
**Faculty of Engineering and Industrial Sciences**
**Smart Structure Laboratory**

# Study on Thermal Behaviour of an External Residential Wall Panel

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NASH NZ

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## Executive Summary

NASH NZ commissioned the Smart Structure Laboratory (SSL) of Swinburne University of Technology to undertake thermal tests on a steel framed residential wall panel to examine the potential for condensation due to thermal gradient across the thickness of the wall. The testing and evaluation of results are preliminary in nature and the scale of work was quite limited to developing basic understanding of the performance of this wall panel.

The wall panel measured approximately 1.9mx1.6m and was made of full scale components. The test panel included building wrap, 10mm XPS thermal break, R2.6 pink batts and 10mm plasterboard. The framing members were made of 0.75mm thick G550 steel 90mmx40mm lipped C sections. The test wall did not have a cladding material.

A number of tests were conducted on the test wall which attempted to form condensation and also to examine the drying potential of the wall due to artificial wetting within the wall construction.

These preliminary findings suggest that condensation is unlikely to occur for this type of construction when the outside temperature is as low as 2°C and the humidity is as high as 70%RH if indoor conditions are 20°C with relative humidity of 50%. The test specimen did not visually show any condensation on the XPS thermal break or on the flanges of the studs.

Due to lack of condensation, the inside face of the XPS thermal break and pink batts were sprayed with approximately 200ml of water over a wall area of about 0.6m$^2$ between two studs. The Hot Room was maintained at 20°C and 50%RH while the Cold Room was maintained at 10°C and 70%RH. At these conditions, it took eight days for the sprayed water to completely dry.

## Contents

# 1. Introduction

The New Zealand National Association of Steel-framed Housing (NASH NZ) commissioned the Smart Structure Laboratory (SSL) of Swinburne University of Technology to undertake preliminary thermal tests on a typical full scale residential steel framed wall panel to examine the potential for condensation due to thermal gradient across the thickness of the wall.

The tests were conducted in an environmental chamber which has two adjacent rooms with their own conditioning systems separated by a movable divider. For this project, the divider was replaced by a wall panel supplied by NASH NZ. Thus, one side of the wall was part of one room (Hot Room simulating indoor environment) and the other side of the wall was part of the adjacent room (Cold Room simulating outdoor environment).

The scope of the work was limited to whether condensation could form within the wall and if moisture would dry out for given indoor and outdoor temperature and humidity scenarios which could be produced by the Hot and Cold Rooms of the environmental chamber. The testing was essentially exploratory in nature and performed as a proactive measure to better understand the performance of typical components used in the test panel.

# 2. Specification of Test Wall

A typical steel framed wall panel was constructed and supplied by NASH NZ for testing. The panel measured 1940mm wide and 1650mm high. The wall panel included an external building wrap, XPS thermal break, insulation batts within the steel framing members and internal plasterboard which are all schematically shown in Figure 1. All the wall components are described in detail below.

It should be noted that wall did not include external cladding material. The omission of the exterior cladding is a conservative assumption which indicates that there is no insulation value offered by the cladding.

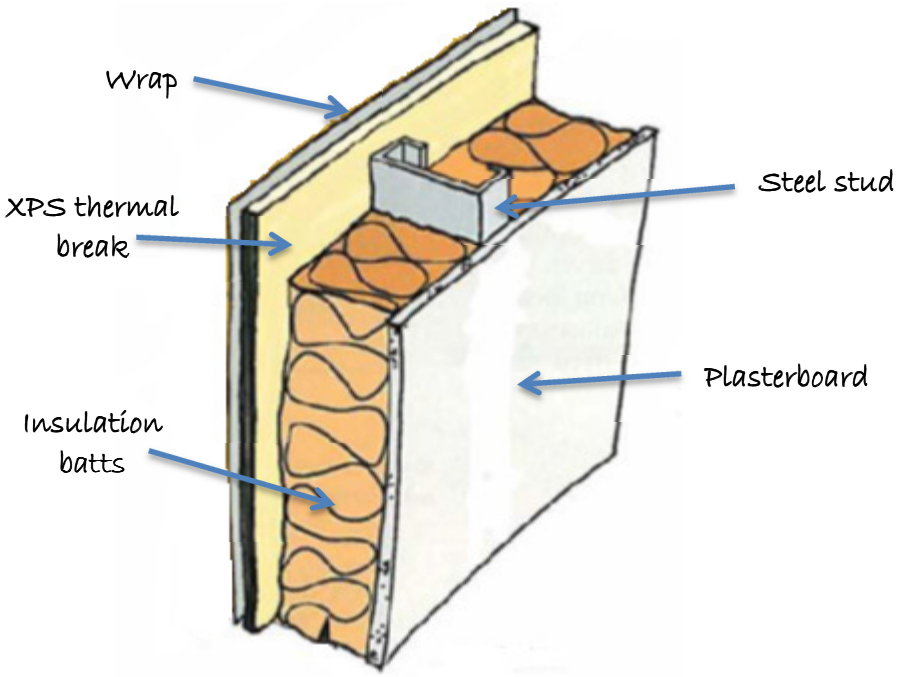



Figure1: Schematic diagram of the test wall.

### 2.1 Steel Framing

The steel frame was made of top and bottom plates, four studs and one raw of noggings at mid-height. The frame was supplied by Axxis Steel with all members made from 0.75mm thick 90mmx40mm lipped C sections G550 Z275 steel. Figure 2 shows the steel frame with the infill insulation batts.

### 2.2 Wrap

The wrap used for the test wall was Watergate Plus which is produced by Thermakraft Industries (NZ) Ltd. Watergate Plus is breathable, absorbent, flexible, synthetic wall underlay for use under direct fixed and non-direct fixed wall cladding on timber and steel framed buildings. For the test panel, the wrap was already glued to the XPS thermal break. Figure 3 shows the appearance of the wrap.

Figure 2: Steel frame with the insulation pink batts.


Figure 3: Appearance of Watergate Plus wrap.

### 2.3 XPS Thermal Break

The thermal break in the test panel was 10mm thick XPS sheets which are yellow in colour. Figure 4 shows the general appearance of the thermal break sheets. The XPS sheets were screwed around the wall perimeter and along the intermediate studs.

