Party Wall Cavity Barrier Effective Edge Seal Testing for ARC Building Solutions Ltd

LEEDS BECKETT UNIVERSITY

Enterprise Services

CUSTOMER SERVICE EXCELLENCE

UK

The Government Standard

Contacts

Contact at Client:

Client:	ARC Building Solutions Ltd
Contact:	Mr. Russell Irving
Position:	Director
Contact No:	0113 252 9428
Email:	russell.irving@arcbuildingsolutions.co.uk
Address:	Units H1/H2 Gildersome Spur Leeds LS27 7JZ

Contacts at Leeds Beckett University:

Contacts:	Professor Christopher Gorse Matthew Brooke-Peat Dominic Miles-Shenton David Farmer
Tel:	0113 8121941
Email:	c.gorse@leedsbeckett.ac.uk m.brooke-peat@leedsbeckett.ac.uk d.miles-shenton@leedsbeckett.ac.uk d.j.farmer@leedsbeckett.ac.uk
Enterprise Services Sponsor:	Janet Mulcrone
Tel:	0113 812 8549
Email:	j.mulcrone@leedsbeckett.ac.uk

Contents

Effective Edge Seal Testing Report

Executive Summary

1.0 Background

ARC Building Solutions Ltd manufacture, market and distribute a range of party wall cavity barriers. Part L of the Building Regulations (HM Government, 2013) stipulates that when cavity barriers are used for edge sealing purposes, then the seal must be effective at restricting air flow between the party wall cavity and the external wall cavity or external environment (Figure 1). The Building Control Alliance (2011) describes how an edge seal is to be judged as being effective in a qualitative manner. However, there is currently no standard test for quantitatively demonstrating the effectiveness of edge sealing using a cavity barrier product. ARC Building Solutions Ltd wished to quantify the effectiveness of the edge seal that could be achieved using the Company's products under test conditions. This information could prove useful when engaging designers, building control bodies and warranty providers.

Table 3 U-values for party walls

Party wall construction	U-value (W/m^{2}K)
Solid	0.0
Unfilled cavity with no effective edge sealing	0.5
Unfilled cavity with effective sealing around all exposed edges and in line with insulation layers in abutting elements	0.2
A fully filled cavity with effective sealing at all exposed edges and in line with insulation layers in abutting elements	0.0

Figure 1 Stipulated U-values for new-build party walls from Approved Document L1A (HM Government, 2013)

As there is currently no quantitative benchmark for what is deemed to be an effective edge seal this project aimed to compare the performance of a recognised 'current practice' solution against ARC Building Solutions Ltd.'s T-Barrier, and as far as possible compare these to an accepted effective edge seal for a number of different party wall and external wall cavity widths. In addition to this comparative testing, this project may also assist in the development and application of a standardised 'Edge Seal Test' for which there is understood to be no current standard or specific precedent.

Whilst the test rig may not be fully representative of the actual construction of a party wall/external wall junction in situ, it is hoped that the results may provide insight as to how the performance of these products may compare in real building situations.

2.0 Test Rig and Equipment

2.1 Subject of Testing

This project relates to the development and application of an effective edge seal test, centring around the comparative performance of accepted solutions to that of the ARC Building Solutions Ltd T-Barrier product.

The test rig was designed to enable the parameters of the rig to be predetermined to allow consistent testing of edge seal solutions, unaffected by the partial deconstruction and reconstruction required to install each cavity barrier test subject. Whilst the materials incorporated into the test rig have a different surface texture to many common construction materials in use, they remain the same for each individual test, limiting the variables between the tests and allowing direct comparisons to be made. The coefficients of friction between the internal surfaces of the party wall cavity may vary from those encountered in real buildings, but are standard throughout the series of tests conducted. Similarly, the pressures generated within a party wall cavity in a real building will be both positive and negative; for simplicity, these tests utilise only a positive pressure in the party wall cavity, compared to the external wall cavity and external environment.

The installation quality of all cavity barriers tested within this project was carried out to the same standard, regarded as what could be considered good practice in the field, without gaps between or around the individual barriers. This may vary from that typically encountered on many building site, but variations in installation and workmanship did not fall within the scope of this project where every effort was made to ensure consistency between individual tests.

2.2 Outline Description of Testing

2.2.1 Test Rig

A test rig was constructed to simulate a party wall/external wall junction. The design of the test rig was agreed between ARC Building Solutions Ltd and the research team at Leeds Beckett University prior to commencement of the testing and illustrated in Figure 2.

