the surface of test wall 1(with the specimen surface area of 1.35 m^2), and test wall 2 (with the specimen surface area of 2.28 m^2). High volume of water was deposited to saturate the stucco layer. Spraying was performed every 30 minutes for a period of 10 hours per day, for duration of 15 days. During this time, the cumulative amount of water sprayed to test wall 1 was 447 L/m^2 and 444 L/m^2 on test wall 2. Between spraying, evaporation from the stucco surface was reduced, and the assemblies were covered with a polyethylene sheet that generated a higher vapour pressure gradient.

5.4.5 Condition monitoring

The temperature inside the three compartments was monitored with several pieces of equipment. In all three compartments, the temperature was measured using EnerCorp thermo hygrograph (chart recorders) with a temperature in the range of (–30±1°C to 45±1°C) and RH between (3±3% to 96±3%). The central compartment had an additional, externally mounted data logger, allowing monitoring to be conducted on the outside of the cold compartment. The stability of the temperature and RH in the three compartments is shown in Appendix C.

5.4.6 Monitoring protocol

The increase in mass of the OSB disk obtained gravimetrically corresponded to the increase in moisture gained. Moisture content was also measured using an electrical resistance type moisture meter. Delmhorst J-2000 moisture meter with an external electrode and insulated 26-ES moisture pins was used to measure spot moisture contents at two points in each assembly. The data however, proved to be highly variable and inconclusive and the measurements were discontinued. The two possible reasons that could explain the high variability in measured data with moisture content meter included (1) the temperature at which the data was obtained, and (2) the nature of the material. The precision of the direct moisture content measurements using the moisture meters decreased rapidly with the decrease in temperature. Even though the temperature function on the moisture meter was adjusted accordingly, the moisture meter could have an excessive error.

5.4.7 Moisture flux in assemblies

Moisture flux to the OSB substrates was measured in the assembly tests. Two series of tests were conducted. In the first series, 36 specimens were tested to examine the effect of penetrations and additives in stucco on moisture flux to the OSB substrate. In the second series, 33 specimens were cycled to examine the effect of WRB type and contact resistance on moisture transmission to an OSB substrate. The results from series 1 test were reported in this section. During series 2 tests, a malfunction of the mechanical equipment occurred, and the test was discontinued. However, partially obtained data was included in the Appendix D. Figure 5.19 shows moisture flux measured with assemblies containing two type C (C1, and C4), and a single type P (P7) products. The initial transient stage lasted approximately 300 hours (13 days).

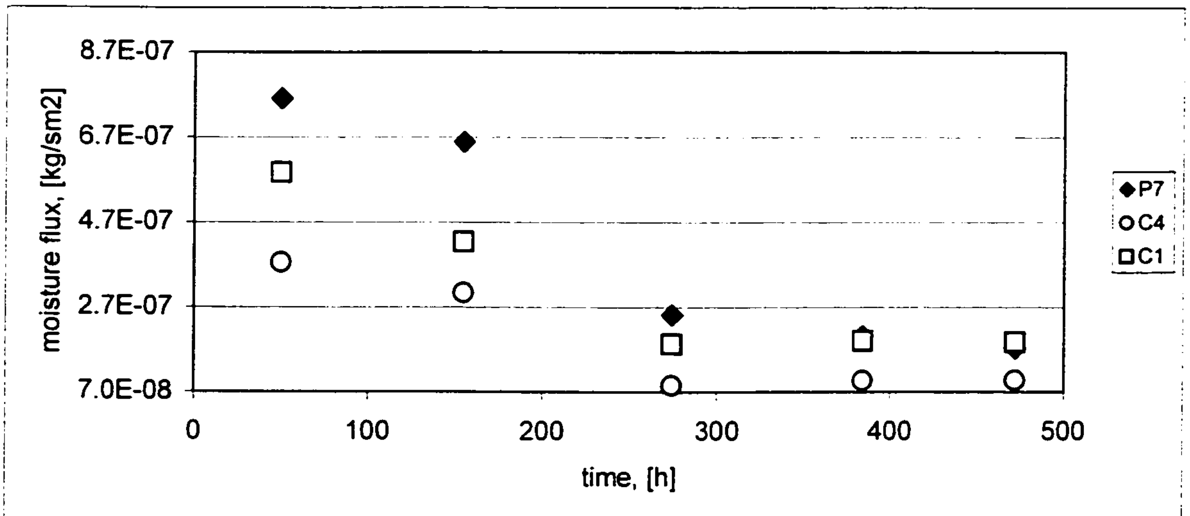

Figure 5.19 Moisture flux to an OSB substrate measured on assemblies with two type C, and a single type P WRB without penetrations.

Having measured moisture flux to an OSB substrate, the effect of penetration introduced through the WRB on moisture transfer in assemblies was examined. Figure 5.20 shows the measured moisture flux in assemblies with a single penetration (20 mm roofing nail) imbedded in the stucco layer. The nail penetrated through the WRB and into a predrilled hole in the removable OSB disks. A minor increase in moisture flux was measured in assemblies with penetrations.

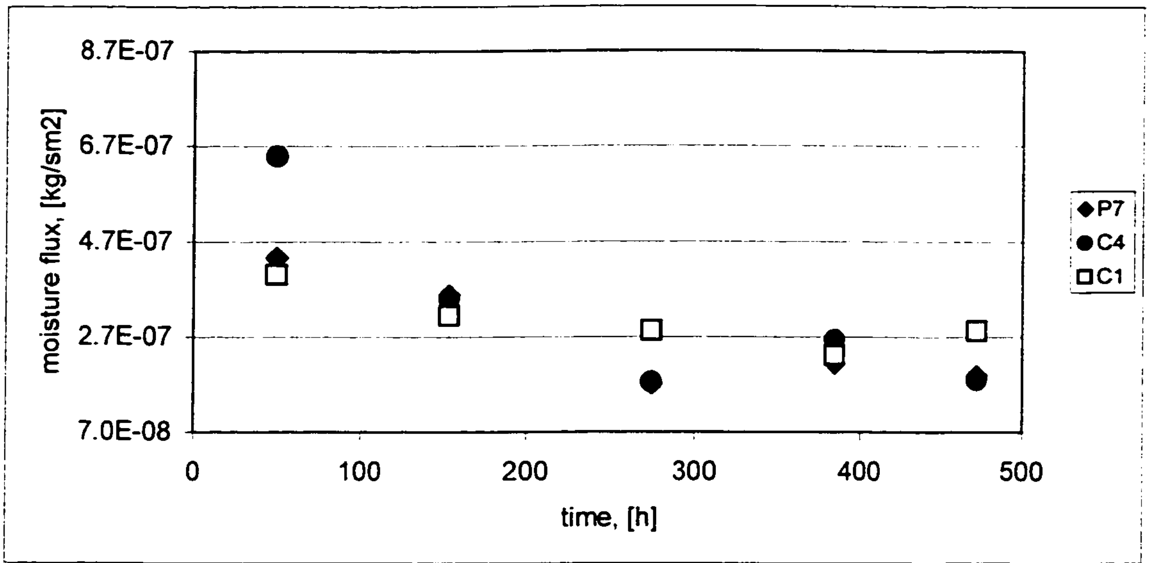

Figure 5.20 Moisture flux measured in assemblies with a single penetration and type C and type P WRB.

Figure 5.21 shows combined effects of penetrations and additives in stucco. Bentonite® was added to scratch coat 2, and Bentonite® and detergent were added to scratch coat 3. The results showed a minor increase in moisture flux when compared with data in Figure 5.19.

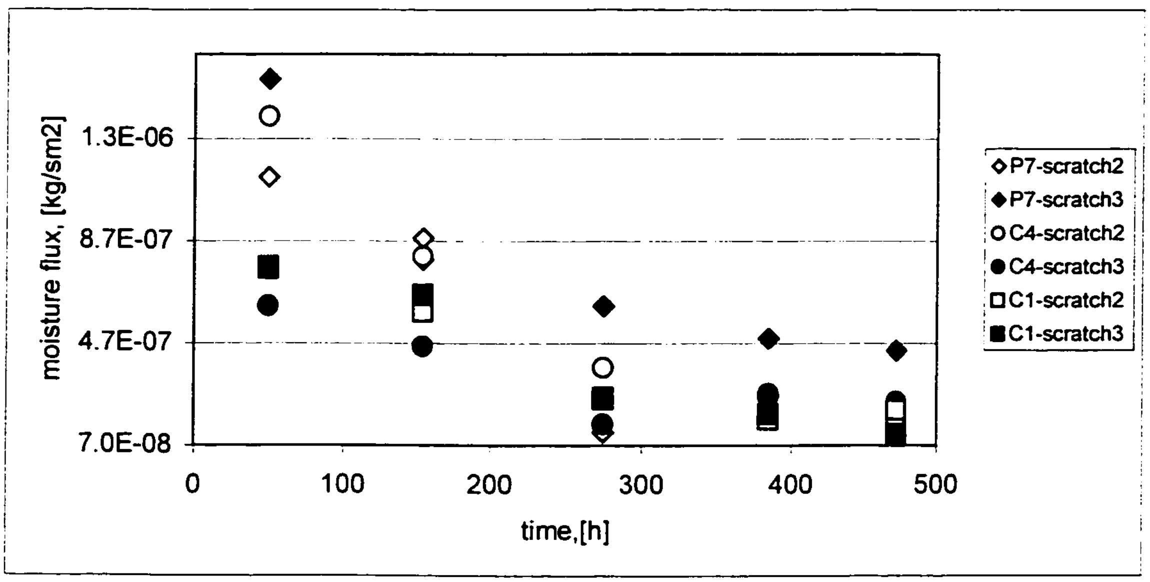

Figure 5.21 Moisture flux measured n assemblies with combined penetrations and additives in stucco.

Generally, the differences in measured moisture flux in assemblies, with and without penetrations, and additives were minor.

The moisture fluxes measured to the OSB substrate with MF test were related to the moisture fluxes measured in assemblies.

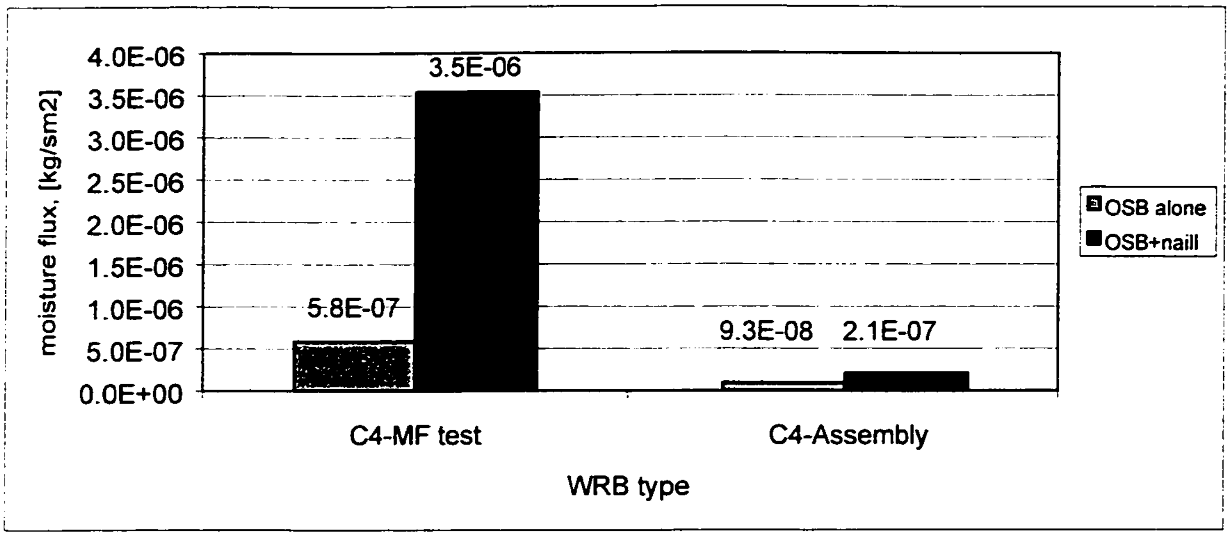

Figure 5.22 Moisture flux measured with MF test and compared with moisture flux measured in assemblies to the OSB substrate without and with a single penetration.

The inclusion of penetration through the WRB had an effect on measured moisture flux in the MF test and in the assembly tests. Figure 5.22 shows that moisture fluxes measured with MF test were an order of magnitude higher than the moisture fluxes measured in assembly tests. This could be attributed to the boundary conditions present at the surface of WRB, and the orientation of WRB during testing. In MF tests, WRB were oriented horizontally and water was in contact with its upper surface for the duration of the test. In assembly tests, WRB was oriented vertically, and the conditions at the surface of WRB depended on the conditions at stucco/WRB interface. The assembly tests indicated an order of magnitude increase in measured moisture fluxes when a single penetration was included.

CHAPTER 6

METHODOLOGY FOR EVALUATING LIQUID APPLIED WRB

So far, the evaluation of WRB products was restricted to materials in the form of a membrane (sheet). There are also new liquid applied (type LA) WRB products. These are either sprayed or trowel applied onto a substrate such as plywood or OSB, typically in a two-coat application: (1) the base coat and (2) the topcoat. The first coat functions to provide a mechanical adhesion of the WRB to the substrate, while the topcoat provides the primary resistance to the flow of water and water vapour. Evaluation of these products involves testing a composite material (WRB and OSB or plywood). To evaluate the performance of the WRB at the joints, the specimens were exposed to a cyclic aging program, which combined both mechanical and environmental loads. MF test measuring moisture flux into the substrate was performed following the aging to characterize the performance of WRB at the joints. Moisture flux was used also to evaluate the resistance offered to the ingress of water into an OSB substrate on specimens without joints. The results were compared with moisture flux to an OSB substrate performed with type C, and P WRB.

6.1 SPECIMEN DESCRIPTION

The specimens delivered for testing were packaged in cardboard boxes and separated with polyethylene sheets to prevent damage to the WRB layer. All specimens consisted of LA-WRB applied onto a 12.8 mm thick OSB sheathing. Two types of specimens were prepared with and without joints. In specimens without joints, the WRB was applied on a single 150 mm by 150 mm piece of OSB substrate. In specimens with joints, the WRB was applied onto two OSB pieces with a separation in the middle. The specimens ranged in size between 150 mm by 153 mm to 150 mm by 175 mm. The sizes of the joints: 3 mm, 6 mm, 9 mm, 12 mm, and 25 mm governed the dimension of the specimen. The joints between two OSB pieces were almost completely filled with the WRB coating, or were left empty (see Figure 6.1). In specimens without joints, the WRB coating was either applied in (1) a standard thickness, or (2) thinner than standard.

Specimens with no joints marked with a suffix (-1) represented standard thickness of the WRB, and specimens marked with a suffix (-2) represented WRB coat that was applied thinner than standard.

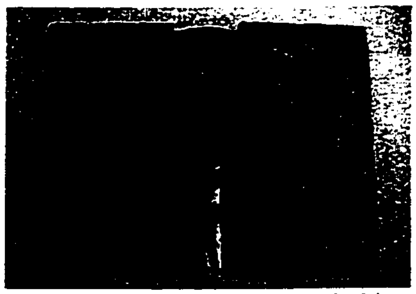

Figure 6.1 Image showing the backside of the OSB joint in composite type LA WRB/OSB specimens.

Table 6.1 lists a detailed description of the type LA WRB specimens prepared for testing.

Table 6.1 Description of specimens fabricated for testing.

No.	Specimen Code	Joint width	Joint description	Specimen Size [mm]	Manufacturer
1	LA1-1	no	no	150×150	1
2	LA1-2	no	no	150×150	1
3	LA2-1	no	no	150×150	1
4	LA2-2	no	no	150×150	1
5	LA3-1	6 mm	mesh/WRB filled	150×156	1
6	LA3-2	3 mm	no mesh/WRB filled	150×153	1
7	LA4-1	12.5 mm	mesh/WRB filled	150×162.5	1
8	LA4-2	6 mm	no mesh/WRB filled	150×156	1
9	LA6-1	6 mm	peel & stick/WRB filled	150×156	1
10	LA6-2	12.5 mm	peel & stick/WRB filled	150×162.5	1
11	LA1-0	no	no	150×150	2
12	LA2-0	no	no	150×150	2
13	LA3-0	no	no	150×150	2
14	LA5-1	3 mm	mesh/WRB filled	150×150	2
15	LA5-2	6 mm	mesh/WRB filled	150×150	2
16	LA7-1	12.5 mm	black membrane/unfilled	150×162.5	2
17	LA7-2	25 mm	black membrane/unfilled	150×175	2
18	LA8-1	12.5 mm	mesh/polystyrene filled	150×162.5	2
19	LA8-2	25 mm	mesh/polystyrene filled	150×175	2
20	LA9-1	no	no	150×150	3
21	LA9-2	no	no	150×150	3
22	LA10-1	3 mm	mesh/WRB filled	150×153	3
23	LA10-2	6 mm	mesh/WRB filled	150×156	3
24	LA10-3	12.5 mm	black membrane/unfilled	150×162.5	3
25	LA10-4	25 mm	black membrane/unfilled	150×175	3

Prior to testing the delivered specimens were stored in dry room conditions at 25±3 °C and 45±10% RH.

6.2 MOISTURE FLUX TO OSB SUBSTRATE

The test was performed on type LA specimens with and without joints and was then compared with moisture performance of type C, and P products. The method involved sealing a hollow container with a 100 mm inside diameter to the specimen's upper surface as seen in Figure 6.2. The specimen's underside and its edges were waxed to ensure one dimensional moisture transport. A 25 mm thick layer of water was introduced on the top surface of the WRB. The weight increase of the specimen represented moisture transmitted to the OSB substrate, and was determined gravimetrically at timed intervals.

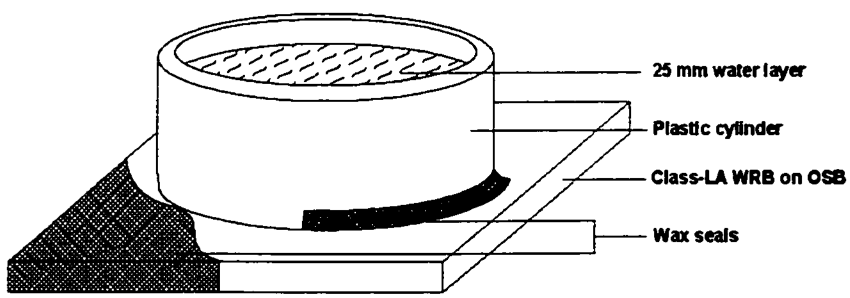

Figure 6.2 Moisture flux experimental set-up for testing composite WRB and OSB specimens.

Table 6.2 and 6.3 respectively lists moisture fluxes measured on fresh specimens with and without joints.

Table 6.2 Moisture flux measured on fresh specimens with no joints.

Specimen code	Moisture flux, [kg/m^{2}s]	Standard Deviation
LA1-0	1.3 E-07	1.3 E-08
LA2-0	1.9 E-07	6.7E-08
LA3-0	1.1 E-07	3.7 E-08
LA1-1	1.7 E-07	4.5 E-08
LA1-2	2.1 E-07	5.0 E-08
LA2-1	2.1 E-07	6.4 E-08
LA2-2	2.5 E-07	5.1 E-08
LA9-1	1.4 E-07	4.9 E-08
LA9-2	2.9 E-07	8.8 E-08

Table 6.3 Moisture flux measured on fresh specimens with joints.

WRB code	Moisture flux, [kg/m^{2}s]	Standard deviation
LA3-1	2.3 E-07	7.4 E-08
LA3-1	2.7 E-07	7.3 E-08
LA4-1	1.5 E-07	6.5 E-08
LA4-2	2.6 E-07	4.3 E-08
LA6-1	1.3 E-07	2.1 E-08
LA6-2	1.9 E-07	7.4 E-08
LA5-1	1.1 E-07	2.2 E-08
LA5-2	1.6 E-07	5.0 E-08
LA7-1	1.9 E-07	9.1 E-08
LA7-2	2.1 E-07	6.0 E-08
LA8-1	1.1 E-07	3.2 E-08
LA8-2	1.3 E-07	2.6 E-08
LA10-1	1.6 E-07	3.1 E-08
LA10-2	1.8 E-07	4.4 E-08
LA10-3	2.1 E-07	8.3 E-08
LA10-4	3.1 E-07	7.3 E-08

The results showed that the inclusion of joints in the specimens had no effect on moisture flux. The magnitude of moisture flux measured on specimens with and without joints was similar. The results in Table 6.2 indicate that moisture flux was slightly higher on specimens (LA1-1, LA2-1, and LA9-1) with a standard thickness of WRB coating. These fluxes were related to those measured with two type C, and two type P products tested with an OSB substrate as seen in Figure 6.3. To eliminate variability, and account for moisture redistribution, both the WRB specimens and the OSB substrate had the same shape and dimensions as type LA composite specimens in Figure 6.2.

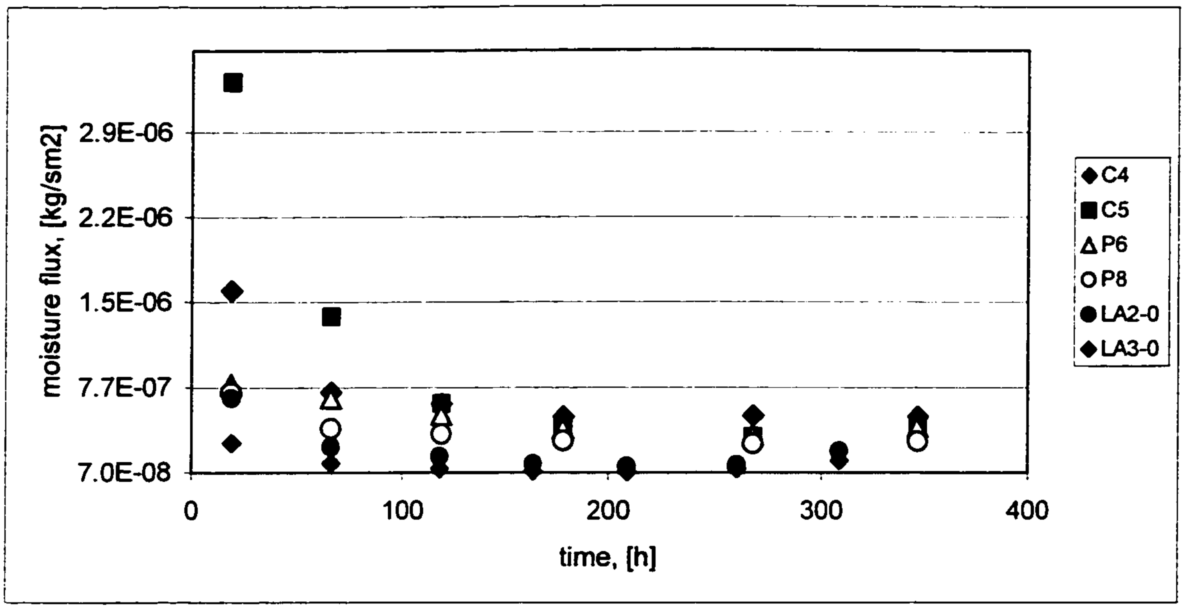

Figure 6.3 Moisture fluxes measured with type C, P, and LA WRB and OSB substrate.

Figure 6.3 shows a similar pattern of moisture flux measured with type LA WRB as with type C, and P products. The moisture fluxes measured following the onset of the steady state were lower but were still within the same order of magnitude as those measured with type C (C4, and C5), and type P (P6, and P8) products.

6.3 DEVELOPMENT OF AN AGING PROGRAM

The presence of joints in specimens with type LA WRB had no significant effect on measured moisture flux. During the service life, WRB could be subjected to (1) mechanical loads generated by the swelling and shrinkage of OSB, and structural movement and deformation of the wood frame, and (2) environmental loads that included thermal fluctuations, and moisture. With type LA WRB, the continuity of the WRB at the joint is critical. The determination of the functional continuity of type LA WRB at the OSB joints required subjecting these materials to combined mechanical and environmental loads. The mechanical load component was introduced by restraining the specimens in rigid frames with predetermined tension or compression. The environmental load was introduced by subjecting the specimens to cyclic variations of temperature and moisture (high RH levels).

6.3.1 Mechanical load component

The specimens were subjected to mechanical stresses in two types of devices. The metal frames in Figures 6.4 and 6.5 were constructed from C profile aluminium channels welded at the corners. Four equidistantly spaced openings were machined through the web of the channels, and served as anchor points for the fasteners, which connected the specimen to the frame. Four fasteners were inserted through the openings and fastened securely into the specimens' edges as illustrated in Figure 6.4. The holes in the specimens were predrilled perpendicularly to the length of the OSB joint. The specimens with the inserted fasteners were restrained in the frame. By tightening the outside nuts, the specimens were subjected to tensile loads. By tightening the nuts on the interior of the frame, the specimens were subjected to compressive loads.

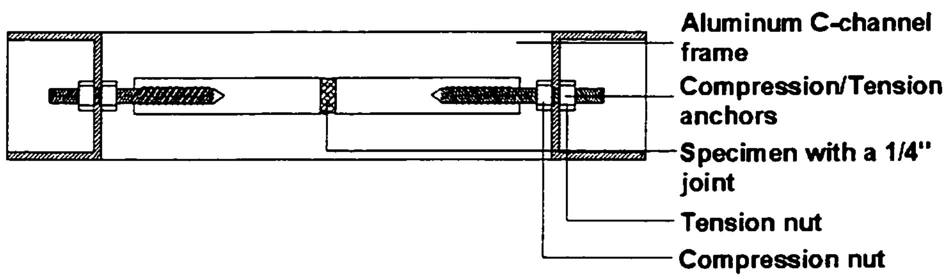

Figure 6.4 Cross-section showing aluminium restraint device.

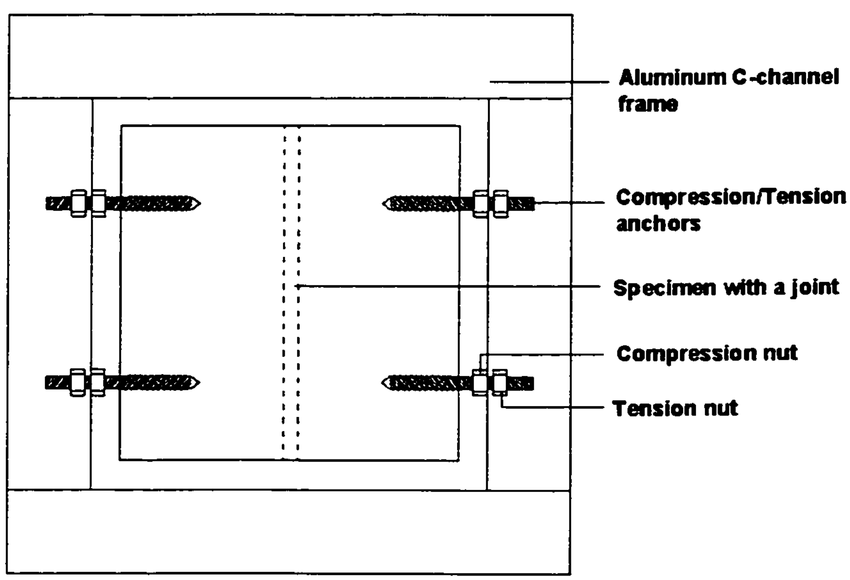

Figure 6.5 Aluminium frame with a specimen mounted for testing.

The second type of device consisted of a top and a bottom wooden plate that measured 0.04 m by 0.08 m by 0.30 m. The two plates were held together with three metal tie rods and nuts. Anchors were inserted through the top of the plate, and predrilled specimens were mounted and fastened securely. Tightening the inner or the outer nuts on the tie rods as seen in Figure 6.6 subjected the specimens to tensile or compressive loads, respectively.

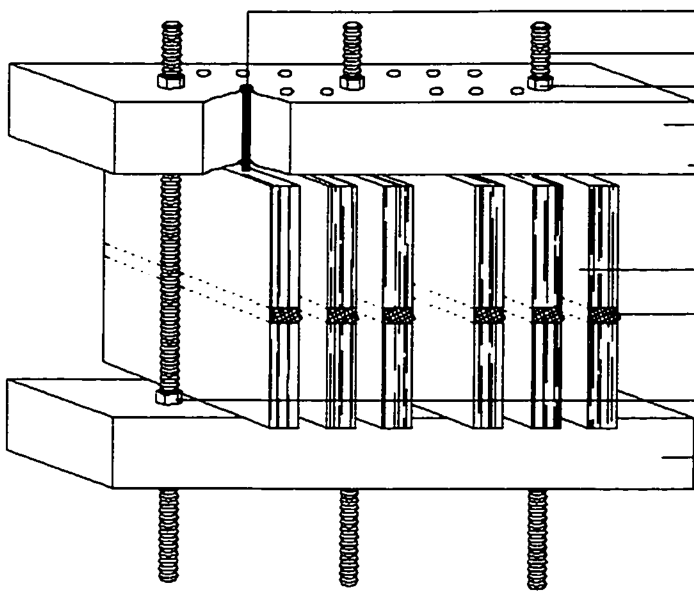

Figure 6.6 Restraint devices constructed with wooden plates.

The amount of load to which the specimens were subjected was represented by the increase or the decrease in the width of the joint, and was equivalent to a 2 mm elongation or shrinkage occurring in a 2.4 m OSB panel. This increase corresponded to a 0.08% stress or strain, and simulated deformations caused by the combined of mechanical and environmental loads. Concurrent to the mechanical loading generated by the restraint devices, the specimens were exposed to cyclic environmental loads.

6.3.2 Environmental load component

The suitability of two separate aging programs was examined for assessing the performance of type LA WRB. The first program involved cyclic exposure between hot/humid conditions and room conditions. Tables 6.4 and 6.5 list the exposure conditions used in the two aging programs. The negative temperature was excluded from the first aging program, which was used primarily to relate the effects of stress and strain on moisture flux to the substrate. The exposure conditions in the second aging program were identical in the hot/humid range. However, an exposure in freezing temperature was added.

Table 6.4 Aging program utilizing positive temperature and high humidity conditions.

Series	Hot conditions	Hot Time	Cold conditions	Cold Time	Total cycles	Total time
A	65 ± 2 [°C] 90 ± 5 [%]RH	18 h (*)	5 ± 3 [°C]	5 h (*)	15	360 [h]

Table 6.5 Aging program utilizing hot/humid and freezing conditions

Series	Hot conditions	Hot Time	Cold conditions	Cold Time	Total cycles	Total time
B	65 ± 2 [°C] 90 ± 5 [%]RH	18 h (*)	-10 ± 3 [°C]	5 h (*)	20	480 [h]

(*) **Note**: A transition period of one hour was applied between high and low temperature exposures. Test specimens were exposed to room conditions (25±5 [°C], and 45±10 [%] RH) to prevent thermal shock.

6.3.3 Environmental cycling facility

The test facility consisted of two chambers used to generate the two extreme environments (1) freezing conditions, and (2) hot/humid conditions. The exposure to freezing conditions was performed in the chamber used for assembly tests, and has been well documented in section 5.5.3. The exposure to hot/humid conditions was performed in an air tight, and well-insulated box with interior dimensions of 0.9 m by 0.9 m by 0.9 m, which corresponded to a volumetric space of 0.73 m^3. The inside of the box was lined with several layers of commercial grade aluminium foil. The chamber was fitted with a 500-watt heating element, and a transformer, which controlled the power output to the heating element. An 8-inch fan was installed and provided continuous mixing of the air inside the chamber. The chamber was also fitted with an additional source of heat, a 200-watt heat lamp, capable of maintaining a constant temperature in the event of a heating element failure. The temperature inside the chamber was controlled using a Honeywell temperature controller. The heating element was mounted inside a stainless steel container filled with water, which was evaporated to generate the high temperature up to 65±3°C and high RH up to 90±5% inside the chamber. The box was fitted with an automatically controlled water refill system that maintained a sufficient water level for continued evaporation.

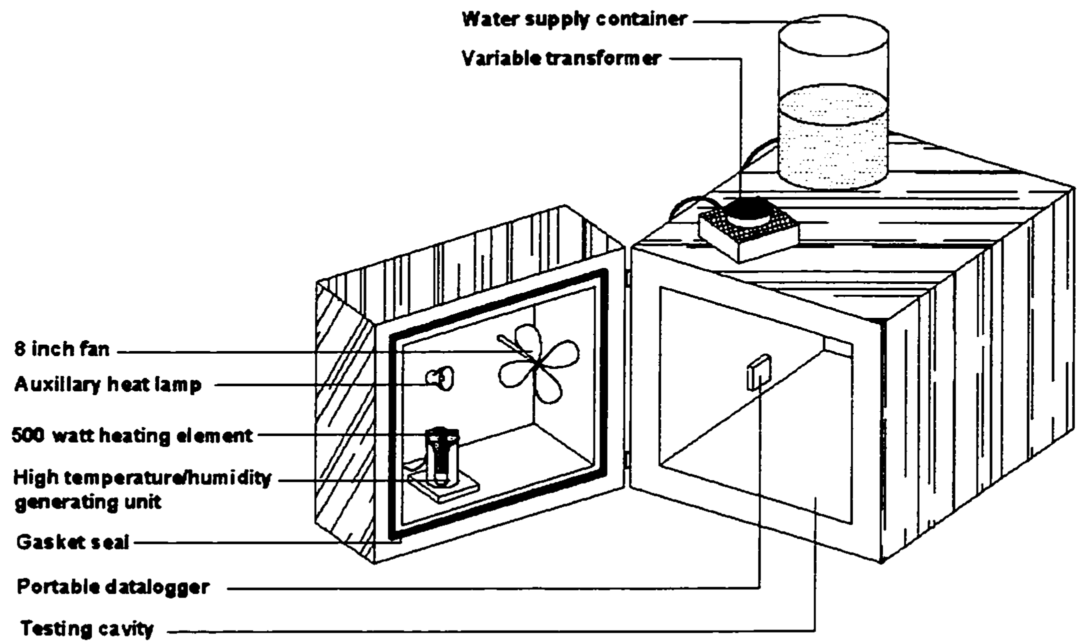

Figure 6.7 Schematic of a small environmental cycling box.