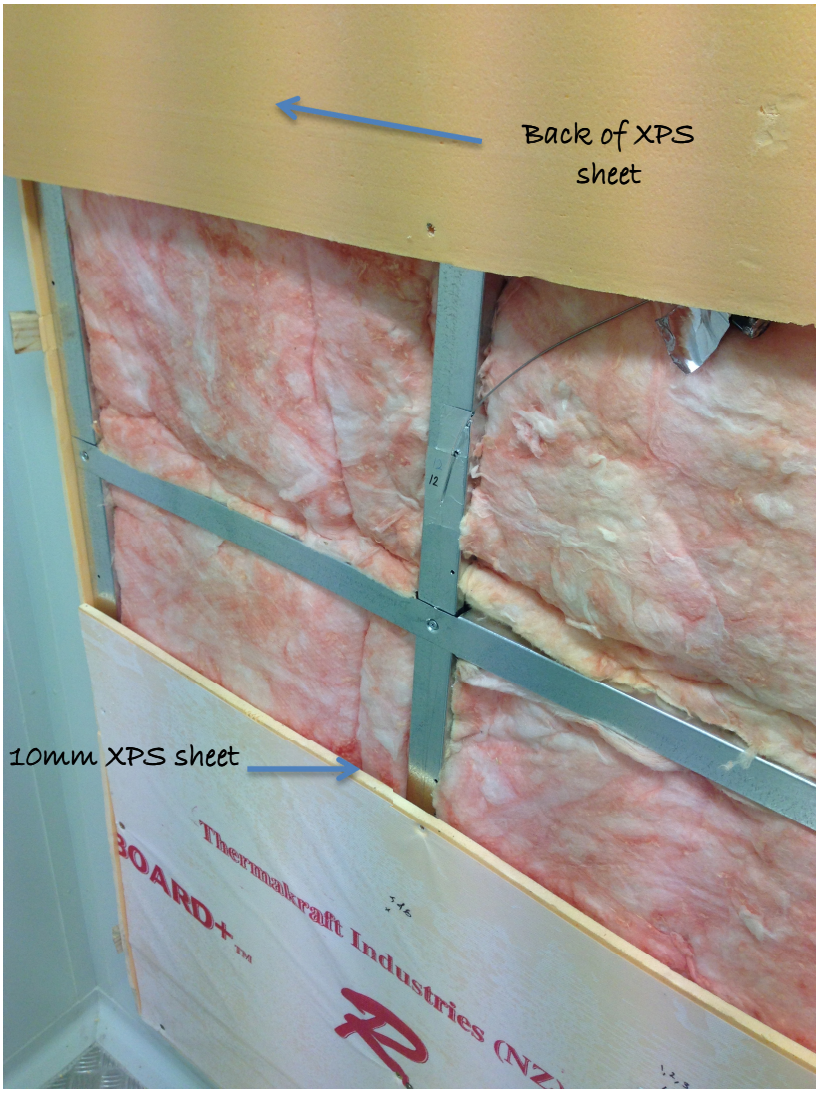



Figure 4: Photo showing XPS thermal break.

### 2.4 Insulation Batts

The insulation batts used for the test wall were R2.6 Ultra wall pink batts as shown in Figure 5.

Figure 5: Pink batts used for the test panel.

### 2.5 Internal Lining

The interior wall lining was made of 10mm Winston wall plasterboard. The plasterboard was painted.

## 3. Test Setup and Instrumentation

The environmental chamber where the tests were conducted is shown in Figure 6. This chamber has two rooms with separate temperature and humidity controllers. The two rooms are separated by an insulated removal partition with each room having its own door access.

(a)

(b)

Figure 6: Photos of the environmental chamber used for testing: (a) exterior of the chamber showing the two access doors; (b) interior view showing the removable partition.

For this test the removable partition was replaced with the wall test panel. The rooms within the chamber were designated Hot Room which was used to simulate interior conditions in a house and Cold Room for exterior conditions as shown in Figure 7. In this setup, the plasterboard side of the wall was facing the Hot Room and the wrap side of the wall was facing the Cold Room. Figure 8 shows a photo of the wall in the chamber during its installation.

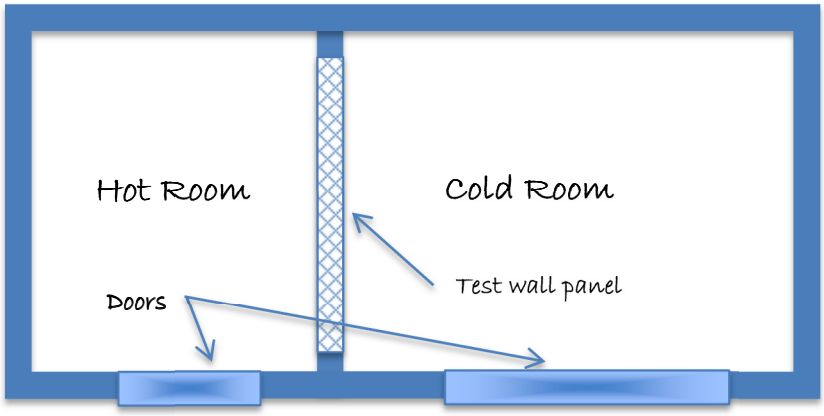



Figure 7: Plan view of the environmental chamber used for testing.


Figure 8: Photo of the wall test panel in the chamber.

The Hot and Cold rooms have in built sensors to measure the temperature and humidity within the rooms. In addition to these sensors, thermocouples were installed in both rooms to measure the temperature close to the wall faces and also measure the temperature within the test wall itself. The locations of the thermocouples within the wall are described in Table 1 and are shown in Figure

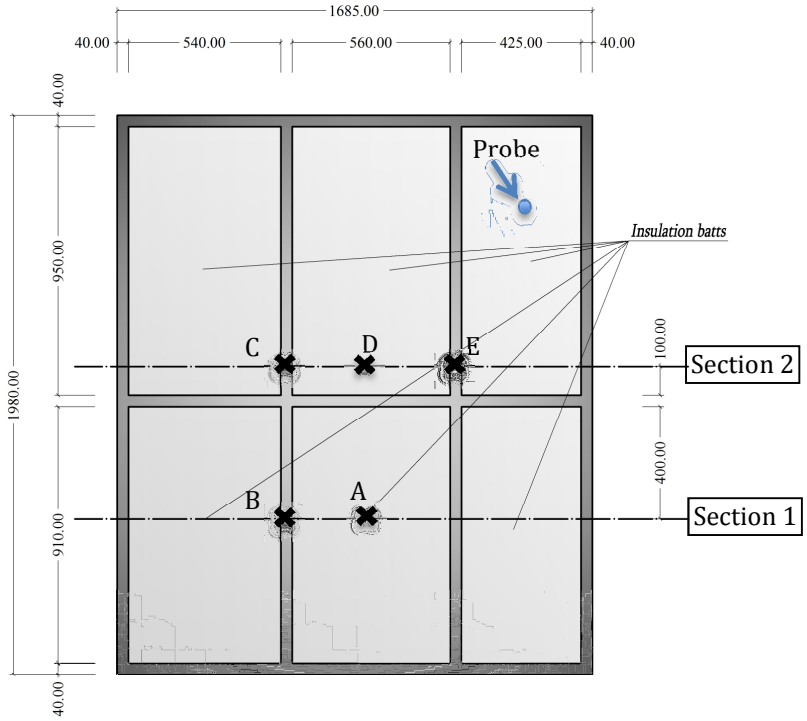
9. The thermocouple measurements were taken manually using a hand held digital device.

Table 1: Locations of thermocouples used in the wall test.