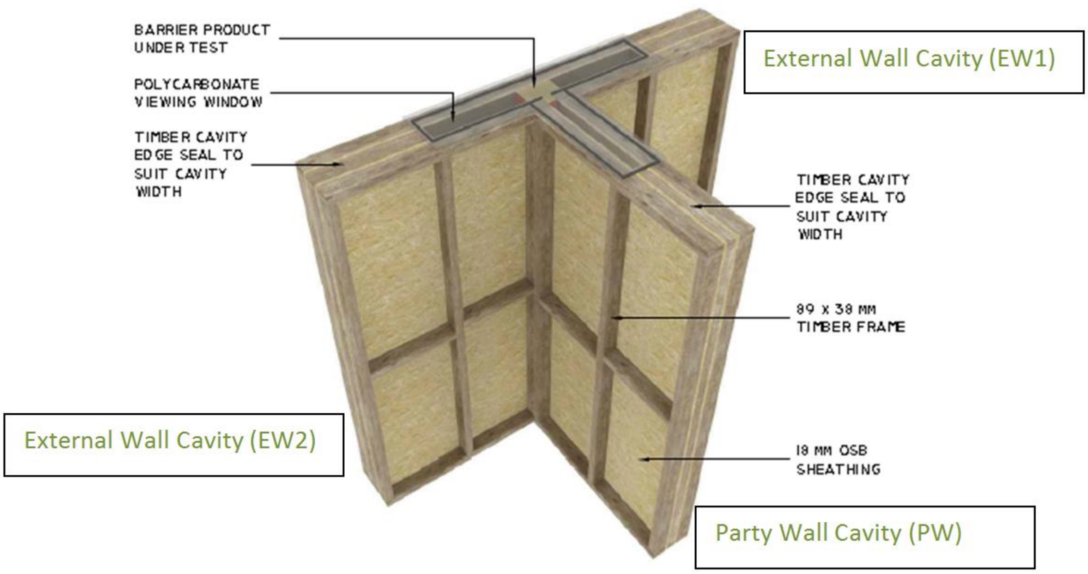

Figure 2 Test rig design

The test rig was assembled inside ARC Building Solutions' factory on a plywood platform, with one leaf of the party wall and external wall permanently fixed in position (PW/EW1 in Figure 2). It was designed to allow the outer leaf of the external wall to be regularly removed and replaced for access to the cavity junction, enabling test products to be installed and exchanged and pre-cut timber cavity edge seals to be inserted to represent different external wall cavity sizes. The other leaf of the party wall and inner leaf of the external wall (PW/EW2) could also be moved, when required, to mimic a variety of party wall cavity widths.

Figure 3 Test rig

2.2.3 Test Equipment

Measurement and monitoring equipment was supplied by the Leeds Beckett University research team and installed into the test rig as shown in Figure 4, with an inventory of the equipment used provided in Table 1.

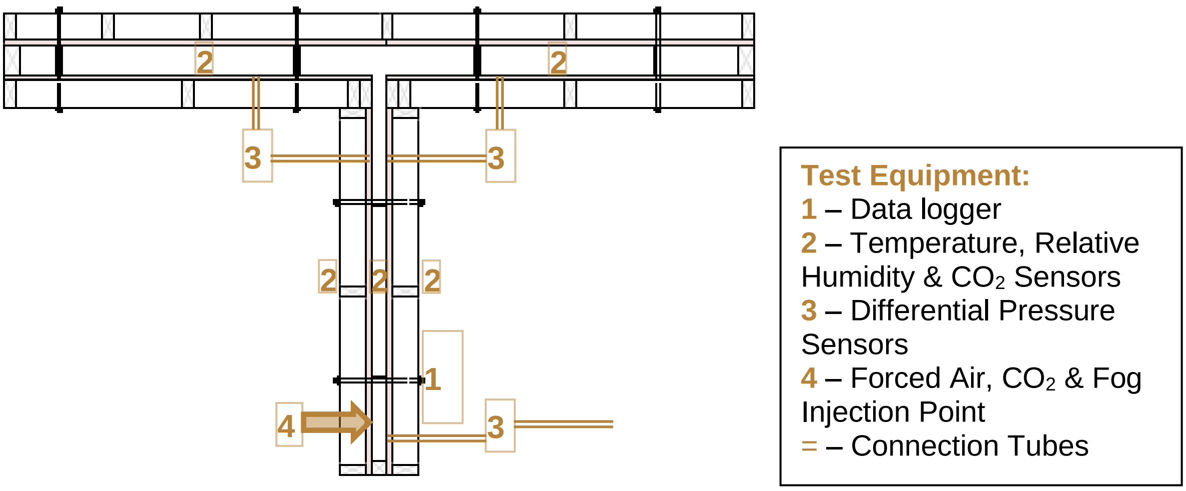

Figure 4 Location of measurement and monitoring equipment

Table 1 Equipment inventory

Datalogger	Eltek RX250AL (logging at 10s intervals)	
CO_2/Temperature/RH Sensors	Eltek GD-47	5 No.
Differential Pressure Sensors	Eltek GD-84	3 No.
Hot Air Gun	Steinel HG231LCD electronic	
Smoke Generator	Chauvet Hurricane 700	
Thermal Camera	Flir B620	

2.2.3 Tracer Gas Test

A bottled carbon dioxide (CO_2) supply and dispersion system was used to inject CO_2, as a tracer gas, into the party wall cavity of the test rig at the injection point (**4** in Figure 4) upon commencement of each test. The level of CO_2 introduced was controlled via a solenoid valve and a regulator set to a known volumetric flow using an inline pocket flow meter, with the injection point near the top of the party wall cavity (Figure 5). A controlled release into the party wall cavity was timed to allow the concentration of CO_2 in the party wall cavity to rise to 1500~2500 ppm above the background level, before the injection tube was removed and the injection hole sealed over. Instrumentation installed in the party wall and external wall cavities, and to the outside of the test rig (**2** in Figure 4), measured CO_2 concentrations at 10 second intervals. These measurements of CO_2 rise and decay are used to determine the direction of airflow between the cavities within the test rig, providing a metric for communication between the test rig cavities.