The temperature and the RH were measured using type T (copper/constantan) thermocouple wire with an uncertainty of ±0.4% for readings above 0°C, which corresponded to ±0.3°C at 65°C. The dry and wet bulb temperature readings were measured, and the psychrometric chart was used to determine the corresponding RH. A second portable and inexpensive temperature and RH data logger was mounted inside the chamber to compare the readings obtained with the thermocouples.

6.3.4 Laboratory aging – test series 1

This test series was performed to compare the effects of stress and strain on dimensional changes of the OSB joints. The restrained specimens were cycled in conditions prescribed in Table 6.6 (Series A). Figure 6.8 illustrates the progression of dimensional changes in the width of the joint during the duration of laboratory aging.

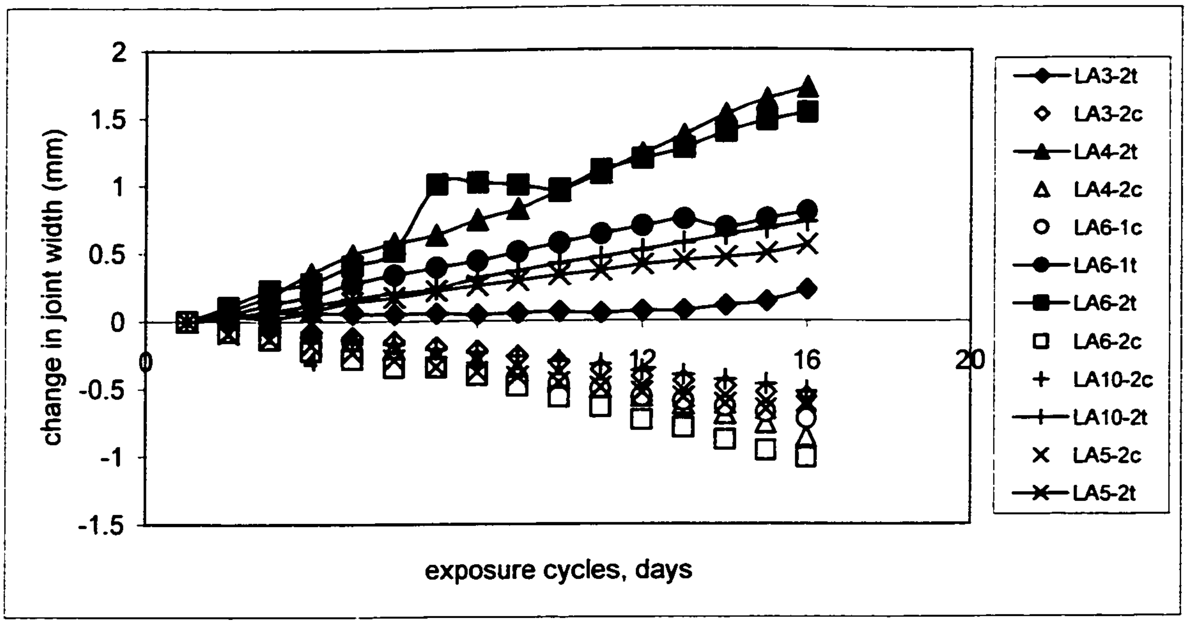

Figure 6.8 Dimensional increase of the joint width subjected to tensile load, and decrease of the joint width subjected to compressive load.

Since all of the above joints were filled with the WRB, the effect of applied tension was greater than the effect of compression. The 12.5 mm joints in specimens (LA4-2), and 6 mm joints in specimens (LA6-1), and (LA6-2) subjected to tension elongated more than the 3 mm joint in specimens (LA3-2), and (LA10-2). Following the aging exposure, moisture flux into the OSB was measured and the data is reported in the Figure 6.9.

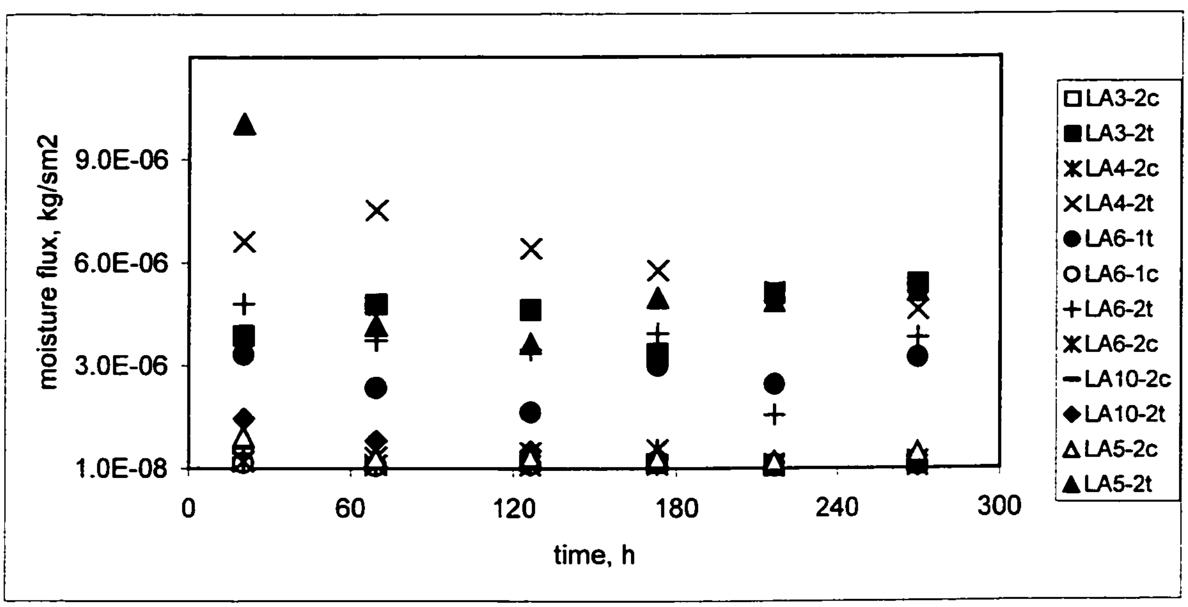

Figure 6.9 Moisture flux measured with several type LA WRB specimens.

The measured moisture flux was higher for specimens subjected to tensile loads than compressive loads. To relate the effect of aging under tension and compression, moisture flux measured on aged specimens was compared in Table 6.6 to those measured on the fresh (unaged specimens).

Table 6.6 Moisture flux measured on fresh and aged specimens.

WRB code	Moisture flux, [kg/sm2]					
	Tension	Standard deviation	Compression	Standard deviation	Fresh specimen	Standard deviation
LA3-2	4.6 E-06	7.8 E-07	1.6 E-07	4.9 E-08	2.7 E-07	7.3 E-08
LA4-2	5.9 E-06	7.8 E-07	3.4 E-07	1.7 E-07	1.5 E-07	4.3 E-08
LA6-1	2.5 E-06	6.2 E-07	1.3 E-07	5.7 E-08	1.3 E-07	2.1 E-08
LA6-2	3.3 E-06	9.9 E-07	9.6 E-08	2.2 E-08	1.9 E-07	7.4 E-08
LA5-2	4.6 E-06	9.5 E-08	2.6 E-07	8.9 E-08	1.6 E-07	5.0 E-08
LA10-2	6.0 E-06	9.8 E-07	3.9 E-07	2.9 E-07	1.8 E-07	4.4 E-08

The results showed that subjecting specimens to tensile loading had a significant effect on the moisture flux to an OSB substrate. The moisture flux measured on specimens subjected to tension was between 17 to 40 times higher than the moisture flux measured on fresh specimen. The increase in moisture flux measured on specimens subjected to compression ranged between 0.6 to 2.3 times. In the next test series, all of the specimens were subjected to tensile loads.

6.3.5 Laboratory aging – test series 2

In the second series of tests, specimens were subjected to tension loads and were cycled under conditions summarized in Table 6.5. The aging program included an exposure to subzero temperatures. The greater temperature range should introduce higher thermal stresses in the specimen, and should affect the aging process. Two issues were examined (1) the substitution of type LA WRB at the joint with materials such as peel and stick membrane, and (2) the determination of both the onset and the type of failure occurring. MF test was modified to include moisture flow through the joint. The test was performed on specimens with visible cracks in the WRB at the joints. Table 6.7 indicates that the inclusion of freezing temperatures in the aging exposure increased the measured moisture flow through the joint. The flow rate measured on five materials had increased several magnitudes and indicated failure at the joint. Table 6.8 shows moisture flux measured on specimens with no visible cracks in the WRB at the joint.

Table 6.7 Rate of moisture flow through the joint measured with specimens that showed visible cracks at the joint.

WRB code	Moisture flux, [kg/sm2]		
	specimen 1	specimen 2	specimen 3
LA3-2	1.3 E+01	4.0 E-01	1.4 E-02
LA4-2	1.5 E-01	2.2 E-01	1.2 E-02
LA5-1	1.1 E-01	1.1 E-01	-
LA8-2	3.8 E+02	1.6 E-01	-
LA10-1	1.3 E-01	1.3 E-01	1.2 E-01

Table 6.8 Rate of moisture flow through the joint measured with specimens that showed no visible cracks at the joint.

WRB code	Moisture flux, [kg/sm2]		
	specimen 1	specimen 2	specimen 3
LA4-1	9.4 E-08	1.4 E-07	5.5 E-08
LA6-1	1.6 E-07	6.9 E-06	-
LA6-2	2.2 E-07	7.5 E-08	-
LA5-2	1.1 E-07	2.4 E-07	-
LA7-1	2.6 E-07	2.8 E-07	3.1 E-07
LA7-2	5.0 E-07	3.5 E-07	3.0 E-07
LA8-1	1.7 E-07	1.7 E-07	1.2 E-07
LA10-2	5.9 E-06	5.4 E-06	-

Figure 6.10 shows the corresponding dimensional changes in the width of the joints. The joints filled with WRB without additional reinforcement such as specimens (LA3-2), and (LA4-2) had the worst performances.

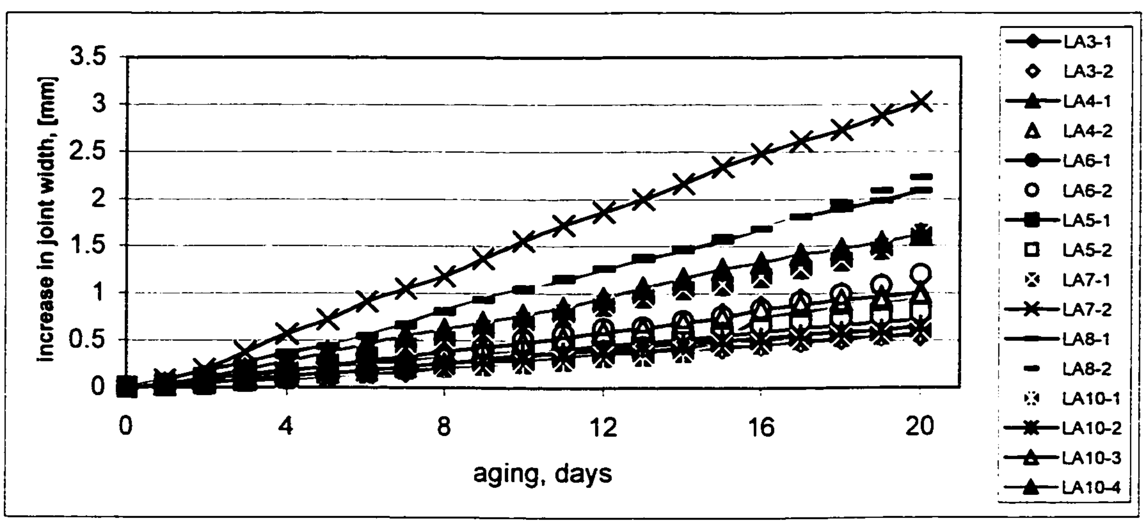

Figure 6.10 Dimensional changes of the OSB joint.

In specimens (LA5-1), delamination of the mesh occurred as seen in Figure 6.11. During the testing, water was trapped at the WRB/OSB interface; the amount of this water increased as the test progressed and lead to the failure. This indicated that the presence of small holes or defects on the WRB surface could be detrimental to the integrity and durability of joints. A similar pattern of failure was observed in specimen (LA8-2), were the partial delamination of the peel and stick membrane had occurred. Specimens (LA6-1), (LA6-2), (LA7-1), (LA7-2), (LA8-2), and (LA10-2) with peel and stick membrane at the joint, retained the resistance to the ingress of water following the aging exposure. It was inferred that the application of membranes at the joint following a full curing of the WRB coating, lowered the possibility of defects that led to moisture accumulation at the WRB/OSB interface. The (LA10-2) specimen showed a slight increase in transmitted moisture, however no visible cracking was observed in the WRB.

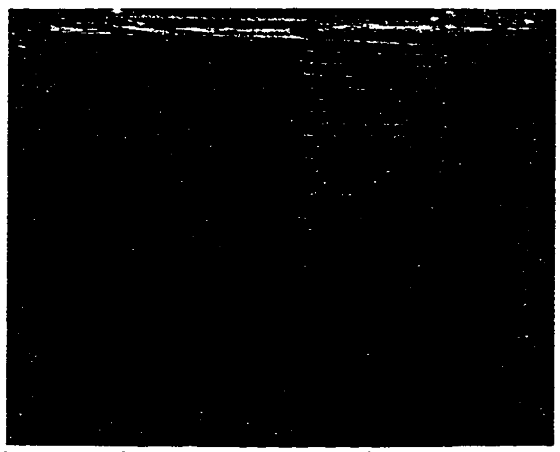

Figure 6.11 Delamination occurring at the reinforced OSB joint.

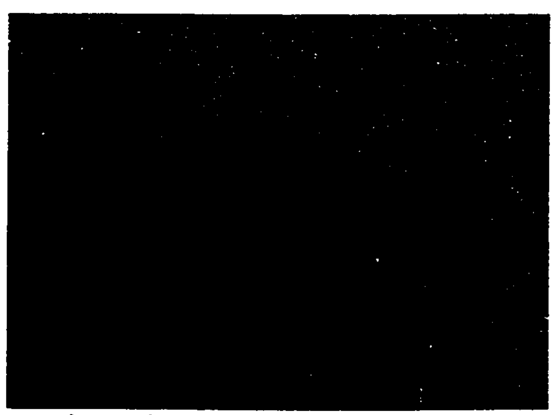

Figure 6.12 Cracking occurring at the non reinforced OSB joint.

Table 6.9 lists the observed patterns of failure. These patterns were distinct and largely dependent on the nature of the joint, and the materials used. Specimens with 3 mm non-reinforced joints indicated the appearance of visible cracks at the joint. Specimens with the peel and stick membrane at the joints showed no visible cracking but rather indicated delamination and sliding of the membrane. A similar pattern of delamination was apparent in specimens with reinforcing mesh embedded in the WRB coating. Three levels were selected as failure criteria of the type LA WRB.

Table 6.9 Criteria for visual determination of failure on tested type LA WRB specimens.

Visual determination of failure							
Specimen type	Level 1	No. of cycles	Level 2	No. of cycles	Level 3	No. of cycles	Manufacturer
LA4-2A	yes	10	yes	17	O		1
LA4-2B	yes	12	yes	18	O		1
LA4-2C	yes	12	yes	18	O		1
LA3-2A	yes	8	yes	15	yes	19	1
LA3-2B	yes	9	yes	15	O		1
LA3-2C	yes	9	yes	16	O		1
LA10-1A	yes	10	O		O		3
LA10-1B	yes	11	O		O		3
LA10-1C	yes	11	yes	18	O		3
LA5-1A	yes	8	yes	11			3
LA5-1B	O		O		O		2
LA5-1C	yes	6	yes		yes	8	2
LA8-2A	O		O		O		2
LA8-2B	yes	11	yes	18	O		2
LA8-2C	O		O		O		2

6.4 **CONCLUSIONS**

To characterize the change in material performance caused by the cyclic aging moisture flux to an OSB substrate was measured. Two series of exposures were used and a comparison of results indicated that exposure to subzero temperatures had an effect on the integrity of these products. Moisture flux into an OSB substrate was measured with fresh specimens without joints, and the data were compared with the results measured on type C, and P WRB. The rate of moisture absorbed by an OSB substrate was within the same order of magnitude. This is important fact because it allows us to set the same acceptance criterion for type LA WRB as for other membrane products.

CHAPTER 7

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

7.1 CONCLUSIONS

The following conclusions may be derived in this thesis:

1. Currently different test methods are used to evaluate various types of WRB i.e., type C products are tested with no hydrostatic pressure, and type P products are tested with high hydrostatic pressures, often in excess of 2 kPa. These tests are restricted to evaluation of membrane products, and cannot be utilized to evaluate liquid applied WRB products.
2. Additional shortcomings were identified. These included: inadequately defined boundary conditions, short test duration, and use of qualitative method (visual observation) of obtaining result. While these tests are adequate for quality control, they are inapt for use in evaluation of moisture performance of WRB products.
3. New methodology to evaluate WRB products was needed. This methodology would allow an examination of moisture performance of WRB in various service conditions i.e., including outdoor weathering, effect of penetrations, and effect of additives in adjacent materials such as stucco and OSB.
4. Numerous tests were performed with a 25 mm layer of water on the top surface and various moisture sinks (desiccant, OSB, vacuum cast gypsum, or empty container) on the bottom surface. The test showed that moisture transport through WRB was dependent on the conditions introduced on the surface of the WRB.
5. The use of 25 mm water head on the upper surface of the WRB, and the use periodically regenerated desiccant on the lower surface of the WRB separated with a 10 mm air space, generated constant and optimum conditions for the vapour phase transport. This led to the development of *Modified Inverted Cup (MIC)* test for measuring vapour dominant total moisture transmission. The test method showed within laboratory repeatability when tested with three replicate specimens, and two operators. The MIC test method was found acceptable and it is recommended for the use in material standards.

6. Since in MIC test vapour phase dominated moisture transport, changes to the surface characteristics of the WRB i.e., changes to the hydrophobic treatment, could not be detected. A second approach was adopted, and involved introduction of a 25 mm water layer on the upper surface of the WRB, and a 50 mm water layer on the lower surface of the specimen. The resulting 250 Pa hydrostatic pressure was the driving force for the flow. This led to the development of *Liquid Penetration Resistance (LPR)* test for determining the onset of liquid penetration, and the rate of filtration following liquid breakthrough.
7. A criterion for the use of LPR was proposed, as the time to the liquid breakthrough the WRB. This time duration should not be lower than one day. Some WRB products (PP9 and PP11) displayed onset of liquid flow within few minutes even though they passed evaluation with the existing test methods.
8. The LPR test method was used to examine changes in moisture transport following an outdoor exposure. The tests results showed a reduction in time to the onset of liquid penetration for a single ply type C WRB products. The test results also indicated an increase in the measured rate of filtration on five type C products.
9. To examine effects of penetrations, and evaluate type LA WRB products moisture flux to a wood based substrate was measured. This led to the development of *moisture flux (MF)*, which measured the rate of moisture flow to an OSB substrate with 250 Pa hydrostatic pressure as the driving force for the flow. This test method was necessary to compare various types of WRB products.
10. An acceptance criterion for MIC was proposed for all WRB products based on analysis of the effects of weathering and penetrations and the results obtained from the MIC test.
11. Finally, the WRB was also tested in assemblies to examine the effect of adjacent components on moisture transport. This was done primarily to examine the effects of penetrations through the WRB and additives in stucco. Moisture was thermally driven through the assembly from hot (stucco side) to the cold (OSB side). Moisture accumulation in the OSB substrate was measured gravimetrically. The results showed that moisture flux in assemblies was an order of magnitude lower than that measured with the MF test.

7.2 FUTURE WORK

The following items are proposed for future research on performance of WRB.

1. The development and improvement of the LPR test is recommended. An evaluation of factors affecting the precision of the test method (Ruggedness study) should be performed. The onset of liquid flow should be measured in a more precise manner. Probably a sensor should be developed.
2. One should also investigate non-isothermal transport through WRB membranes. The test methods could be improved to accommodate testing under thermal gradient. Area, which still requires exploration, is the significance of contact resistance on moisture transport through WRB. The results of the LPR test showed that water-to-water transport increased when the water to air interface was eliminated. Little information is available on moisture transport across material interface.
3. Finally, the durability of WRB was not addressed in this research. LPR test method would provide a good tool for such a study.

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APPENDIX A

RECALCULATION OF AIR PERMEANCE TO WATER PERMEANCE

The recalculation of water permeance from air permeance was performed to relate the measured water permeance with LPR test. Zhang (2003) measured the air permeance through the WRB at 25°C.

Table A.1 Measured air permeance and corresponding standard deviation

WRB code	Air permeance (L/sm^2Pa)	Standard deviation
C1	1.7E-03	2.6E-05
C2	8.9E-04	8.5E-05
C3	5.6E-04	3.2E-05
C4	2.6E-03	7.3E-05
C5	2.2E-03	4.5E-05
P6	1.2E-04	8.5E-06
P7	1.1E-04	6.3E-06
P8	2.6E-05	1.2E-06

The first step involved recalculating volumetric air flow to mass flow by multiplying the air permeance by the density of air at a 25°C temperature 1.184 kg/m3 as illustrated in Equation (A1.1). For (C4) WRB the air permeance was measured at 2.6E-03 (L/sm^2Pa).

$$Massflow = \frac{2.6E-03\ L}{sm^2Pa}\ X\ \frac{1.184\ kg}{m^3}\ X\ \frac{0.001\ m^3}{L} = 3.1E-06\ kg\ /\ sm^2Pa \qquad (A1.1)$$

Assuming the same intrinsic permeability the ratio of kinematic viscosity (v) of air (1.5E-05 m^2/s) at 25°C to water (1.0E-06 m^2/s) at 20°C could be used to recalculate the mass of airflow to the mass of liquid flow:

Kinematic viscosity:

Air (v_K) at 25°C - 1.5e-5 m^2/s
Water(v_W) at 20°C - 1.0e-6 m^2/s

$$\frac{v_W}{v_A} = \frac{Water\ permeance}{Air\ permeance\ (mass\ flow)} \qquad (A1.2)$$

$$\frac{1.0E-06\ m^2\ /\ s}{1.5E-05\ m^2\ /\ s} = \frac{Water\ permeance}{3.1E-06\ kg\ /\ sm^2Pa}$$

$$Water\ permeance\ = 2.2E-07\ kg\ /\ sm^2Pa$$

The calculation was repeated for several WRB products, and the results are reported in a Table A.2.

Table A.2 Comparison of recalculated water permeance with measured values

WRB code	Recalculated water permeance (kg/sm^2Pa)	Measured water permeance with LPR test (kg/sm^2Pa)
C1	1.3E-07	8.6E-08
C2	7.0E-08	7.2E-08
C3	4.5E-08	7.5E-08
C4	2.2E-07	8.4E-08
C5	1.8E-07	8.7E-08
P6	9.5E-09	-
P7	8.5E-09	-
P8	2.1E-09	-

APPENDIX B

WEATHER DATA RECORDS

The weather data records were obtained from Environment Canada for Dorval International Airport weather station (ID#7025250) in Montreal Canada. The weather station is located at a latitude of 73°45', and at an elevation of 36 m above sea. The data was obtained for the duration of the outdoor exposure for the series I and II of WRB products between July 27th through March 27th 2001/2002.

Date	Mean Temp. (°C)	Max Temp. (°C)	Min Temp. (°C)	Dew point (°C)	Sea level pressure hPa	Wind speed (km/h)	Max wind speed (km/h)	Gust speed (km/h)	Events
27-Jul-01	15.0	22.0	8.0	7.1	1024.8	8.3	14.8	N/A	-
28-Jul-01	16.0	26.0	6.0	8.7	1024.7	8.5	11.1	N/A	-
29-Jul-01	19.5	27.0	12.0	11.2	1020.5	13.7	18.3	N/A	-
30-Jul-01	20.5	25.0	16.0	14.3	1020.5	7.0	14.8	N/A	-
31-Jul-01	22.5	30.0	15.0	16.1	1023.0	4.8	9.4	N/A	-
1-Aug-01	22.0	32.0	12.0	14.9	1024.8	8.7	9.4	N/A	-
2-Aug-01	22.5	29.0	16.0	17.7	1018.6	8.7	22.2	37.0	Rain
3-Aug-01	23.5	30.0	17.0	18.4	1014.0	11.9	16.5	N/A	Fog
4-Aug-01	22.0	30.0	15.0	12.4	1014.6	9.3	14.8	N/A	-
5-Aug-01	23.0	34.0	12.0	14.8	1018.2	9.4	18.3	N/A	-
6-Aug-01	24.5	34.0	15.0	16.7	1015.5	11.3	18.3	N/A	Rain, thunderstorm
7-Aug-01	27.0	34.0	20.0	19.3	1011.2	11.7	18.3	N/A	-
8-Aug-01	25.5	36.0	15.0	17.2	1009.8	18.7	27.8	35.2	-
9-Aug-01	28.0	35.0	21.0	20.6	1006.8	13.7	27.8	37.0	Rain,thunderstorm
10-Aug-01	28.5	34.8	22.2	17.4	1004.0	33.5	40.7	59.4	Rain, thunderstorm
11-Aug-01	20.0	27.0	13.0	10.5	1017.7	8.5	16.5	N/A	-
12-Aug-01	22.7	30.6	14.9	14.1	1017.5	10.4	18.3	N/A	-
13-Aug-01	21.5	27.0	16.0	15.8	1013.8	10.6	18.3	33.5	-
14-Aug-01	17.0	26.0	8.0	9.2	1016.5	8.7	18.3	N/A	-
15-Aug-01	18.5	30.0	7.0	9.9	1015.8	15.0	18.3	27.8	-
16-Aug-01	20.0	29.0	11.0	12.6	1014.1	10.4	18.3	29.4	-
17-Aug-01	22.5	28.0	17.0	17.0	1008.6	17.4	40.7	64.8	Rain, thunderstorm
18-Aug-01	22.5	26.0	19.0	15.8	1011.2	15.2	18.3	27.8	
19-Aug-01	21.0	28.0	14.0	15.1	1013.2	6.7	13.0	N/A	Rain
20-Aug-01	20.0	24.0	16.0	16.6	1013.4	15.6	25.9	38.9	Rain, thunderstorm
21-Aug-01	21.0	25.0	17.0	17.9	1012.6	8.3	14.8	N/A	Rain, fog
22-Aug-01	23.0	29.0	17.0	16.8	1014.7	8.7	18.3	31.3	Rain
23-Aug-01	20.5	26.0	15.0	16.3	1014.9	9.4	18.3	N/A	Rain
24-Aug-01	17.5	24.0	11.0	8.0	1021.2	10.4	18.3	N/A	-
25-Aug-01	16.0	26.0	6.0	8.2	1020.9	9.1	18.3	N/A	-
26-Aug-01	19.1	27.1	11.1	14.1	1012.1	13.7	24.1	31.3	Rain
27-Aug-01	20.0	28.0	12.0	15.3	1009.5	11.3	18.3	N/A	-
28-Aug-01	19.5	22.0	17.0	16.2	1009.4	8.3	13.0	N/A	Rain

29-Aug-01	13.5	19.0	8.0	9.1	1017.5	9.1	18.3	N/A	-
30-Aug-01	17.5	26.0	9.0	10.8	1015.4	12.2	18.3	27.8	-
31-Aug-01	20.0	24.0	16.0	16.8	1006.7	13.5	22.2	N/A	Rain
1-Sep-01	15.5	20.0	11.0	8.2	1014.2	16.5	22.2	33.5	Rain
2-Sep-01	12.5	17.0	8.0	6.3	1016.4	12.4	22.4	29.6	-
3-Sep-01	15.0	20.0	10.0	7.1	1016.6	5.3	14.8	N/A	-
4-Sep-01	No data								
5-Sep-01	12.5	20.0	5.0	6.6	1021.8	6.1	9.3	N/A	-
6-Sep-01	14.5	24.0	5.0	8.1	1021.7	7.9	22.2	N/A	-
7-Sep-01	19.0	29.0	9.0	12.9	1016.4	5.4	18.5	N/A	-
8-Sep-01	24.0	32.0	16.0	17.3	1012.7	13.2	18.5	27.8	-
9-Sep-01	27.5	32.0	23.0	18.9	1016.7	12.4	18.5	29.6	-
10-Sep-01	29.0	32.0	26.0	18.7	1015.5	14.2	18.5	27.8	-
11-Sep-01	17.5	26.0	9.0	9.4	1020.2	10.4	18.5	37.0	-
12-Sep-01	17.5	22.0	13.0	6.8	1020.2	12.4	18.5	27.8	-
13-Sep-01	17.5	23.0	12.0	9.4	1020.5	16.5	22.2	33.3	-
14-Sep-01	12.0	16.0	8.0	5.6	1021.7	11.4	16.7	N/A	-
15-Sep-01	9.5	15.0	4.0	4.6	1024.0	6.4	16.7	31.5	-
16-Sep-01	12.0	21.0	3.0	7.2	1019.1	10.0	22.2	31.5	Fog
17-Sep-01	No data								-
18-Sep-01	18.0	23.0	13.0	12.6	1016.8	3.6	18.5	N/A	Rain
19-Sep-01	17.0	22.0	12.0	8.9	1021.3	13.9	18.5	27.8	-
20-Sep-01	19.0	23.0	15.0	13.2	1015.2	15.6	81.5	29.6	Rain
21-Sep-01	20.5	24.0	17.0	15.9	15.9	11.7	20.4	33.3	Rain
22-Sep-01	16.0	18.0	14.0	12.2	1013.2	3.7	7.4	N/A	Rain
23-Sep-01	15.5	22.0	9.0	13.1	1018.1	5.7	18.5	N/A	Fog
24-Sep-01	18.0	24.0	12.0	12.4	1014.2	7.5	14.8	N/A	Rain, thunderstorm
25-Sep-01	17.0	17.0	17.0	16.2	1009.2	9.9	14.8	27.8	Rain
26-Sep-01	10.0	15.0	5.0	9.4	1010.0	5.9	14.8	N/A	Fog, rain
27-Sep-01	9.0	14.0	4.0	6.7	1011.3	4.8	18.5	N/A	-
28-Sep-01	11.5	14.0	9.0	8.8	1017.5	5.6	13.0	N/A	Rain
29-Sep-01	No data								
30-Sep-01	11.0	18.0	4.0	4.0	1026.3	5.6	11.1	N/A	-
1-Oct-01	11.5	22.0	1.0	8.1	1013.3	9.8	18.3	N/A	-
2-Oct-01	15.5	21.0	10.0	9.8	1009.2	8.5	16.5	N/A	Fog
3-Oct-01	17.0	25.0	9.0	11.9	1009.9	13.3	22.2	37.0	Fog, rain
4-Oct-01	18.0	22.0	14.0	11.7	1008.0	16.5	25.9	38.9	-
5-Oct-01	11.0	12.0	10.0	9.4	1013.0	7.2	9.4	N/A	Rain
6-Oct-01	8.0	10.0	6.0	6.4	1005.1	16.5	18.3	38.9	Rain
7-Oct-01	6.0	10.0	2.0	3.9	1009.5	14.6	27.8	38.9	Rain
8-Oct-01	3.0	6.0	0.0	0.2	1017.3	18.4	27.8	40.7	Rain, snow
9-Oct-01	3.5	12.0	-5.0	-0.5	1033.5	2.9	11.1	N/A	Fog

10-Oct-01	10.5	13.0	8.0	5.3	1027.7	6.0	13.0	N/A	Rain
11-Oct-01	14.5	19.0	10.0	8.6	1022.0	7.0	14.8	27.8	-
12-Oct-01	13.0	15.0	11.0	12.7	1019.7	10.4	14.8	N/A	-
13-Oct-01	No data								
14-Oct-01	No data								
15-Oct-01	No data								
16-Oct-01	9.0	15.0	3.0	6.2	1019.3	11.0	18.5	37.0	Fog
17-Oct-01	15.0	16.0	14.0	6.5	1009.0	20.0	27.8	37.0	Rain
18-Oct-01	3.5	7.0	0.0	-3.3	1019.2	19.1	22.2	37.0	-
19-Oct-01	7.5	15.0	0.0	0.9	1020.4	9.0	18.5	29.6	-
20-Oct-01	11.0	16.0	6.0	5.2	1011.3	9.9	18.5	N/A	Rain
21-Oct-01	11.5	17.0	6.0	5.5	1013.1	15.0	37.0	64.8	Rain
22-Oct-01	10.0	11.0	9.0	9.4	1013.2	7.2	11.1	N/A	Rain
23-Oct-01	6.0	8.0	4.0	4.2	1014.4	12.7	18.5	29.6	Rain
24-Oct-01	11.5	14.0	9.0	11.5	1003.1	6.1	10.6	N/A	-
25-Oct-01	13.0	14.0	12.0	9.1	995.3	18.1	37.0	59.3	Rain
26-Oct-01	9.5	14.0	5.0	0.6	995.8	27.4	37.0	50.0	Rain
27-Oct-01	5.0	7.0	3.0	0.6	997.6	21.0	29.6	51.9	Rain
28-Oct-01	2.5	6.0	-1.0	-3.7	1027.4	13.2	22.2	37.0	-
29-Oct-01	3.5	10.0	-3.0	-2.0	1031.0	8.0	20.4	27.8	-
30-Oct-01	No data								
31-Oct-01	-0.5	6.0	-7.0	-6.8	1034.7	7.7	22.2	N/A	Snow
1-Nov-01	5.0	10.0	0.0	2.3	1021.1	14.4	20.4	N/A	Rain, snow
2-Nov-01	13.5	16.0	11.0	9.5	1013.8	15.5	22.2	29.6	Rain
3-Nov-01	9.0	15.0	3.0	9.5	1019.7	14.1	25.9	27.8	Rain
4-Nov-01	8.0	11.0	5.0	4.4	1021.9	8.5	16.7	N/A	Rain
5-Nov-01	6.5	10.0	3.0	2.1	1016.9	18.5	29.6	46.3	Rain
6-Nov-01	3.0	8.0	-2.0	-0.1	1022.3	13.0	22.2	37.0	-
7-Nov-01	7.0	10.0	4.0	1.3	1017.1	12.0	22.2	46.3	-
8-Nov-01	3.0	10.0	-4.0	-3.0	1022.3	13.2	22.2	37.0	Rain
9-Nov-01	3.0	5.0	1.0	-1.5	1021.5	18.0	27.8	40.7	Rain, snow
10-Nov-01	0.5	4.0	-3.0	-1.8	1017.7	5.8	18.5	29.6	Rain
11-Nov-01	2.0	4.0	0.0	-2.7	1017.1	14.3	22.2	33.3	Rain
12-Nov-01	-1.0	3.0	-5.0	-7.0	1026.6	11.2	20.4	33.3	-
13-Nov-01	-3.0	2.0	-8.0	-6.3	1030.9	8.4	20.4	27.8	-
14-Nov-01	3.0	7.0	-1.0	-0.4	1023.5	6.4	9.3	N/A	-
15-Nov-01	8.5	12.0	5.0	8.2	1014.0	11.0	22.2	31.5	Fog, rain
16-Nov-01	5.0	13.0	-3.0	0.5	1018.0	14.6	24.1	35.2	-
17-Nov-01	-2.0	1.0	-5.0	-7.0	1031.9	3.1	11.1	N/A	-
18-Nov-01	4.0	10.0	-2.0	1.5	1022.0	10.7	20.4	31.5	-