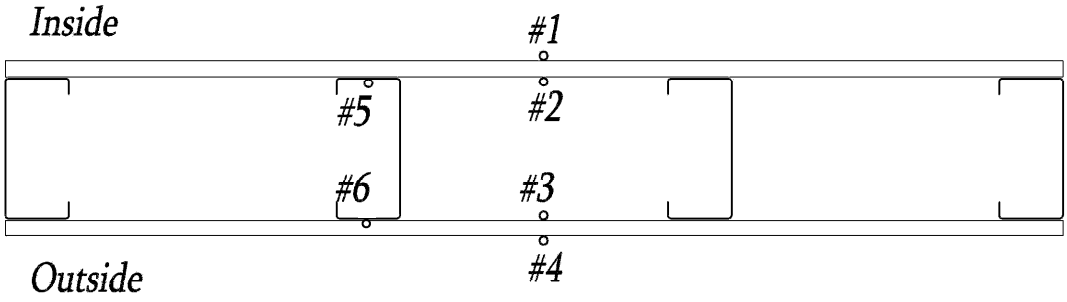
| Thermocouple No. | Location |
|---|---|
| 1 | On outer face of plasterboard at Location A (Hot Room) |
| 2 | On inner face of plasterboard at Location A |
| 3 | On inner face of the XPS sheet at Location A |
| 4 | On outer face the XPS sheet at Location A (Cold Room) |
| 5 | On the stud flange on plasterboard side at Location B |
| 6 | On the stud flange on XPS sheet side at Location B |
| 7 | On the stud flange on the plasterboard site at Location E where pink batts were removed from within the stud |
| 8 | On the stud flange on the XPS sheet side at Location E where pink batts were removed from within the stud |
| 9 | On inner face of plasterboard at Location D |
| 10 | On inner face of the XPS sheet at Location D |
| 11 | On the stud flange on plasterboard side at Location C |
| 12 | On the stud flange on XPS sheet side at Location C |
| 13# | Inside Cold Room |
| 14# | Inside Hot Room |

*# These thermocouples were used as confirmatory measurements to the in-built sensors in the chamber, but they often produced higher temperatures due to the body heat of the person taking the measurements.*

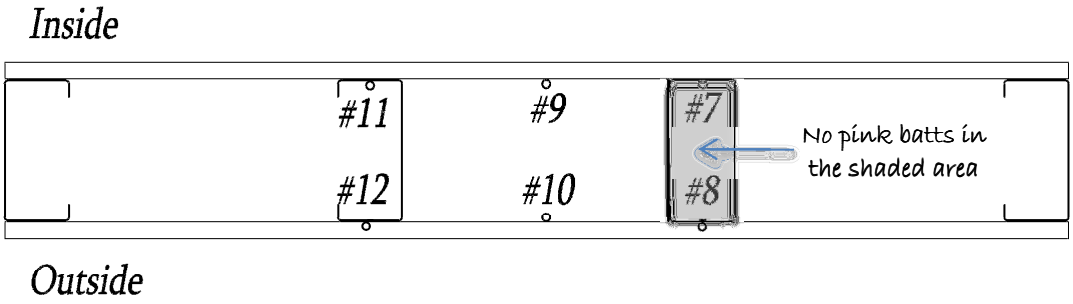
The humidity in each room was measured using the inbuilt sensors. In addition, a hand held probe meter was used to measure the temperature and humidity within the panel at one location which is shown on Figure 11 (identified as probe). This probe was close to the interface between the XPS sheet and pink batts between two studs. Furthermore, two probe digital cameras were installed within the wall to view the inner face of the XPS sheet at its interface to the pink batts. The cameras were essentially utilized to assess whether condensation was forming.




View from the outside face of the test wall




Section 1




Section 2

Figure 9: Locations of thermocouples (1 to 12) on the test wall panel.

# 4. Test Programs and Results

Three separate test programs were conducted on the wall panel. These are described in detail below.

## 4.1 Test Program I

In this test program, the Hot Room was set to a temperature of 20°C with 50% RH. The Cold Room was set to a target temperature of 0°C with 90% RH. The target conditions for the cold room were optimistic as the room conditioning system was not designed for this scenario.

The temperatures at the locations shown in Figure 9 and relative humidity of the chambers were recorded manually every 30 minutes during working hours. The temperature and humidity readings taken during testing are reported in Appendix A.

From about 9am on 17/1/2013 to 5pm on the same day, the temperature of the cold room decreased from an initial condition of 24°C and 48% humidity to 7.6°C and 88% RH.

The lowest temperature on the inside face of the XPS sheet was recorded by Thermocouple No 10 at 10.7°C (see Table A1). No condensation was observed. This is consistent with the Dew Point calculation shown in Figure 10.

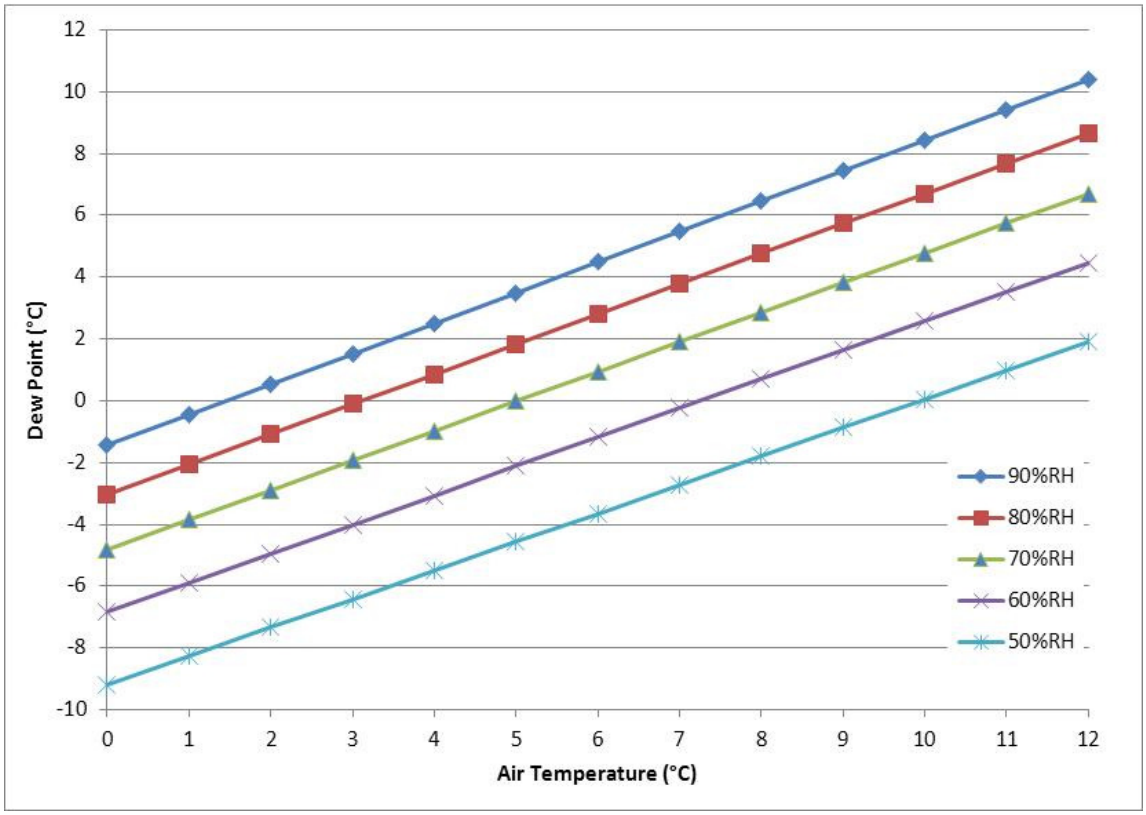



Figure 10: Approximate Dew Point Temperatures for different levels of humidity estimated using the Magnus Formula.

The same conditions for both the Hot and Cold Rooms were maintained overnight until about 7:00am on the following day. At the time the Cold Room temperature was still higher than required (8.4°C) and the humidity was 90%. No condensation was observed.