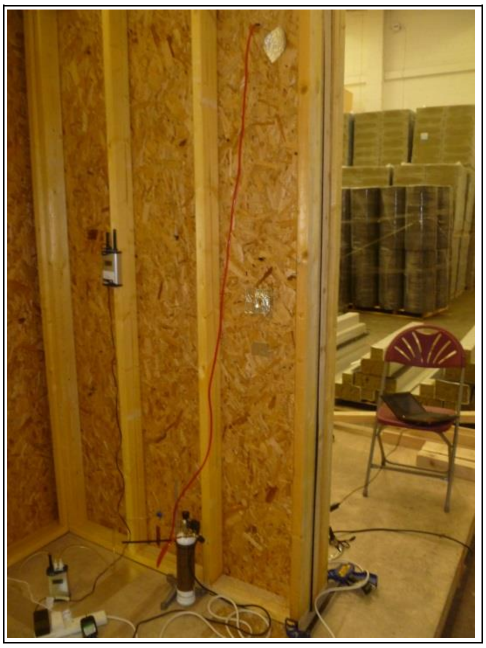

Figure 5 Tracer gas (CO_2) cylinder, regulator, solenoid valve and injection tube.

2.2.4 Pressure Test

A Steinel HG231LCD electronic hot air gun with a regulated volumetric flow was applied to the injection point (**4** in Figure 4) to create a positive pressure in the party wall cavity. A silicone seal was built up around the injection point using Sugru™ to ensure consistent airflow into the party wall cavity from the air gun (Figure 6), the flow settings on the air gun were set to either a nominal 150 or 250 l/min depending on which test procedure was being followed. The differential pressure between the party wall cavity and the external environment was recorded for each edge seal solution to provide a metric for how successfully each option sealed the party wall. Differential pressures between the party wall cavity and each of the external wall cavities was also recorded to illustrate how effective an edge seal was achieved at the party/external wall junction in particular.

Figure 6 Forced air injection point and seal

2.2.5 Smoke Test

A fog machine was used to fill the party wall cavity with a non-toxic water based fog. The intention of using fog was to visually identify any air leakage issues with the product that was subject to the test. This process was initially recorded using digital still and video cameras through the viewing window at the top of the testing rig. This technique proved inconclusive, as neither method of image capture adequately illustrated either the path of the smoke or comparative severities. A number of attempts to improve the images obtained were undertaken, line lasers were introduced at the top of the test rig and additional windows were cut into the external wall frame (Figure 7); but it was still not possible to satisfactorily capture the movement of the smoke using digital imaging devices (Figure 8).

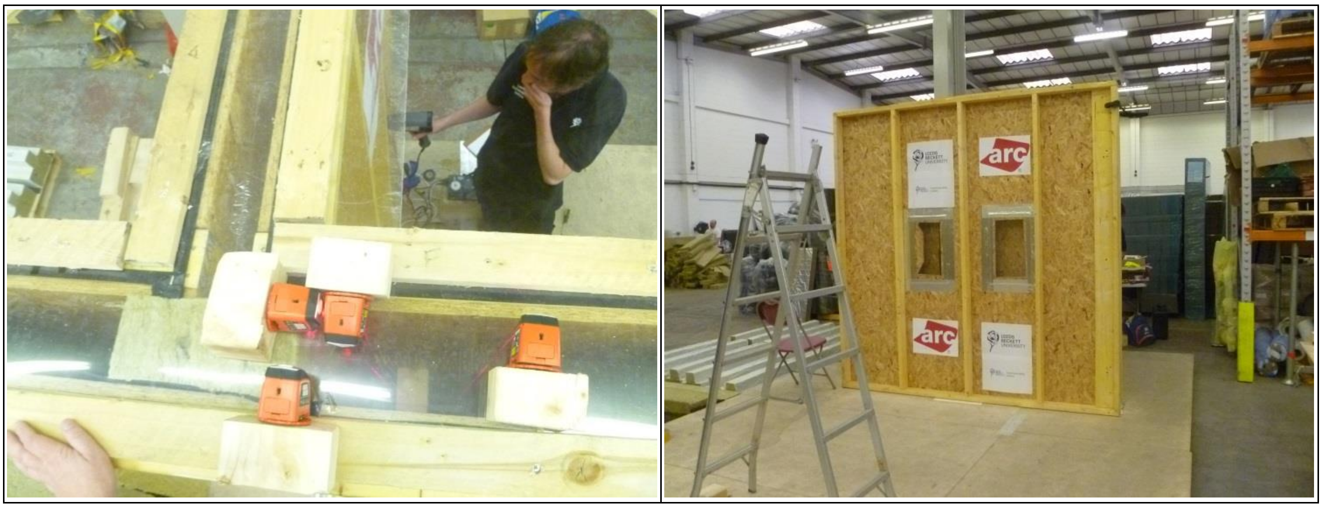

Figure 7 Laser lines and additional viewing windows introduced to assist smoke testing

Figure 8 Images capturing of smoke proved inadequate for purpose

2.2.6 Test Dates and Procedures

The Leeds Beckett University research team began testing on site on Monday 1st June 2015, to set up the measurement and monitoring equipment and develop a test protocol which could be applied to test the full range of edge seal solutions which were intended to be tested. The initial tests performed on the test rig were carried out using either a tracer gas or smoke introduced into the party wall cavity without any induced pressure applied, this proved unsuccessful as diffusion alone was not enough to establish a measureable result. Tests were then carried out using an electronic hot air gun to blow air into the party wall cavity to generate a pressure differential between this cavity and both the other cavities and the external factory environment.

With the party wall cavity and external wall cavity set to 50 mm a test procedure was established for testing each of the edge seal solutions, Test Procedure 1.