19-Nov-01	9.0	14.0	4.0	5.1	1009.7	8.0	20.4	33.3	Fog, rain
20-Nov-01	3.5	11.0	-4.0	-2.8	1009.2	16.1	33.3	46.3	Rain, snow
21-Nov-01	-1.5	3.0	-6.0	-4.4	1014.8	6.1	14.8	N/A	Rain
22-Nov-01	3.5	6.0	1.0	-0.3	1017.9	3.7	9.3	N/A	-
23-Nov-01	3.5	7.0	0.0	-0.2	1024.0	14.2	22.2	29.6	-
24-Nov-01	4.5	9.0	0.0	1.9	1025.9	10.7	16.7	N/A	Rain
25-Nov-01	12.0	16.0	8.0	10.2	1017.0	12.7	25.9	38.9	Rain
26-Nov-01	9.0	12.0	6.0	6.6	1018.9	9.7	18.5	N/A	-
27-Nov-01	3.0	7.0	-1.0	-1.8	1021.5	17.5	25.9	33.3	Rain
28-Nov-01	-1.5	0.0	-3.0	-4.4	1028.2	14.6	22.2	33.3	Rain
29-Nov-01	-3.0	-1.0	-5.0	-5.1	1025.2	23.2	35.2	44.4	Rain, snow
30-Nov-01	0.0	1.0	-1.0	-1.3	1016.3	10.7	18.5	N/A	Rain
1-Dec-01	3.5	7.0	0.0	2.5	1011.7	10.4	22.2	35.2	Fog, rain
2-Dec-01	4.0	7.0	1.0	2.1	1021.8	8.3	16.7	31.5	Rain
3-Dec-01	2.5	6.0	-1.0	1.2	1020.4	7.7	16.7	N/A	Rain
4-Dec-01	4.0	7.0	1.0	1.7	1024.0	5.4	11.1	N/A	Rain
5-Dec-01	6.5	9.0	4.0	6.4	1020.9	3.8	11.1	N/A	Fog, rain
6-Dec-01	9.0	13.0	5.0	3.3	1007.9	20.9	37.0	59.3	Fog, rain
7-Dec-01	1.5	5.0	-2.0	-6.0	1014.3	13.7	20.4	38.9	-
8-Dec-01	-4.0	0.0	-8.0	-9.2	1022.9	4.9	9.3	N/A	-
9-Dec-01	-1.5	2.0	-5.0	-7.5	1019.9	8.0	16.7	N/A	-
10-Dec-01	0.5	6.0	-5.0	-3.4	1023.5	11.0	24.1	29.6	-
11-Dec-01	2.0	6.0	-2.0	-2.3	1027.9	8.7	14.8	N/A	-
12-Dec-01	-1.5	1.0	-4.0	-6.6	1031.4	12.0	20.4	31.5	Rain
13-Dec-01	4.5	9.0	0.0	1.9	1012.0	7.7	20.4	31.5	Fog, rain
14-Dec-01	3.0	7.0	-1.0	-1.9	1013.5	12.4	25.9	35.2	Snow
15-Dec-01	-3.0	0.0	-6.0	-9.4	1024.1	10.6	16.7	N/A	Snow
16-Dec-01	-8.0	-4.0	-12.0	-11.6	1033.2	2.7	7.4	N/A	-
17-Dec-01	-5.0	-3.0	-7.0	-7.5	1014.8	15.5	22.2	31.5	Snow
18-Dec-01	-1.0	1.0	-3.0	-3.7	999.0	9.1	18.5	29.6	Snow
19-Dec-01	0.5	2.0	-1.0	-2.4	1006.9	8.1	18.5	N/A	Snow
20-Dec-01	-0.5	0.0	-1.0	-1.9	1003.2	10.9	18.5	27.8	Snow
21-Dec-01	-3.0	-1.0	-5.0	-7.5	1015.9	9.8	14.8	N/A	Snow
22-Dec-01	-9.5	-6.0	-13.0	-12.8	1028.8	8.6	16.7	N/A	-
23-Dec-01	-8.0	-4.0	-12.0	-10.5	1018.6	14.4	24.1	37.0	Rain
24-Dec-01	-2.0	0.0	-4.0	-3.5	1007.1	6.1	14.8	N/A	Rain, snow
25-Dec-01	-2.5	-1.0	-4.0	-4.1	1011.0	6.9	11.1	N/A	Snow
26-Dec-01	-2.5	-1.0	-4.0	-4.7	1009.0	6.6	13.0	N/A	Snow
27-Dec-01	-6.5	-4.0	-9.0	-8.1	1000.6	6.8	13.0	N/A	Snow
28-Dec-01	-7.5	-4.0	-11.0	-8.8	999.3	6.4	16.7	N/A	Snow

29-Dec-01	-7.5	-4.0	-11.0	-10.3	1000.8	14.1	18.5	27.8	Snow
30-Dec-01	-7.0	-4.0	-10.0	-8.6	1001.9	14.9	22.2	35.2	Snow
31-Dec-01	No data								
1-Jan-02	-12.0	-9.0	-15.0	-15.4	1014.5	11.9	22.2	33.5	-
2-Jan-02	-8.0	-5.0	-11.0	-12.8	1018.0	19.6	29.4	40.7	Snow
3-Jan-02	-4.5	-3.0	-6.0	-7.7	1012.3	15.6	25.9	35.2	Fog, snow
4-Jan-02	-11.5	-6.0	-17.0	-15.3	1013.4	7.8	13.0	N/A	-
5-Jan-02	-4.0	-1.0	-7.0	-6.3	1011.8	7.0	14.8	N/A	Snow
6-Jan-02	0.0	1.0	-1.0	-0.9	1010.1	9.6	16.5	N/A	Rain, snow
7-Jan-02	-4.0	0.0	-0.8	-8.9	1007.8	9.6	18.3	27.8	-
8-Jan-02	-10.0	-5.0	-15.0	-13.5	1009.6	8.0	16.5	N/A	Snow
9-Jan-02	-1.5	0.0	-3.0	-3.6	1001.2	10.2	24.1	37.0	Rain, snow
10-Jan-02	1.0	3.0	-1.0	0.2	998.5	13.7	22.2	31.3	Rain, snow
11-Jan-02	1.0	2.0	0.0	-0.2	1003.2	9.3	20.6	N/A	Fog, rain, snow
12-Jan-02	-4.5	0.0	-9.0	-8.4	1007.5	9.6	20.6	31.3	Rain, snow
13-Jan-02	-1.0	2.0	-4.0	-3.6	996.9	12.6	24.1	35.2	Rain, snow
14-Jan-02	-9.5	-5.0	-14.0	-14.9	1014.3	15.0	33.5	48.2	-
15-Jan-02	-8.0	-6.0	-10.0	-11.7	1012.2	19.8	25.9	35.2	Snow
16-Jan-02	-7.5	-5.0	-10.0	-10.2	1014.8	11.9	18.3	29.4	Snow
17-Jan-02	-9.0	-6.0	-12.0	-11.3	1012.6	9.8	20.6	N/A	Snow
18-Jan-02	-7.0	-4.0	-10.0	-8.9	1011.9	9.1	16.5	N/A	Snow
19-Jan-02	-15.5	-10.0	-21.0	-16.1	1019.3	6.7	13.0	N/A	Snow
20-Jan-02	-7.5	-3.0	-12.0	-11.1	1012.2	7.2	13.0	N/A	Snow
21-Jan-02	-3.0	0.0	-6.0	-5.6	1010.6	5.9	16.5	N/A	Snow
22-Jan-02	-3.0	-1.0	-5.0	-5.5	1013.2	12.0	18.3	27.8	Snow
23-Jan-02	-2.0	3.0	-7.0	-5.5	1013.9	8.5	25.9	37.0	Rain, snow
24-Jan-02	0.0	2.0	-2.0	-1.9	1007.5	12.4	20.6	27.8	Fog, snow
25-Jan-02	-7.5	-1.0	-14.0	-11.2	1009.9	9.6	20.6	29.4	Snow
26-Jan-02	-2.1	5.7	-9.9	-2.6	1012.1	20.7	40.7	53.5	Snow
27-Jan-02	-0.3	6.1	-6.7	-7.9	1019.5	18.3	27.8	57.6	-
28-Jan-02	-2.4	3.0	-7.8	-6.6	1014.6	8.5	16.5	N/A	Fog
29-Jan-02	-2.5	2.9	-7.9	-5.6	1014.8	19.1	25.9	31.3	-
30-Jan-02	-5.0	0.7	-10.8	-12.3	1022.1	16.5	25.9	33.5	Snow
31-Jan-02	-11.5	-8.0	-15.0	-21.3	1033.8	14.1	27.8	37.0	Snow
1-Feb-02	-6.5	2.0	-15.0	-12.7	1011.9	25.4	40.7	61.1	Fog, snow, rain
2-Feb-02	-8.0	-2.0	-14.0	-16.9	1018.4	21.1	48.2	75.9	Snow
3-Feb-02	-14.0	-9.0	-19.0	-15.2	1017.2	13.7	24.1	29.6	Snow
4-Feb-02	-9.5	-6.0	-13.0	-11.3	1010.8	5.9	13.0	N/A	Fog, snow
5-Feb-02	-16.5	-13.0	-20.0	-18.9	1018.3	10.5	16.7	27.8	Snow
6-Feb-02	-14.0	-10.0	-18.0	-17.6	1020.4	7.9	14.8	N/A	Snow

7-Feb-02	-8.0	-3.0	-13.0	-8.3	1011.2	9.1	14.8	N/A	Snow
8-Feb-02	-9.0	-4.0	-14.0	-13.7	1021.0	9.5	16.7	N/A	-
9-Feb-02	-14.0	-9.0	-19.0	-20.4	1034.1	5.6	13.0	N/A	-
10-Feb-02	-6.0	0.0	-12.0	-10.2	1017.5	12.1	29.6	38.9	Rain, snow
11-Feb-02	-11.5	-5.0	-18.0	-19.2	1017.8	15.4	37.0	48.2	Snow
12-Feb-02	-8.5	1.0	-18.0	-12.3	1004.0	14.2	38.9	55.6	Snow
13-Feb-02	-12.0	-5.0	-19.0	-20.9	1018.7	16.0	25.9	38.9	Snow
14-Feb-02	-9.5	1.0	-20.0	-13.4	1020.1	8.3	27.8	37.0	Snow
15-Feb-02	2.0	6.0	-2.0	-5.4	1010.9	18.0	27.8	46.3	Rain
16-Feb-02	1.0	4.0	-2.0	-1.0	1006.2	14.4	24.1	33.3	Rain
17-Feb-02	-3.5	0.0	-7.0	-10.3	1011.7	18.7	25.9	37.0	Snow
18-Feb-02	-10.0	-6.0	-14.0	-16.3	1027.1	5.3	11.1	N/A	-
19-Feb-02	-7.5	-1.0	-14.0	-8.7	1024.0	6.8	16.7	N/A	Fog
20-Feb-02	-0.5	2.0	-3.0	-2.1	1015.0	18.4	31.5	40.7	Rain, snow
21-Feb-02	3.0	5.0	1.0	2.1	1006.2	8.9	16.7	N/A	Fog, rain
22-Feb-02	-1.0	2.0	-4.0	-2.5	1009.8	11.6	20.4	33.3	Snow
23-Feb-02	-7.0	-4.0	-10.0	-11.2	1020.4	10.7	22.2	31.5	-
24-Feb-02	-7.5	-3.0	-12.0	-10.0	1024.1	7.1	13.0	N/A	-
25-Feb-02	-0.5	3.0	-4.0	-4.1	1016.0	12.3	20.4	N/A	Rain
26-Feb-02	2.0	4.0	0.0	-0.1	1004.3	14.2	29.6	40.7	Rain
27-Feb-02	-1.0	2.0	-4.0	-3.8	999.7	14.8	22.2	37.0	Snow
28-Feb-02	-7.0	-4.0	-10.0	-13.3	1008.9	19.9	31.5	44.4	Snow
1-Mar-02	-4.0	0.0	-8.0	-6.3	1023.6	15.1	27.8	38.9	Snow
2-Mar-02	-7.5	-3.0	-12.0	-12.2	1031.6	16.1	29.6	35.2	Snow
3-Mar-02	1.0	5.0	-3.0	0.3	1001.1	19.5	48.2	70.4	Rain, snow
4-Mar-02	-10.0	-5.0	-15.0	-17.8	1011.9	18.5	38.9	57.4	-
5-Mar-02	-9.5	-4.0	-15.0	-13.5	1020.8	11.7	22.2	35.2	Snow
6-Mar-02	-6.0	-1.0	-11.0	-7.8	1021.4	9.0	14.8	N/A	Snow
7-Mar-02	-3.5	-1.0	-6.0	-10.0	1027.4	8.6	14.8	N/A	Snow
8-Mar-02	-4.0	-2.0	-6.0	-10.9	1030.8	19.4	29.6	38.9	Rain
9-Mar-02	1.5	5.0	-2.0	0.1	1019.2	15.6	27.8	27.8	Rain
10-Mar-02	1.5	11.0	-8.0	-8.1	1006.3	33.8	53.7	79.6	Rain, snow
11-Mar-02	-6.0	-2.0	-10.0	-14.6	1022.0	20.4	33.3	48.2	-
12-Mar-02	-0.5	3.0	-4.0	-4.9	1019.1	7.9	25.9	27.8	Snow
13-Mar-02	1.0	4.0	-2.0	-0.8	1013.7	9.9	16.7	N/A	Fog
14-Mar-02	1.5	4.0	-1.0	-7.8	1016.6	12.9	20.4	37.0	-
15-Mar-02	-5.0	-2.0	-8.0	-10.3	1016.3	26.7	42.6	55.6	Rain, snow
16-Mar-02	-3.0	1.0	-7.0	-8.3	1021.6	9.3	25.9	N/A	Snow
17-Mar-02	-3.0	2.0	-8.0	-11.4	1034.8	8.5	16.7	N/A	-
18-Mar-02	-3.0	-2.0	-4.0	-6.7	1027.1	21.8	29.6	40.7	Snow

19-Mar-02	-1.0	1.0	-3.0	-4.1	1028.5	8.0	20.4	29.6	Snow
20-Mar-02	-0.5	3.0	-4.0	-1.8	1019.0	12.1	20.4	35.2	Snow
21-Mar-02	-6.0	0.0	-12.0	-5.3	1009.2	13.3	27.8	38.9	Snow
22-Mar-02	-13.0	-9.0	-17.0	-18.0	1011.3	15.0	27.8	44.4	Snow
23-Mar-02	-7.5	-1.0	-14.0	-9.3	1006.8	15.5	24.1	35.2	Snow
24-Mar-02	-8.0	-4.0	-12.0	-14.6	1018.3	11.0	24.1	29.6	-
25-Mar-02	-10.5	-6.0	-15.0	-19.0	1031.0	8.6	18.5	N/A	-
26-Mar-02	-7.0	-1.0	-13.0	-10.5	1028.0	19.2	25.9	37.0	Snow
27-Mar-02	0.0	1.0	-1.0	-2.0	1013.2	14.3	22.2	31.5	Snow
28-Mar-02	0.0	5.0	-5.0	-4.2	1016.6	10.0	16.7	N/A	Fog

APPENDIX C

CONDITION MONITORING

Temperature and RH stability of the chambers measured during testing

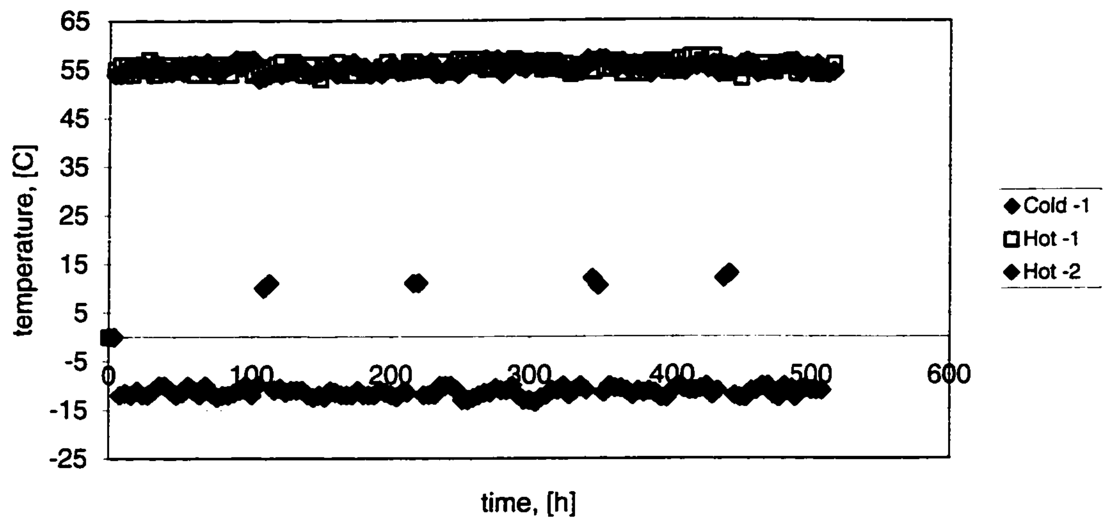

Figure C.1 Temperature measured in the inside the two hot compartments, and the cold compartment in the environmental chamber during assembly test

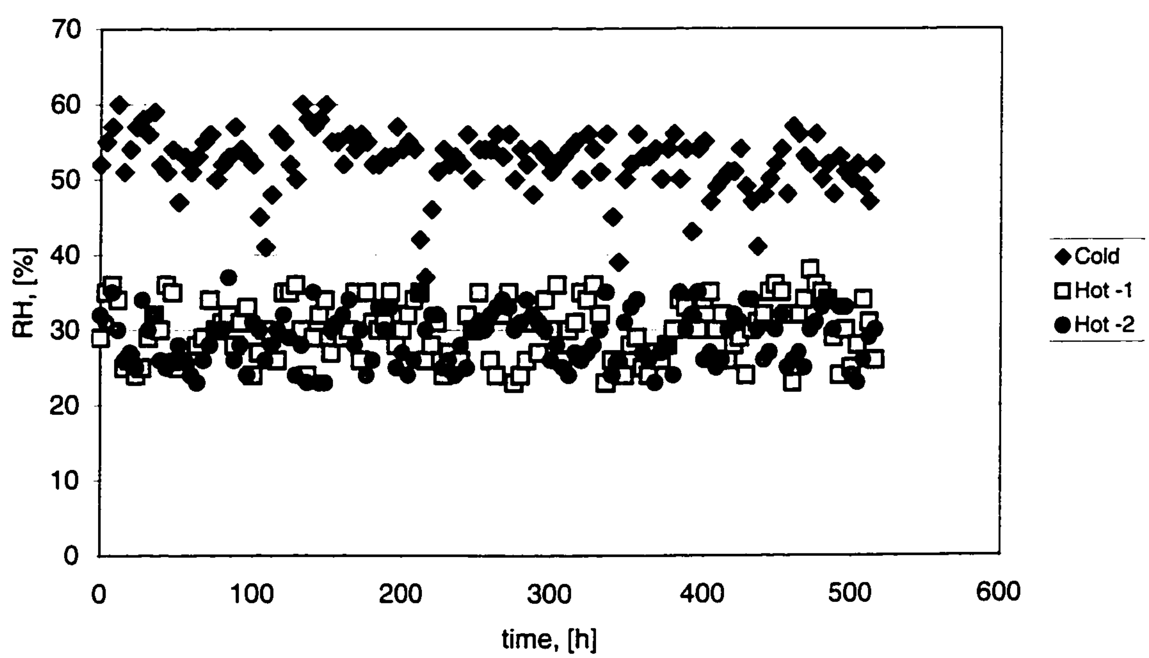

Figure C.2 RH measured inside the two hot compartments, and the cold compartment in the environmental chamber during assembly test.

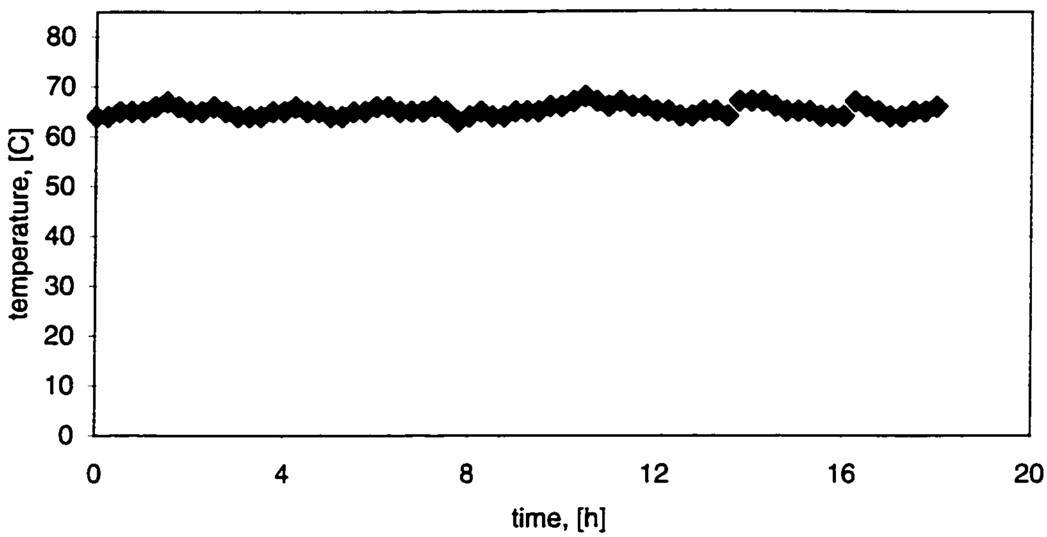

Figure C.3 Temperature measured inside the small environmental box during high temperature and high humidity aging of type LA WRB.

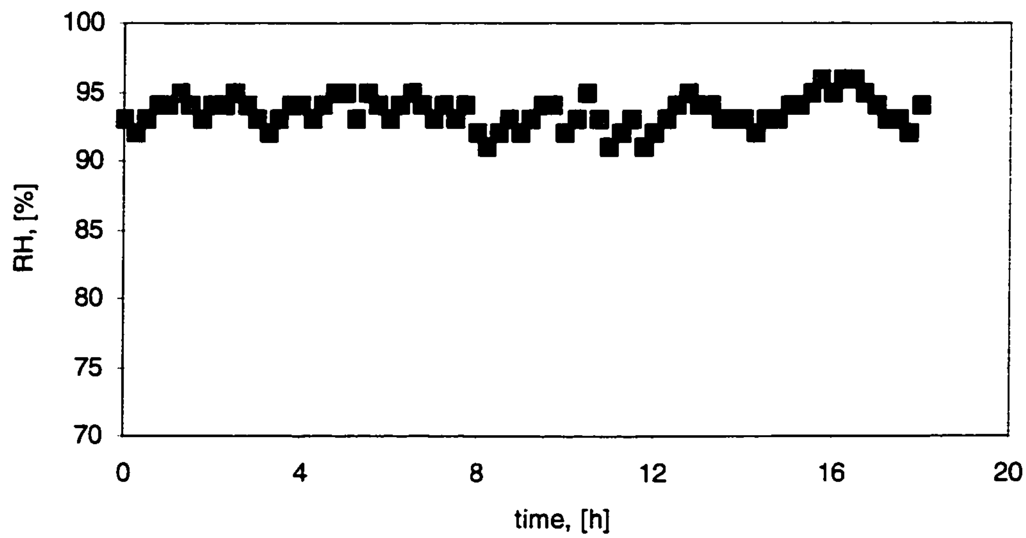

Figure C.4 RH measured inside the small environmental box during high temperature and high humidity aging of type LA WRB.

APPENDIX D

TEST DATA

Moisture flux – 25 mm water head and blotting paper as a substrate- type C and type P WRB

Start date: 01/08/2001 End date: 13/08/2001

Laboratory conditions
Temperature: 21.5±0.1°C
RH: 48%

			Mass increase (g)			Moisture flux (kg/sm2)		
Time (h)	Time (s)	Time mid-int, (h)	C1-A	C1-B	Average	C1-A	C1-B	Average
0	0	0	0	0	0	0	0	0
48	172800	24	4.02	4.37	4.20	3.2E-06	3.5E-06	3.3E-06
124	446400	86	5.32	5.67	5.49	6.5E-07	6.5E-07	6.5E-07
174	626400	149	5.79	6.08	5.94	3.6E-07	3.2E-07	3.4E-07
222	799200	198	6.07	6.33	6.20	2.2E-07	2.0E-07	2.1E-07
290	1044000	256	6.77	6.75	6.76	3.9E-07	2.4E-07	3.1E-07
					Mean	4.1E-07	3.5E-07	
					S	1.8E-07	2.1E-07	

		Time mid-	Mass increase (g)			Moisture flux (kg/sm2)		
Time (h)	Time (s)	int, (h)	C2-A	C2-B	Average	C2-A	C2-B	Average
0	0	0	0	0	0	0	0	0
65	233100	32	4.02	4.52	4.27	2.4E-06	2.7E-06	2.5E-06
117	419400	91	4.52	5.23	4.88	3.7E-07	5.3E-07	4.5E-07
140	504900	128	4.78	5.76	5.27	4.2E-07	8.5E-07	6.3E-07
188	677700	164	4.99	6.13	5.56	1.7E-07	2.9E-07	2.3E-07
242	872100	215	5.23	6.38	5.80	1.7E-07	1.8E-07	1.7E-07
290	1044000	266	5.39	6.62	6.01	1.3E-07	2.0E-07	1.6E-07
					Mean	2.2E-07	3.8E-07	
					S	1.3E-07	3.2E-07	

Time (h)	Time (s)	Time mid-int, (h)	Mass increase (g) C4-A	C4-B	Average	Moisture flux (kg/sm2) C4-A	C4-B	Average
0	0	0	0	0	0	0	0	0
48	172800	24	4.19	3.84	4.02	3.3E-06	3.1E-06	3.2E-06
124	446400	86	5.15	4.30	4.72	4.8E-07	2.3E-07	3.5E-07
174	626400	149	5.48	4.63	5.05	2.5E-07	2.6E-07	2.5E-07
222	799200	198	5.75	4.95	5.35	2.2E-07	2.5E-07	2.4E-07
290	1044000	256	6.25	5.47	5.86	2.8E-07	2.9E-07	2.9E-07
					Mean	3.1E-07	2.6E-07	
					S	1.2E-07	2.7E-08	

Time (h)	Time (s)	Time mid-int, (h)	Mass increase (g) C5-1	C5-2	Average	Moisture flux (kg/sm2) C5-1	C5-2	Average
0	0	0	0	0	0	0	0	0
65	233100	32	5.08	5.17	5.12	3.0E-06	3.0E-06	3.0E-06
117	419400	91	5.91	6.04	5.97	6.1E-07	6.4E-07	6.3E-07
140	504900	128	6.40	6.64	6.52	7.9E-07	9.6E-07	8.8E-07
188	677700	164	6.70	6.95	6.83	2.4E-07	2.5E-07	2.5E-07
242	872100	215	6.99	7.32	7.15	2.0E-07	2.6E-07	2.3E-07
290	1044000	266	7.25	7.69	7.47	2.1E-07	2.9E-07	2.5E-07
					Mean	3.6E-07	4.4E-07	
					S	2.9E-07	3.5E-07	

			Mass increase (g)			Moisture flux (kg/sm2)		
Time (h)	Time (s)	Time (s/2)	P6-1	P6-2	Average	P6-1	P6-2	Average
0	0	0	0	0	0	0	0	0
48	172800	24	2.01	1.86	1.93	1.6E-06	1.5E-06	1.5E-06
124	446400	86	2.78	2.56	2.67	3.9E-07	3.5E-07	3.7E-07
174	626400	149	3.27	2.95	3.11	3.8E-07	3.0E-07	3.4E-07
222	799200	198	3.70	3.31	3.51	3.4E-07	2.9E-07	3.1E-07
290	1044000	256	4.22	3.87	4.05	2.9E-07	3.1E-07	3.0E-07
					Mean	3.5E-07	3.1E-07	
					S	4.3E-08	2.7E-08	

			Mass increase (g)			Moisture flux (kg/sm2)		
Time (h)	Time (s)	Time (s/2)	P7-1	P7-2	Average	P7-1	P7-2	Average
0	0	0	0	0	0	0	0	0
65	233100	32	2.26	2.11	2.18	1.3E-06	1.2E-06	1.3E-06
117	419400	91	2.56	2.51	2.54	2.3E-07	2.9E-07	2.6E-07
140	504900	128	2.79	2.72	2.76	3.7E-07	3.4E-07	3.5E-07
188	677700	164	3.05	2.98	3.01	2.1E-07	2.1E-07	2.1E-07
242	872100	215	3.37	3.30	3.34	2.3E-07	2.3E-07	2.3E-07
290	1044000	266	3.68	3.58	3.63	2.5E-07	2.3E-07	2.4E-07
					Mean	2.6E-07	2.5E-07	
					S	7.3E-08	6.0E-08	

Moisture flux - 25 mm layer of water & various hygroscopic sinks:;
OSB, blotter, vacuum cast gypsum, desiccant, & empty container-type C WRB

Start date: 02/09/2001 End date: 12/09/2001

Laboratory conditions
Temperature: 20.8±0.1°C
RH: 40%

OSB SUBSTRATE

	Time (h)	Time (s)	Time (s) (mid-interval)	Mass increase (g)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	16.5	59400	8.3	2.01	1.90	1.93	1.95	4.7E-06	4.4E-06	4.5E-06	4.5E-06
3	39.8	143100	28.1	2.67	2.49	2.52	2.56	1.1E-06	9.7E-07	9.6E-07	1.0E-06
4	80.5	289800	60.1	3.64	3.38	3.46	3.49	9.1E-07	8.4E-07	8.8E-07	8.8E-07
5	184.5	664200	132.5	5.71	5.32	5.47	5.26	6.8E-07	6.4E-07	6.3E-07	6.5E-07
6	240.0	864000	212.3	6.37	5.93	5.99	6.10	5.9E-07	5.6E-07	5.6E-07	5.7E-07
							Mean	3.3E-06	3.0E-06	3.0E-06	
							S	2.2E-07	1.9E-07	1.9E-07	

EMPTY CONTAINER (30 mm)

	Time (h)	Time (s)	Time (h) (mid-int.)	Mass increase (g)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	28	99000	14	1.04	1.04	1.05	1.04	1.4E-06	1.4E-06	1.5E-06	1.4E-06
3	52	185400	40	1.09	1.10	1.16	1.12	7.3E-08	1.0E-07	1.7E-07	1.2E-07
4	92	331200	72	1.29	1.32	1.28	1.30	1.9E-07	2.1E-07	1.2E-07	1.7E-07
5	196	706500	144	2.32	1.61	1.77	1.90	3.8E-07	1.0E-07	1.8E-07	2.2E-07
6	250	900000	223	2.65	1.76	1.91	2.11	2.3E-07	1.1E-07	1.0E-07	1.5E-07
							Mean	8.7E-07	5.2E-07	5.7E-07	
							S	1.3E-07	5.0E-08	3.7E-08	

BLOTTER

				Mass increase (g)				Moisture flux (kg/sm2)			
	Time (h)	Time (s)	Time int.	C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	24	86400	12	2.80	3.18	2.90	2.99	4.5E-06	5.1E-06	4.6E-06	4.8E-06
3	72	259200	48	3.47	4.27	4.13	3.87	5.3E-07	8.7E-07	9.8E-07	7.0E-07
4	120	432000	96	3.85	4.86	4.35	4.36	3.0E-07	4.7E-07	1.7E-07	3.9E-07
5	144	518400	132	3.89	4.99	4.56	4.44	6.2E-08	2.1E-07	3.3E-07	1.4E-07
6	192	691200	168	4.16	5.25	4.72	4.70	2.1E-07	2.0E-07	1.3E-07	2.1E-07
7	240	864000	216	4.25	5.34	5.02	4.79	7.3E-08	7.6E-08	2.4E-07	7.4E-08
							Mean	3.5E-07	4.8E-07	7.0E-07	
							S	8.4E-08	7.5E-08	1.0E-07	