It was decided at that point to lower the humidity in the Cold Room to decrease its temperature. Hence the humidity was lowered to about 70% and within about 1 hour, the temperature of the Cold Room dropped to 2.6°C as shown in Table A2.

This setup was maintained until 4pm on 18/01/2013. During this time the lowest temperature on the interior side of the XPS thermal break was 5.4°C (see Table A2). No condensation was observed and it seemed unlikely to occur. Similarly, the lowest temperature on the stud flange was 12.5°C (Thermocouple No 8) (see Table A2) with no sign of any moisture forming.

It was decided to artificially wet the inside face of the XPS sheet between the two intermediate studs. This was performed by spraying 75ml of water directly on the XPS sheet and adjacent pink batts. The Cold Room temperature setting was increased to 22 degrees to assess how long it would take for the moisture to dry out. After two full days at this setting, the wall was completely dry.

### 4.2 Test Program II

This test program was concerned with the drying potential of the artificially wetted wall considering temperature variation on the exterior side of the wall during day and night cycles.

The Hot Room was set to 20°C while the Cold Room was set to vary in temperature between about 10°C (day temperature) and 3°C (night temperature) with approximately 70%RH. The Cold Room was set to achieve the day temperature for approximately 6 hours (approx. 10am to 4pm) and after that the room cooled down to as low as it can be achieved from about 4pm to 9am the following day. Observations and readings were made twice a day as listed in Appendix B.

The test started on Monday 5/2/13 with one cycle of day and night temperatures before spraying 192ml of water on the XPS sheet and adjacent pink batts between the two intermediate studs on Tuesday 6/2/2013. These cycles were maintained for 3 days until Friday 8/2/2013. Until that time, moisture was still in the wall. It was decided for the weekend (9/2-10/2) to maintain an average temperature in the Cold Room of 6°C which is the average between 3°C and 10°C until Monday 11/2. However, upon inspection on Monday 11/2 it was found that lowest temperature in the Cold Room was 11°C. Due to malfunction of the conditioning unit of the Cold Room, the temperature could not be lowered than 10°C. Hence, the Cold Room temperature was maintained at about 10°C until the wall dried out completely. This occurred on 14/2/13, eight days after the spraying of water.

### 4.3 Test Program III

This test program was essentially a repeat of Test Program II, after repair of the Cold Room. In this test, the Hot Room was set to be at 20°C and 50% RH and the Cold Room set to 10°C and approximately 70% RH. These temperatures and relative humidity values remained constant throughout the test period. No temperature readings were taken from the thermocouples. Similar to Test Program II, 200ml of water was sprayed on the XPS sheet and pink batts between the two intermediate studs over an area of about 0.6m$^2$. The dampness of the batts and XPS sheet was checked every day by opening the wall and performing the inspection. It was observed that after eight days from the time of spraying the water, the XPS sheet and batts were completely dry.

## 5. Summary and Conclusions

Preliminary tests were performed on a typical external steel-framed residential wall panel to assess the potential for consideration within the wall due to differential indoor and outdoor temperatures.

The wall panel measured approximately 1.9mx1.6m and was made of full scale components. The test panel included typical materials including building wrap, 10mm XPS thermal break, R2.6 pink batts and 10mm plasterboard. The framing members were made of 0.75mm thick G550 steel 90mmx40mm lipped C sections. The test wall did not have a cladding material.

The exterior side of the wall was located in a Cold Room which attempted to simulate outdoor conditions and the interior side was in a Hot Room which simulated indoor conditions (20°C and 50%RH). The lowest temperature achieved in the Cold Room was approximately 2°C with 70% RH. For these conditions of Hot and Cold Rooms there was no condensation visible on the XPS thermal break of stud flanges.

These preliminary findings suggest that condensation is unlikely to occur for this type of construction when outside temperature is as low as 2°C and the humidity is as high as 70%RH.

Due to lack of condensation, the inside face of the XPS thermal break and pink batts were sprayed with approximately 200ml of water over a wall area of about 0.6m$^2$ between two studs. The Hot Room was maintained at 20°C and 50%RH while the Cold Room was marinated at 10°C and 70%RH. At these conditions, it took eight days for the sprayed water to completely dry.

Further testing and analysis would be beneficial to consider other cooler climate conditions to fully assess the performance of this type of construction.

## Appendix A –Test Program I Results

Table A1: Readings from first day of testing

| Test Program I | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Day** | **Thursday** | | | | | | | | | | | | | | | |
| **Date** | **17/01/2013** | | | | | | | | | | | | | | | |
| **Time** | **9:30 AM** | **10:00 AM** | **10:30 AM** | **11:00 AM** | **11:30 AM** | **12:00 PM** | **12:30 PM** | **1:00 PM** | **1:30 PM** | **2:00 PM** | **2:30 PM** | **3:00 PM** | **3:30 PM** | **4:00 PM** | **4:30 PM** | **5:00 PM** |
| **Cold Room temp** | 24 | 15.3 | 12.6 | 11.7 | 10.4 | 9.9 | 9.2 | 9 | 8.7 | 8.5 | 8.3 | 8.4 | 8.1 | 7.8 | 7.6 | 7.6 |
| **Cold Room RH** | 48% | 75% | 80% | 84% | 84% | 85% | 86% | 86% | 87% | 87% | 87% | 87% | 87% | 88% | 88% | 88% |
| **Hot Room temp** | 19 | 19.7 | 19.8 | 19.9 | 19.9 | 19.9 | 20 | 20 | 20 | 19.9 | 19.9 | 19.9 | 20 | 19.9 | 20 | 20.1 |
| **Hot Room RH** | 58% | 60% | 52% | 52% | 51% | 52% | 50% | 50% | 50% | 50% | 50% | 50% | 49% | 49% | 50% | 48% |
| **Probe Temp** | | | | | | | | | | | | 12.1 | 11.4 | 11.2 | 11 | |
| **Probe RH** | | | | | | | | | | | | 83.1% | 86.1% | 87.1% | 87.5% | |
| **Thermocouple readings in degrees** | | | | | | | | | | | | | | | | |
| **1** | 21 | 20.7 | 20.7 | 20.6 | 20.5 | 20.7 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.7 |
| **2** | 21.3 | 20.7 | 20.5 | 20.5 | 20.4 | 20.5 | 20.3 | 20.3 | 20.4 | 20.4 | 20.3 | 20.4 | 20.4 | 20.4 | 20.4 | 20.4 |
| **3** | 23.3 | 18.4 | 16.6 | 15.9 | 15.2 | 14.7 | 14.3 | 14.4 | 14 | 14 | 14.5 | 13.8 | 13.7 | 13.5 | 13.4 | 13.3 |
| **4** | 23.3 | 17.1 | 14.4 | 13.7 | 12.8 | 12.3 | 11.9 | 11.7 | 11.4 | 11.3 | 11.9 | 11.1 | 10.9 | 10.9 | 10.6 | 10.2 |
| **5** | 22.2 | 21 | 19.9 | 19.3 | 19 | 18.9 | 18.7 | 18.5 | 18.5 | 18.5 | 18.6 | 18.4 | 18.4 | 18.3 | 18.2 | 18.3 |
| **6** | 22.8 | 20.7 | 18.7 | 17.9 | 17.4 | 17.1 | 16.7 | 16.5 | 16.4 | 16.4 | 16.4 | 16.4 | 16.3 | 16.1 | 16 | 16.1 |
| **7** | 22.4 | 20.9 | 19.5 | 18.9 | 18.6 | 18.4 | 18.2 | 18 | 18 | 18 | 17.9 | 18 | 17.8 | 17.7 | 17.7 | 17.8 |
| **8** | 22.9 | 20.5 | 18.8 | 18 | 17.4 | 17.2 | 16.8 | 16.7 | 16.5 | 16.6 | 16.6 | 16.6 | 16.4 | 16.3 | 16.2 | 16.3 |
| **9** | 21.5 | 20.8 | 20.9 | 20.6 | 20.5 | 20.5 | 20.4 | 20.4 | 20.4 | 20.7 | 20.4 | 20.4 | 20.5 | 20.4 | 20.4 | 20.5 |
| **10** | 23.5 | 17.8 | 14.9 | 13.9 | 13.2 | 12.5 | 12.1 | 12 | 11.7 | 11.6 | 12 | 11.5 | 11.1 | 11.1 | 10.9 | 10.7 |
| **11** | 22.2 | 21.1 | 20.3 | 19.8 | 19.5 | 19.4 | 19.3 | 19.2 | 19.3 | 19.4 | 19.2 | 19.3 | 19.2 | 19.1 | 19 | 19.2 |
| **12** | 22.9 | 20.4 | 18.5 | 17.1 | 17.3 | 16.9 | 16.6 | 16.6 | 16.7 | 16.5 | 16.4 | 16.4 | 16.3 | 16.1 | 16 | 16 |
| **13** | | 15.6 | 13.3 | 12.3 | 11.4 | 10.8 | 10.3 | 10.2 | 9.8 | 9.7 | 8.9 | 9 | 8.9 | 8.4 | 8.5 | |
| **14** | | 21 | 21.4 | 20.9 | 21 | 21 | 21.2 | 21.2 | 21.4 | 21.2 | 21 | 21.2 | 21 | 21.2 | 21.2 | 21 |