Test Procedure 1:

1. Inject CO_2 at 5 litres/minute for 15 seconds into the party wall cavity
2. Blow warm air into the party wall cavity at a nominal 150 l/min for 30 minutes
3. Record the pressure differentials between the party wall cavity and a) the surrounding environment and b) the 2 external wall cavities over the 30 minute period
4. Record the CO_2 concentrations in the party wall and external wall cavities over the 30 minute period

Whilst this adopted test procedure was believed to simulate those pressure differentials encountered in party wall cavities in real dwellings under natural conditions, it did not appear to be a vigorous enough test to provide distinct and measureable test results; particularly between the better performing edge seal solutions, the mineral wool in a polythene sock and the ARC T-Barrier. Two alternative test procedures were evaluated, increasing the amount of CO_2 introduced over a prolonged period at a reduced rate (Test Procedure 2) and the rate of introduction of CO_2 (Test Procedure 3) with the test over a reduced time period as it was noted that the peak CO_2 readings in the external wall cavities were being achieved within 15 minutes of pressurisation of the party wall cavity commencing. The latter was adopted for first set of tests on the 75 mm party wall cavity, with a 100 mm external wall cavity.

Test Procedure 2:

1. Inject CO_2 at 1 l/min for 6 minutes into the party wall cavity
2. Blow warm air into the party wall cavity (as Test Procedure 1) for 30 minutes
3. Record the pressure differentials (as Test Procedure 1) over the 30 minute period
4. Record the CO_2 concentrations (as Test Procedure 1) over the 30 minute period

Test Procedure 3:

1. Inject CO_2 at 6 l/min for 25 seconds into the party wall cavity
2. Blow warm air into the party wall cavity at a nominal 150 l/min for 15 minutes
3. Record the pressure differentials between the party wall cavity and a) the surrounding environment and b) the 2 external wall cavities over the 15 minute period
4. Record the CO_2 concentrations in the party wall and external wall cavities over the 15 minute period

Although these amended test procedures provided some improvement in the distinction between different edge seal solutions the research team concluded that it was necessary to use higher pressure differentials to provide greater clarity between the different products' test performance. Test procedure 4 was introduced with the air gun flow setting increased from 150 l/min to 250 l/min. This procedure was adopted for all the subsequent tests.

Test Procedure 4:

1. Inject CO_2 at 6 l/min for 30 seconds into the party wall cavity
2. Blow warm air into the party wall cavity at a nominal 250 l/min for 15 minutes
3. Record the pressure differentials (as Test Procedure 3) over the 15 minute period
4. Record the CO_2 concentrations (as Test Procedure 3) over the 15 minute period

For tests 4.15, 4.16 & 4.17, additional measurements were taken at the end of the 15 minute period with the air input set to a nominal 200 l/min and 150 l/min for additional periods.

Table 2 Individual tests performed

Test Reference	Date	Procedure	Party Wall Cavity (mm)	External Wall Cavity (mm)	Edge Seal Measure Installed
1.1	02Jun2015	1	50	50	Single sleeved cavity sock
1.2	03Jun2015	1	50	50	Twin sleeved cavity socks
1.3	03Jun2015	1	50	50	Mineral wool
1.4	03Jun2015	1	50	50	T-Barrier
2.5	04Jun2015	2	50	50	T-Barrier
3.6	04Jun2015	3	75	100	Mineral wool + dpc
3.7	04Jun2015	3	75	100	T-Barrier
3.8	05Jun2015	3	75	100	Protect membrane
4.9	05Jun2015	4	75	125	Protect membrane
4.10	05Jun2015	4	75	125	T-Barrier
4.11	05Jun2015	4	75	125	Mineral wool + dpc
4.12	08Jun2015	4	75	150	T-Barrier
4.13	08Jun2015	4	75	150	Mineral wool + dpc
4.14	09Jun2015	4	100	150	Mineral wool + dpc
4.15	09Jun2015	4	100	150	T-Barrier
4.16	09Jun2015	4	100	125	T-Barrier
4.17	09Jun2015	4	100	125	Mineral wool + dpc
4.18	16Jun2015	4	100	100	Airtightness sealing tape
4.19	16Jun2015	4	100	100	T-Barrier
4.20	16Jun2015	4	100	100	Mineral wool + dpc

2.3 Limitations

The proposal for this project suggested the development and application of a test for which there is understood to be no current standard or specific precedent. With the test rig designed to enable partial deconstruction and reconstruction it was not fully representative of the actual construction of a party wall/external wall junction *in situ* but did provide a pragmatic proxy. The materials incorporated into the test rig have a more uniform topography than that encountered in real buildings, but remain consistent throughout the test programme. The pressures generated within a party wall cavity *in situ* will vary in both magnitude and direction, the test procedures were only possible to measure one direction and had to use standard flows to allow comparisons between products to be valid. The test procedure evolved as the series of tests progressed, limiting direct comparisons of results to between those tests conducted to the same test procedure. Finally and most prudently, without a quantitative benchmark for what is deemed to be an effective edge seal absolute values and units are avoided wherever possible in this report, as any quantitative measurements are of the product and test rig combined, not of the product alone.

2.4 Project Team

The development and application of the effective edge seal test was undertaken by staff from the Centre for the Built Environment (C*e*BE) Group within the Leeds Sustainable Institute at Leeds Beckett University and staff at ARC Building Solutions Ltd. The C*e*BE group have some history with party wall issues, as it was studies performed by C*e*BE as part of the Stamford Brook field trials (Lowe et al., 2007; Wingfield et al., 2011) that were fundamental in the U-values shown in Figure 1being adopted for masonry cavity party walls.