VACUUM CAST GYPSUM

				Mass increase (g)				Moisture flux (kg/sm2)			
	Time (h)	Time (s)	Time int.	C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	48	172800	24	3.52	3.37	3.25	3.38	2.8E-06	2.7E-06	2.6E-06	2.7E-06
3	72	259200	60	4.73	4.45	4.59	4.59	1.9E-06	1.7E-06	2.1E-06	1.8E-06
4	120	432000	96	5.57	5.19	5.38	5.38	6.7E-07	5.9E-07	6.3E-07	6.3E-07
5	168	604800	144	6.67	5.82	6.27	6.25	8.7E-07	5.0E-07	7.1E-07	6.9E-07
6	192	691200	180	7.02	6.16	6.49	6.56	5.6E-07	5.5E-07	3.5E-07	5.5E-07
7	240	864000	216	8.03	7.14	7.34	7.50	8.0E-07	7.8E-07	6.8E-07	7.9E-07
							Mean	2.2E-06	1.8E-06	1.7E-06	
							S	1.6E-07	1.5E-07	2.0E-07	

DESICCANT

	Time (h)	Time (s)	Time (h) (mid-int.)	Mass increase (g)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	25.75	92700	12.875	3.84	3.90	3.84	3.86	5.7E-06	5.8E-06	5.7E-06	5.7E-06
3	51.25	184500	38.5	8.16	8.18	7.83	8.06	6.5E-06	6.4E-06	6.0E-06	6.3E-06
4	75.75	272700	63.5	12.44	12.28	11.90	12.21	6.7E-06	6.4E-06	6.3E-06	6.5E-06
5	132.5	477000	104.125	19.43	19.34	19.38	19.38	4.7E-06	4.7E-06	5.0E-06	4.8E-06
6	168.5	606600	150.5	25.13	24.95	24.89	24.99	6.0E-06	6.0E-06	5.8E-06	5.9E-06
7	219.75	791100	194.125	32.12	31.32	32.23	31.89	5.2E-06	4.7E-06	5.5E-06	5.1E-06
8	274.5	988200	247.125	39.45	38.35	40.33	39.38	5.1E-06	4.9E-06	5.6E-06	5.2E-06
							Mean	5.7E-06	5.5E-06	5.7E-06	
							S	5.1E-07	6.6E-07	1.8E-07	

Moisture flux - 25 mm layer of water & various hygroscopic sinks:;
OSB, blotter, vacuum cast gypsum, desiccant, & empty container - type P WRB

Start date: 02/09/2001

End date: 12/09/2001

Laboratory conditions
Temperature: 20.8±0.1°C
RH: 40%

OSB SUBSTRATE

	Time (h)	Time (s)	Time (s) (mid-minterval)	Mass increase (g)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	17	59400	8	0.91	0.82	0.85	0.86	2.1E-06	1.9E-06	2.0E-06	2.0E-06
3	40	143100	28	1.32	1.19	1.24	1.25	6.7E-07	6.1E-07	6.4E-07	6.4E-07
4	81	289800	60	2.64	1.79	1.85	2.09	1.2E-06	5.6E-07	5.8E-07	7.9E-07
5	185	664200	133	3.43	2.95	3.00	3.13	2.9E-07	4.3E-07	4.2E-07	3.8E-07
6	240	864000	212	3.88	3.50	3.57	3.65	3.1E-07	3.8E-07	3.9E-07	3.6E-07
							Mean	2.5E-06	2.0E-06	2.0E-06	
							S	4.5E-07	1.1E-07	1.2E-07	

EMPTY CONTAINER (30 mm)

	Time (h)	Time (s)	Time (h) (mid-int.)	Mass increase (g)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	27.5	99000	13.75	0.11	0.09	0.06	0.09	1.5E-07	1.3E-07	8.0E-08	1.2E-07
3	51.5	185400	39.5	0.12	0.10	0.08	0.10	2.1E-08	3.2E-09	3.8E-08	2.1E-08
4	92	331200	71.75	0.22	0.16	0.10	0.16	8.7E-08	6.5E-08	1.7E-08	5.6E-08
5	196.25	706500	144.125	0.24	0.22	0.21	0.22	9.5E-09	2.0E-08	4.0E-08	2.3E-08
6	250	900000	223.125	0.31	0.29	0.28	0.29	4.6E-08	4.8E-08	5.3E-08	4.9E-08
							Mean	1.6E-07	1.4E-07	1.5E-07	
							S	3.4E-08	2.8E-08	1.5E-08	

BLOTTER

				Mass increase (g)				Moisture flux (kg/sm2)			
	Time (h)	Time (s)	Time int.	6-A	6-B	6-C	Average	6-A	6-B	6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	24	86400	12	1.74	1.80	1.68	1.74	2.8E-06	2.9E-06	2.7E-06	2.8E-06
3	72	259200	48	2.14	2.20	2.08	2.14	3.2E-07	3.2E-07	3.2E-07	3.2E-07
4	120	432000	96	2.68	3.09	2.58	2.78	4.3E-07	7.1E-07	4.0E-07	5.7E-07
5	144	518400	132	2.75	3.33	3.03	3.03	1.1E-07	3.7E-07	7.2E-07	2.4E-07
6	192	691200	168	2.84	3.62	3.41	3.29	7.9E-08	2.4E-07	3.0E-07	1.6E-07
7	240	864000	216	2.93	3.70	3.52	3.38	6.9E-08	6.1E-08	8.7E-08	6.5E-08
							Mean	6.8E-07	1.4E-06	1.5E-06	
							S	1.7E-07	2.8E-07	2.6E-07	

VACUUM CAST GYPSUM

				Mass increase (g)				Moisture flux (kg/sm2)			
	Time (h)	Time (s)	Time int.	P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	48	172800	24	3.56	4.79	4.24	4.20	2.8E-06	3.8E-06	3.3E-06	3.3E-06
3	72	259200	60	4.83	6.50	5.47	5.60	2.0E-06	2.7E-06	2.4E-06	2.4E-06
4	120	432000	96	5.75	7.76	6.32	6.61	7.2E-07	1.0E-06	8.6E-07	8.6E-07
5	168	604800	144	6.15	7.88	7.21	7.08	3.2E-07	9.6E-08	2.1E-07	2.1E-07
6	192	691200	180	6.32	8.41	7.54	7.42	2.8E-07	8.4E-07	5.6E-07	5.6E-07
7	240	864000	216	6.95	9.01	7.96	7.97	5.0E-07	4.8E-07	4.9E-07	4.9E-07
							Mean	1.8E-06	2.4E-06	2.1E-06	
							S	2.0E-07	4.0E-07	2.7E-07	

DESICCANT

	Time (h)	Time (s)	Time (h) (mid-int.)	Mass increase (g)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	26	92700	13	3.32	3.50	3.74	3.52	4.9E-06	5.2E-06	5.5E-06	5.2E-06
3	51	184500	39	6.73	7.11	7.83	7.23	5.1E-06	5.4E-06	6.1E-06	5.5E-06
4	76	272700	64	10.08	10.52	11.77	10.79	5.2E-06	5.3E-06	6.1E-06	5.5E-06
5	133	477000	104	15.77	16.17	18.17	16.70	3.8E-06	3.8E-06	4.3E-06	4.0E-06
6	169	606600	151	20.38	21.09	23.31	21.59	4.9E-06	5.2E-06	5.4E-06	5.2E-06
7	220	791100	194	26.39	27.52	30.27	28.06	4.5E-06	4.8E-06	5.2E-06	4.8E-06
8	275	988200	247	32.53	34.62	37.69	34.95	4.3E-06	4.9E-06	5.2E-06	4.8E-06
							Mean	1.7E-05	1.9E-05	2.0E-05	
							S	4.4E-07	6.2E-07	5.0E-07	

Ruggedness study-effect of parameters on

Start date: 10/10/2001

:

End date: 23/10/2001

Laboratory conditions
Temperature: 20.1±0.1
RH: 33%

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				$C4\text{-}A_{1A}$	$C4\text{-}B_{1B}$	Average	$C4\text{-}A_{1A}$	$C4\text{-}B_{1B}$	Average
1	0	0	0	0	0	0	0	0	0
2	24	87300	12	4.43	4.31	4.37	5.1E-05	4.9E-05	5.0E-05
3	49	176400	37	6.51	6.51	6.51	2.3E-05	2.5E-05	2.4E-05
4	67	241200	58	7.42	7.91	7.66	1.4E-05	2.2E-05	1.8E-05
5	88	315900	77	7.95	9.01	8.48	7.1E-06	1.5E-05	1.1E-05
6	130	468000	109	8.48	9.67	9.08	3.5E-06	4.4E-06	3.9E-06
7	144	517212	137	8.53	11.09	9.81	1.1E-06	2.9E-05	1.5E-05
8	181	652500	162	8.78	11.73	10.26	1.8E-06	4.7E-06	3.3E-06
9	193	693900	187	8.93	12.31	10.62	3.6E-06	1.4E-05	8.9E-06
10	215	774000	204	9.15	12.42	10.79	2.7E-06	1.4E-06	2.1E-06
11	235	845712	225	9.54	13.29	11.41	5.3E-06	1.2E-05	8.7E-06
12	259	933624	247	10.00	13.67	11.83	5.2E-06	4.3E-06	4.8E-06
13	281	1012824	270	10.52	13.81	12.17	6.6E-06	1.8E-06	4.2E-06
						Mean	3.7E-06	8.9E-06	
						S	1.9E-06	9.3E-06	

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				$C4\text{-}A_{2A}$	$C4\text{-}B_{2B}$	Average	$C4\text{-}A_{2A}$	$C4\text{-}B_{2B}$	Average
1	0	0	0	0	0	0	0	0	0
2	22	77400	11	2.85	2.82	2.83	3.7E-05	3.6E-05	3.7E-05
3	47	168300	34	5.05	4.98	5.01	2.4E-05	2.4E-05	2.4E-05
4	64	230400	55	6.48	6.26	6.37	2.3E-05	2.1E-05	2.2E-05
5	85	305100	74	7.73	7.47	7.60	1.7E-05	1.6E-05	1.6E-05
6	127	458388	106	9.59	9.18	9.39	1.2E-05	1.1E-05	1.2E-05
7	141	506088	134	10.03	9.57	9.80	9.2E-06	8.1E-06	8.6E-06
8	179	642600	160	10.98	10.51	10.74	6.9E-06	6.9E-06	6.9E-06
9	190	684000	184	11.22	10.76	10.99	5.9E-06	6.1E-06	6.0E-06
10	212	763200	201	11.60	11.13	11.36	4.8E-06	4.6E-06	4.7E-06
11	232	835200	222	11.94	11.46	11.70	4.7E-06	4.6E-06	4.7E-06
12	257	923400	244	12.37	11.86	12.11	4.8E-06	4.6E-06	4.7E-06
13	279	1002600	268	12.76	12.28	12.52	5.0E-06	5.2E-06	5.1E-06
						Mean	6.7E-06	6.4E-06	
						S	2.7E-06	2.3E-06	

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				$C4\text{-}A_{3A}$	$C4\text{-}B_{3B}$	Average	$C4\text{-}A_{3A}$	$C4\text{-}B_{3B}$	Average
1	0	0	0	0	0	0	0	0	0
2	47	170100	24	1.58	1.73	1.65	9.3E-06	1.0E-05	9.7E-06
3	86	308088	66	2.72	2.97	2.84	8.2E-06	9.0E-06	8.6E-06
4	142	509688	114	4.15	4.65	4.40	7.1E-06	8.3E-06	7.7E-06
5	191	686988	166	5.48	6.20	5.84	7.5E-06	8.7E-06	8.1E-06
6	233	838800	212	6.65	7.51	7.08	7.7E-06	8.7E-06	8.2E-06
7	280	1006488	256	7.88	8.84	8.36	7.4E-06	7.9E-06	7.6E-06
						Mean	5.9E-06	6.6E-06	
						S	3.1E-06	3.4E-06	

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				$C4\text{-}A_{4A}$	$C4\text{-}B_{4B}$	Average	$C4\text{-}A_{4A}$	$C4\text{-}B_{4B}$	Average
1	0	0	0	0	0	0	0	0	0
2	48	172800	24	2.08	2.24	2.16	1.2E-05	1.3E-05	1.2E-05
3	86	311112	67	3.33	3.53	3.43	9.1E-06	9.3E-06	9.2E-06
4	142	512100	114	5.05	5.33	5.19	8.5E-06	9.0E-06	8.7E-06
5	192	689688	167	6.57	6.75	6.66	8.6E-06	8.0E-06	8.3E-06
6	234	841788	213	7.61	7.88	7.74	6.8E-06	7.4E-06	7.1E-06
7	280	1009476	257	8.56	8.81	8.69	5.7E-06	5.6E-06	5.6E-06
						Mean	6.3E-06	6.5E-06	
						S	3.8E-06	4.0E-06	

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				C4-A_{5A}	C4-B_{5B}	Average	C4-A_{5A}	C4-B_{5B}	Average
1	0	0	0	0	0	0	0	0	0
2	22	78300	11	2.20	2.29	2.25	2.8E-05	2.9E-05	2.9E-05
3	47	168300	34	3.99	4.00	3.99	2.0E-05	1.9E-05	1.9E-05
4	64	231300	56	5.29	4.98	5.13	2.1E-05	1.6E-05	1.8E-05
5	85	306000	75	6.41	5.74	6.07	1.5E-05	1.0E-05	1.3E-05
6	128	461088	107	7.83	6.70	7.26	9.1E-06	6.2E-06	7.7E-06
7	142	509976	135	8.12	7.01	7.56	6.0E-06	6.2E-06	6.1E-06
8	179	645588	160	8.85	7.94	8.39	5.4E-06	6.9E-06	6.1E-06
9	191	686088	185	9.12	8.23	8.67	6.6E-06	7.2E-06	6.9E-06
10	212	764100	201	9.70	8.81	9.25	7.4E-06	7.4E-06	7.4E-06
11	233	837612	222	10.26	9.32	9.79	7.7E-06	6.9E-06	7.3E-06
12	257	923724	245	10.90	9.94	10.42	7.5E-06	7.3E-06	7.4E-06
13	279	1004436	268	11.47	10.52	10.99	7.0E-06	7.1E-06	7.0E-06
						Mean	7.1E-06	6.9E-06	
						S	1.2E-06	4.6E-07	

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				C4-A_{6A}	C4-B_{6B}	Average	C4-A_{6A}	C4-B_{6B}	Average
1	0	0	0	0	0	0	0	0	0
2	47	169200	24	4.63	4.77	4.70	2.7E-05	2.8E-05	2.8E-05
3	86	307800	66	7.97	8.25	8.11	2.4E-05	2.5E-05	2.5E-05
4	142	509400	114	12.24	12.41	12.33	2.1E-05	2.1E-05	2.1E-05
5	191	686700	166	14.98	14.30	14.64	1.5E-05	1.1E-05	1.3E-05
6	233	839988	212	18.02	16.64	17.33	2.0E-05	1.5E-05	1.8E-05
7	280	1007388	257	20.81	18.71	19.76	1.7E-05	1.2E-05	1.5E-05
						Mean	1.6E-05	1.4E-05	
						S	8.9E-06	9.6E-06	

	Time (h)	Time (s)	Time (s) (mid-int.)	Mass increase (g)			Moisture flux (kg/sm2)		
				C4-A_{7A}	C4-B_{7B}	Average	C4-A_{7A}	C4-B_{7B}	Average
1	0	0	0	0	0	0	0	0	0
2	48	172800	24	1.50	1.46	1.48	8.7E-06	8.5E-06	8.6E-06
3	99	355500	73	2.88	3.59	3.24	7.5E-06	1.2E-05	9.6E-06
4	143	513900	121	4.51	5.49	5.00	1.0E-05	1.2E-05	1.1E-05
5	192	691200	167	6.02	6.85	6.43	8.5E-06	7.7E-06	8.1E-06
6	234	843912	213	7.61	8.39	8.00	1.0E-05	1.0E-05	1.0E-05
7	281	1011312	258	9.00	9.82	9.41	8.3E-06	8.6E-06	8.4E-06
						Mean	6.7E-06	7.3E-06	
						S	3.5E-06	4.0E-06	

Moisture flux - various water heads 25 mm, 50 mm, 100 mm with empty bottom container (30 mm) high

Start date: 01/11/2001

End date: 11/11/2001

Laboratory conditions
Temperature: 21.0±0.1°C
RH: 39%

TRANSMISSION COEFFICIENT CALCULATED WITH HYDROSTATIC PRESSURE AS THE DRIVING FORCE

		Time (mid-	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
Time (h)	Time (s)	interval)	C4-1(25)	C4-2(25)	C4-3(25)	Average	C4-1(25)	C4-2(25)	C4-3(25)	Average	C4-1(25)	C4-2(25)	C4-3(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.81	0.82	0.83	0.82	6.7E-07	6.8E-07	6.9E-07	6.8E-07	2.7E-09	2.7E-09	2.8E-09	2.7E-09
91.5	329400	69	1.03	1.09	1.02	1.05	1.8E-07	2.3E-07	1.6E-07	1.9E-07	7.4E-10	9.1E-10	6.4E-10	7.6E-10
144	518400	118	1.15	1.21	1.22	1.19	8.7E-08	8.7E-08	1.5E-07	1.1E-07	3.5E-10	3.5E-10	5.8E-10	4.3E-10
189	680400	167	1.29	1.34	1.4	1.34	1.2E-07	1.1E-07	1.5E-07	1.3E-07	4.7E-10	4.4E-10	6.1E-10	5.1E-10
240	864000	215	1.44	1.49	1.54	1.49	1.1E-07	1.1E-07	1.0E-07	1.1E-07	4.5E-10	4.5E-10	4.2E-10	4.4E-10
						Mean	1.3E-07	1.3E-07	1.4E-07	1.3E-07	5.0E-10	5.4E-10	5.6E-10	5.3E-10
						S	4.2E-08	6.3E-08	2.5E-08	3.9E-08	1.7E-10	2.5E-10	9.8E-11	1.6E-10

		Time (mid-	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
Time (h)	Time (s)	interval)	C4-1(50)	C4-2(50)	C4-3(50)	Average	C4-1(50)	C4-2(50)	C4-3(50)	Average	C4-1(50)	C4-2(50)	C4-3(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.89	0.94	0.88	0.90	7.4E-07	7.8E-07	7.3E-07	7.5E-07	1.5E-09	1.6E-09	1.5E-09	1.5E-09
92	329400	69	1.08	1.18	1.07	1.11	1.6E-07	2.0E-07	1.6E-07	1.7E-07	3.2E-10	4.0E-10	3.2E-10	3.5E-10
144	518400	118	1.28	1.36	1.29	1.31	1.5E-07	1.3E-07	1.6E-07	1.5E-07	2.9E-10	2.6E-10	3.2E-10	2.9E-10
189	680400	167	1.35	1.5	1.52	1.46	5.9E-08	1.2E-07	2.0E-07	1.2E-07	1.2E-10	2.4E-10	3.9E-10	2.5E-10
240	864000	215	1.48	1.71	1.73	1.64	9.7E-08	1.6E-07	1.6E-07	1.4E-07	1.9E-10	3.1E-10	3.1E-10	2.7E-10
						Mean	1.2E-07	1.5E-07	1.7E-07	1.5E-07	2.3E-10	3.0E-10	3.4E-10	2.9E-10
						S	4.6E-08	3.7E-08	1.8E-08	2.1E-08	9.2E-11	7.3E-11	3.6E-11	4.1E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g) C4-1(100)	C4-2(100)	C4-3(100)	Average	Moisture flux (kg/sm2) C4-1(100)	C4-2(100)	C4-3(100)	Average	Coefficient of transmission (kg/Pasm2) C4-1(100)	C4-2(100)	C4-3(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.93	0.96	0.91	0.93	7.7E-07	8.0E-07	7.5E-07	7.7E-07	7.7E-10	8.0E-10	7.5E-10	7.7E-10
92	329400	69	1.11	1.18	1.19	1.16	1.5E-07	1.8E-07	2.3E-07	1.9E-07	1.5E-10	1.8E-10	2.3E-10	1.9E-10
144	518400	118	1.51	1.48	1.43	1.47	2.9E-07	2.2E-07	1.7E-07	2.3E-07	2.9E-10	2.2E-10	1.7E-10	2.3E-10
189	680400	167	1.74	1.71	1.63	1.69	2.0E-07	2.0E-07	1.7E-07	1.9E-07	2.0E-10	2.0E-10	1.7E-10	1.9E-10
240	864000	215	1.94	1.9	1.83	1.89	1.5E-07	1.4E-07	1.5E-07	1.5E-07	1.5E-10	1.4E-10	1.5E-10	1.5E-10
						Mean	2.0E-07	1.8E-07	1.8E-07	1.9E-07	2.0E-10	1.8E-10	1.8E-10	1.9E-10
						S	6.6E-08	3.2E-08	3.7E-08	3.3E-08	6.6E-11	3.2E-11	3.7E-11	3.3E-11

Time (h)	Time (s)	Time (s) (mid-int)	Mass increase (g) C4-A-250	C4-B-250	C4-C-250	Average	Moisture flux (kg/sm2) C4-A-250	C4-B-250	C4-C-250	Average	Coefficient (kg/Pasm2) C4-A-250	C4-B-250	C4-C-250	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	167400	23	2.26	1.73	2.14	2.04	1.9E-06	1.4E-06	1.8E-06	1.7E-06	7.4E-10	5.7E-10	7.0E-10	6.7E-10
120	432000	83	2.45	2.18	2.26	2.30	9.9E-08	2.3E-07	6.2E-08	1.3E-07	3.9E-11	9.3E-11	2.5E-11	5.3E-11
184	660600	152	2.62	2.47	2.59	2.56	1.0E-07	1.7E-07	2.0E-07	1.6E-07	4.1E-11	7.0E-11	7.9E-11	6.3E-11
238	857700	211	3.05	2.99	2.91	2.98	3.0E-07	3.6E-07	2.2E-07	3.0E-07	1.2E-10	1.4E-10	8.9E-11	1.2E-10
254	912600	246	3.12	3.08	2.99	3.06	1.8E-07	2.3E-07	2.0E-07	2.0E-07	7.0E-11	9.0E-11	8.0E-11	8.0E-11
						Mean	1.7E-07	2.5E-07	1.7E-07	2.0E-07	6.8E-11	1.0E-10	6.8E-11	
						S	9.4E-08	8.0E-08	7.3E-08	StDev	3.8E-11	3.2E-11	2.9E-11	

TRANSMISSION COEFFICIENT CALCULATED WITH PARTIAL VAPOUR PRESSURE AS THE DRIVING FORCE

		Time (mid-	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
Time (h)	Time (s)	interval)	C4-A(25)	C4-B(25)	C4-C(25)	Average	C4-A(25)	C4-B(25)	C4-C(25)	Average	C4-A(25)	C4-B(25)	C4-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.81	0.82	0.83	0.82	6.7E-07	6.8E-07	6.9E-07	6.8E-07	2.4E-10	2.4E-10	2.5E-10	2.4E-10
92	329400	69	1.03	1.09	1.02	1.05	1.8E-07	2.3E-07	1.6E-07	1.9E-07	6.6E-11	8.1E-11	5.7E-11	6.8E-11
144	518400	118	1.15	1.21	1.22	1.19	8.7E-08	8.7E-08	1.5E-07	1.1E-07	3.1E-11	3.1E-11	5.2E-11	3.8E-11
189	680400	167	1.29	1.34	1.4	1.34	1.2E-07	1.1E-07	1.5E-07	1.3E-07	4.2E-11	3.9E-11	5.4E-11	4.5E-11
240	864000	215	1.44	1.49	1.54	1.49	1.1E-07	1.1E-07	1.0E-07	1.1E-07	4.0E-11	4.0E-11	3.7E-11	3.9E-11
						Mean	1.3E-07	1.3E-07	1.4E-07	1.3E-07	4.5E-11	4.8E-11	5.0E-11	4.7E-11
						S	4.2E-08	6.3E-08	2.5E-08	3.9E-08	1.5E-11	2.2E-11	8.7E-12	1.4E-11

		Time (mid-	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
Time (h)	Time (s)	interval)	C4-A(50)	C4-B(50)	C4-C(50)	Average	C4-A(50)	C4-B(50)	C4-C(50)	Average	C4-A (50)	C4-B(50)	C4-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.89	0.94	0.88	0.90	7.4E-07	7.8E-07	7.3E-07	7.5E-07	2.6E-10	2.8E-10	2.6E-10	2.7E-10
92	329400	69	1.08	1.18	1.07	1.11	1.6E-07	2.0E-07	1.6E-07	1.7E-07	5.7E-11	7.2E-11	5.7E-11	6.2E-11
144	518400	118	1.28	1.36	1.29	1.31	1.5E-07	1.3E-07	1.6E-07	1.5E-07	5.2E-11	4.7E-11	5.7E-11	5.2E-11
189	680400	167	1.35	1.5	1.52	1.46	5.9E-08	1.2E-07	2.0E-07	1.2E-07	2.1E-11	4.2E-11	6.9E-11	4.4E-11
240	864000	215	1.48	10.71	1.73	4.64	9.7E-08	6.9E-06	1.6E-07	2.4E-06	3.5E-11	2.5E-09	5.6E-11	8.5E-10
						Mean	1.2E-07	1.8E-06	1.7E-07	7.1E-07	4.1E-11	6.5E-10	6.0E-11	2.5E-10
						S	4.6E-08	3.4E-06	1.8E-08	1.1E-06	1.6E-11	1.2E-09	6.5E-12	4.0E-10

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g) C4-A(100)	C4-B(100)	C4-C(100)	Average	Moisture flux (kg/sm2) C4-A(100)	C4-B(100)	C4-C(100)	Average	Coefficient of transmission (kg/Pasm2) C4-A(100)	C4-B(100)	C4-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.93	0.96	0.91	0.93	7.7E-07	8.0E-07	7.5E-07	7.7E-07	2.7E-10	2.8E-10	2.7E-10	2.8E-10
92	329400	69	1.11	1.18	1.19	1.16	1.5E-07	1.8E-07	2.3E-07	1.9E-07	5.4E-11	6.6E-11	8.4E-11	6.8E-11
144	518400	118	1.51	1.48	1.43	1.47	2.9E-07	2.2E-07	1.7E-07	2.3E-07	1.0E-10	7.8E-11	6.2E-11	8.1E-11
189	680400	167	1.74	1.71	1.63	1.69	2.0E-07	2.0E-07	1.7E-07	1.9E-07	6.9E-11	6.9E-11	6.0E-11	6.6E-11
240	864000	215	1.94	1.9	1.83	1.89	1.5E-07	1.4E-07	1.5E-07	1.5E-07	5.3E-11	5.1E-11	5.3E-11	5.2E-11
						Mean	2.0E-07	1.8E-07	1.8E-07	1.9E-07	7.0E-11	6.6E-11	6.5E-11	6.7E-11
						S	6.6E-08	3.2E-08	3.7E-08	3.3E-08	2.4E-11	1.1E-11	1.3E-11	1.2E-11

Time (h)	Time (s)	Time (s) (mid-int)	Mass increase (g) C4-A(250)	C4-B(250)	C4-C(250)	Average	Moisture flux (kg/sm2) C4-A(250)	C4-B(250)	C4-C(250)	Average	Coefficient (kg/Pasm2) C4-A(250)	C4-B(250)	C4-C(250)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	167400	23	2.26	1.73	2.14	2.04	1.9E-06	1.4E-06	1.8E-06	1.7E-06	7.4E-10	5.7E-10	7.0E-10	6.7E-10
120	432000	83	2.45	2.18	2.26	2.30	9.9E-08	2.3E-07	6.2E-08	1.3E-07	3.9E-11	9.3E-11	2.5E-11	5.3E-11
184	660600	152	2.62	2.47	2.59	2.56	1.0E-07	1.7E-07	2.0E-07	1.6E-07	4.1E-11	7.0E-11	7.9E-11	6.3E-11
238	857700	211	3.05	2.99	2.91	2.98	3.0E-07	3.6E-07	2.2E-07	3.0E-07	1.2E-10	1.4E-10	8.9E-11	1.2E-10
254	912600	246	3.12	3.08	2.99	3.06	1.8E-07	2.3E-07	2.0E-07	2.0E-07	7.0E-11	9.0E-11	8.0E-11	8.0E-11
						Mean	1.7E-07	2.5E-07	1.7E-07	2.0E-07	6.8E-11	1.0E-10	6.8E-11	
						S	9.4E-08	8.0E-08	7.3E-08	StDev	3.8E-11	3.2E-11	2.9E-11	

TRANSMISSION COEFFICIENT CALCULATED WITH HYDROSTATIC PRESSURE AS THE DRIVING FORCE

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.12	0.12	0.1	0.11	1.0E-07	1.0E-07	8.3E-08	9.4E-08	4.0E-10	4.0E-10	3.3E-10	3.8E-10
92	329400	69	0.2	0.2	0.19	0.20	6.7E-08	6.7E-08	7.5E-08	7.0E-08	2.7E-10	2.7E-10	3.0E-10	2.8E-10
144	518400	118	0.25	0.22	0.22	0.23	3.6E-08	1.5E-08	2.2E-08	2.4E-08	1.5E-10	5.8E-11	8.7E-11	9.7E-11
189	680400	167	0.29	0.24	0.27	0.27	3.4E-08	1.7E-08	4.2E-08	3.1E-08	1.4E-10	6.8E-11	1.7E-10	1.2E-10
240	864000	215	0.34	0.27	0.31	0.31	3.7E-08	2.2E-08	3.0E-08	3.0E-08	1.5E-10	9.0E-11	1.2E-10	1.2E-10
						Mean	4.4E-08	3.0E-08	4.2E-08	3.9E-08	1.7E-10	1.2E-10	1.7E-10	1.6E-10
						S	1.6E-08	2.5E-08	2.4E-08	2.1E-08	6.3E-11	9.9E-11	9.4E-11	8.4E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.12	0.16	0.19	0.16	1.0E-07	1.3E-07	1.6E-07	1.3E-07	2.0E-10	2.7E-10	3.2E-10	2.6E-10
92	329400	69	0.26	0.27	0.31	0.28	1.2E-07	9.2E-08	1.0E-07	1.0E-07	2.3E-10	1.8E-10	2.0E-10	2.1E-10
144	518400	118	0.3	0.35	0.34	0.33	2.9E-08	5.8E-08	2.2E-08	3.6E-08	5.8E-11	1.2E-10	4.4E-11	7.3E-11
189	680400	167	0.33	0.42	0.37	0.37	2.5E-08	5.9E-08	2.5E-08	3.7E-08	5.1E-11	1.2E-10	5.1E-11	7.3E-11
240	864000	215	0.38	0.49	0.4	0.42	3.7E-08	5.2E-08	2.2E-08	3.7E-08	7.5E-11	1.0E-10	4.5E-11	7.5E-11
						Mean	5.2E-08	6.6E-08	4.3E-08	5.3E-08	1.0E-10	1.3E-10	8.5E-11	1.1E-10
						S	4.4E-08	1.8E-08	3.9E-08	3.3E-08	8.7E-11	3.6E-11	7.7E-11	6.7E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(100)	P6-B(100)	P6-C(100)	Average	P6-A(100)	P6-B(100)	P6-C(100)	Average	P6-A(100)	P6-B(100)	P6-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.25	0.22	0.17	0.21	2.1E-07	1.8E-07	1.4E-07	1.8E-07	2.1E-10	1.8E-10	1.4E-10	1.8E-10
92	329400	69	0.44	0.41	0.47	0.44	1.6E-07	1.6E-07	2.5E-07	1.9E-07	1.6E-10	1.6E-10	2.5E-10	1.9E-10
144	518400	118	0.58	0.51	0.6	0.56	1.0E-07	7.3E-08	9.4E-08	9.0E-08	1.0E-10	7.3E-11	9.4E-11	9.0E-11
189	680400	167	0.72	0.62	0.74	0.69	1.2E-07	9.3E-08	1.2E-07	1.1E-07	1.2E-10	9.3E-11	1.2E-10	1.1E-10
240	864000	215	0.86	0.75	0.87	0.83	1.0E-07	9.7E-08	9.7E-08	1.0E-07	1.0E-10	9.7E-11	9.7E-11	1.0E-10
						Mean	1.2E-07	1.1E-07	1.4E-07	1.2E-07	1.2E-10	1.1E-10	1.4E-10	1.2E-10
						S	2.7E-08	3.7E-08	7.5E-08	4.6E-08	2.7E-11	3.7E-11	7.5E-11	4.6E-11

Time (h)	Time (s)	Time (s) (mid-int)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient (kg/Pasm2)			
			P6-A(250)	P6-B(250)	P6-C(250)	Average	P6-A(250)	P6-B(250)	P6-C(250)	Average	P6-A(250)	P6-B(250)	P6-C(250)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	167400	23	1.24	1.26	1.28	1.26	1.0E-06	1.0E-06	1.1E-06	1.0E-06	4.1E-09	4.1E-09	4.2E-09	4.1E-09
120	432000	83	1.85	1.68	2.02	1.85	3.2E-07	2.2E-07	3.8E-07	3.1E-07	1.3E-09	8.7E-10	1.5E-09	1.2E-09
184	660600	152	2.25	1.93	3.1	2.43	2.4E-07	1.5E-07	6.5E-07	3.5E-07	9.6E-10	6.0E-10	2.6E-09	1.4E-09
238	857700	211	2.6	2.4	3.2	2.73	2.4E-07	3.3E-07	7.0E-08	2.1E-07	9.8E-10	1.3E-09	2.8E-10	8.5E-10
254	912600	246	2.65	2.44	3.21	2.77	1.3E-07	1.0E-07	2.5E-08	8.3E-08	5.0E-10	4.0E-10	1.0E-10	3.3E-10
						Mean	2.3E-07	2.0E-07	2.8E-07	2.4E-07	9.3E-10	8.0E-10	1.1E-09	
						S	7.9E-08	9.8E-08	2.9E-07	StDev	3.2E-10	3.9E-10	1.2E-09	