Table A2: Readings from second day of testing

| Test Program I | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Day** | **Friday** | | | | | | | | | | | | | | | | | | |
| **Date** | **18/01/2013** | | | | | | | | | | | | | | | | | | |
| **Time** | **6:50AM** | **8:00 AM** | **8:30 AM** | **9:00 AM** | **9:30 AM** | **10:00 AM** | **10:30 AM** | **11:00 AM** | **11:30 AM** | **12:00 PM** | **12:30 PM** | **1:00 PM** | **1:30 PM** | **2:00 PM** | **2:30 PM** | **3:00 PM** | **3:30 PM** | **4:00 PM** | **4:30 PM** |
| **Cold Room temp** | 8.4 | 2.6 | 3 | 2.3 | 2.2 | 2 | 2 | 1.9 | 1.8 | 1.8 | 1.9 | 2.3 | 2.1 | 2 | 2.1 | 2.3 | 3 | 3.5 | 21.5 |
| **Cold Room RH** | 90% | 70% | 70% | 71% | 71% | 72% | 72% | 72% | 72% | 72% | 72% | 71% | 71% | 71% | 71% | 71% | 71% | 70% | 67% |
| **Hot Room temp** | 20 | 20 | 20 | 19.9 | 19.9 | 19.9 | 20 | 20 | 19.9 | 20 | 20 | 17.8 | 17.9 | 18 | 17.9 | 18 | 17.9 | 18.2 | 21.8 |
| **Hot Room RH** | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 53% | 52% | 52% | 52% | 52% | 52% | 56% | 58% |
| **Probe Temp** | | 6.5 | | 6.2 | | 5.8 | | | | | 5.7 | | | | 5.4 | | | 7 | 19.9 |
| **Probe RH** | | 97.0% | | 98.0% | | 98.6% | | | | | 99.1% | | | | 97.5% | | | 96.1% | 80.0% |
| **Thermocouple readings in degrees** | | | | | | | | | | | | | | | | | | | |
| **1** | 20.5 | 20.8 | 20.5 | 20.4 | 20.3 | 20.5 | 20.3 | 20.3 | 20.4 | 20.3 | 20.3 | 19.2 | 18.5 | 18.4 | 18.4 | 18.4 | 18.5 | 18.5 | 19.6 |
| **2** | 20.3 | 20.5 | 20.3 | 20.3 | 20.1 | 20.3 | 20.2 | 20.2 | 20.3 | 20.2 | 20.1 | 19 | 18.4 | 18.3 | 18.3 | 18.4 | 18.4 | 18.4 | 19.5 |
| **3** | 14.9 | 13.4 | 12.8 | 12.5 | 12.4 | 12.5 | 12.3 | 12.3 | 12.4 | 12.3 | 12.3 | 11.7 | 11.4 | 11.5 | 11.5 | 11.7 | 11.6 | 10.5 | 19.5 |
| **4** | 10.2 | 6.9 | 6.8 | 6.4 | 6.2 | 6.1 | 6.2 | 6 | 6 | 5.9 | 6 | 6.2 | 5.8 | 5.7 | 5.7 | 5.8 | 5.8 | 6.2 | 20.8 |
| **5** | 18.5 | 17.8 | 17.4 | 17.4 | 17.1 | 17.1 | 17.1 | 17.1 | 17 | 17 | 17 | 16.5 | 15.8 | 15.7 | 15.7 | 15.8 | 15.8 | 15.9 | 18.3 |
| **6** | 16.3 | 14.7 | 14.4 | 14.3 | 14 | 14 | 14 | 13.9 | 13.9 | 13.8 | 13.8 | 13.8 | 13.2 | 12.9 | 12.9 | 13 | 12.9 | 13.2 | 18.2 |
| **7** | 17.7 | 16.7 | 16.3 | 16.2 | 15.9 | 15.9 | 15.8 | 15.8 | 15.8 | 15.7 | 15.8 | 15.4 | 14.7 | 14.4 | 14.4 | 14.6 | 14.5 | 14.8 | 17.8 |
| **8** | 16.2 | 14.5 | 14.2 | 14 | 13.8 | 13.7 | 13.7 | 13.7 | 13.5 | 13.5 | 13.5 | 13.5 | 12.9 | 12.5 | 12.5 | 12.7 | 12.7 | 13 | 17.8 |
| **9** | 20.5 | 20.7 | 20.2 | 20.2 | 20 | 20.3 | 20 | 20.1 | 20.1 | 20.1 | 20.2 | 18.9 | 19.4 | 18.3 | 18.4 | 18.5 | 18.4 | 18.4 | 19.8 |
| **10** | 10.3 | 6.9 | 6.8 | 6.3 | 6 | 5.9 | 5.9 | 5.8 | 5.8 | 5.7 | 5.8 | 6 | 5.7 | 5.4 | 5.5 | 5.7 | 5.7 | 6.8 | 19.8 |
| **11** | 19.4 | 19 | 18.7 | 18.5 | 18.4 | 18.5 | 18.4 | 18.4 | 18.4 | 18.4 | 18.4 | 17.6 | 17 | 16.8 | 16.9 | 17 | 17 | 17 | 18.9 |
| **12** | 16.4 | 14.8 | 14.7 | 14.5 | 14.2 | 14.2 | 14.2 | 14.2 | 14.1 | 14.1 | 14.2 | 14 | 13.4 | 13.1 | 13.2 | 13.3 | 13.4 | 13.5 | 18.5 |
| **13** | | 4.3 | | 3.4 | | 3 | | | | | 2.8 | | | | | | | | 22 |
| **14** | 21 | 21.8 | 21.4 | 21.1 | 21.1 | 21.7 | 21.2 | 21.2 | 21.2 | 21.2 | 21.7 | 19.3 | 19.2 | 19.3 | 20 | 19.8 | 19.8 | 19.3 | 20.5 |