2.5 Project Outputs

The main project output comprises this report, presenting the results and findings of the testing. An initial interim technical note and preliminary data analysis was submitted to ARC Building Solutions Ltd. upon completion of the tests, some of the data in this this report has undergone additional analysis and supersedes that presented in the interim report. This report completes the required submissions agreed prior to commencement of the project.

3.0 Results

3.1 Individual Test Results

CO_2 tracer gas and pressure differential plots are displayed below for each individual test undertaken; these are presented in chronological order and grouped according to the party wall cavity width being tested. Whilst some brief comments on individual tests are included in this section, summaries and comparisons between the tests are expanded upon in sections 3.2 and 3.3 of this report.

The CO_2 concentration plots (Figure 10 through to Figure 68) show the maximum concentration in the party wall cavity occurring around 2½ minutes after the release of CO_2 into the chamber, this period shows little variation between different test procedures, air input rates and cavity widths, so is deemed to be the reaction time of the Eltek GD-47 CO_2 sensors for this application. The pressure differential plots (Figure 11 through to Figure 69) show instantaneous reaction from the Eltek GD-84 pressure sensors. The horizontal time axis on both the CO_2 and pressure plots for each individual test are synchronised, although the period of time from the commencement of data logging to the start of the actual test does vary between tests.

3.1.1 50 mm Party Wall Cavity

Tests 1.1 to 2.5 (as defined in Table 2) were undertaken with the party wall cavity width set to 50 mm, the external wall cavity width was also set to 50 mm throughout this set of tests.

Test 1.1: Single sleeved cavity sock

Figure 9 Test 1.1, single sleeved sock, 50 mm party wall, 50 mm external wall

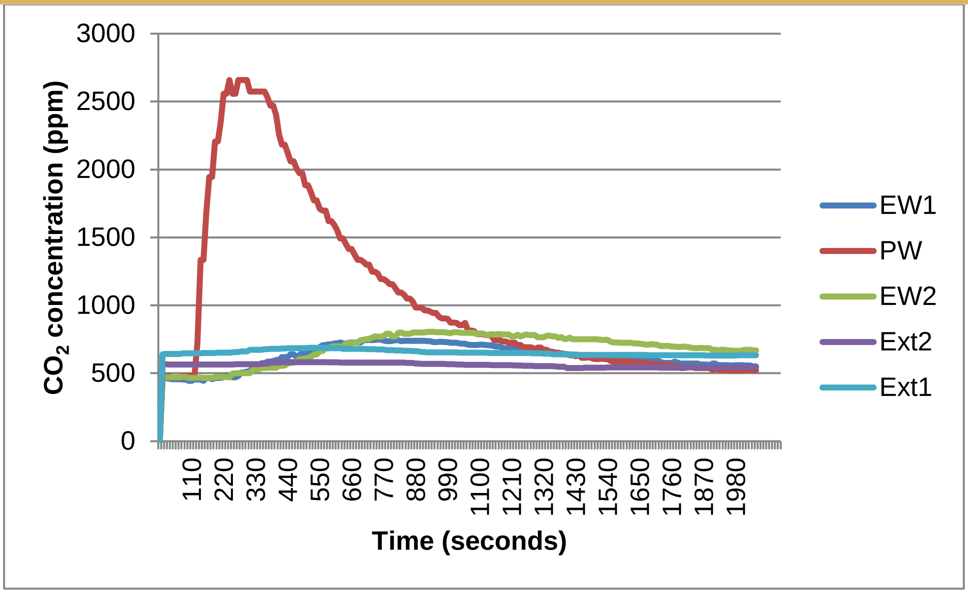

Figure 10 Test 1.1 CO_2 concentrations

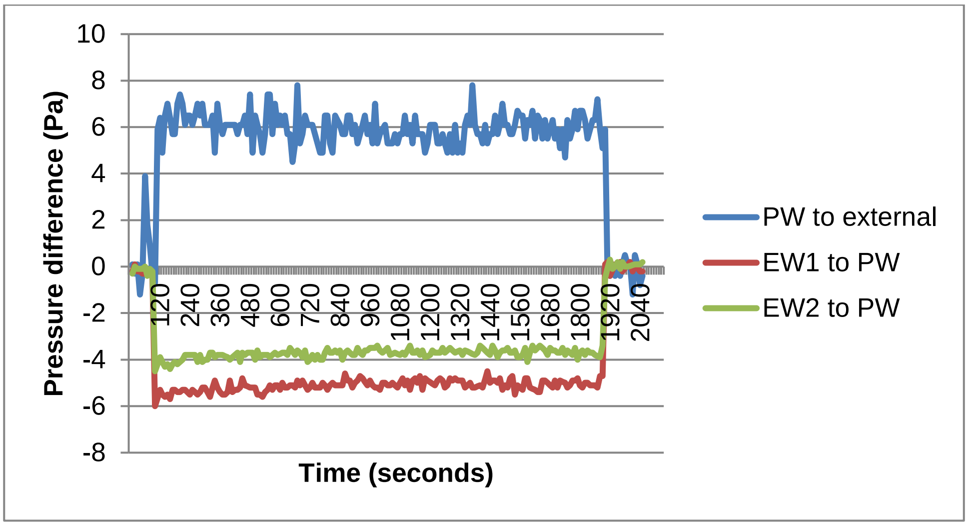

Figure 11 Test 1.1 Pressure differentials

Figure 10 shows the measured CO_2 concentration in the party wall increasing rapidly from a background level of around 470 ppm to a maximum of 2660 ppm, this is followed by the CO_2 levels in the external wall cavities increasing from 460 and 470 ppm to 750 and 810 ppm for EW1 and EW2 respectfully; whilst the CO_2 sensors positioned on outside of the test rig remain relatively constant. This suggests that the party wall cavity is communicating with the external wall cavities, with movement of the tracer gas from the party wall cavity into both external wall cavities.