TRANSMISSION COEFFICIENT CALCULATED WITH PARTIAL VAPOUR PRESSURE AS THE DRIVING FORCE- 30 mm COLLECTION CONTAINER

		Time (mid-	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
Time (h)	Time (s)	interval)	C4-1(25)	C4-2(25)	C4-3(25)	Average	C4-1(25)	C4-2(25)	C4-3(25)	Average	C4-1(25)	C4-2(25)	C4-3(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.81	0.82	0.83	0.82	6.7E-07	6.8E-07	6.9E-07	6.8E-07	2.4E-10	2.4E-10	2.5E-10	2.4E-10
92	329400	69	1.03	1.09	1.02	1.05	1.8E-07	2.3E-07	1.6E-07	1.9E-07	6.6E-11	8.1E-11	5.7E-11	6.8E-11
144	518400	118	1.15	1.21	1.22	1.19	8.7E-08	8.7E-08	1.5E-07	1.1E-07	3.1E-11	3.1E-11	5.2E-11	3.8E-11
189	680400	167	1.29	1.34	1.4	1.34	1.2E-07	1.1E-07	1.5E-07	1.3E-07	4.2E-11	3.9E-11	5.4E-11	4.5E-11
240	864000	215	1.44	1.49	1.54	1.49	1.1E-07	1.1E-07	1.0E-07	1.1E-07	4.0E-11	4.0E-11	3.7E-11	3.9E-11
						Mean	1.3E-07	1.3E-07	1.4E-07	1.3E-07	4.5E-11	4.8E-11	5.0E-11	4.7E-11
						S	4.2E-08	6.3E-08	2.5E-08	3.9E-08	1.5E-11	2.2E-11	8.7E-12	1.4E-11

		Time (mid-	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
Time (h)	Time (s)	interval)	C4-1(50)	C4-2(50)	C4-3(50)	Average	C4-1(50)	C4-2(50)	C4-3(50)	Average	C4-1(50)	C4-2(50)	C4-3(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.89	0.94	0.88	0.90	7.4E-07	7.8E-07	7.3E-07	7.5E-07	2.6E-10	2.8E-10	2.6E-10	2.7E-10
92	329400	69	1.08	1.18	1.07	1.11	1.6E-07	2.0E-07	1.6E-07	1.7E-07	5.7E-11	7.2E-11	5.7E-11	6.2E-11
144	518400	118	1.28	1.36	1.29	1.31	1.5E-07	1.3E-07	1.6E-07	1.5E-07	5.2E-11	4.7E-11	5.7E-11	5.2E-11
189	680400	167	1.35	1.5	1.52	1.46	5.9E-08	1.2E-07	2.0E-07	1.2E-07	2.1E-11	4.2E-11	6.9E-11	4.4E-11
240	864000	215	1.48	10.71	1.73	4.64	9.7E-08	6.9E-06	1.6E-07	2.4E-06	3.5E-11	2.5E-09	5.6E-11	8.5E-10
						Mean	1.2E-07	1.8E-06	1.7E-07	7.1E-07	4.1E-11	6.5E-10	6.0E-11	2.5E-10
						S	4.6E-08	3.4E-06	1.8E-08	1.1E-06	1.6E-11	1.2E-09	6.5E-12	4.0E-10

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A(100)	C4-B(100)	C4-C(100)	Average	C4-A(100)	C4-B(100)	C4-C(100)	Average	C4-A(100)	C4-B(100)	C4-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.93	0.96	0.91	0.93	7.7E-07	8.0E-07	7.5E-07	7.7E-07	2.7E-10	2.8E-10	2.7E-10	2.8E-10
92	329400	69	1.11	1.18	1.19	1.16	1.5E-07	1.8E-07	2.3E-07	1.9E-07	5.4E-11	6.6E-11	8.4E-11	6.8E-11
144	518400	118	1.51	1.48	1.43	1.47	2.9E-07	2.2E-07	1.7E-07	2.3E-07	1.0E-10	7.8E-11	6.2E-11	8.1E-11
189	680400	167	1.74	1.71	1.63	1.69	2.0E-07	2.0E-07	1.7E-07	1.9E-07	6.9E-11	6.9E-11	6.0E-11	6.6E-11
240	864000	215	1.94	1.9	1.83	1.89	1.5E-07	1.4E-07	1.5E-07	1.5E-07	5.3E-11	5.1E-11	5.3E-11	5.2E-11
						Mean	2.0E-07	1.8E-07	1.8E-07	1.9E-07	7.0E-11	6.6E-11	6.5E-11	6.7E-11
						S	6.6E-08	3.2E-08	3.7E-08	3.3E-08	2.4E-11	1.1E-11	1.3E-11	1.2E-11

TRANSMISSION COEFFICIENT CALCULATED WITH PARTIAL VAPOUR PRESSURE AS THE DRIVING FORCE- 30 mm COLLECTION CONTAINER

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.12	0.12	0.1	0.11	1.0E-07	1.0E-07	8.3E-08	9.4E-08	3.5E-11	3.5E-11	3.0E-11	3.3E-11
92	329400	69	0.2	0.2	0.19	0.20	6.7E-08	6.7E-08	7.5E-08	7.0E-08	2.4E-11	2.4E-11	2.7E-11	2.5E-11
144	518400	118	0.25	0.22	0.22	0.23	3.6E-08	1.5E-08	2.2E-08	2.4E-08	1.3E-11	5.2E-12	7.8E-12	8.6E-12
189	680400	167	0.29	0.24	0.27	0.27	3.4E-08	1.7E-08	4.2E-08	3.1E-08	1.2E-11	6.0E-12	1.5E-11	1.1E-11
240	864000	215	0.34	0.27	0.31	0.31	3.7E-08	2.2E-08	3.0E-08	3.0E-08	1.3E-11	8.0E-12	1.1E-11	1.1E-11
						Mean	4.4E-08	3.0E-08	4.2E-08	3.9E-08	1.6E-11	1.1E-11	1.5E-11	1.4E-11
						S	1.6E-08	2.5E-08	2.4E-08	2.1E-08	5.6E-12	8.8E-12	8.4E-12	7.5E-12

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.12	0.16	0.19	0.16	1.0E-07	1.3E-07	1.6E-07	1.3E-07	3.5E-11	4.7E-11	5.6E-11	4.6E-11
92	329400	69	0.26	0.27	0.31	0.28	1.2E-07	9.2E-08	1.0E-07	1.0E-07	4.2E-11	3.3E-11	3.6E-11	3.7E-11
144	518400	118	0.3	0.35	0.34	0.33	2.9E-08	5.8E-08	2.2E-08	3.6E-08	1.0E-11	2.1E-11	7.8E-12	1.3E-11
189	680400	167	0.33	0.42	0.37	0.37	2.5E-08	5.9E-08	2.5E-08	3.7E-08	9.1E-12	2.1E-11	9.1E-12	1.3E-11
240	864000	215	0.38	0.49	0.4	0.42	3.7E-08	5.2E-08	2.2E-08	3.7E-08	1.3E-11	1.9E-11	8.0E-12	1.3E-11
						Mean	5.2E-08	6.6E-08	4.3E-08	5.3E-08	1.9E-11	2.3E-11	1.5E-11	1.9E-11
						S	4.4E-08	1.8E-08	3.9E-08	3.3E-08	1.6E-11	6.4E-12	1.4E-11	1.2E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(100)	P6-B(100)	P6-C(100)	Average	P6-A(100)	P6-B(100)	P6-C(100)	Average	P6-A(100)	P6-B(100)	P6-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.25	0.22	0.17	0.21	2.1E-07	1.8E-07	1.4E-07	1.8E-07	7.4E-11	6.5E-11	5.0E-11	6.3E-11
92	329400	69	0.44	0.41	0.47	0.44	1.6E-07	1.6E-07	2.5E-07	1.9E-07	5.7E-11	5.7E-11	9.0E-11	6.8E-11
144	518400	118	0.58	0.51	0.6	0.56	1.0E-07	7.3E-08	9.4E-08	9.0E-08	3.6E-11	2.6E-11	3.4E-11	3.2E-11
189	680400	167	0.72	0.62	0.74	0.69	1.2E-07	9.3E-08	1.2E-07	1.1E-07	4.2E-11	3.3E-11	4.2E-11	3.9E-11
240	864000	215	0.86	0.75	0.87	0.83	1.0E-07	9.7E-08	9.7E-08	1.0E-07	3.7E-11	3.5E-11	3.5E-11	3.6E-11
						Mean	1.2E-07	1.1E-07	1.4E-07	1.2E-07	4.3E-11	3.8E-11	5.0E-11	4.4E-11
						S	2.7E-08	3.7E-08	7.5E-08	4.6E-08	9.4E-12	1.3E-11	2.7E-11	1.6E-11

TRANSMISSION COEFFICIENT CALCULATED WITH HYDROSTATIC PRESSURE AS THE DRIVING FORCE- 3 mm COLLECTION CONTAINER

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A(25)	C4-B(25)	C4-C(25)	Average	C4-A(25)	C4-B(25)	C4-C(25)	Average	C4-A(25)	C4-B(25)	C4-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.75	0.78	0.86	0.80	6.22E-07	6.47E-07	7.13E-07	6.61E-07	2.49E-09	2.59E-09	2.85E-09	2.64E-09
92	329400	69	0.89	0.91	0.99	0.93	1.17E-07	1.09E-07	1.09E-07	1.12E-07	4.70E-10	4.36E-10	4.36E-10	4.47E-10
144	518400	118	1.01	1.04	1.12	1.06	8.72E-08	9.45E-08	9.45E-08	9.21E-08	3.49E-10	3.78E-10	3.78E-10	3.68E-10
189	680400	167	1.15	1.2	1.25	1.20	1.19E-07	1.36E-07	1.10E-07	1.22E-07	4.75E-10	5.43E-10	4.41E-10	4.86E-10
240	864000	215	1.27	1.33	1.4	1.33	8.98E-08	9.73E-08	1.12E-07	9.98E-08	3.59E-10	3.89E-10	4.49E-10	3.99E-10
						Mean	1.03E-07	1.09E-07	1.06E-07	1.06E-07	4.13E-10	4.36E-10	4.26E-10	4.25E-10
						S	1.71E-08	1.88E-08	8.11E-09	1.30E-08	6.84E-11	7.52E-11	3.25E-11	5.21E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A(50)	C4-B(50)	C4-C(50)	Average	C4-A(50)	C4-B(50)	C4-C(50)	Average	C4-A(50)	C4-B(50)	C4-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.78	0.79	0.75	0.77	6.47E-07	6.55E-07	6.22E-07	6.41E-07	1.3E-09	1.3E-09	1.2E-09	1.3E-09
92	329400	69	1.03	0.99	0.95	0.99	2.10E-07	1.68E-07	1.68E-07	1.82E-07	4.2E-10	3.4E-10	3.4E-10	3.6E-10
144	518400	118	1.16	1.09	1.09	1.11	9.45E-08	7.27E-08	1.02E-07	8.96E-08	1.9E-10	1.5E-10	2.0E-10	1.8E-10
189	680400	167	1.25	1.18	1.17	1.20	7.63E-08	7.63E-08	6.78E-08	7.35E-08	1.5E-10	1.5E-10	1.4E-10	1.5E-10
240	864000	215	1.39	1.27	1.31	1.32	1.05E-07	6.73E-08	1.05E-07	9.23E-08	2.1E-10	1.3E-10	2.1E-10	1.8E-10
						Mean	1.21E-07	9.60E-08	1.11E-07	1.09E-07	2.4E-10	1.9E-10	2.2E-10	2.2E-10
						S	6.01E-08	4.79E-08	4.17E-08	4.90E-08	1.2E-10	9.6E-11	8.3E-11	9.8E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A(100)	C4-B(100)	C4-C(100)	Average	C4-A(100)	C4-B(100)	C4-C(100)	Average	C4-A(100)	C4-B(100)	C4-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.79	0.79	0.91	0.83	6.55E-07	6.55E-07	7.55E-07	6.88E-07	6.6E-10	6.6E-10	7.5E-10	6.9E-10
92	329400	69	1.05	1.04	1.15	1.08	2.18E-07	2.10E-07	2.01E-07	2.10E-07	2.2E-10	2.1E-10	2.0E-10	2.1E-10
144	518400	118	1.26	1.2	1.29	1.25	1.53E-07	1.16E-07	1.02E-07	1.24E-07	1.5E-10	1.2E-10	1.0E-10	1.2E-10
189	680400	167	1.44	1.3	1.39	1.38	1.53E-07	8.48E-08	8.48E-08	1.07E-07	1.5E-10	8.5E-11	8.5E-11	1.1E-10
240	864000	215	1.52	1.39	1.46	1.46	5.99E-08	6.73E-08	5.24E-08	5.99E-08	6.0E-11	6.7E-11	5.2E-11	6.0E-11
						Mean	1.46E-07	1.20E-07	1.10E-07	1.25E-07	1.5E-10	1.2E-10	1.1E-10	1.3E-10
						S	6.51E-08	6.34E-08	6.42E-08	6.25E-08	6.5E-11	6.3E-11	6.4E-11	6.3E-11

TRANSMISSION COEFFICIENT CALCULATED WITH PARTIAL VAPOUR PRESSURE AS THE DRIVING FORCE- 3 mm COLLECTION CONTAINER

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A(25)	C4-B(25)	C4-C(25)	Average	C4-A(25)	C4-B(25)	C4-C(25)	Average	C4-A(25)	C4-B(25)	C4-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.75	0.78	0.86	0.80	6.22E-07	6.47E-07	7.13E-07	6.61E-07	2.2E-10	2.3E-10	2.5E-10	2.4E-10
92	329400	69	0.89	0.91	0.99	0.93	1.17E-07	1.09E-07	1.09E-07	1.12E-07	4.2E-11	3.9E-11	3.9E-11	4.0E-11
144	518400	118	1.01	1.04	1.12	1.06	8.72E-08	9.45E-08	9.45E-08	9.21E-08	3.1E-11	3.4E-11	3.4E-11	3.3E-11
189	680400	167	1.15	1.2	1.25	1.20	1.19E-07	1.36E-07	1.10E-07	1.22E-07	4.2E-11	4.8E-11	3.9E-11	4.3E-11
240	864000	215	1.27	1.33	1.4	1.33	8.98E-08	9.73E-08	1.12E-07	9.98E-08	3.2E-11	3.5E-11	4.0E-11	3.6E-11
						Mean	1.03E-07	1.09E-07	1.06E-07	1.06E-07	3.7E-11	3.9E-11	3.8E-11	3.8E-11
						S	1.71E-08	1.88E-08	8.11E-09	1.30E-08	6.1E-12	6.7E-12	2.9E-12	4.6E-12

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A (50)	C4-B(50)	C4-C(50)	Average	C4-A(50)	C4-B(50)	C4-C(50)	Average	C4-A(50)	C4-B(50)	C4-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.78	0.79	0.75	0.77	6.47E-07	6.55E-07	6.22E-07	6.41E-07	1.3E-09	1.3E-09	1.2E-09	1.3E-09
92	329400	69	1.03	0.99	0.95	0.99	2.10E-07	1.68E-07	1.68E-07	1.82E-07	4.2E-10	3.4E-10	3.4E-10	3.6E-10
144	518400	118	1.16	1.09	1.09	1.11	9.45E-08	7.27E-08	1.02E-07	8.96E-08	1.9E-10	1.5E-10	2.0E-10	1.8E-10
189	680400	167	1.25	1.18	1.17	1.20	7.63E-08	7.63E-08	6.78E-08	7.35E-08	1.5E-10	1.5E-10	1.4E-10	1.5E-10
240	864000	215	1.39	1.27	1.31	1.32	1.05E-07	6.73E-08	1.05E-07	9.23E-08	2.1E-10	1.3E-10	2.1E-10	1.8E-10
						Mean	1.21E-07	9.60E-08	1.11E-07	1.09E-07	2.4E-10	1.9E-10	2.2E-10	2.2E-10
						S	6.01E-08	4.79E-08	4.17E-08	4.90E-08	1.2E-10	9.6E-11	8.3E-11	9.8E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			C4-A(100)	C4-B(100)	C4-C(100)	Average	C4-A(100)	C4-B(100)	C4-C(100)	Average	C4-A(100)	C4-B(100)	C4-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.79	0.79	0.91	0.83	6.55E-07	6.55E-07	7.55E-07	6.88E-07	2.3E-10	2.3E-10	2.7E-10	2.5E-10
92	329400	69	1.05	1.04	1.15	1.08	2.18E-07	2.10E-07	2.01E-07	2.10E-07	2.2E-10	2.1E-10	2.0E-10	2.1E-10
144	518400	118	1.26	1.2	1.29	1.25	1.53E-07	1.16E-07	1.02E-07	1.24E-07	1.5E-10	1.2E-10	1.0E-10	1.2E-10
189	680400	167	1.44	1.3	1.39	1.38	1.53E-07	8.48E-08	8.48E-08	1.07E-07	1.5E-10	8.5E-11	8.5E-11	1.1E-10
240	864000	215	1.52	1.39	1.46	1.46	5.99E-08	6.73E-08	5.24E-08	5.99E-08	6.0E-11	6.7E-11	5.2E-11	6.0E-11
						Mean	1.46E-07	1.20E-07	1.10E-07	1.25E-07	1.5E-10	1.2E-10	1.1E-10	1.3E-10
						S	6.51E-08	6.34E-08	6.42E-08	6.25E-08	6.5E-11	6.3E-11	6.4E-11	6.3E-11

TRANSMISSION COEFFICIENT CALCULATED WITH HYDROSTATIC PRESSURE AS THE DRIVING FORCE- 3 mm COLLECTION CONTAINER

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.08	0.09	0.12	0.10	6.6E-08	7.5E-08	1.0E-07	8.0E-08	2.7E-10	3.0E-10	4.0E-10	3.2E-10
92	329400	69	0.13	0.12	0.14	0.13	4.2E-08	2.5E-08	1.7E-08	2.8E-08	1.7E-10	1.0E-10	6.7E-11	1.1E-10
144	518400	118	0.17	0.16	0.19	0.17	2.9E-08	2.9E-08	3.6E-08	3.1E-08	1.2E-10	1.2E-10	1.5E-10	1.3E-10
189	680400	167	0.2	0.19	0.24	0.21	2.5E-08	2.5E-08	4.2E-08	3.1E-08	1.0E-10	1.0E-10	1.7E-10	1.2E-10
240	864000	215	0.25	0.24	0.29	0.26	3.7E-08	3.7E-08	3.7E-08	3.7E-08	1.5E-10	1.5E-10	1.5E-10	1.5E-10
						Mean	3.3E-08	2.9E-08	3.3E-08	3.2E-08	1.3E-10	1.2E-10	1.3E-10	1.3E-10
						S	7.5E-09	5.7E-09	1.1E-08	3.9E-09	3.0E-11	2.3E-11	4.5E-11	1.6E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.08	0.06	0.09	0.08	6.6E-08	5.0E-08	7.5E-08	6.4E-08	1.3E-10	1.0E-10	1.5E-10	1.3E-10
92	329400	69	0.15	0.17	0.19	0.17	5.9E-08	9.2E-08	8.4E-08	7.8E-08	1.2E-10	1.8E-10	1.7E-10	1.6E-10
144	518400	118	0.25	0.24	0.22	0.24	7.3E-08	5.1E-08	2.2E-08	4.8E-08	1.5E-10	1.0E-10	4.4E-11	9.7E-11
189	680400	167	0.3	0.28	0.26	0.28	4.2E-08	3.4E-08	3.4E-08	3.7E-08	8.5E-11	6.8E-11	6.8E-11	7.3E-11
240	864000	215	0.35	0.31	0.3	0.32	3.7E-08	2.2E-08	3.0E-08	3.0E-08	7.5E-11	4.5E-11	6.0E-11	6.0E-11
						Mean	5.3E-08	5.0E-08	4.2E-08	4.8E-08	1.1E-10	1.0E-10	8.5E-11	9.7E-11
						S	1.6E-08	3.1E-08	2.8E-08	2.1E-08	3.2E-11	6.1E-11	5.6E-11	4.3E-11

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g) P6-A(100)	P6-B(100)	P6-C(100)	Average	Moisture flux (kg/sm2) P6-A(100)	P6-B(100)	P6-C(100)	Average	Coefficient of transmission (kg/Pasm2) P6-A(100)	P6-B(100)	P6-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.2	0.21	0.11	0.17	1.7E-07	1.7E-07	9.1E-08	1.4E-07	1.7E-10	1.7E-10	9.1E-11	1.4E-10
92	329400	69	0.46	0.35	0.25	0.35	2.2E-07	1.2E-07	1.2E-07	1.5E-07	2.2E-10	1.2E-10	1.2E-10	1.5E-10
144	518400	118	0.6	0.51	0.39	0.50	1.0E-07	1.2E-07	1.0E-07	1.1E-07	1.0E-10	1.2E-10	1.0E-10	1.1E-10
189	680400	167	0.63	0.56	0.44	0.54	2.5E-08	4.2E-08	4.2E-08	3.7E-08	2.5E-11	4.2E-11	4.2E-11	3.7E-11
240	864000	215	0.67	0.6	0.49	0.59	3.0E-08	3.0E-08	3.7E-08	3.2E-08	3.0E-11	3.0E-11	3.7E-11	3.2E-11
						Mean	9.4E-08	7.7E-08	7.5E-08	8.2E-08	9.4E-11	7.7E-11	7.5E-11	8.2E-11
						S	9.0E-08	4.7E-08	4.1E-08	5.7E-08	9.0E-11	4.7E-11	4.1E-11	5.7E-11

TRANSMISSION COEFFICIENT CALCULATED WITH PARTIAL VAPOUR PRESSURE AS THE DRIVING FORCE- 3 mm COLLECTION CONTAINER

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average	P6-A(25)	P6-B(25)	P6-C(25)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.08	0.09	0.12	0.10	6.6E-08	7.5E-08	1.0E-07	8.0E-08	2.4E-11	2.7E-11	3.5E-11	2.9E-11
92	329400	69	0.13	0.12	0.14	0.13	4.2E-08	2.5E-08	1.7E-08	2.8E-08	1.5E-11	9.0E-12	6.0E-12	9.9E-12
144	518400	118	0.17	0.16	0.19	0.17	2.9E-08	2.9E-08	3.6E-08	3.1E-08	1.0E-11	1.0E-11	1.3E-11	1.1E-11
189	680400	167	0.2	0.19	0.24	0.21	2.5E-08	2.5E-08	4.2E-08	3.1E-08	9.1E-12	9.1E-12	1.5E-11	1.1E-11
240	864000	215	0.25	0.24	0.29	0.26	3.7E-08	3.7E-08	3.7E-08	3.7E-08	1.3E-11	1.3E-11	1.3E-11	1.3E-11
						Mean	3.3E-08	2.9E-08	3.3E-08	3.2E-08	1.2E-11	1.0E-11	1.2E-11	1.1E-11
						S	7.5E-09	5.7E-09	1.1E-08	3.9E-09	2.7E-12	2.0E-12	4.0E-12	1.4E-12

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average	P6-A(50)	P6-B(50)	P6-C(50)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.08	0.06	0.09	0.08	6.6E-08	5.0E-08	7.5E-08	6.4E-08	2.4E-11	1.8E-11	2.7E-11	2.3E-11
91.5	329400	69	0.15	0.17	0.19	0.17	5.9E-08	9.2E-08	8.4E-08	7.8E-08	2.1E-11	3.3E-11	3.0E-11	2.8E-11
144	518400	118	0.25	0.24	0.22	0.24	7.3E-08	5.1E-08	2.2E-08	4.8E-08	2.6E-11	1.8E-11	7.8E-12	1.7E-11
189	680400	167	0.3	0.28	0.26	0.28	4.2E-08	3.4E-08	3.4E-08	3.7E-08	1.5E-11	1.2E-11	1.2E-11	1.3E-11
240	864000	215	0.35	0.31	0.3	0.32	3.7E-08	2.2E-08	3.0E-08	3.0E-08	1.3E-11	8.0E-12	1.1E-11	1.1E-11
						Mean	5.3E-08	5.0E-08	4.2E-08	4.8E-08	1.9E-11	1.8E-11	1.5E-11	1.7E-11
						S	1.6E-08	3.1E-08	2.8E-08	2.1E-08	5.7E-12	1.1E-11	1.0E-11	7.6E-12

Time (h)	Time (s)	Time (mid-interval)	Mass increase (g)				Moisture flux (kg/sm2)				Coefficient of transmission (kg/Pasm2)			
			P6-A(100)	P6-B(100)	P6-C(100)	Average	P6-A(100)	P6-B(100)	P6-C(100)	Average	P6-A(100)	P6-B(100)	P6-C(100)	Average
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	165600	23	0.2	0.21	0.11	0.17	1.7E-07	1.7E-07	9.1E-08	1.4E-07	5.9E-11	6.2E-11	3.2E-11	5.1E-11
92	329400	69	0.46	0.35	0.25	0.35	2.2E-07	1.2E-07	1.2E-07	1.5E-07	7.8E-11	4.2E-11	4.2E-11	5.4E-11
144	518400	118	0.6	0.51	0.39	0.50	1.0E-07	1.2E-07	1.0E-07	1.1E-07	3.6E-11	4.1E-11	3.6E-11	3.8E-11
189	680400	167	0.63	0.56	0.44	0.54	2.5E-08	4.2E-08	4.2E-08	3.7E-08	9.1E-12	1.5E-11	1.5E-11	1.3E-11
240	864000	215	0.67	0.6	0.49	0.59	3.0E-08	3.0E-08	3.7E-08	3.2E-08	1.1E-11	1.1E-11	1.3E-11	1.2E-11
						Mean	9.4E-08	7.7E-08	7.5E-08	8.2E-08	3.3E-11	2.7E-11	2.7E-11	2.9E-11
						S	9.0E-08	4.7E-08	4.1E-08	5.7E-08	3.2E-11	1.7E-11	1.5E-11	2.0E-11

Modified inverted cup (MIC) - fresh WRB

Start date: 03/12/2001

End date: 16/12/2001

Laboratory conditions
Temperature: 20.4±0.1°C
RH: 25%

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C1-A	C1-B	C1-C	Average	C1-A	C1-B	C1-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	6.3E-03	6.1E-03	6.1E-03	6.2E-03	3.7E-06	3.6E-06	3.6E-06	3.6E-06
3	87	311400	76	8.5E-03	8.4E-03	8.4E-03	8.4E-03	4.0E-06	4.1E-06	4.0E-06	4.0E-06
4	143	516300	115	1.4E-02	1.4E-02	1.4E-02	1.4E-02	3.8E-06	3.6E-06	3.8E-06	3.7E-06
5	195	702900	169	2.0E-02	1.9E-02	1.9E-02	1.9E-02	4.1E-06	3.6E-06	3.5E-06	3.7E-06
6	256	922500	226	2.6E-02	2.5E-02	2.5E-02	2.5E-02	4.1E-06	3.9E-06	3.8E-06	3.9E-06
7	304	1095300	280	3.1E-02	3.0E-02	3.0E-02	3.0E-02	3.6E-06	4.1E-06	3.8E-06	3.8E-06
8	330	1188000	317	3.3E-02	3.2E-02	3.2E-02	3.3E-02	3.9E-06	3.5E-06	4.0E-06	3.8E-06
							Mean	3.9E-06	3.8E-06	3.8E-06	
							S	2.0E-07	2.7E-07	1.7E-07	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C2-A	C2-B	C2-C	Average	C2-A	C2-B	C2-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	8.4E-03	8.4E-03	8.0E-03	8.3E-03	4.9E-06	4.9E-06	4.7E-06	4.8E-06
3	87	311400	76	1.1E-02	1.1E-02	1.1E-02	1.1E-02	4.9E-06	4.3E-06	5.0E-06	4.7E-06
4	143	516300	115	1.8E-02	1.8E-02	1.8E-02	1.8E-02	4.9E-06	4.6E-06	4.7E-06	4.8E-06
5	195	702900	169	2.5E-02	2.4E-02	2.4E-02	2.4E-02	4.7E-06	4.6E-06	4.6E-06	4.6E-06
6	256	922500	226	3.1E-02	3.1E-02	3.2E-02	3.1E-02	4.1E-06	4.7E-06	4.6E-06	4.5E-06
7	304	1095300	280	3.7E-02	3.7E-02	3.7E-02	3.7E-02	4.6E-06	4.7E-06	4.4E-06	4.6E-06
8	330	1188000	317	4.0E-02	4.1E-02	4.0E-02	4.0E-02	4.7E-06	4.7E-06	4.3E-06	4.5E-06
							Mean	4.7E-06	4.6E-06	4.6E-06	
							S	2.9E-07	1.8E-07	2.4E-07	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C3-A	C3-B	C3-C	Average	C3-A	C3-B	C3-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	4.6E-03	4.9E-03	4.4E-03	4.7E-03	2.7E-06	2.9E-06	2.6E-06	2.7E-06
3	87	311400	76	6.1E-03	6.5E-03	6.0E-03	6.2E-03	2.8E-06	2.8E-06	2.7E-06	2.8E-06
4	143	516300	115	9.8E-03	9.7E-03	9.6E-03	9.7E-03	2.4E-06	2.2E-06	2.4E-06	2.3E-06
5	195	702900	169	1.4E-02	1.3E-02	1.3E-02	1.3E-02	2.8E-06	2.6E-06	2.6E-06	2.7E-06
6	256	922500	226	1.8E-02	1.7E-02	1.7E-02	1.7E-02	2.6E-06	2.6E-06	2.5E-06	2.5E-06
7	304	1095300	280	2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.3E-06	2.6E-06	2.8E-06	2.6E-06
8	330	1188000	317	2.2E-02	2.2E-02	2.3E-02	2.2E-02	2.4E-06	2.3E-06	2.8E-06	2.5E-06
							Mean	2.5E-06	2.5E-06	2.7E-06	
							S	1.9E-07	2.3E-07	1.5E-07	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	5.3E-03	5.2E-03	5.3E-03	5.3E-03	3.1E-06	3.0E-06	3.1E-06	3.1E-06
3	87	311400	76	7.4E-03	6.9E-03	7.0E-03	7.1E-03	3.6E-06	3.1E-06	3.0E-06	3.2E-06
4	143	516300	115	1.2E-02	1.1E-02	1.2E-02	1.2E-02	3.3E-06	2.8E-06	3.2E-06	3.1E-06
5	195	702900	169	1.6E-02	1.5E-02	1.6E-02	1.6E-02	3.1E-06	3.2E-06	2.8E-06	3.0E-06
6	256	922500	226	2.1E-02	2.0E-02	2.1E-02	2.1E-02	3.0E-06	2.9E-06	3.2E-06	3.0E-06
7	304	1095300	280	2.6E-02	2.3E-02	2.5E-02	2.5E-02	3.5E-06	2.7E-06	3.1E-06	3.1E-06
8	330	1188000	317	2.8E-02	2.6E-02	2.7E-02	2.7E-02	3.0E-06	3.1E-06	3.2E-06	3.1E-06
							Mean	3.3E-06	3.0E-06	3.1E-06	
							S	2.7E-07	1.8E-07	1.4E-07	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Liquid flux (kg/sm2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	5.9E-03	5.7E-03	5.4E-03	5.7E-03	3.5E-06	3.3E-06	3.2E-06	3.3E-06
3	87	311400	76	7.7E-03	7.6E-03	7.3E-03	7.5E-03	3.2E-06	3.3E-06	3.3E-06	3.3E-06
4	143	516300	115	1.2E-02	1.2E-02	1.2E-02	1.2E-02	3.2E-06	2.9E-06	2.9E-06	3.0E-06
5	195	702900	169	1.7E-02	1.6E-02	1.6E-02	1.6E-02	3.3E-06	3.1E-06	3.1E-06	3.2E-06
6	256	922500	226	2.2E-02	2.1E-02	2.1E-02	2.1E-02	3.2E-06	3.1E-06	2.9E-06	3.1E-06
7	304	1095300	280	2.6E-02	2.5E-02	2.4E-02	2.5E-02	3.0E-06	3.1E-06	2.8E-06	3.0E-06
8	330	1188000	317	2.8E-02	2.7E-02	2.6E-02	2.7E-02	2.9E-06	3.1E-06	2.9E-06	3.0E-06
							Mean	3.1E-06	3.1E-06	3.0E-06	
							S	1.2E-07	1.5E-07	1.9E-07	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	7.0E-03	7.0E-03	7.4E-03	7.1E-03	4.1E-06	4.1E-06	4.3E-06	4.2E-06
3	87	311400	76	9.5E-03	9.5E-03	9.9E-03	9.6E-03	4.4E-06	4.4E-06	4.4E-06	4.4E-06
4	143	516300	115	1.6E-02	1.6E-02	1.6E-02	1.6E-02	4.6E-06	4.5E-06	4.2E-06	4.4E-06
5	195	702900	169	2.3E-02	2.2E-02	2.2E-02	2.2E-02	4.6E-06	4.4E-06	4.5E-06	4.5E-06
6	256	922500	226	3.0E-02	3.0E-02	2.9E-02	2.9E-02	4.4E-06	4.6E-06	4.2E-06	4.4E-06
7	304	1095300	280	3.5E-02	3.5E-02	3.4E-02	3.5E-02	4.4E-06	4.6E-06	4.2E-06	4.4E-06
8	330	1188000	317	3.8E-02	3.8E-02	3.7E-02	3.8E-02	4.4E-06	4.6E-06	4.3E-06	4.4E-06
							Mean	4.5E-06	4.5E-06	4.3E-06	
							S	1.1E-07	9.1E-08	1.4E-07	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				P7-A	P7-B	P7-C	Average	P7-A	P7-B	P7-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	6.3E-03	6.8E-03	6.5E-03	6.5E-03	3.7E-06	4.0E-06	3.8E-06	3.8E-06
3	87	311400	76	8.3E-03	8.9E-03	8.8E-03	8.7E-03	3.5E-06	3.8E-06	4.2E-06	3.9E-06
4	143	516300	115	1.4E-02	1.5E-02	1.5E-02	1.5E-02	3.8E-06	4.0E-06	4.2E-06	4.0E-06
5	195	702900	169	1.9E-02	2.1E-02	2.1E-02	2.0E-02	4.0E-06	4.3E-06	4.1E-06	4.1E-06
6	256	922500	226	2.6E-02	2.7E-02	2.7E-02	2.7E-02	4.0E-06	4.1E-06	4.0E-06	4.1E-06
7	304	1095300	280	3.1E-02	3.2E-02	3.2E-02	3.2E-02	3.8E-06	4.1E-06	4.1E-06	4.0E-06
8	330	1188000	317	3.3E-02	3.5E-02	3.5E-02	3.5E-02	3.9E-06	4.3E-06	4.1E-06	4.1E-06
							Mean	3.9E-06	4.1E-06	4.1E-06	
							S	1.8E-07	1.9E-07	7.8E-08	