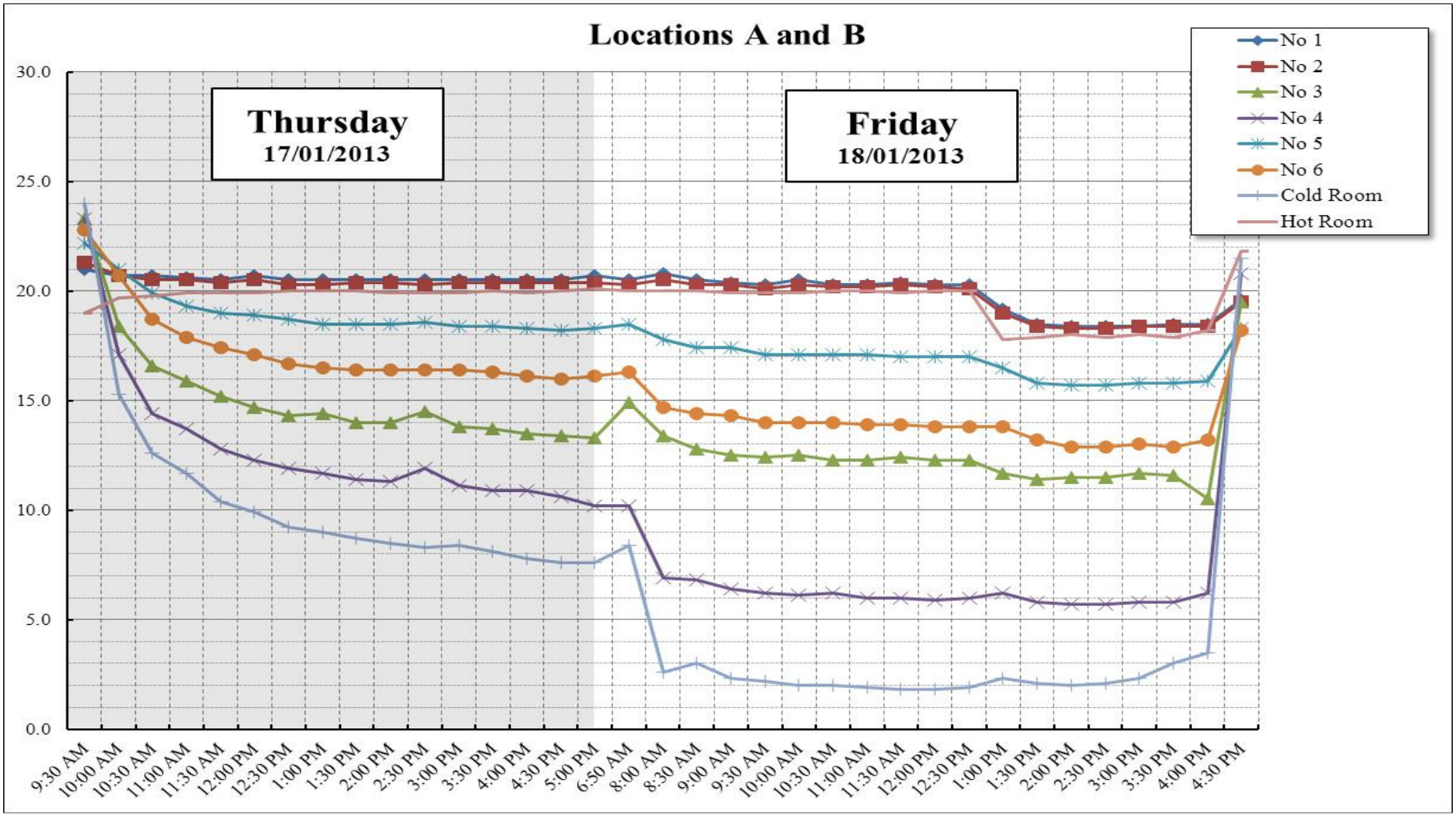



Figure A1: Thermocouple readings for Test Program I at locations A and B (refer to Figure 9 for location details)

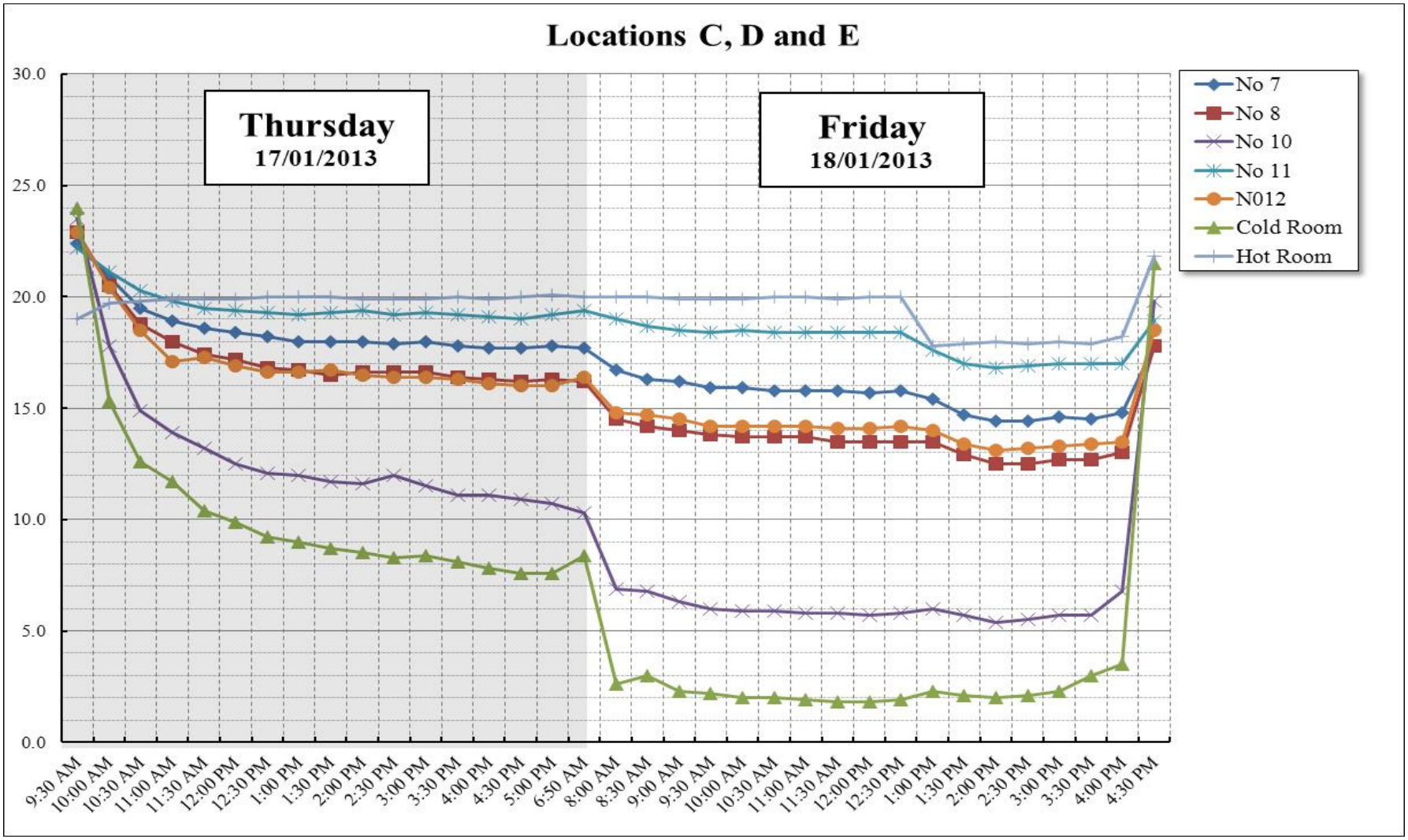



Figure A2: Thermocouple readings for Test Program I at locations C, D and E (refer to Figure 9 for location details)