Figure 11 displays the forced air into the party wall cavity elevating the pressure within the cavity to an average of 5.98 Pa above the environment pressure. Differential pressures between the party wall cavity and the external wall cavities of 5.12 and 3.71 Pa for EW1 and EW2 show that there is some pressurisation (relative to the environment) of both external wall cavities, confirming communication between the party wall and external wall cavities. The difference between the pressures recorded for EW1 and EW2 also indicated that the edge seal varied between either of the external wall cavity chambers; the side with the less effective seal (EW2) showing a lower pressure differential with the party wall cavity and greater exchange of CO_2 between these two cavities.

Test 1.2: Twin sleeved cavity socks

Figure 12 Test 1.2, twin sleeved socks, 50 mm party wall, 50 mm external wall

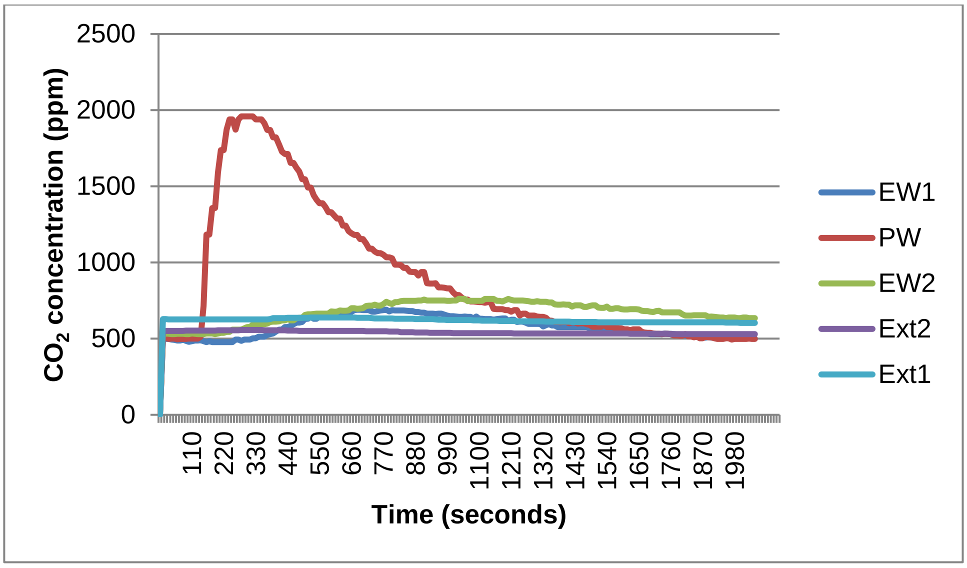

Figure 13 Test 1.2 CO_2 concentrations

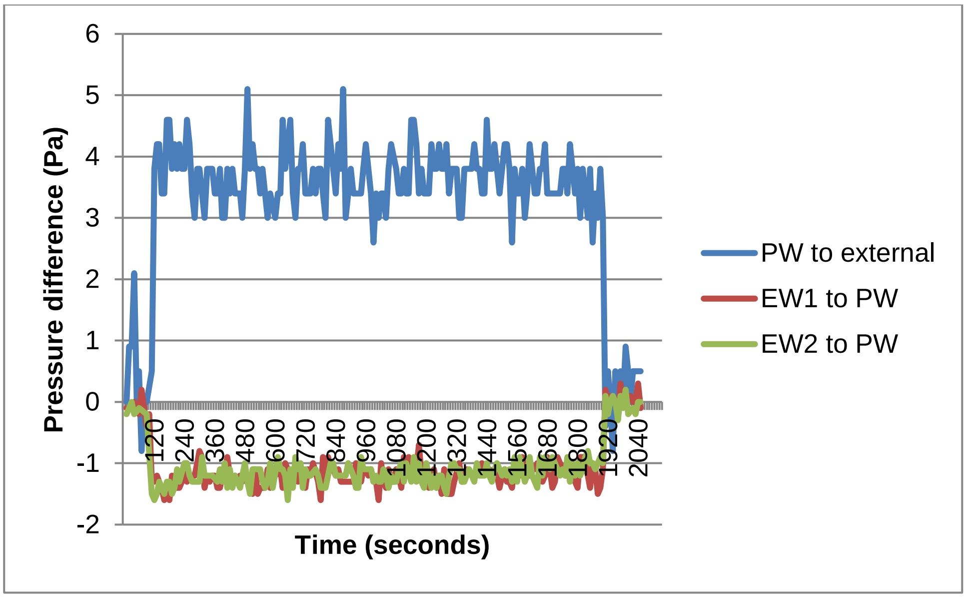

Figure 14 Test 1.2 Pressure differentials

Figure 14 displays the smallest pressure differentials achieved in any of the tests conducted, ostensibly due to the party wall cavity being open to the external wall cavity at the junction. This had the combined effect of not only increasing the volume of the party wall cavity, but also exposing the party wall cavity to other potential air leakage paths from the test rig itself.