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				P8-A	P8-B	P8-C	Average	P8-A	P8-B	P8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	65	234900	33	4.8E-03	5.5E-03	5.3E-03	5.2E-03	2.8E-06	3.2E-06	3.1E-06	3.0E-06
3	87	311400	76	6.6E-03	7.4E-03	7.4E-03	7.1E-03	3.3E-06	3.5E-06	3.8E-06	3.5E-06
4	143	516300	115	1.2E-02	1.2E-02	1.2E-02	1.2E-02	3.3E-06	3.2E-06	3.2E-06	3.2E-06
5	195	702900	169	1.6E-02	1.7E-02	1.7E-02	1.7E-02	3.0E-06	3.6E-06	3.4E-06	3.3E-06
6	256	922500	226	2.0E-02	2.2E-02	2.2E-02	2.1E-02	2.8E-06	3.3E-06	3.2E-06	3.1E-06
7	304	1095300	280	2.4E-02	2.7E-02	2.6E-02	2.6E-02	3.1E-06	3.4E-06	3.2E-06	3.2E-06
8	330	1188000	317	2.6E-02	2.9E-02	2.8E-02	2.8E-02	3.2E-06	3.2E-06	3.6E-06	3.3E-06
							Mean	3.1E-06	3.4E-06	3.4E-06	
							S	2.1E-07	1.6E-07	2.3E-07	

Liquid filtration-250 Pa pressure difference

Start date: Jan 08/2003 End date: Jan 08/2003 Water temperature: 20.2°C

RH: 23%

				Mass increase, g				Liquid flux (kg/sm2)			
No	Time, h	Time, s	Time (int), h	C1-A	C1-B	C1-C	Average	C1-A	C1-B	C1-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	3.156	4.345	4.76	4.1	1.5E-05	2.1E-05	2.3E-05	2.0E-05
3	20.5	73800	13.9	12.063	12.241	11.874	12.1	2.4E-05	2.1E-05	1.9E-05	2.1E-05
4	40.0	144000	30.3	24.408	23.831	22.138	23.5	2.2E-05	2.1E-05	1.9E-05	2.1E-05
5	50.5	181800	45.3	30.864	31.281	28.044	30.1	2.2E-05	2.5E-05	2.0E-05	2.2E-05
6	64.0	230400	57.3	39.211	39.879	35.824	38.3	2.2E-05	2.3E-05	2.0E-05	2.2E-05
7	71.5	257400	67.8	43.881	44.159	40.619	42.9	2.2E-05	2.0E-05	2.3E-05	2.2E-05
8	94.5	340200	83.0	58.331	56.737	54.599	56.6	2.2E-05	1.9E-05	2.2E-05	2.1E-05
							Mean	2.2E-05	2.2E-05	2.0E-05	2.1E-05
							S	7.4E-07	2.0E-06	1.5E-06	5.4E-07

				Mass increase, g				Liquid flux (kg/sm2)			
No	Time, h	Time, s	Time (int), h	C2-A	C2-B	C2-C	Average	C2-A	C2-B	C2-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	4.14	3.205	2.947	3.4	2.0E-05	1.6E-05	1.4E-05	1.7E-05
3	20.5	73800	13.9	10.893	9.324	10.235	10.2	1.8E-05	1.6E-05	1.9E-05	1.8E-05
4	40.0	144000	30.3	20.462	19.113	20.239	19.9	1.7E-05	1.8E-05	1.8E-05	1.8E-05
5	50.5	181800	45.3	25.64	24.402	26.37	25.5	1.7E-05	1.8E-05	2.1E-05	1.9E-05
6	64.0	230400	57.3	32.207	31.047	33.448	32.2	1.7E-05	1.7E-05	1.9E-05	1.8E-05
7	71.5	257400	67.8	35.938	34.944	37.459	36.1	1.8E-05	1.8E-05	1.9E-05	1.8E-05
8	94.5	340200	83.0	46.616	46.334	49.237	47.4	1.6E-05	1.8E-05	1.8E-05	1.7E-05
							Mean	1.7E-05	1.8E-05	1.9E-05	1.8E-05
							S	5.3E-07	6.8E-07	9.7E-07	4.6E-07

No	Time, h	Time, s	Time (int), h	Mass increase, g				Liquid flux (kg/sm2)			
				C3-A	C3-B	C3-C	Average	C3-A	C3-B	C3-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	3.478	3.11	4.796	3.8	1.7E-05	1.5E-05	2.3E-05	1.9E-05
3	20.5	73800	13.9	10.312	9.677	12.114	10.7	1.8E-05	1.8E-05	2.0E-05	1.8E-05
4	40.0	144000	30.3	20.879	19.8	21.623	20.8	1.9E-05	1.8E-05	1.7E-05	1.8E-05
5	50.5	181800	45.3	26.72	25.907	26.921	26.5	2.0E-05	2.1E-05	1.8E-05	1.9E-05
6	64.0	230400	57.3	34.02	33.314	33.913	33.7	1.9E-05	1.9E-05	1.8E-05	1.9E-05
7	71.5	257400	67.8	37.917	37.816	37.801	37.8	1.8E-05	2.1E-05	1.8E-05	1.9E-05
8	94.5	340200	83.0	50.481	49.019	50.29	49.9	1.9E-05	1.7E-05	1.9E-05	1.9E-05
							Mean	1.9E-05	1.9E-05	1.8E-05	1.9E-05
							S	5.6E-07	1.6E-06	8.5E-07	4.6E-07

No	Time, h	Time, s	Time (int), h	Mass increase, g				Liquid flux (kg/sm2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	4.727	3.603	4.459	4.3	2.3E-05	1.8E-05	2.2E-05	2.1E-05
3	20.5	73800	13.9	13.452	10.842	12.31	12.2	2.3E-05	1.9E-05	2.1E-05	2.1E-05
4	40.0	144000	30.3	26.227	22.515	24.425	24.4	2.3E-05	2.1E-05	2.2E-05	2.2E-05
5	50.5	181800	45.3	33.374	28.701	30.435	30.8	2.4E-05	2.1E-05	2.0E-05	2.2E-05
6	64.0	230400	57.3	40.671	36.859	38.149	38.6	1.9E-05	2.1E-05	2.0E-05	2.0E-05
7	71.5	257400	67.8	45.451	40.612	42.597	42.9	2.3E-05	1.8E-05	2.1E-05	2.0E-05
8	94.5	340200	83.0	58.807	53.456	54.81	55.7	2.1E-05	2.0E-05	1.9E-05	2.0E-05
							Mean	2.2E-05	2.0E-05	2.1E-05	2.1E-05
							S	1.9E-06	1.4E-06	1.1E-06	9.3E-07

No	Time, h	Time, s	Time (int), h	Mass increase, g				Liquid flux (kg/sm2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	3.788	5.435	3.554	4.3	1.8E-05	2.7E-05	1.7E-05	2.1E-05
3	20.5	73800	13.9	11.178	13.681	12.545	12.5	2.0E-05	2.2E-05	2.4E-05	2.2E-05
4	40.0	144000	30.3	23.848	24.688	25.219	24.6	2.3E-05	2.0E-05	2.3E-05	2.2E-05
5	50.5	181800	45.3	29.909	30.821	32.473	31.1	2.0E-05	2.1E-05	2.4E-05	2.2E-05
6	64.0	230400	57.3	37.477	39.971	41.184	39.5	2.0E-05	2.4E-05	2.3E-05	2.2E-05
7	71.5	257400	67.8	42.552	45.046	44.849	44.1	2.4E-05	2.4E-05	1.7E-05	2.2E-05
8	94.5	340200	83.0	55.977	58.471	57.413	57.3	2.1E-05	2.1E-05	1.9E-05	2.0E-05
							Mean	2.1E-05	2.2E-05	2.2E-05	2.2E-05
							S	1.8E-06	1.7E-06	2.9E-06	7.2E-07

No	Time, h	Time, s	Time (int), h	Mass increase, g				Liquid flux (kg/sm2)			
				PP9-A	PP9-B	PP9-C	Average	PP9-A	PP9-B	PP9-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	43.345	44.945	43.838	44.0	2.1E-04	2.2E-04	2.1E-04	2.1E-04
3	20.5	73800	13.9	135.801	135.511	132.324	134.5	2.5E-04	2.4E-04	2.4E-04	2.4E-04
4	40.0	144000	30.3	262.307	263.422	255.635	260.5	2.3E-04	2.3E-04	2.2E-04	2.3E-04
5	50.5	181800	45.3	328.628	325.83	315.646	323.4	2.2E-04	2.1E-04	2.0E-04	2.1E-04
6	64.0	230400	57.3	416.651	409.235	401.324	409.1	2.3E-04	2.2E-04	2.2E-04	2.2E-04
7	71.5	257400	67.8	462.041	456.858	452.077	457.0	2.1E-04	2.2E-04	2.4E-04	2.3E-04
8	94.5	340200	83.0	597.471	597.531	589.094	594.7	2.1E-04	2.2E-04	2.1E-04	2.1E-04
							Mean	2.3E-04	2.2E-04	2.2E-04	2.2E-04
							S	1.4E-05	1.1E-05	1.4E-05	1.1E-05

Sorption (adsorption) isotherms - Desiccant, vacuum cast gypsum, blotter & OSB

Start date: 10/02/2002 End date: 05/02/2002 Temperature: 21.1±0.1°C

EQUILIBRIUM MOISTURE CONTENT OF DESICCANT

Equilibrium moisture for desiccant at 32% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	3.42	3.63	3.64	3.56
3	3.73	3.78	3.69	3.73
4	3.81	3.84	3.80	3.82
5	3.83	3.86	3.84	3.84
Moisture content (g/g)	7.6E-02	7.7E-02	7.6E-02	7.6E-02

Equilibrium moisture for desiccant at 52% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	3.96	4.12	4.14	4.07
3	4.50	4.51	4.46	4.49
4	4.59	4.60	4.55	4.58
5	4.62	4.63	4.58	4.61
Moisture content (g/g)	9.2E-02	9.2E-02	9.1E-02	9.2E-02

Equilibrium moisture for desiccant at 75% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	7.86	7.84	7.97	7.89
3	8.75	8.81	8.78	8.78
4	8.92	8.91	8.93	8.92
5	8.96	8.94	8.92	8.94
Moisture content (g/g)	1.8E-01	1.8E-01	1.8E-01	1.8E-01

Equilibrium moisture for desiccant at 84% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	11.22	11.32	11.12	11.22
3	13.64	13.71	13.66	13.67
4	13.90	13.94	13.97	13.94
5	13.92	13.97	14.02	13.97
Moisture content (g/g)	2.8E-01	2.8E-01	2.8E-01	2.8E-01

Equilibrium moisture for desiccant at 93% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	17.20	17.26	17.18	17.21
3	17.97	18.09	18.05	18.04
4	18.32	18.34	18.27	18.31
5	18.38	18.44	18.35	18.39
Moisture content (g/g)	3.7E-01	3.7E-01	3.7E-01	3.7E-01

EQUILIBRIUM MOISTURE CONTENT OF BLOTTER

Equilibrium moisture for blotter at 32% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.02	0.02	0.02	0.02
3	0.03	0.03	0.03	0.03
4	0.03	0.03	0.03	0.03
5	0.03	0.03	0.03	0.03
Moisture content (g/g)	1.9E-03	1.9E-03	1.9E-03	1.9E-03

Equilibrium moisture for blotter at 52% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.03	0.04	0.03	0.03
3	0.06	0.08	0.07	0.07
4	0.11	0.11	0.11	0.11
5	0.12	0.12	0.11	0.12
Moisture content (g/g)	7.7E-03	7.7E-03	7.1E-03	7.5E-03

Equilibrium moisture for blotter at 75% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.14	0.16	0.18	0.16
3	0.26	0.30	0.33	0.30
4	0.39	0.44	0.46	0.43
5	0.42	0.46	0.48	0.45
Moisture content (g/g)	2.7E-02	3.0E-02	3.1E-02	2.9E-02

Equilibrium moisture for blotter at 84% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.34	0.31	0.37	0.34
3	0.79	0.76	0.78	0.78
4	0.89	0.95	0.99	0.94
5	0.94	0.98	1.01	0.98
Moisture content (g/g)	6.0E-02	6.3E-02	6.5E-02	6.3E-02

Equilibrium moisture for blotter at 93% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.82	0.87	0.99	0.89
3	1.41	1.35	1.34	1.37
4	1.54	1.60	1.58	1.57
5	1.57	1.64	1.66	1.62
Moisture content (g/g)	1.0E-01	1.1E-01	1.1E-01	1.0E-01

EQUILIBRIUM MOISTURE CONTENT FOR VACUUM CAST GYPSUM

Equilibrium moisture for vacuum cast gypsum at 32% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.04	0.05	0.04	0.04
3	0.10	0.11	0.08	0.10
4	0.15	0.16	0.13	0.15
5	0.17	0.19	0.15	0.17
Moisture content (g/g)	7.4E-04	8.3E-04	6.5E-04	7.4E-04

Equilibrium moisture for vacuum cast gypsum at 52% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	0.27	0.33	0.26	0.29
3	0.59	0.63	0.61	0.61
4	0.89	0.87	0.90	0.89
5	0.93	0.92	0.95	0.93
Moisture content (g/g)	4.0E-03	4.0E-03	4.1E-03	4.1E-03

Equilibrium moisture for vacuum cast gypsum at 75% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	1.00	1.13	1.05	1.06
3	1.80	1.91	1.79	1.83
4	2.23	1.29	1.21	1.58
5	2.42	2.39	2.37	2.39
Moisture content (g/g)	1.1E-02	1.0E-02	1.0E-02	1.0E-02

Equilibrium moisture for vacuum cast gypsum at 84% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	1.25	1.39	1.44	1.36
3	2.01	2.17	2.06	2.08
4	2.42	2.41	2.38	2.40
5	3.54	3.59	3.53	3.55
Moisture content (g/g)	1.5E-02	1.6E-02	1.5E-02	1.5E-02

Equilibrium moisture for vacuum cast gypsum at 93% RH

No	Mass increase (g)			
	Des-1	Des-2	Des-3	Mean
1	0	0	0	0
2	1.56	1.71	1.67	1.65
3	3.91	3.94	4.10	3.98
4	5.41	5.45	5.49	5.45
5	5.49	5.58	5.61	5.56
Moisture content (g/g)	2.4E-02	2.4E-02	2.4E-02	2.4E-02

Surface tension

Start date: 16/07/2002 End date: 16/07/2002

Temperature of water: 21.0±0.1°C

Surfactant Concentration (%)	Surface tension (N/m)					Mean	S
	A-1	A-2	A-3	A-4	A-5		
100.00	2.95E-02	2.82E-02	2.87E-02	2.89E-02	2.93E-02	2.89E-02	4.6E-04
50.00	2.99E-02	3.11E-02	3.09E-02	3.08E-02	3.13E-02	3.08E-02	4.8E-04
25.00	3.13E-02	3.07E-02	3.19E-02	3.05E-02	3.13E-02	3.11E-02	5.0E-04
6.25	3.37E-02	3.21E-02	3.20E-02	3.18E-02	3.16E-02	3.22E-02	7.5E-04
1.56	3.41E-02	3.33E-02	3.34E-02	3.39E-02	3.40E-02	3.37E-02	3.3E-04
0.39	4.05E-02	3.97E-02	3.98E-02	4.01E-02	4.03E-02	4.01E-02	3.0E-04
0.10	4.66E-02	4.65E-02	4.69E-02	4.62E-02	4.64E-02	4.65E-02	2.3E-04
0.02	6.32E-02	6.40E-02	6.28E-02	6.27E-02	6.39E-02	6.33E-02	5.4E-04

Concentration (%)	Temp (°C)
100.00	23.8
50.00	23.6
25.00	23.2
6.25	23.2
1.56	23.2
0.39	23.2
0.10	23.2
0.02	23.3

Salt solution Concentration (%)	Test readings (N/m)					Mean	S
	A-1	A-2	A-3	A-4	A-5		
100.00	7.50E-02	7.51E-02	7.47E-02	7.49E-02	7.42E-02	7.48E-02	3.2E-04
50.00	7.25E-02	7.41E-02	7.16E-02	7.17E-02	7.26E-02	7.25E-02	9.0E-04
25.00	7.16E-02	7.12E-02	7.21E-02	7.24E-02	7.16E-02	7.18E-02	4.2E-04
6.25	7.10E-02	7.15E-02	7.12E-02	7.10E-02	7.12E-02	7.12E-02	1.8E-04
1.56	7.20E-02	7.19E-02	7.14E-02	7.09E-02	7.13E-02	7.15E-02	4.0E-04
0.39	7.26E-02	7.26E-02	7.28E-02	7.27E-02	7.25E-02	7.26E-02	1.0E-04
0.10	7.21E-02	7.27E-02	7.22E-02	7.17E-02	7.23E-02	7.22E-02	3.2E-04
0.02	7.15E-02	7.25E-02	7.25E-02	7.21E-02	7.25E-02	7.22E-02	3.9E-04

Concentration (%)	Temp (°C)
100.00	23.7
50.00	23.7
25.00	23.7
6.25	24
1.56	23.8
0.39	23.9
0.10	23.6
0.02	23.8

Moisture flux – 25 mm water head and OSB substrate – type C and type PWRB

Start date: 03/03/2002 End date: 19/03/2002

Laboratory conditions
Temperature: 19.8±0.2°C
RH:37%

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	1.6E-03	1.8E-03	1.5E-03	1.6E-03	1.6E-06	1.9E-06	1.5E-06	1.7E-06
3	94	337500	66	2.8E-03	2.7E-03	2.4E-03	2.6E-03	7.9E-07	5.6E-07	6.4E-07	6.6E-07
4	145	521100	119	3.7E-03	3.6E-03	3.3E-03	3.5E-03	7.3E-07	6.9E-07	6.4E-07	6.8E-07
5	212	764100	179	4.8E-03	4.5E-03	4.2E-03	4.5E-03	5.9E-07	5.4E-07	5.0E-07	5.4E-07
6	323	1163700	268	6.4E-03	5.9E-03	5.5E-03	5.9E-03	5.7E-07	4.7E-07	4.6E-07	5.0E-07
7	370	1332000	347	7.2E-03	6.6E-03	6.1E-03	6.6E-03	5.9E-07	5.2E-07	4.7E-07	5.3E-07
							Mean	6.5E-07	5.6E-07	5.4E-07	
							S	9.8E-08	8.0E-08	9.1E-08	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	2.1E-03	2.9E-03	2.2E-03	2.4E-03	2.1E-06	3.0E-06	2.2E-06	2.4E-06
3	94	337500	66	2.7E-03	4.1E-03	2.9E-03	3.2E-03	4.0E-07	8.2E-07	4.7E-07	5.6E-07
4	145	521100	119	2.9E-03	4.9E-03	3.7E-03	3.8E-03	1.9E-07	5.7E-07	6.4E-07	4.6E-07
5	212	764100	179	4.1E-03	6.1E-03	4.6E-03	4.9E-03	6.6E-07	6.6E-07	4.8E-07	6.0E-07
6	323	1163700	268	5.1E-03	7.2E-03	5.7E-03	6.0E-03	3.7E-07	3.8E-07	3.8E-07	3.8E-07
7	370	1332000	347	5.7E-03	7.3E-03	6.4E-03	6.5E-03	4.4E-07	1.1E-07	6.3E-07	3.9E-07
							Mean	4.1E-07	5.1E-07	5.2E-07	
							S	1.7E-07	2.7E-07	1.1E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	9.0E-04	3.7E-04	1.1E-03	7.8E-04	9.2E-07	3.8E-07	1.1E-06	7.9E-07
3	94	337500	66	1.5E-03	1.6E-03	1.9E-03	1.6E-03	3.8E-07	8.1E-07	5.8E-07	5.9E-07
4	145	521100	119	2.3E-03	2.4E-03	2.6E-03	2.4E-03	6.7E-07	5.9E-07	5.2E-07	5.9E-07
5	212	764100	179	3.1E-03	3.0E-03	3.7E-03	3.3E-03	4.2E-07	3.9E-07	6.0E-07	4.7E-07
6	323	1163700	268	4.1E-03	4.1E-03	4.9E-03	4.4E-03	3.4E-07	3.7E-07	4.1E-07	3.7E-07
7	370	1332000	347	4.7E-03	4.6E-03	5.4E-03	4.9E-03	4.9E-07	4.2E-07	4.2E-07	4.4E-07
							Mean	4.6E-07	5.2E-07	5.1E-07	
							S	1.3E-07	1.9E-07	8.7E-08	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	6.7E-04	7.2E-04	7.5E-04	7.1E-04	6.8E-07	7.3E-07	7.6E-07	7.3E-07
3	94	337500	66	1.3E-03	1.4E-03	1.2E-03	1.3E-03	4.0E-07	4.8E-07	3.1E-07	4.0E-07
4	145	521100	119	1.8E-03	2.0E-03	1.7E-03	1.9E-03	4.3E-07	4.5E-07	4.0E-07	4.2E-07
5	212	764100	179	2.4E-03	2.7E-03	2.3E-03	2.4E-03	3.2E-07	3.5E-07	3.2E-07	3.3E-07
6	323	1163700	268	3.3E-03	3.7E-03	3.1E-03	3.3E-03	3.0E-07	3.4E-07	2.8E-07	3.1E-07
7	370	1332000	347	3.6E-03	4.1E-03	3.5E-03	3.7E-03	3.0E-07	3.7E-07	3.0E-07	3.2E-07
							Mean	3.5E-07	4.0E-07	3.2E-07	
							S	6.0E-08	6.3E-08	4.4E-08	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	3.8E-03	9.6E-03	3.4E-03	5.6E-03	2.0E-06	5.0E-06	1.8E-06	2.9E-06
3	121	434700	97	1.2E-02	1.3E-02	7.4E-03	1.1E-02	6.4E-06	2.7E-06	3.1E-06	4.1E-06
4	217	779400	169	2.2E-02	1.9E-02	1.4E-02	1.9E-02	4.2E-06	2.4E-06	2.7E-06	3.1E-06
5	261	940500	239	2.8E-02	2.4E-02	1.6E-02	2.3E-02	4.9E-06	4.1E-06	2.1E-06	3.7E-06
6	309	1113300	285	3.3E-02	2.9E-02	2.0E-02	2.7E-02	3.7E-06	4.0E-06	3.1E-06	3.6E-06
7	370	1332000	340	3.9E-02	3.4E-02	2.5E-02	3.3E-02	3.7E-06	3.2E-06	2.9E-06	3.3E-06
							Mean	4.6E-06	3.3E-06	2.8E-06	
							S	1.1E-06	7.4E-07	4.3E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	5.2E-03	6.8E-03	8.7E-03	6.9E-03	2.7E-06	3.6E-06	4.6E-06	3.6E-06
3	121	434700	97	8.5E-03	1.2E-02	1.6E-02	1.2E-02	2.7E-06	4.1E-06	6.0E-06	4.3E-06
4	217	779400	169	1.1E-02	2.0E-02	2.3E-02	1.8E-02	1.0E-06	3.1E-06	2.7E-06	2.3E-06
5	261	940500	239	1.2E-02	2.4E-02	2.5E-02	2.0E-02	8.8E-07	3.5E-06	1.5E-06	2.0E-06
6	309	1113300	285	1.3E-02	2.8E-02	2.8E-02	2.3E-02	8.6E-07	3.1E-06	2.8E-06	2.2E-06
7	370	1332000	340	1.5E-02	3.3E-02	3.1E-02	2.7E-02	1.1E-06	3.4E-06	1.9E-06	2.1E-06
							Mean	1.3E-06	3.4E-06	3.0E-06	
							S	7.7E-07	4.1E-07	1.8E-06	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	72.75	261900	36.38	2.0E-03	2.0E-03	2.0E-03	2.0E-03	1.0E-06	1.0E-06	1.0E-06	1.0E-06
3	120.75	434700	96.75	4.2E-03	3.3E-03	4.2E-03	3.9E-03	1.7E-06	1.1E-06	1.7E-06	1.5E-06
4	216.5	779400	168.63	6.3E-03	4.3E-03	9.1E-03	6.6E-03	8.7E-07	3.7E-07	1.9E-06	1.1E-06
5	261.25	940500	238.88	6.7E-03	5.8E-03	1.3E-02	8.7E-03	3.4E-07	1.3E-06	3.7E-06	1.8E-06
6	309.25	1113300	285.25	8.6E-03	6.5E-03	1.6E-02	1.0E-02	1.4E-06	5.2E-07	2.0E-06	1.3E-06
7	370	1332000	339.63	1.0E-02	8.1E-03	1.9E-02	1.3E-02	1.1E-06	1.0E-06	2.0E-06	1.4E-06
							Mean	1.3E-06	3.4E-06	3.0E-06	
							S	7.7E-07	4.1E-07	1.8E-06	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	72.75	261900	36.38	1.0E-03	9.4E-04	9.7E-04	9.7E-04	5.3E-07	4.9E-07	5.1E-07	5.1E-07
3	120.75	434700	96.75	2.1E-03	1.9E-03	2.6E-03	2.2E-03	9.0E-07	7.6E-07	1.3E-06	9.8E-07
4	216.5	779400	168.63	3.0E-03	2.6E-03	3.9E-03	3.2E-03	3.3E-07	2.8E-07	5.3E-07	3.8E-07
5	261.25	940500	238.88	4.8E-03	3.2E-03	4.5E-03	4.2E-03	1.6E-06	5.5E-07	5.4E-07	8.9E-07
6	309.25	1113300	285.25	6.5E-03	4.1E-03	5.4E-03	5.3E-03	1.3E-06	6.8E-07	6.8E-07	9.0E-07
7	370	1332000	339.63	7.8E-03	5.2E-03	6.5E-03	6.5E-03	8.0E-07	6.8E-07	7.0E-07	7.2E-07
							Mean	1.3E-06	3.4E-06	3.0E-06	
							S	7.7E-07	4.1E-07	1.8E-06	

Moištrure flux - type C & P WRB - OSB substrate and staple

Start date: 05/04/2002 End date: 20/04/2002

Laboratory conditions
Temperature: 19.8±0.1°C
RH :37%

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	74	265800	37	9.2E-03	1.0E-02	8.4E-03	9.2E-03	4.7E-06	5.2E-06	4.3E-06	4.7E-06
3	126	453000	100	1.6E-02	1.7E-02	1.2E-02	1.5E-02	4.8E-06	5.2E-06	2.8E-06	4.3E-06
4	168	604200	147	1.7E-02	3.2E-02	2.0E-02	2.3E-02	1.2E-06	1.4E-05	6.9E-06	7.3E-06
5	216	777000	192	3.3E-02	4.0E-02	2.8E-02	3.3E-02	1.2E-05	5.7E-06	6.7E-06	8.3E-06
6	264	950400	240	4.6E-02	4.4E-02	3.6E-02	4.2E-02	1.1E-05	3.2E-06	6.4E-06	6.8E-06
7	343	1233300	303	5.2E-02	5.0E-02	4.5E-02	4.9E-02	2.9E-06	3.1E-06	4.4E-06	3.5E-06
8	370	1332000	356	5.4E-02	5.2E-02	4.8E-02	5.1E-02	2.1E-06	3.0E-06	4.2E-06	3.1E-06
							Mean	5.7E-06	5.7E-06	5.2E-06	
							S	4.7E-06	4.2E-06	1.7E-06	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73.8	265800	36.9	2.2E-03	2.1E-03	4.6E-03	2.9E-03	1.1E-06	1.1E-06	2.4E-06	1.5E-06
3	125.8	453000	99.8	2.9E-03	2.9E-03	5.0E-03	3.6E-03	5.7E-07	6.2E-07	3.2E-07	5.0E-07
4	167.8	604200	146.8	4.5E-03	3.6E-03	5.6E-03	4.6E-03	1.4E-06	5.9E-07	5.3E-07	8.4E-07
5	215.8	777000	191.8	4.7E-03	4.0E-03	6.0E-03	4.9E-03	1.8E-07	3.6E-07	3.3E-07	2.9E-07
6	264.0	950400	239.9	5.4E-03	4.6E-03	6.7E-03	5.6E-03	5.1E-07	4.5E-07	5.4E-07	5.0E-07
7	342.6	1233300	303.3	5.7E-03	6.3E-03	7.6E-03	6.5E-03	1.6E-07	8.5E-07	4.3E-07	4.8E-07
8	370.0	1332000	356.3	6.2E-03	6.7E-03	7.8E-03	6.9E-03	6.4E-07	5.0E-07	2.4E-07	4.6E-07
							Mean	5.8E-07	5.6E-07	4.0E-07	
							S	4.6E-07	1.7E-07	1.2E-07	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	74	265800	37	1.1E-03	1.2E-03	1.2E-03	1.2E-03	5.6E-07	6.3E-07	6.4E-07	6.1E-07
3	126	453000	100	1.8E-03	2.1E-03	3.7E-03	2.5E-03	5.0E-07	6.2E-07	1.8E-06	9.8E-07
4	168	604200	147	1.1E-02	4.2E-03	8.0E-03	7.8E-03	8.6E-06	1.9E-06	3.9E-06	4.8E-06
5	216	777000	192	1.8E-02	9.0E-03	1.3E-02	1.4E-02	5.6E-06	3.9E-06	4.3E-06	4.6E-06
6	264	950400	240	3.5E-02	3.0E-02	2.5E-02	3.0E-02	1.3E-05	1.6E-05	8.8E-06	1.3E-05
7	343	1233300	303	4.7E-02	4.4E-02	3.9E-02	4.3E-02	5.6E-06	7.1E-06	7.0E-06	6.6E-06
8	370	1332000	356	5.0E-02	5.3E-02	4.6E-02	5.0E-02	4.7E-06	1.2E-05	9.5E-06	8.8E-06
							Mean	6.4E-06	7.0E-06	5.9E-06	
							S	4.3E-06	6.2E-06	3.0E-06	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	74	265800	37	8.4E-04	4.4E-03	2.0E-03	2.4E-03	4.3E-07	2.3E-06	1.0E-06	1.2E-06
3	126	453000	100	1.5E-03	1.3E-02	5.6E-03	6.6E-03	4.6E-07	6.2E-06	2.6E-06	3.1E-06
4	168	604200	147	1.9E-03	2.6E-02	1.5E-02	1.4E-02	4.0E-07	1.2E-05	8.9E-06	7.0E-06
5	216	777000	192	2.3E-03	3.4E-02	2.6E-02	2.1E-02	3.2E-07	6.5E-06	8.1E-06	5.0E-06
6	264	950400	240	2.8E-03	3.7E-02	3.3E-02	2.4E-02	3.6E-07	2.7E-06	5.8E-06	2.9E-06
7	343	1233300	303	5.3E-03	4.4E-02	4.1E-02	3.0E-02	1.2E-06	3.2E-06	3.8E-06	2.7E-06
8	370	1332000	356	6.6E-03	4.8E-02	4.2E-02	3.2E-02	1.9E-06	5.3E-06	1.7E-06	3.0E-06
							Mean	7.7E-07	5.9E-06	5.2E-06	
							S	6.3E-07	3.2E-06	2.9E-06	

Moisture flux - type C & P WRB - OSB substrate & staple II

Start date: 05/04/2002

End date: 20/04/2002

Laboratory conditions
Temperature: 19.8±0.1°C
RH: 37%

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	9.2E-03	1.1E-02	9.1E-03	9.8E-03	4.8E-06	5.9E-06	4.8E-06	5.2E-06
3	121	434700	97	1.2E-02	2.1E-02	2.0E-02	1.8E-02	2.5E-06	8.2E-06	8.4E-06	6.4E-06
4	217	779400	169	3.1E-02	2.9E-02	3.6E-02	3.2E-02	7.3E-06	3.0E-06	6.4E-06	5.6E-06
5	261	940500	239	3.6E-02	3.6E-02	4.4E-02	3.9E-02	4.4E-06	6.2E-06	6.7E-06	5.8E-06
6	309	1113300	285	4.3E-02	4.5E-02	5.1E-02	4.6E-02	5.6E-06	6.6E-06	5.7E-06	6.0E-06
7	370	1332000	340	5.4E-02	5.7E-02	5.8E-02	5.6E-02	6.9E-06	7.7E-06	4.1E-06	6.2E-06
							Mean	5.3E-06	6.3E-06	6.3E-06	
							S	2.0E-06	2.0E-06	1.6E-06	