# Appendix B –Test Program II Results

Table B1: Readings from Test Program II

| Test Program II | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Day** | **Tue** | **Wed** | **Wed** | **Thu** | **Thu** | **Fri** | **Fri** | **Mon** | **Mon** | **Tue** | **Tue** | **Wed** | **Wed** | **Thu** |
| **Date** | 5/02/2013 | 6/02/2013 | 6/02/2013 | 7/02/2013 | 7/02/2013 | 8/02/2013 | 8/02/2013 | 11/02/2013 | 11/02/2013 | 12/02/2013 | 12/02/2013 | 13/02/2013 | 13/02/2013 | 14/02/2013 |
| **Time** | 9:00 AM | 9:20 AM | 4:10 PM | 9:00 AM | 4:00 PM | 9:00 AM | 4:00 PM | 10:00 AM | 4:30 PM | 9:00 AM | 5:00 PM | 9:00 AM | 4:00 PM | 9:00 AM |
| **Cold Room temp** | 2.4 | 8.4 | 10 | 2.3 | 10 | 3.3 | 10 | 11.5 | 10 | 13.8 | 10.3 | 10 | 10 | 10 |
| **Cold Room RH** | 72% | 65% | 66% | 73% | 67% | 73% | 68% | 68% | 60% | 67% | 63% | 65% | 65% | 68% |
| **Hot Room temp** | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| **Hot Room RH** | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 50% |
| **Probe Temp** | _ | _ | 14.8 | 10.4 | 14.8 | 11 | 14.8 | 16.1 | 16.6 | _ | _ | _ | _ | _ |
| **Probe RH** | _ | _ | 81.60% | 76.42% | 78.80% | 77.80% | 75.80% | 61.20% | 60.00% | _ | _ | _ | _ | _ |
| **Thermocouple readings** | | | | | | | | | | | | | | |
| **1** | 20.6 | 20.6 | 20.7 | 20.5 | 20.8 | 20.5 | 20.6 | 20.8 | 20.7 | 20.8 | 20.9 | 20.9 | 20.8 | 20.6 |
| **2** | 20.4 | 20.5 | 20.6 | 20.4 | 20.7 | 20.3 | 20.3 | 20.7 | 20.7 | 20.7 | 20.8 | 20.8 | 20.7 | 20.5 |
| **3** | 8.2 | 12 | 12.3 | 8.8 | 12.7 | 9.2 | 12.8 | 15.8 | 15.5 | 17.8 | 15.3 | 15.1 | 15 | 16 |
| **4** | 5.5 | 9.8 | 11.7 | 5.5 | 11.8 | 6.3 | 11.8 | 13.9 | 13.6 | 16.7 | 12.9 | 12.8 | 12.7 | 12.9 |
| **5** | 17.2 | 17.7 | 18.7 | 17.1 | 18.9 | 17.3 | 18.8 | 19.3 | 19.1 | 19.8 | 19.2 | 19.1 | 19.1 | 19 |
| **6** | 14 | 14.9 | 16.4 | 13.9 | 17.1 | 14.3 | 16.9 | 17.8 | 17.6 | 18.9 | 17 | 17.6 | 17.5 | 17.5 |
| **7** | 16 | 16.9 | 18.2 | 15.9 | 18.3 | 16.4 | 18.4 | 18.9 | 18.7 | 19.6 | 18.5 | 18.5 | 18.5 | 18.4 |
| **8** | 13.5 | 14.9 | 16.7 | 13.5 | 16.9 | 14.2 | 17 | 17.8 | 17.7 | 19 | 17.3 | 17.2 | 17.2 | 17.1 |
| **9** | 20.4 | 20.4 | 20.7 | 20.2 | 20.8 | 20.1 | 20.5 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.6 | 20.5 |
| **10** | 6.8 | 11 | 12.4 | 6.7 | 12.4 | 7.7 | 12.3 | 14 | 14.5 | 17 | 13.9 | 13.8 | 13.7 | 13.7 |
| **11** | 18.5 | 18.8 | 19.5 | 18.2 | 19.7 | 18.4 | 19.5 | 20.5 | 19.9 | 20.4 | 20.7 | 20 | 20 | 19.9 |
| **12** | 14.4 | 15 | 16.8 | 14.1 | 17.2 | 14.4 | 17.1 | 18.2 | 18.1 | 19.4 | 18.4 | 18.4 | 18.4 | 18.2 |
| **13** | 4.3 | _ | 10.8 | 3.8 | 10.7 | 4.1 | _ | _ | _ | _ | _ | _ | _ | _ |
| **14** | 21.6 | 21.3 | 21.6 | 21.3 | 21.8 | 21.3 | 21.4 | 21.3 | 21.2 | 21.2 | 21.3 | 21.4 | 21.6 | 21.3 |
| **Inside the wall** | ✔ checked | ✔ checked | ✔ checked | _ | ✔ checked | _ | ✔ checked | ✔ checked | ✔ checked | ✔ checked | ✔ checked | ✔ checked | ✔ checked | ✔ checked |
| **Inside the wall Condition report** | | Sprayed 192g of water on the inside of the XPS sheet and insulation @ 9:00 am (cold room temp was 4.6 degree). | Both panel and insulation were wet same as in the morning. | The cold room was at 2.3. The chamber is not capable of reaching a lower temperature. | Both panel and insulation were wet same as morning. | The cold room temperture was 3.3 in the morning. | Inside the wall was wet but not as much as last observation. | Inside the wall was still wet, specially bottom section. | A bit dryer than morning. | The top panel was dryer than Monday. But bottom section was still wet. | The top section was almost dry. | The top panel and insulation were 100% dry. The bottom section was a bit wet. | Drayer than morning. | Wall panel compeletly dry. |
| **Notes** | Initial conditioning of the test wall. | The readings were taken after spraying. | Decreased cold room temp to reach a target of about 2 degrees during the night. | Increase cold room temperture to 10 degrees and let it stay at this temp for 6 hours. | Decreased cold room temp to reach a target of about 2 degrees during the night. | Increase cold room temperture to 10 degree and let it stay at this temp for 6 hours. | Cold room set at 6 degree during weekend, which is between 3 and 10 degrees. | The Chamber temperture in the morning was 11.5 instead of 6. | Decreased cold room temp to target 2 degrees during the night. | The temperture was 13.8 in the morning. The chamber could not keep temperture under 10. | It decided to keep cold room temperture at 10 degrees. | _ | _ | _ |
| **Figure no** | B1 | B2 | B3 | _ | B4 | _ | B5 | _ | B6 | _ | B7 | _ | B8 | B9 |