Test 1.3: Mineral wool

Figure 15 Test 1.3, unsleeved mineral wool sock, 50 mm party wall, 50 mm external wall

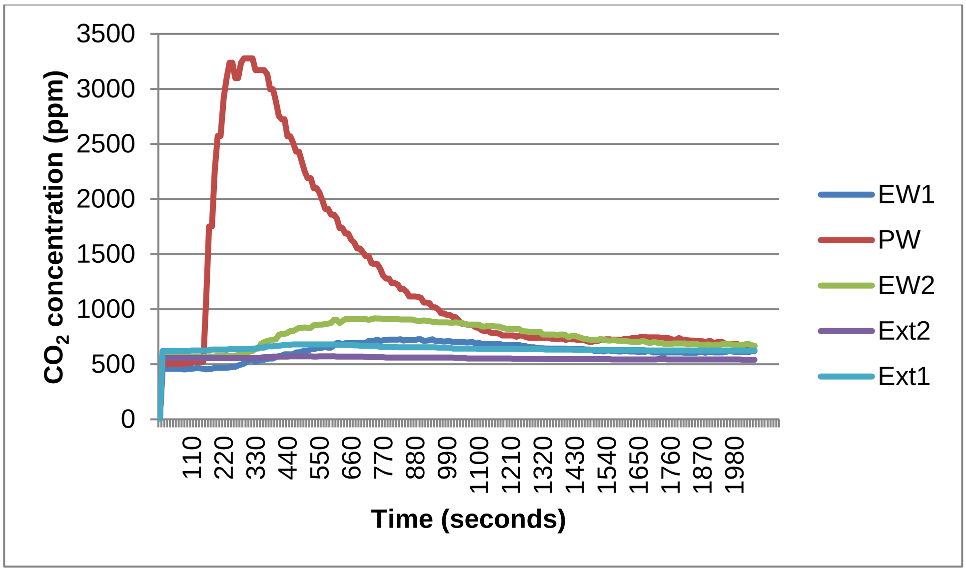

Figure 16 Test 1.3 CO_2 concentrations

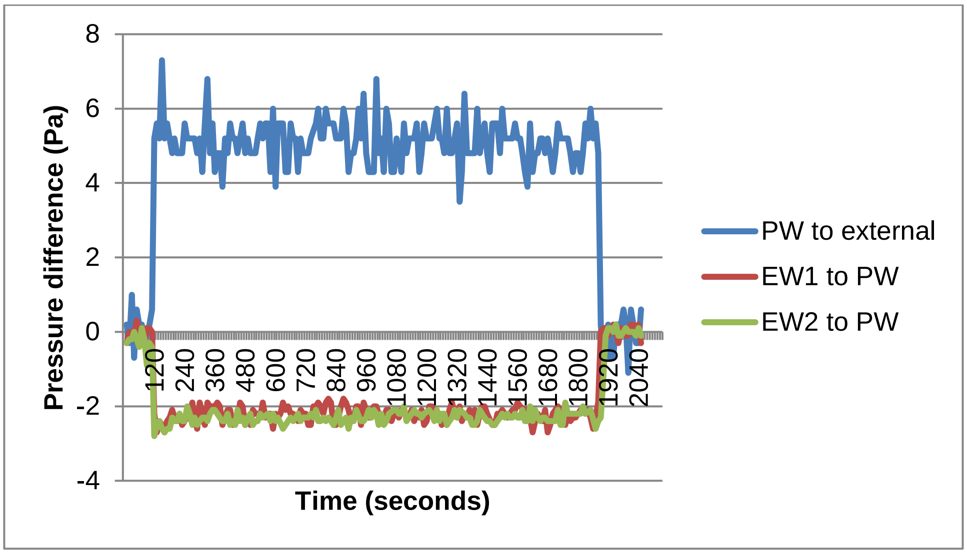

Figure 17 Test 1.3 Pressure differentials

The mineral wool edge seal displayed lower pressure differentials (Figure 17) than the previous edge seal solutions tested, illustrating that mineral wool without any impermeable sleeve is unlikely to provide as effective an barrier against air movement even at the lower range of pressures applied in this test. The +5 Pa pressurisation of the party wall cavity, whilst being fairly typical of the types of pressure differentials this junction would encounter in real buildings, was still enough to allow pressurisation of the external wall cavities consistently throughout the duration of this test.