No	Time (h)	Time (s)	Time interval (h)	Weight increase (kg)				Transmission rate (kg/s.m2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	3.8E-03	2.6E-03	2.6E-03	3.0E-03	2.0E-06	1.4E-06	1.4E-06	1.6E-06
3	121	434700	97	4.5E-03	3.4E-03	3.7E-03	3.9E-03	6.2E-07	6.4E-07	9.2E-07	7.3E-07
4	217	779400	169	2.0E-02	5.1E-03	5.1E-03	1.0E-02	6.3E-06	6.6E-07	5.4E-07	2.5E-06
5	261	940500	239	2.9E-02	5.6E-03	5.7E-03	1.4E-02	7.6E-06	4.3E-07	5.1E-07	2.8E-06
6	309	1113300	285	3.6E-02	7.4E-03	7.9E-03	1.7E-02	5.4E-06	1.4E-06	1.8E-06	2.9E-06
7	370	1332000	340	4.4E-02	1.0E-02	1.1E-02	2.2E-02	5.1E-06	1.7E-06	1.6E-06	2.8E-06
							Mean	5.0E-06	9.7E-07	1.1E-06	
							S	2.6E-06	5.5E-07	6.0E-07	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	3.1E-03	7.9E-03	7.9E-03	6.3E-03	1.6E-06	4.1E-06	4.1E-06	3.3E-06
3	121	434700	97	8.7E-03	1.0E-02	1.3E-02	1.1E-02	4.5E-06	2.1E-06	3.7E-06	3.4E-06
4	217	779400	169	1.7E-02	2.1E-02	1.9E-02	1.9E-02	3.2E-06	4.3E-06	2.5E-06	3.4E-06
5	261	940500	239	1.9E-02	3.1E-02	2.3E-02	2.4E-02	2.0E-06	8.1E-06	3.1E-06	4.4E-06
6	309	1113300	285	2.1E-02	3.9E-02	2.8E-02	2.9E-02	1.5E-06	6.8E-06	4.0E-06	4.1E-06
7	370	1332000	340	2.4E-02	4.7E-02	3.2E-02	3.4E-02	1.9E-06	5.0E-06	2.7E-06	3.2E-06
							Mean	2.6E-06	5.3E-06	3.2E-06	
							S	1.2E-06	2.3E-06	6.5E-07	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	4.2E-03	7.7E-03	1.2E-03	4.4E-03	2.2E-06	4.1E-06	6.1E-07	2.3E-06
3	121	434700	97	1.5E-02	1.5E-02	1.8E-03	1.1E-02	8.7E-06	5.7E-06	4.8E-07	5.0E-06
4	217	779400	169	3.1E-02	3.4E-02	2.2E-02	2.9E-02	6.1E-06	7.5E-06	8.2E-06	7.3E-06
5	261	940500	239	3.2E-02	3.6E-02	3.3E-02	3.4E-02	1.6E-06	1.9E-06	8.7E-06	4.1E-06
6	309	1113300	285	3.4E-02	3.7E-02	4.4E-02	3.8E-02	1.2E-06	7.1E-07	8.6E-06	3.5E-06
7	370	1332000	340	3.5E-02	3.9E-02	4.5E-02	4.0E-02	4.9E-07	1.5E-06	9.0E-07	9.7E-07
							Mean	3.6E-06	3.5E-06	5.4E-06	
							S	3.6E-06	3.0E-06	4.3E-06	

Moisture flux – 25 mm water head and plywood substrate – type C and type P WRB

Start date: 02/06/2002

End date 17/06/2002

Laboratory conditions
Temperature: 20.4±0.1°C
RH: 40%

No	Time (h)	Time (s)	Time interval (h)	Weight increase (kg)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	1.9E-03	2.5E-03	2.7E-03	2.4E-03	2.0E-06	2.5E-06	2.8E-06	2.4E-06
3	94	337500	66	3.1E-03	3.3E-03	3.8E-03	3.4E-03	7.8E-07	5.4E-07	7.1E-07	6.8E-07
4	145	521100	119	4.3E-03	4.6E-03	4.7E-03	4.5E-03	9.4E-07	9.6E-07	7.3E-07	8.7E-07
5	212	764100	179	5.5E-03	6.0E-03	5.8E-03	5.7E-03	6.5E-07	8.0E-07	5.9E-07	6.8E-07
6	323	1163700	268	7.2E-03	7.8E-03	8.0E-03	7.7E-03	6.0E-07	6.4E-07	7.8E-07	6.7E-07
7	370	1332000	347	8.0E-03	8.7E-03	8.9E-03	8.5E-03	6.4E-07	6.7E-07	6.9E-07	6.7E-07
							Mean	7.2E-07	7.2E-07	7.0E-07	
							S	1.4E-07	1.6E-07	7.1E-08	

No	Time (h)	Time (s)	Time interval (h)	Weight increase (kg)				Moisture flux (kg/s.m2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	2.0E-03	2.5E-03	2.6E-03	2.3E-03	2.0E-06	2.5E-06	2.6E-06	2.4E-06
3	94	337500	66	3.4E-03	3.2E-03	2.9E-03	3.2E-03	9.6E-07	4.8E-07	2.0E-07	5.4E-07
4	145	521100	119	4.3E-03	4.2E-03	4.0E-03	4.1E-03	6.7E-07	7.6E-07	8.1E-07	7.5E-07
5	212	764100	179	5.4E-03	5.2E-03	5.2E-03	5.3E-03	6.1E-07	5.9E-07	7.2E-07	6.4E-07
6	323	1163700	268	7.1E-03	6.8E-03	6.9E-03	6.9E-03	5.9E-07	5.4E-07	5.7E-07	5.7E-07
7	370	1332000	347	7.9E-03	7.5E-03	7.5E-03	7.6E-03	6.6E-07	5.5E-07	5.1E-07	5.7E-07
							Mean	7.0E-07	5.9E-07	5.6E-07	
							S	1.5E-07	1.1E-07	2.3E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-06	1.1E-06	1.0E-06	1.1E-06
3	94	337500	66	2.3E-03	1.7E-03	2.3E-03	2.1E-03	8.6E-07	4.5E-07	8.8E-07	7.3E-07
4	145	521100	119	3.1E-03	2.6E-03	3.4E-03	3.0E-03	6.1E-07	6.4E-07	8.1E-07	6.8E-07
5	212	764100	179	3.9E-03	3.7E-03	4.5E-03	4.1E-03	4.5E-07	6.6E-07	6.4E-07	5.8E-07
6	323	1163700	268	5.5E-03	5.0E-03	6.1E-03	5.5E-03	5.3E-07	4.2E-07	5.3E-07	4.9E-07
7	370	1332000	347	6.0E-03	5.7E-03	7.1E-03	6.3E-03	4.5E-07	6.0E-07	8.7E-07	6.4E-07
							Mean	5.8E-07	5.5E-07	7.4E-07	
							S	1.7E-07	1.1E-07	1.6E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	38	135000	19	7.6E-04	1.0E-03	8.4E-04	8.7E-04	7.7E-07	1.0E-06	8.5E-07	8.9E-07
3	94	337500	66	1.5E-03	2.1E-03	1.7E-03	1.8E-03	5.2E-07	7.1E-07	5.8E-07	6.0E-07
4	145	521100	119	2.2E-03	3.0E-03	2.5E-03	2.6E-03	5.2E-07	6.8E-07	6.0E-07	6.0E-07
5	212	764100	179	2.9E-03	3.9E-03	3.3E-03	3.4E-03	4.1E-07	5.2E-07	4.7E-07	4.7E-07
6	323	1163700	268	4.0E-03	5.2E-03	4.5E-03	4.6E-03	3.6E-07	4.5E-07	4.1E-07	4.1E-07
7	370	1332000	347	4.5E-03	5.8E-03	5.1E-03	5.1E-03	4.2E-07	4.5E-07	4.5E-07	4.4E-07
							Mean	4.5E-07	5.6E-07	5.0E-07	
							S	7.2E-08	1.2E-07	8.3E-08	

Moisture flux - type C & P WRB - plywood substrate & nail for penetration

Start date: 02/06/200 End date: 17/06/2002

Laboratory conditions
Temperature: 19.8±0.1°C
RH: 40%

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	53	189900	26	2.3E-03	6.2E-03	6.4E-03	5.0E-03	1.7E-06	4.5E-06	4.6E-06	3.6E-06
3	102	367200	77	7.0E-03	8.9E-03	1.1E-02	8.9E-03	3.6E-06	2.1E-06	3.4E-06	3.0E-06
4	150	540000	126	8.5E-03	1.0E-02	1.7E-02	1.2E-02	1.2E-06	1.0E-06	4.7E-06	2.3E-06
5	244	878400	197	1.1E-02	1.5E-02	2.4E-02	1.7E-02	1.1E-06	2.0E-06	2.9E-06	2.0E-06
6	288	1036800	266	1.2E-02	1.8E-02	2.6E-02	1.9E-02	7.8E-07	2.3E-06	2.0E-06	1.7E-06
7	370	1332000	329	1.4E-02	2.2E-02	3.0E-02	2.2E-02	8.3E-07	1.8E-06	1.7E-06	1.4E-06
							Mean	1.5E-06	1.8E-06	2.9E-06	
							S	1.2E-06	4.8E-07	1.2E-06	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	53	189900	26	1.1E-02	6.3E-03	7.3E-03	8.2E-03	8.1E-06	4.5E-06	5.2E-06	6.0E-06
3	102	367200	77	1.7E-02	9.4E-03	1.1E-02	1.2E-02	4.3E-06	2.4E-06	2.8E-06	3.2E-06
4	150	540000	126	2.2E-02	1.1E-02	1.6E-02	1.6E-02	3.9E-06	1.6E-06	4.3E-06	3.3E-06
5	244	878400	197	2.4E-02	1.3E-02	2.4E-02	2.0E-02	7.7E-07	6.8E-07	3.0E-06	1.5E-06
6	288	1036800	266	2.6E-02	1.4E-02	2.7E-02	2.2E-02	2.4E-06	5.0E-07	2.8E-06	1.9E-06
7	370	1332000	329	2.9E-02	1.6E-02	3.2E-02	2.6E-02	1.4E-06	9.4E-07	2.5E-06	1.6E-06
							Mean	2.5E-06	1.2E-06	3.1E-06	
							S	1.5E-06	7.9E-07	7.2E-07	

Moisture flux – 25 mm water head and OSB substrate with staples

Start date: 02/06/2002

End date: 17/06/2002

Laboratory conditions
Temperature: 20.4±0.1°C
RH: 40%

No	Time (h)	Time (s)	Time interval (h)	Weight increase (kg)				Moisture flux (kg/s.m2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	74	265800	37	2.3E-03	6.0E-03	1.3E-02	7.1E-03	1.2E-06	3.1E-06	6.7E-06	3.7E-06
3	126	453000	100	3.7E-03	1.0E-02	1.7E-02	1.0E-02	1.0E-06	3.3E-06	3.1E-06	2.5E-06
4	168	604200	147	4.7E-03	1.3E-02	2.0E-02	1.3E-02	9.0E-07	2.3E-06	2.7E-06	2.0E-06
5	216	777000	192	5.6E-03	1.5E-02	2.3E-02	1.4E-02	7.3E-07	1.3E-06	2.0E-06	1.3E-06
6	264	950400	240	6.7E-03	1.5E-02	2.6E-02	1.6E-02	8.3E-07	5.7E-07	2.4E-06	1.3E-06
7	343	1233300	303	7.9E-03	1.6E-02	2.7E-02	1.7E-02	6.2E-07	2.8E-07	8.5E-07	5.8E-07
8	370	1332000	356	8.3E-03	1.6E-02	2.8E-02	1.7E-02	5.3E-07	4.6E-07	9.3E-07	6.4E-07
							Mean	7.2E-07	9.7E-07	1.8E-06	1.2E-06
							S	1.5E-07	8.3E-07	8.3E-07	5.6E-07

No	Time (h)	Time (s)	Time interval (h)	Weight increase (kg)				Moisture flux (kg/s.m2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	74	265800	37	2.3E-03	2.4E-03	2.3E-03	2.3E-03	1.2E-06	1.2E-06	1.2E-06	1.2E-06
3	126	453000	100	3.5E-03	3.6E-03	3.3E-03	3.5E-03	8.6E-07	9.1E-07	7.3E-07	8.3E-07
4	168	604200	147	4.3E-03	-7.2E-04	1.5E-02	6.4E-03	7.8E-07	-3.9E-06	1.1E-05	2.6E-06
5	216	777000	192	5.1E-03	5.4E-03	2.1E-02	1.0E-02	6.4E-07	4.8E-06	4.2E-06	3.2E-06
6	264	950400	240	6.0E-03	6.3E-03	2.6E-02	1.3E-02	6.5E-07	7.6E-07	4.2E-06	1.9E-06
7	343	1233300	303	6.9E-03	7.5E-03	3.2E-02	1.5E-02	4.8E-07	5.7E-07	2.8E-06	1.3E-06
8	370	1332000	356	7.4E-03	8.1E-03	3.4E-02	1.7E-02	5.7E-07	7.9E-07	3.8E-06	1.7E-06
							Mean	6.2E-07	6.1E-07	5.2E-06	2.1E-06
							S	1.1E-07	3.1E-06	3.3E-06	7.8E-07

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	53	189900	26	1.3E-03	2.5E-02	1.5E-03	9.2E-03	9.8E-07	1.8E-05	1.1E-06	6.7E-06
3	102	367200	77	4.3E-03	2.9E-02	2.7E-03	1.2E-02	2.3E-06	3.1E-06	9.1E-07	2.1E-06
4	150	540000	126	5.9E-03	3.3E-02	3.8E-03	1.4E-02	1.2E-06	3.3E-06	8.6E-07	1.8E-06
5	244	878400	197	7.6E-03	3.6E-02	4.8E-03	1.6E-02	7.1E-07	1.3E-06	4.3E-07	8.1E-07
6	288	1036800	266	8.1E-03	3.7E-02	5.4E-03	1.7E-02	4.7E-07	7.2E-07	4.8E-07	5.6E-07
7	370	1332000	329	1.2E-02	3.8E-02	7.4E-03	1.9E-02	1.6E-06	2.3E-07	9.7E-07	9.3E-07
							Mean	1.3E-06	1.7E-06	7.3E-07	
							S	7.2E-07	1.4E-06	2.6E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	53	189900	26	1.1E-02	4.4E-03	9.1E-03	8.3E-03	8.1E-06	3.2E-06	6.6E-06	6.0E-06
3	102	367200	77	1.5E-02	1.5E-02	1.0E-02	1.4E-02	2.9E-06	8.3E-06	9.8E-07	4.1E-06
4	150	540000	126	1.6E-02	1.9E-02	1.6E-02	1.7E-02	8.4E-07	2.7E-06	4.5E-06	2.7E-06
5	244	878400	197	1.7E-02	2.7E-02	2.3E-02	2.2E-02	5.3E-07	3.3E-06	2.7E-06	2.2E-06
6	288	1036800	266	1.8E-02	2.9E-02	2.9E-02	2.5E-02	4.2E-07	1.9E-06	5.1E-06	2.5E-06
7	370	1332000	329	1.9E-02	3.8E-02	3.2E-02	3.0E-02	6.2E-07	4.1E-06	1.5E-06	2.1E-06
							Mean	1.1E-06	4.1E-06	3.0E-06	
							S	1.0E-06	2.5E-06	1.8E-06	

Moisture flux – 25 mm water head and OSB substrate with staples II

Start date: 02/06/2002

End date: 17/06/2002

Laboratory conditions
Temperature: 20.4±0.1°C
RH: 40%

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	2.4E-03	3.0E-03	3.0E-03	2.8E-03	1.3E-06	1.6E-06	1.6E-06	1.5E-06
3	121	434700	97	3.5E-03	4.5E-03	4.5E-03	4.2E-03	8.9E-07	1.2E-06	1.2E-06	1.1E-06
4	217	779400	169	5.0E-03	6.5E-03	6.4E-03	5.9E-03	5.8E-07	8.0E-07	7.7E-07	7.1E-07
5	261	940500	239	5.8E-03	7.5E-03	7.4E-03	6.9E-03	7.1E-07	8.7E-07	8.8E-07	8.2E-07
6	309	1113300	285	6.7E-03	8.4E-03	8.4E-03	7.9E-03	7.2E-07	7.6E-07	7.9E-07	7.6E-07
7	370	1332000	340	7.8E-03	9.6E-03	9.5E-03	9.0E-03	7.1E-07	7.6E-07	7.1E-07	7.3E-07
							Mean	7.2E-07	8.7E-07	8.6E-07	
							S	1.1E-07	1.7E-07	1.8E-07	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/s.m2)			
			interval (h)	C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	2.7E-03	2.9E-03	2.8E-03	2.8E-03	1.4E-06	1.5E-06	1.5E-06	1.5E-06
3	121	434700	97	3.8E-03	4.1E-03	3.8E-03	3.9E-03	8.6E-07	9.3E-07	8.0E-07	8.6E-07
4	217	779400	169	5.2E-03	6.8E-03	5.2E-03	5.8E-03	5.8E-07	1.1E-06	5.6E-07	7.4E-07
5	261	940500	239	6.0E-03	8.4E-03	5.9E-03	6.8E-03	6.5E-07	1.3E-06	6.1E-07	8.6E-07
6	309	1113300	285	6.7E-03	1.0E-02	7.0E-03	8.0E-03	5.2E-07	1.6E-06	8.5E-07	9.9E-07
7	370	1332000	340	7.7E-03	1.3E-02	8.2E-03	9.5E-03	6.4E-07	1.3E-06	7.7E-07	9.1E-07
							Mean	6.5E-07	1.3E-06	7.2E-07	
							S	1.3E-07	2.5E-07	1.2E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	1.4E-02	5.8E-03	1.3E-02	1.1E-02	7.3E-06	3.0E-06	6.7E-06	5.7E-06
3	121	434700	97	2.1E-02	9.8E-03	1.6E-02	1.5E-02	5.5E-06	3.2E-06	2.3E-06	3.7E-06
4	217	779400	169	2.8E-02	1.5E-02	1.9E-02	2.1E-02	2.9E-06	2.2E-06	1.5E-06	2.2E-06
5	261	940500	239	2.9E-02	1.8E-02	2.0E-02	2.2E-02	6.2E-07	2.2E-06	3.2E-07	1.1E-06
6	309	1113300	285	2.9E-02	2.0E-02	2.0E-02	2.3E-02	4.0E-07	1.5E-06	1.2E-07	6.9E-07
7	370	1332000	340	3.0E-02	2.0E-02	2.0E-02	2.3E-02	6.6E-07	1.6E-07	1.3E-07	3.2E-07
							Mean	2.0E-06	1.9E-06	8.6E-07	
							S	2.2E-06	1.1E-06	9.8E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/s.m2)			
				C8-A	C8-B	C8-C	Average	C8-A	C8-B	C8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	73	261900	36	7.2E-03	1.5E-02	2.2E-03	8.2E-03	3.8E-06	7.9E-06	1.2E-06	4.3E-06
3	121	434700	97	1.5E-02	2.0E-02	5.5E-03	1.4E-02	6.2E-06	4.1E-06	2.6E-06	4.3E-06
4	217	779400	169	2.0E-02	2.9E-02	1.8E-02	2.3E-02	1.9E-06	3.6E-06	5.2E-06	3.6E-06
5	261	940500	239	2.1E-02	4.1E-02	2.5E-02	2.9E-02	9.5E-07	9.9E-06	5.2E-06	5.3E-06
6	309	1113300	285	2.2E-02	4.7E-02	3.1E-02	3.3E-02	7.7E-07	4.5E-06	5.0E-06	3.4E-06
7	370	1332000	340	2.3E-02	5.8E-02	3.9E-02	4.0E-02	5.4E-07	7.4E-06	5.2E-06	4.4E-06
							Mean	2.1E-06	5.9E-06	4.6E-06	
							S	2.4E-06	2.7E-06	1.1E-06	

Moisture flux-desiccant-25 mm water head and desiccant with weathered WRB membranes (July 27th - November 27th)

Start date: 07/05/2002 End date: 21/05/2002

Laboratory conditions
Temperature: 20.1±0.1°C
RH: 39%

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/sm2)			
			interval (h)	C1-A	C1-B	C1-C	Average	C1-A	C1-B	C1-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	4.6E-03	4.2E-03	4.5E-03	4.4E-03	2.5E-06	2.3E-06	2.5E-06	2.4E-06
3	126	454200	98	8.1E-03	7.4E-03	7.8E-03	7.8E-03	2.3E-06	2.2E-06	2.3E-06	2.3E-06
4	177	637200	152	1.2E-02	1.1E-02	1.1E-02	1.1E-02	2.7E-06	2.5E-06	2.7E-06	2.6E-06
5	241	869100	209	1.6E-02	1.5E-02	1.5E-02	1.5E-02	2.6E-06	2.4E-06	1.9E-06	2.3E-06
6	289	1041900	265	1.9E-02	1.8E-02	1.8E-02	1.9E-02	2.4E-06	2.7E-06	3.0E-06	2.7E-06
7	330	1188000	310	2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.1E-06	2.4E-06	2.8E-06	2.5E-06
							Mean	2.4E-06	2.4E-06	2.5E-06	
							S	2.4E-07	2.1E-07	4.5E-07	

No	Time (h)	Time (s)	Time	Mass increase (kg)				Moisture flux (kg/sm2)			
			interval (h)	C2-A	C2-B	C2-C	Average	C2-A	C2-B	C2-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	3.8E-03	8.4E-03	8.2E-03	6.8E-03	1.9E-06	4.6E-06	4.5E-06	3.7E-06
3	126	454200	98	9.7E-03	1.4E-02	1.4E-02	1.3E-02	3.7E-06	3.8E-06	3.8E-06	3.8E-06
4	177	637200	152	1.6E-02	2.0E-02	2.0E-02	1.9E-02	4.7E-06	4.8E-06	4.5E-06	4.7E-06
5	241	869100	209	2.4E-02	2.8E-02	2.7E-02	2.6E-02	4.1E-06	4.4E-06	4.1E-06	4.2E-06
6	289	1041900	265	3.0E-02	3.4E-02	3.3E-02	3.2E-02	4.5E-06	4.7E-06	4.6E-06	4.6E-06
7	330	1188000	310	3.5E-02	3.9E-02	3.8E-02	3.7E-02	4.5E-06	4.9E-06	4.7E-06	4.7E-06
							Mean	4.3E-06	4.5E-06	4.4E-06	
							S	3.9E-07	4.2E-07	4.0E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/sm2)			
				C3-A	C3-B	C3-C	Average	C3-A	C3-B	C3-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	3.5E-03	3.2E-03	3.3E-03	3.3E-03	1.9E-06	1.7E-06	1.8E-06	1.8E-06
3	126	454200	98	5.7E-03	5.5E-03	5.8E-03	5.6E-03	1.5E-06	1.6E-06	1.7E-06	1.6E-06
4	177	637200	152	8.2E-03	7.9E-03	8.3E-03	8.1E-03	1.9E-06	1.8E-06	1.9E-06	1.9E-06
5	241	869100	209	1.1E-02	1.1E-02	1.1E-02	1.1E-02	1.7E-06	1.7E-06	1.7E-06	1.7E-06
6	289	1041900	265	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.6E-06	2.1E-06	1.8E-06	1.8E-06
7	330	1188000	310	1.4E-02	1.5E-02	1.6E-02	1.5E-02	1.3E-06	1.8E-06	2.1E-06	1.7E-06
							Mean	1.6E-06	1.8E-06	1.8E-06	
							S	2.0E-07	1.9E-07	1.9E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Moisture flux (kg/sm2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	3.6E-03	4.2E-03	2.7E-03	3.5E-03	2.0E-06	2.3E-06	1.5E-06	1.9E-06
3	126	454200	98	6.4E-03	7.3E-03	4.9E-03	6.2E-03	1.9E-06	2.1E-06	1.4E-06	1.8E-06
4	177	637200	152	9.2E-03	1.1E-02	7.0E-03	9.0E-03	2.1E-06	2.5E-06	1.6E-06	2.1E-06
5	241	869100	209	1.2E-02	1.4E-02	9.5E-03	1.2E-02	1.9E-06	2.2E-06	1.5E-06	1.9E-06
6	289	1041900	265	1.5E-02	1.6E-02	1.3E-02	1.5E-02	2.1E-06	1.7E-06	2.6E-06	2.1E-06
7	330	1188000	310	1.8E-02	1.8E-02	1.5E-02	1.7E-02	2.3E-06	1.8E-06	2.3E-06	2.1E-06
							Mean	2.1E-06	2.0E-06	1.9E-06	
							S	1.5E-07	3.4E-07	5.4E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Transmission rate (kg/sm2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	5.2E-03	5.0E-03	5.0E-03	5.1E-03	2.9E-06	2.8E-06	2.7E-06	2.8E-06
3	126	454200	98	8.9E-03	8.9E-03	8.7E-03	8.8E-03	2.5E-06	2.6E-06	2.5E-06	2.5E-06
4	177	637200	152	1.3E-02	1.3E-02	1.3E-02	1.3E-02	2.9E-06	2.9E-06	2.9E-06	2.9E-06
5	241	869100	209	1.7E-02	1.7E-02	1.7E-02	1.7E-02	2.7E-06	2.5E-06	2.6E-06	2.6E-06
6	289	1041900	265	2.1E-02	2.1E-02	2.0E-02	2.1E-02	2.7E-06	3.1E-06	2.5E-06	2.8E-06
7	330	1188000	310	2.4E-02	2.4E-02	2.3E-02	2.3E-02	3.0E-06	2.5E-06	2.3E-06	2.6E-06
							Mean	2.8E-06	2.7E-06	2.6E-06	
							S	1.8E-07	2.5E-07	2.3E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Transmission rate (kg/sm2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	6.4E-03	7.0E-03	7.2E-03	6.9E-03	3.5E-06	3.9E-06	3.9E-06	3.8E-06
3	126	454200	98	1.2E-02	1.3E-02	1.3E-02	1.3E-02	3.8E-06	3.9E-06	3.8E-06	3.8E-06
4	177	637200	152	1.8E-02	1.9E-02	1.9E-02	1.9E-02	4.6E-06	4.5E-06	4.4E-06	4.5E-06
5	241	869100	209	2.4E-02	2.5E-02	2.5E-02	2.5E-02	3.7E-06	3.8E-06	3.8E-06	3.8E-06
6	289	1041900	265	2.9E-02	3.1E-02	3.0E-02	3.0E-02	3.7E-06	4.1E-06	4.0E-06	3.9E-06
7	330	1188000	310	3.3E-02	3.5E-02	3.5E-02	3.4E-02	3.8E-06	4.2E-06	4.2E-06	4.1E-06
							Mean	3.9E-06	4.1E-06	4.0E-06	
							S	3.8E-07	2.6E-07	2.6E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Transmission rate (kg/sm2)			
				P7-A	P7-B	P7-C	Average	P7-A	P7-B	P7-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	6.9E-03	7.9E-03	6.2E-03	7.0E-03	3.8E-06	4.4E-06	3.4E-06	3.8E-06
3	126	454200	98	1.2E-02	1.4E-02	1.2E-02	1.3E-02	3.7E-06	3.9E-06	3.8E-06	3.8E-06
4	177	637200	152	1.9E-02	2.0E-02	1.8E-02	1.9E-02	4.7E-06	4.9E-06	4.8E-06	4.8E-06
5	241	869100	209	2.5E-02	2.7E-02	2.5E-02	2.5E-02	3.7E-06	3.7E-06	3.8E-06	3.7E-06
6	289	1041900	265	3.0E-02	3.4E-02	3.0E-02	3.1E-02	3.9E-06	5.5E-06	4.6E-06	4.7E-06
7	330	1188000	310	3.6E-02	3.9E-02	3.5E-02	3.7E-02	5.3E-06	5.4E-06	4.4E-06	5.0E-06
							Mean	4.3E-06	4.7E-06	4.3E-06	
							S	7.2E-07	8.2E-07	4.5E-07	

No	Time (h)	Time (s)	Time interval (h)	Mass increase (kg)				Transmission rate (kg/sm2)			
				P8-A	P8-B	P8-C	Average	P8-A	P8-B	P8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	69	249900	35	5.4E-03	6.8E-03	6.2E-03	6.1E-03	3.0E-06	3.7E-06	3.4E-06	3.4E-06
3	126	454200	98	1.0E-02	1.1E-02	1.1E-02	1.1E-02	3.1E-06	3.1E-06	3.0E-06	3.1E-06
4	177	637200	152	1.5E-02	1.6E-02	1.5E-02	1.6E-02	3.8E-06	3.8E-06	3.6E-06	3.8E-06
5	241	869100	209	2.1E-02	2.2E-02	2.1E-02	2.1E-02	3.2E-06	3.3E-06	3.2E-06	3.2E-06
6	289	1041900	265	2.4E-02	2.7E-02	2.6E-02	2.6E-02	2.7E-06	4.0E-06	3.9E-06	3.5E-06
7	330	1188000	310	2.8E-02	3.1E-02	2.9E-02	3.0E-02	4.0E-06	3.9E-06	3.3E-06	3.7E-06
							Mean	3.4E-06	3.6E-06	3.4E-06	
							S	5.3E-07	4.1E-07	3.6E-07	

Modified Inverted Cup – 25 mm water head and desiccant with weathered WRB (November 27th-March 27th)

Start date: 07/05/2002

End date: 21/05/2002

Temperature: 20.1±0.1°C
RH: 39%

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C1-A	C1-B	C1-C	Average	C1-A	C1-B	C1-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	4.0E-03	3.9E-03	3.7E-03	3.9E-03	2.6E-06	2.5E-06	2.4E-06	2.5E-06
3	121	436500	91	7.9E-03	7.9E-03	7.8E-03	7.9E-03	2.4E-06	2.5E-06	2.5E-06	2.5E-06
4	167	602100	144	1.1E-02	1.2E-02	1.1E-02	1.2E-02	2.9E-06	3.5E-06	2.8E-06	3.1E-06
5	212	763200	190	1.5E-02	1.6E-02	1.4E-02	1.5E-02	3.0E-06	3.6E-06	2.8E-06	3.2E-06
6	266	955800	239	1.9E-02	1.9E-02	1.8E-02	1.9E-02	2.7E-06	2.2E-06	2.3E-06	2.4E-06
7	313	1127400	289	2.2E-02	2.3E-02	2.1E-02	2.2E-02	2.5E-06	2.5E-06	2.5E-06	2.5E-06
8	330	1188000	322	2.3E-02	2.4E-02	2.2E-02	2.3E-02	2.5E-06	2.4E-06	2.9E-06	2.6E-06
							Mean	2.7E-06	2.8E-06	2.6E-06	2.7E-06
							S	2.5E-07	6.2E-07	2.6E-07	3.3E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C2-A	C2-B	C2-C	Average	C2-A	C2-B	C2-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	6.6E-03	6.8E-03	6.5E-03	6.6E-03	4.2E-06	4.3E-06	4.1E-06	4.2E-06
3	121	436500	91	1.2E-02	1.2E-02	1.2E-02	1.2E-02	3.4E-06	3.4E-06	3.3E-06	3.4E-06
4	167	602100	144	1.8E-02	1.9E-02	1.8E-02	1.8E-02	5.2E-06	5.2E-06	5.3E-06	5.3E-06
5	212	763200	190	2.4E-02	2.4E-02	2.4E-02	2.4E-02	4.7E-06	4.8E-06	4.9E-06	4.8E-06
6	266	955800	239	2.8E-02	2.9E-02	2.8E-02	2.8E-02	3.0E-06	3.1E-06	3.2E-06	3.1E-06
7	313	1127400	289	3.3E-02	3.4E-02	3.3E-02	3.3E-02	3.9E-06	3.9E-06	4.0E-06	4.0E-06
8	330	1188000	322	3.5E-02	3.5E-02	3.6E-02	3.5E-02	3.9E-06	4.3E-06	5.8E-06	4.6E-06
							Mean	4.0E-06	4.1E-06	4.4E-06	4.2E-06
							S	8.2E-07	8.0E-07	1.1E-06	8.5E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C3-A	C3-B	C3-C	Average	C3-A	C3-B	C3-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	3.2E-03	3.2E-03	3.3E-03	3.2E-03	2.0E-06	2.0E-06	2.1E-06	2.0E-06
3	121	436500	91	5.8E-03	5.9E-03	5.9E-03	5.8E-03	1.6E-06	1.7E-06	1.6E-06	1.6E-06
4	167	602100	144	8.1E-03	8.2E-03	8.2E-03	8.2E-03	1.9E-06	1.9E-06	1.9E-06	1.9E-06
5	212	763200	190	1.0E-02	1.0E-02	1.1E-02	1.0E-02	2.0E-06	1.9E-06	2.0E-06	2.0E-06
6	266	955800	239	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.6E-06	1.6E-06	1.6E-06	1.6E-06
7	313	1127400	289	1.5E-02	1.5E-02	1.5E-02	1.5E-02	2.0E-06	2.0E-06	2.0E-06	2.0E-06
8	330	1188000	322	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.4E-06	1.9E-06	1.7E-06	1.7E-06
							Mean	1.7E-06	1.8E-06	1.8E-06	1.8E-06
							S	2.4E-07	1.6E-07	1.8E-07	1.8E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	2.3E-03	2.3E-03	2.5E-03	2.4E-03	1.4E-06	1.3E-06	1.5E-06	1.4E-06
3	121	436500	91	4.8E-03	4.5E-03	4.7E-03	4.7E-03	1.4E-06	1.3E-06	1.3E-06	1.3E-06
4	167	602100	144	6.9E-03	6.4E-03	6.6E-03	6.7E-03	1.6E-06	1.4E-06	1.5E-06	1.5E-06
5	212	763200	190	9.1E-03	8.3E-03	8.6E-03	8.7E-03	1.7E-06	1.5E-06	1.5E-06	1.6E-06
6	266	955800	239	1.1E-02	1.0E-02	1.1E-02	1.1E-02	1.4E-06	1.3E-06	1.3E-06	1.4E-06
7	313	1127400	289	1.4E-02	1.2E-02	1.3E-02	1.3E-02	1.7E-06	1.6E-06	1.6E-06	1.6E-06
8	330	1188000	322	1.4E-02	1.3E-02	1.4E-02	1.4E-02	1.7E-06	1.6E-06	1.6E-06	1.6E-06
							Mean	1.6E-06	1.4E-06	1.5E-06	1.5E-06
							S	1.3E-07	1.4E-07	1.5E-07	1.4E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	4.3E-03	4.2E-03	4.4E-03	4.3E-03	2.5E-06	2.5E-06	2.5E-06	2.5E-06
3	121	436500	91	7.8E-03	7.4E-03	7.8E-03	7.7E-03	2.0E-06	1.8E-06	2.0E-06	1.9E-06
4	167	602100	144	1.1E-02	1.0E-02	1.1E-02	1.1E-02	2.3E-06	2.3E-06	2.5E-06	2.3E-06
5	212	763200	190	1.4E-02	1.3E-02	1.4E-02	1.4E-02	2.5E-06	2.4E-06	2.5E-06	2.4E-06
6	266	955800	239	1.7E-02	1.7E-02	1.7E-02	1.7E-02	2.1E-06	2.0E-06	2.0E-06	2.0E-06
7	313	1127400	289	2.0E-02	1.9E-02	2.0E-02	2.0E-02	2.1E-06	2.0E-06	2.2E-06	2.1E-06
8	330	1188000	322	2.1E-02	2.0E-02	2.1E-02	2.1E-02	2.0E-06	2.2E-06	2.3E-06	2.2E-06
							Mean	2.2E-06	2.1E-06	2.2E-06	2.2E-06
							S	1.9E-07	2.1E-07	2.1E-07	1.9E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	6.4E-03	6.7E-03	6.9E-03	6.6E-03	3.7E-06	3.9E-06	4.0E-06	3.9E-06
3	121	436500	91	1.3E-02	1.3E-02	1.3E-02	1.3E-02	3.6E-06	3.4E-06	3.5E-06	3.5E-06
4	167	602100	144	1.8E-02	1.7E-02	1.7E-02	1.7E-02	3.8E-06	3.6E-06	3.4E-06	3.6E-06
5	212	763200	190	2.2E-02	2.2E-02	2.2E-02	2.2E-02	3.7E-06	3.9E-06	3.9E-06	3.8E-06
6	266	955800	239	2.9E-02	2.8E-02	2.8E-02	2.8E-02	4.1E-06	3.7E-06	3.7E-06	3.8E-06
7	313	1127400	289	3.4E-02	3.4E-02	3.2E-02	3.3E-02	3.8E-06	4.0E-06	3.3E-06	3.7E-06
8	330	1188000	322	3.6E-02	3.5E-02	3.4E-02	3.5E-02	3.9E-06	3.4E-06	3.6E-06	3.6E-06
							Mean	3.8E-06	3.7E-06	3.5E-06	3.7E-06
							S	1.6E-07	2.4E-07	2.1E-07	1.3E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				P7-A	P7-B	P7-C	Average	P7-A	P7-B	P7-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	7.0E-03	7.2E-03	6.8E-03	7.0E-03	4.1E-06	4.2E-06	3.9E-06	4.1E-06
3	121	436500	91	1.2E-02	1.2E-02	1.2E-02	1.2E-02	3.0E-06	2.9E-06	3.0E-06	3.0E-06
4	167	602100	144	1.8E-02	1.8E-02	1.8E-02	1.8E-02	4.5E-06	4.3E-06	4.5E-06	4.4E-06
5	212	763200	190	2.3E-02	2.3E-02	2.3E-02	2.3E-02	3.8E-06	3.9E-06	3.9E-06	3.9E-06
6	266	955800	239	2.8E-02	2.7E-02	2.7E-02	2.7E-02	3.2E-06	2.7E-06	2.5E-06	2.8E-06
7	313	1127400	289	3.2E-02	3.1E-02	3.1E-02	3.1E-02	3.0E-06	3.1E-06	3.3E-06	3.1E-06
8	330	1188000	322	3.4E-02	3.3E-02	3.4E-02	3.4E-02	4.7E-06	4.7E-06	4.8E-06	4.7E-06
							Average	3.7E-06	3.6E-06	3.7E-06	3.7E-06
							S	7.4E-07	8.4E-07	9.0E-07	8.2E-07