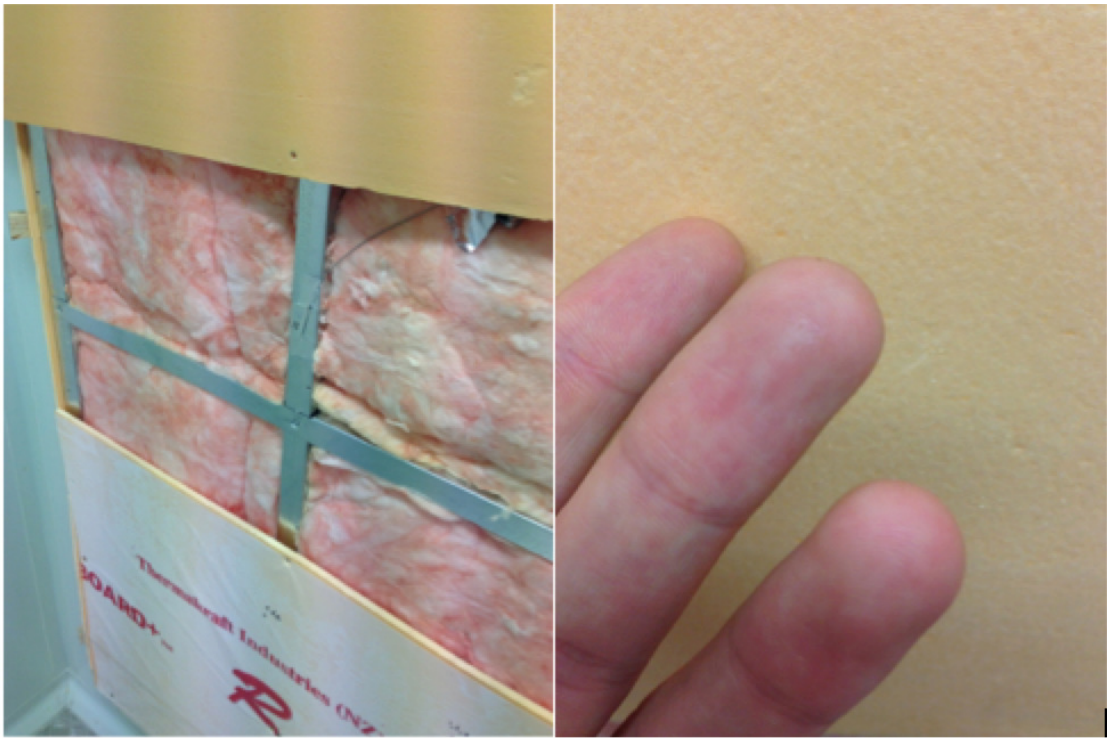


Figure B1. Dry state of XPS foam and insulation batts

Figure B2. Spraying water to insulation batts and XPS foam

Figure B3. First day check

Figure B4. Second day check

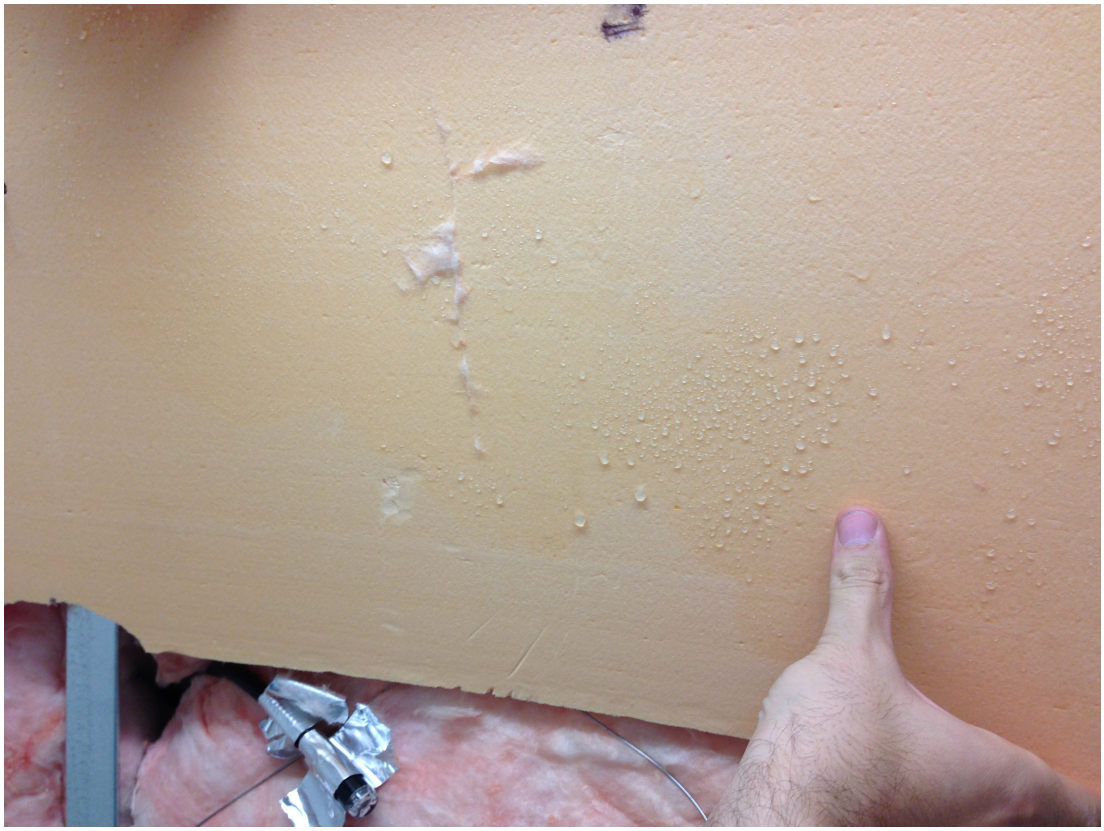


Figure B5. Third day check

Figure B6. Fourth day check

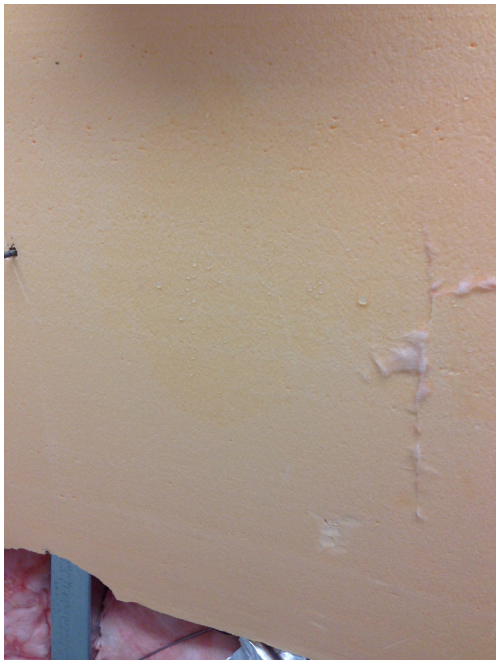


Figure B7. Fifth day check

Figure B8. Sixth day check

Figure B9. Eighth day check (Completely dry)