No	Time (h)	Time (s)	Time interval (h)	Increase in weight (kg)				Moisture flux (kg/sm2)			
				P8-A	P8-B	P8-C	Average	P8-A	P8-B	P8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	60	216000	30	6.0E-03	5.8E-03	5.3E-03	5.7E-03	3.5E-06	3.4E-06	3.1E-06	3.3E-06
3	121	436500	91	1.0E-02	1.0E-02	9.5E-03	1.0E-02	2.5E-06	2.5E-06	2.4E-06	2.5E-06
4	167	602100	144	1.5E-02	1.5E-02	1.4E-02	1.5E-02	3.7E-06	3.5E-06	3.3E-06	3.5E-06
5	212	763200	190	2.0E-02	1.9E-02	1.8E-02	1.9E-02	3.4E-06	2.9E-06	3.1E-06	3.1E-06
6	266	955800	239	2.4E-02	2.2E-02	2.2E-02	2.3E-02	2.8E-06	2.6E-06	2.7E-06	2.7E-06
7	313	1127400	289	2.7E-02	2.6E-02	2.6E-02	2.6E-02	2.7E-06	2.9E-06	2.7E-06	2.8E-06
8	330	1188000	322	2.9E-02	2.8E-02	2.7E-02	2.8E-02	3.0E-06	3.6E-06	3.9E-06	3.5E-06
							Average	3.0E-06	3.0E-06	3.0E-06	3.0E-06
							S	4.3E-07	4.6E-07	5.2E-07	4.2E-07

Liquid penetration resistance (LPR) – weathered WRB (Nov 27th –March 27th)

Start date: 02/12/2002

End date: 06/12/2002

Laboratory conditions
Temperature: 20.4±0.1°C
RH: 32%

No	Time, h	Time, s	Time (int), h	Mass increase (g)				Moisture flux (kg/sm2)			
				C1-A	C1-B	C1-C	Average	C1-A	C1-B	C1-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	10.2	8.6	9.2	9.3	5.0E-05	4.2E-05	4.5E-05	4.6E-05
3	20.5	73800	13.9	29.6	29.1	27.5	28.7	5.2E-05	5.5E-05	4.9E-05	5.2E-05
4	40.0	144000	30.3	58.8	55.6	55.4	56.6	5.3E-05	4.8E-05	5.1E-05	5.1E-05
5	50.5	181800	45.3	73.9	72.3	70.0	72.0	5.1E-05	5.6E-05	4.9E-05	5.2E-05
6	64.0	230400	57.3	95.4	92.7	88.7	92.3	5.6E-05	5.3E-05	4.9E-05	5.3E-05
7	71.5	257400	67.8	106.5	104.8	99.1	103.5	5.2E-05	5.7E-05	4.9E-05	5.3E-05
8	94.5	340200	83.0	140.9	137.4	134.6	137.7	5.3E-05	5.0E-05	5.5E-05	5.3E-05
							Mean	5.3E-05	5.3E-05	5.0E-05	5.2E-05
							S	1.9E-06	3.6E-06	2.3E-06	9.0E-07

No	Time, h	Time, s	Time (int), h	Mass increase (g)				Moisture flux (kg/sm2)			
				C2-A	C2-B	C2-C	Average	C2-A	C2-B	C2-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	13.4	11.1	9.4	11.3	6.6E-05	5.4E-05	4.6E-05	5.5E-05
3	20.5	73800	13.9	35.0	29.2	28.8	31.0	5.7E-05	4.8E-05	5.2E-05	5.3E-05
4	40.0	144000	30.3	65.0	56.6	56.9	59.5	5.4E-05	5.0E-05	5.1E-05	5.2E-05
5	50.5	181800	45.3	81.0	71.8	70.6	74.5	5.4E-05	5.1E-05	4.6E-05	5.0E-05
6	64.0	230400	57.3	102.9	89.1	90.0	94.0	5.7E-05	4.5E-05	5.1E-05	5.1E-05
7	71.5	257400	67.8	114.9	100.5	99.6	105.0	5.7E-05	5.4E-05	4.5E-05	5.2E-05
8	94.5	340200	83.0	150.4	133.9	130.3	138.2	5.5E-05	5.1E-05	4.7E-05	5.1E-05
							Mean	5.6E-05	5.0E-05	4.9E-05	5.2E-05
							S	1.6E-06	3.0E-06	2.8E-06	7.6E-07

No	Time, h	Time, s	Time (int), h	Mass increase (g)				Moisture flux (kg/sm2)			
				C3-A	C3-B	C3-C	Average	C3-A	C3-B	C3-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	9.5	10.4	8.9	9.6	4.6E-05	5.1E-05	4.3E-05	4.7E-05
3	20.5	73800	13.9	25.8	27.8	27.3	27.0	4.4E-05	4.7E-05	4.9E-05	4.6E-05
4	40.0	144000	30.3	49.2	53.5	55.1	52.6	4.3E-05	4.7E-05	5.0E-05	4.6E-05
5	50.5	181800	45.3	64.3	67.5	67.6	66.5	5.1E-05	4.7E-05	4.2E-05	4.7E-05
6	64.0	230400	57.3	80.7	86.9	86.2	84.6	4.3E-05	5.1E-05	4.9E-05	4.8E-05
7	71.5	257400	67.8	92.0	97.3	95.5	94.9	5.3E-05	4.9E-05	4.4E-05	4.9E-05
8	94.5	340200	83.0	122.4	128.8	128.1	126.4	4.7E-05	4.8E-05	5.0E-05	4.8E-05
							Mean	4.7E-05	4.8E-05	4.7E-05	4.7E-05
							S	4.4E-06	1.6E-06	3.5E-06	9.8E-07

No	Time, h	Time, s	Time (int), h	Mass increase (g)				Moisture flux (kg/sm2)			
				C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	9.7	10.6	11.0	10.4	4.7E-05	5.2E-05	5.4E-05	5.1E-05
3	20.5	73800	13.9	29.2	31.6	31.5	30.7	5.2E-05	5.6E-05	5.5E-05	5.4E-05
4	40.0	144000	30.3	56.5	57.0	65.7	59.7	5.0E-05	4.6E-05	6.2E-05	5.3E-05
5	50.5	181800	45.3	72.4	71.8	83.2	75.8	5.4E-05	5.0E-05	5.9E-05	5.4E-05
6	64.0	230400	57.3	94.1	91.3	103.5	96.3	5.7E-05	5.1E-05	5.3E-05	5.4E-05
7	71.5	257400	67.8	105.0	102.8	115.4	107.7	5.2E-05	5.4E-05	5.6E-05	5.4E-05
8	94.5	340200	83.0	138.1	134.5	148.0	140.2	5.1E-05	4.9E-05	5.0E-05	5.0E-05
							Mean	5.2E-05	5.1E-05	5.6E-05	5.3E-05
							S	2.5E-06	3.6E-06	4.2E-06	1.6E-06

No	Time, h	Time, s	Time (int), h	Mass increase (g)				Moisture flux (kg/sm2)			
				C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	10.1	9.5	8.4	9.3	4.9E-05	4.6E-05	4.1E-05	4.6E-05
3	20.5	73800	13.9	30.2	31.9	26.9	29.6	5.4E-05	6.0E-05	4.9E-05	5.4E-05
4	40.0	144000	30.3	59.3	63.2	53.0	58.5	5.3E-05	5.7E-05	4.7E-05	5.2E-05
5	50.5	181800	45.3	74.0	82.0	68.3	74.7	4.9E-05	6.3E-05	5.2E-05	5.5E-05
6	64.0	230400	57.3	95.3	101.4	86.6	94.4	5.6E-05	5.1E-05	4.8E-05	5.2E-05
7	71.5	257400	67.8	107.7	112.1	96.0	105.3	5.9E-05	5.0E-05	4.5E-05	5.1E-05
8	94.5	340200	83.0	139.8	145.8	125.4	137.0	4.9E-05	5.2E-05	4.5E-05	4.9E-05
							Mean	5.3E-05	5.6E-05	4.8E-05	5.2E-05
							S	3.6E-06	5.4E-06	2.6E-06	2.2E-06

Liquid filtration-250 Pa hydrostatic pressure difference – type C and type P WRB

Start date: Jan 08/2003
Time: 12:01 p.m.

End date: Jan 08/2003
Time: 3:30 p.m.

Laboratory conditions
Temperature: 20.7±0.1°C
RH: 28%
Water temperature: 20.0±0.1°C

				Mass increase (g)				Moisture flux (kg/sm2)			
No	Time, h	Time, s	Time (int), h	C4-A	C4-B	C4-C	Average	C4-A	C4-B	C4-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	1.1E+02	1.1E+02	1.1E+02	1.1E+02	5.4E-04	5.5E-04	5.6E-04	5.5E-04
3	20.5	73800	13.9	3.3E+02	3.3E+02	3.4E+02	3.4E+02	6.0E-04	5.9E-04	6.0E-04	6.0E-04
4	40.0	144000	30.3	6.6E+02	6.6E+02	6.7E+02	6.6E+02	5.8E-04	5.9E-04	6.0E-04	5.9E-04
5	50.5	181800	45.3	8.3E+02	8.4E+02	8.6E+02	8.4E+02	5.9E-04	6.0E-04	6.2E-04	6.1E-04
6	64.0	230400	57.3	1.1E+03	1.1E+03	1.1E+03	1.1E+03	6.0E-04	6.1E-04	6.2E-04	6.1E-04
7	71.5	257400	67.8	1.2E+03	1.2E+03	1.2E+03	1.2E+03	5.9E-04	6.0E-04	6.3E-04	6.1E-04
8	94.5	340200	83.0	1.6E+03	1.6E+03	1.6E+03	1.6E+03	5.9E-04	6.0E-04	6.0E-04	6.0E-04
							Mean	5.9E-04	6.0E-04	6.1E-04	6.0E-04
							S	5.4E-06	6.2E-06	1.3E-05	6.8E-06

				Mass increase (g)				Moisture flux (kg/sm2)			
No	Time, h	Time, s	Time (int), h	C5-A	C5-B	C5-C	Average	C5-A	C5-B	C5-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	1.1E+02	1.0E+02	1.0E+02	1.1E+02	5.3E-04	5.1E-04	5.0E-04	5.1E-04
3	20.5	73800	13.9	3.0E+02	3.0E+02	2.9E+02	3.0E+02	5.2E-04	5.2E-04	5.1E-04	5.1E-04
4	40.0	144000	30.3	5.9E+02	5.7E+02	5.6E+02	5.8E+02	5.2E-04	5.0E-04	4.9E-04	5.0E-04
5	50.5	181800	45.3	7.4E+02	7.2E+02	7.1E+02	7.2E+02	5.2E-04	5.0E-04	4.9E-04	5.0E-04
6	64.0	230400	57.3	9.4E+02	9.1E+02	9.0E+02	9.2E+02	5.2E-04	5.1E-04	4.9E-04	5.1E-04
7	71.5	257400	67.8	1.1E+03	1.0E+03	1.0E+03	1.0E+03	5.2E-04	5.0E-04	4.9E-04	5.0E-04
8	94.5	340200	83.0	1.4E+03	1.3E+03	1.3E+03	1.3E+03	5.1E-04	5.0E-04	4.9E-04	5.0E-04
							Mean	5.2E-04	5.0E-04	4.9E-04	5.0E-04
							S	5.1E-06	7.8E-06	9.0E-06	6.1E-06

				Mass increase (g)				Moisture flux (kg/sm2)			
No	Time, h	Time, s	Time (int), h	P6-A	P6-B	P6-C	Average	P6-A	P6-B	P6-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	8.8E-01	5.1E-01	9.0E-01	7.6E-01	4.3E-06	2.5E-06	4.4E-06	3.7E-06
3	20.5	73800	13.9	2.5E+00	2.0E+00	2.6E+00	2.4E+00	4.4E-06	4.1E-06	4.7E-06	4.4E-06
4	40.0	144000	30.3	4.6E+00	4.3E+00	4.9E+00	4.6E+00	3.8E-06	4.2E-06	4.1E-06	4.0E-06
5	50.5	181800	45.3	5.9E+00	5.7E+00	6.2E+00	6.0E+00	4.5E-06	4.7E-06	4.5E-06	4.5E-06
6	64.0	230400	57.3	7.7E+00	7.5E+00	7.9E+00	7.7E+00	4.7E-06	4.6E-06	4.5E-06	4.6E-06
7	71.5	257400	67.8	8.6E+00	8.4E+00	8.8E+00	8.6E+00	4.3E-06	4.5E-06	4.2E-06	4.3E-06
8	94.5	340200	83.0	1.2E+01	1.1E+01	1.2E+01	1.2E+01	4.6E-06	4.6E-06	4.4E-06	4.5E-06
							Mean	4.4E-06	4.4E-06	4.4E-06	4.4E-06
							S	3.1E-07	2.5E-07	1.9E-07	2.0E-07

				Mass increase (g)				Moisture flux (kg/sm2)			
No	Time, h	Time, s	Time (int), h	P8-A	P8-B	P8-C	Average	P8-A	P8-B	P8-C	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	7.3	26100	3.6	7.3E-01	6.0E-01	4.6E-01	6.0E-01	3.5E-06	2.9E-06	2.2E-06	2.9E-06
3	20.5	73800	13.9	2.5E+00	1.8E+00	2.3E+00	2.2E+00	4.6E-06	3.3E-06	4.9E-06	4.3E-06
4	40.0	144000	30.3	5.2E+00	4.5E+00	4.4E+00	4.7E+00	5.0E-06	4.9E-06	3.8E-06	4.6E-06
5	50.5	181800	45.3	6.4E+00	5.7E+00	5.4E+00	5.8E+00	3.9E-06	4.0E-06	3.4E-06	3.8E-06
6	64.0	230400	57.3	7.7E+00	6.9E+00	7.1E+00	7.2E+00	3.4E-06	3.0E-06	4.5E-06	3.6E-06
7	71.5	257400	67.8	9.5E+00	8.6E+00	8.6E+00	8.9E+00	8.4E-06	8.3E-06	6.8E-06	7.8E-06
8	94.5	340200	83.0	1.3E+01	1.1E+01	1.1E+01	1.2E+01	5.2E-06	4.4E-06	3.4E-06	4.3E-06
							Mean	5.1E-06	4.6E-06	4.5E-06	4.7E-06
							S	1.8E-06	1.9E-06	1.3E-06	1.6E-06

Assembly test:

Start date: November 4th, 2002   Start time: Monday 8:30 a.m

End dat: November 26th, 2002   End time: Tuesday 8:00 p.m.

Test duration: 516 h

Condition: Cold side; Temperature -12 to -10 degrees C   Relative humidity 45-55%

Hot side-1; Temperature 54-57 degrees C   Relative humidity 20-30%

Moisutre load: 2L /1.35m2/1h = 4.12e-4 L/m2/s -- Moisutre load 14.8 L per day - - for duration of 15 days -- Total moisutre load = 222 L

This corresponds to 1/5th of the annual rain load received in Wilmington (NC)

The second test wall received same moisture load.

3.4 L/ 2.28m/ 1h = 4.14e-4 L/m2/s -- Moisture load 14.9 L per day -- for duration of 15 days -- Total moisture load = 223 L

Specimens test: Assembly composition: No penetrations, 3 types of WRB; C1, C4, P7, WRB in contact with substrate, No additives

NO PENETRATIONS AND ADDITIVES – TEST ASSEMBLIES COMPOSED OF OSB, WRB (P7), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	2-P7-top	2- P7-centre	2-P7-bottom	Average	2-P7-top	2- P7-centre	2-P7-bottom	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	2.9E-03	3.3E-03	3.6E-03	3.3E-03	6.8E-07	7.7E-07	8.3E-07	7.6E-07
3	208	748800	154	5.1E-03	7.4E-03	6.4E-03	6.3E-03	4.8E-07	8.9E-07	6.0E-07	6.6E-07
4	340	1224000	274	6.5E-03	9.4E-03	7.3E-03	7.7E-03	2.4E-07	3.6E-07	1.6E-07	2.5E-07
5	428	1540800	384	7.6E-03	1.0E-02	7.6E-03	8.4E-03	2.9E-07	2.0E-07	9.3E-08	1.9E-07
6	516	1857600	472	7.7E-03	1.1E-02	7.8E-03	8.9E-03	4.6E-08	2.4E-07	5.8E-08	1.1E-07
							Mean	2.6E-07	4.2E-07	2.3E-07	
							S	1.8E-07	3.2E-07	2.5E-07	

NO PENETRATIONS AND ADDITIVES – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C4), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	2-C4-top	2-C4-center	2-C4-bottom	Average	2-C4-top	2-C4-center	2-C4-bottom	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	1.2E-03	2.7E-03	9.9E-04	1.6E-03	2.7E-07	6.2E-07	2.3E-07	3.7E-07
3	208	748800	154	1.8E-03	5.4E-03	1.8E-03	3.0E-03	1.5E-07	5.9E-07	1.7E-07	3.0E-07
4	340	1224000	274	1.9E-03	5.8E-03	2.7E-03	3.5E-03	1.5E-08	7.6E-08	1.7E-07	8.5E-08
5	428	1540800	384	2.0E-03	6.5E-03	3.0E-03	3.8E-03	2.4E-08	1.9E-07	7.5E-08	9.6E-08
6	516	1857600	472	2.1E-03	7.0E-03	3.5E-03	4.2E-03	1.7E-08	1.3E-07	1.5E-07	9.7E-08
							Mean	5.2E-08	2.5E-07	1.4E-07	
							S	6.6E-08	2.3E-07	4.4E-08	

NO PENETRATIONS AND ADDITIVES – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C2), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	2-C1-top	2-C1-centre	2-C1-bottom	Average	2-C1-top	2-C1-centre	2-C1-bottom	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	1.2E-03	2.7E-03	3.7E-03	2.5E-03	2.7E-07	6.3E-07	8.6E-07	5.9E-07
3	208	748800	154	1.9E-03	4.8E-03	6.7E-03	4.5E-03	1.6E-07	4.5E-07	6.6E-07	4.2E-07
4	340	1224000	274	2.4E-03	6.1E-03	8.0E-03	5.5E-03	8.6E-08	2.3E-07	2.3E-07	1.8E-07
5	428	1540800	384	3.0E-03	7.3E-03	8.4E-03	6.2E-03	1.6E-07	3.1E-07	1.0E-07	1.9E-07
6	516	1857600	472	3.7E-03	8.1E-03	8.9E-03	6.9E-03	2.0E-07	2.4E-07	1.3E-07	1.9E-07
							Mean	1.5E-07	3.1E-07	2.8E-07	
							S	4.7E-08	1.0E-07	2.6E-07	

PENETRATIONS (NAIL) THROUGH WRB – TEST ASSEMBLIES COMPOSED OF OSB, WRB (P7), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	P7-top-Mix1	P7-centre-Mix1	P7-bottom-Mix1	Average	P7-top-Mix1	P7-centre-Mix1	P7-bottom-Mix1	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	1.8E-03	1.1E-03	2.7E-03	1.9E-03	4.1E-07	2.5E-07	6.4E-07	4.4E-07
3	208	748800	154	3.5E-03	2.7E-03	4.4E-03	3.5E-03	3.7E-07	3.4E-07	3.6E-07	3.6E-07
4	340	1224000	274	5.1E-03	3.1E-03	5.2E-03	4.5E-03	2.9E-07	7.9E-08	1.5E-07	1.7E-07
5	428	1540800	384	6.0E-03	3.5E-03	6.4E-03	5.3E-03	2.4E-07	1.1E-07	3.0E-07	2.1E-07
6	516	1857600	472	6.4E-03	3.9E-03	7.7E-03	6.0E-03	1.1E-07	9.7E-08	3.6E-07	1.9E-07
							Mean	2.5E-07	1.6E-07	2.9E-07	
							S	1.1E-07	1.2E-07	1.0E-07	

PENETRATIONS (NAIL) THROUGH WRB AND BENTONITE ADDED TO STUCCO – TEST ASSEMBLIES COMPOSED OF OSB, WRB (P7), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	P7-top-Mix2	P7-centre-Mix2	P7-bottom-Mix2	Average	P7-top-Mix2	P7-centre-Mix2	P7-bottom-Mix2	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	7.0E-03	3.8E-03	3.6E-03	4.8E-03	1.6E-06	8.8E-07	8.4E-07	1.1E-06
3	208	748800	154	1.2E-02	7.5E-03	6.9E-03	8.8E-03	1.1E-06	8.0E-07	7.2E-07	8.8E-07
4	340	1224000	274	1.3E-02	8.5E-03	7.5E-03	9.5E-03	9.6E-08	1.7E-07	9.6E-08	1.2E-07
5	428	1540800	384	1.4E-02	9.6E-03	7.8E-03	1.1E-02	4.0E-07	3.1E-07	8.7E-08	2.7E-07
6	516	1857600	472	1.5E-02	1.0E-02	8.0E-03	1.1E-02	1.8E-07	8.9E-08	6.2E-08	1.1E-07
							Mean	4.5E-07	3.4E-07	2.4E-07	
							S	4.6E-07	3.2E-07	3.2E-07	

PENETRATIONS (NAIL) THROUGH WRB AND BENTONITE AND DETERGENT ADDED TO STUCCO – TEST ASSEMBLIES COMPOSED OF OSB, WRB (P7), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	P7-top-Mix3	P7-centre-Mix3	P7-bottom-Mix3	Average	P7-top-Mix3	P7-centre-Mix3	P7-bottom-Mix3	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	8.4E-03	7.9E-03	3.0E-03	6.4E-03	2.0E-06	1.8E-06	7.0E-07	1.5E-06
3	208	748800	154	1.3E-02	1.2E-02	5.3E-03	1.0E-02	9.3E-07	9.6E-07	5.0E-07	8.0E-07
4	340	1224000	274	1.8E-02	1.7E-02	6.1E-03	1.4E-02	8.7E-07	8.4E-07	1.4E-07	6.2E-07
5	428	1540800	384	1.9E-02	2.0E-02	7.1E-03	1.5E-02	4.5E-07	7.6E-07	2.5E-07	4.9E-07
6	516	1857600	472	2.0E-02	2.2E-02	7.7E-03	1.6E-02	7.9E-08	5.5E-07	1.6E-07	2.6E-07
							Mean	5.8E-07	7.8E-07	2.6E-07	
							S	4.0E-07	1.7E-07	1.7E-07	

PENETRATIONS (NAIL) THROUGH WRB – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C4), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	C4-top Mix1	C4-center-Mix1	C4-bottom-Mix1	Average	C4-top Mix1	C4-center-Mix1	C4-bottom-Mix1	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	1.1E-03	2.1E-03	5.1E-03	2.8E-03	2.6E-07	4.9E-07	1.2E-06	6.5E-07
3	208	748800	154	2.2E-03	3.1E-03	7.9E-03	4.4E-03	2.4E-07	2.1E-07	6.0E-07	3.5E-07
4	340	1224000	274	3.5E-03	3.6E-03	9.1E-03	5.4E-03	2.3E-07	8.9E-08	2.0E-07	1.7E-07
5	428	1540800	384	4.7E-03	4.2E-03	1.0E-02	6.4E-03	3.1E-07	1.7E-07	3.0E-07	2.6E-07
6	516	1857600	472	5.4E-03	4.9E-03	1.1E-02	7.0E-03	1.9E-07	1.8E-07	1.8E-07	1.8E-07
							Mean	2.4E-07	1.6E-07	3.2E-07	
							S	5.3E-08	5.1E-08	1.9E-07	

PENETRATIONS (NAIL) THROUGH WRB AND BENTONITE ADDED TO STUCCO – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C4), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	C4-top Mix2	C4-center-Mix2	C4-bottom-Mix2	Average	C4-top Mix2	C4-center-Mix2	C4-bottom-Mix2	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	6.6E-03	5.8E-03	5.0E-03	5.8E-03	1.5E-06	1.4E-06	1.2E-06	1.4E-06
3	208	748800	154	1.0E-02	9.7E-03	8.9E-03	9.5E-03	7.5E-07	8.3E-07	8.4E-07	8.1E-07
4	340	1224000	274	1.3E-02	1.1E-02	1.1E-02	1.2E-02	5.0E-07	2.2E-07	3.9E-07	3.7E-07
5	428	1540800	384	1.4E-02	1.1E-02	1.3E-02	1.3E-02	2.9E-07	1.1E-07	3.8E-07	2.6E-07
6	516	1857600	472	1.5E-02	1.2E-02	1.3E-02	1.3E-02	2.5E-07	6.8E-08	1.4E-07	1.5E-07
							Mean	4.5E-07	3.1E-07	4.4E-07	
							S	2.3E-07	3.6E-07	2.9E-07	

PENETRATIONS (NAIL) THROUGH WRB AND BENTONITE AND DETERGENT ADDED TO STUCCO – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C4), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	C4-top Mix3	C4-center-Mix3	C4-bottom-Mix3	Average	C4-top Mix3	C4-center-Mix3	C4-bottom-Mix3	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	3.3E-03	2.2E-03	2.4E-03	2.6E-03	7.7E-07	5.2E-07	5.5E-07	6.1E-07
3	208	748800	154	6.2E-03	3.9E-03	4.1E-03	4.7E-03	6.3E-07	3.7E-07	3.7E-07	4.6E-07
4	340	1224000	274	8.0E-03	4.3E-03	4.6E-03	5.6E-03	3.1E-07	6.1E-08	8.7E-08	1.5E-07
5	428	1540800	384	1.0E-02	4.8E-03	4.9E-03	6.6E-03	5.7E-07	1.5E-07	1.0E-07	2.7E-07
6	516	1857600	472	1.1E-02	6.1E-03	5.2E-03	7.5E-03	3.3E-07	3.3E-07	5.9E-08	2.4E-07
							Mean	4.6E-07	2.3E-07	1.5E-07	
							S	1.6E-07	1.5E-07	1.5E-07	

PENETRATIONS (NAIL) THROUGH WRB – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C1), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	C1-top-Mix1	C1-Centre-M1	C1-bottom-Mix1	Average	C1-top-Mix1	C1-center Mix1	C1-bottom-Mix1	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	1.8E-03	1.5E-03	1.8E-03	1.7E-03	4.2E-07	3.6E-07	4.3E-07	4.0E-07
3	208	748800	154	2.8E-03	2.8E-03	3.9E-03	3.2E-03	2.2E-07	2.7E-07	4.6E-07	3.1E-07
4	340	1224000	274	4.9E-03	3.3E-03	6.1E-03	4.8E-03	3.7E-07	9.7E-08	3.8E-07	2.8E-07
5	428	1540800	384	5.7E-03	3.9E-03	7.4E-03	5.6E-03	2.0E-07	1.4E-07	3.5E-07	2.3E-07
6	516	1857600	472	6.6E-03	4.4E-03	9.2E-03	6.7E-03	2.4E-07	1.4E-07	4.7E-07	2.8E-07
							Mean	2.6E-07	1.6E-07	4.1E-07	
							S	8.0E-08	7.4E-08	5.7E-08	

PENETRATIONS (NAIL) THROUGH WRB AND BENTONITE ADDED TO STUCCO – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C1), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	C1-top-Mix2	C1-center-Mix2	C1-bottom-Mix2	Average	C1-top-Mix2	C1-center-Mix2	C1-bottom-Mix2	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	2.0E-03	4.1E-03	3.8E-03	3.3E-03	4.7E-07	9.6E-07	8.8E-07	7.7E-07
3	208	748800	154	3.6E-03	7.7E-03	6.9E-03	6.0E-03	3.4E-07	7.7E-07	6.7E-07	5.9E-07
4	340	1224000	274	4.7E-03	9.4E-03	8.3E-03	7.5E-03	2.1E-07	3.1E-07	2.6E-07	2.6E-07
5	428	1540800	384	5.4E-03	9.8E-03	9.2E-03	8.1E-03	1.7E-07	1.2E-07	2.2E-07	1.7E-07
6	516	1857600	472	6.0E-03	1.0E-02	1.1E-02	8.9E-03	1.6E-07	9.5E-08	3.7E-07	2.1E-07
							Mean	2.2E-07	3.2E-07	3.8E-07	
							S	8.0E-08	3.1E-07	2.0E-07	

PENETRATIONS (NAIL) THROUGH WRB AND BENTONITE AND DETERGENT ADDED TO STUCCO – TEST ASSEMBLIES COMPOSED OF OSB, WRB (C1), AND STUCCO

				Mass increase (kg)				Moisture flux (kg/m2s)			
No	Time, h	Time, s	Time int.	C1-top-Mix3	C1-center-Mix3	C1-bottom-Mix3	Average	C1-top-Mix3	C1-center-Mix3	C1-bottom-Mix3	Average
1	0	0	0	0	0	0	0	0	0	0	0
2	100	360000	50	2.9E-03	3.3E-03	3.6E-03	3.3E-03	6.8E-07	7.7E-07	8.3E-07	7.6E-07
3	208	748800	154	5.1E-03	7.4E-03	6.4E-03	6.3E-03	4.8E-07	8.9E-07	6.0E-07	6.6E-07
4	340	1224000	274	6.5E-03	9.4E-03	7.3E-03	7.7E-03	2.4E-07	3.6E-07	1.6E-07	2.5E-07
5	428	1540800	384	7.6E-03	1.0E-02	7.6E-03	8.4E-03	2.9E-07	2.0E-07	9.3E-08	1.9E-07
6	516	1857600	472	7.7E-03	1.1E-02	7.8E-03	8.9E-03	4.6E-08	2.4E-07	5.8E-08	1.1E-07
							Mean	2.6E-07	4.2E-07	2.3E-07	
							S	1.8E-07	3.2E-07	2.5E-07	