Test 1.4: ARC T-Barrier

Figure 18 Test 1.4, ARC T-Barrier, 50 mm party wall, 50 mm external wall

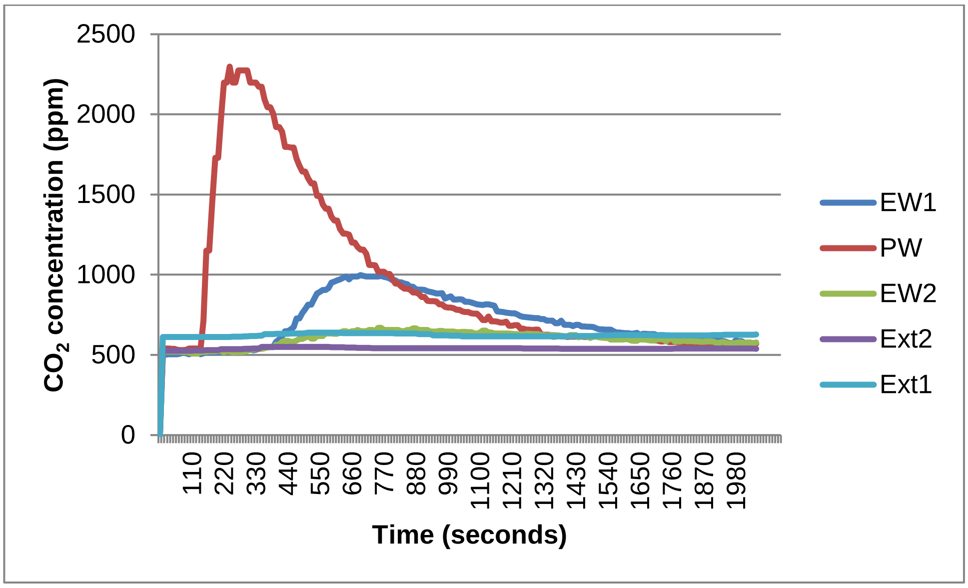

Figure 19 Test 1.4 CO_2 concentrations

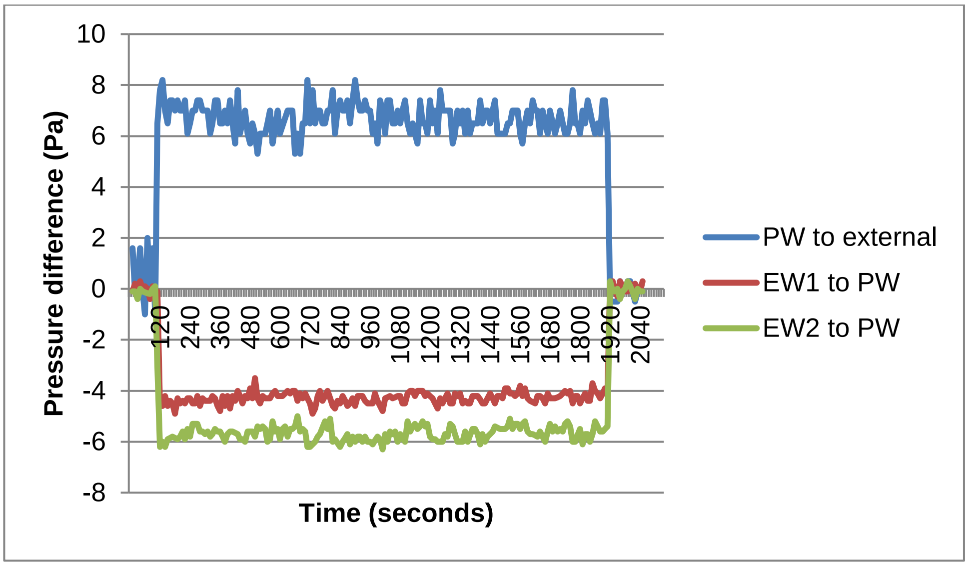

Figure 20 Test 1.4 Pressure differentials

Of all the tests conducted using test procedure 1, the ARC T-Barrier produced the greatest pressure in the party wall cavity and the greatest pressure differential between the party wall cavity and the external wall cavities. Although the ARC T-Barrier performed significantly better as an edge seal than the twin socks and unsleeved mineral wool solutions, the improvement over the single sock solution utilised in test 1.1 was not so marked and changes to the test procedure were deemed necessary to enhance any distinguishability between the better performing edge seal solutions.

Test 2.5: ARC T-Barrier

With the test rig unaltered from test 1.4, test 2.5 was conducted the following day with the intention of introducing CO_2 into the party wall cavity more slowly but over a prolonged period (test procedure 2). The ARC T-Barrier proved to be too good a seal of the party wall cavity for this adapted procedure, with the CO2 level in the party wall cavity rapidly exceeding the measurement range of the Eltek GD-47 sensor (Figure 21).

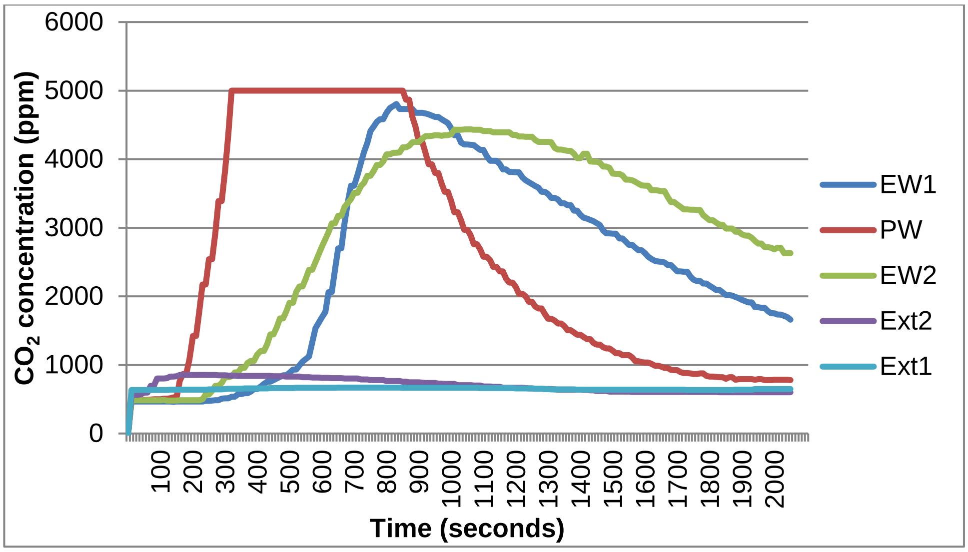

Figure 21 Test 2.5 CO_2 concentrations

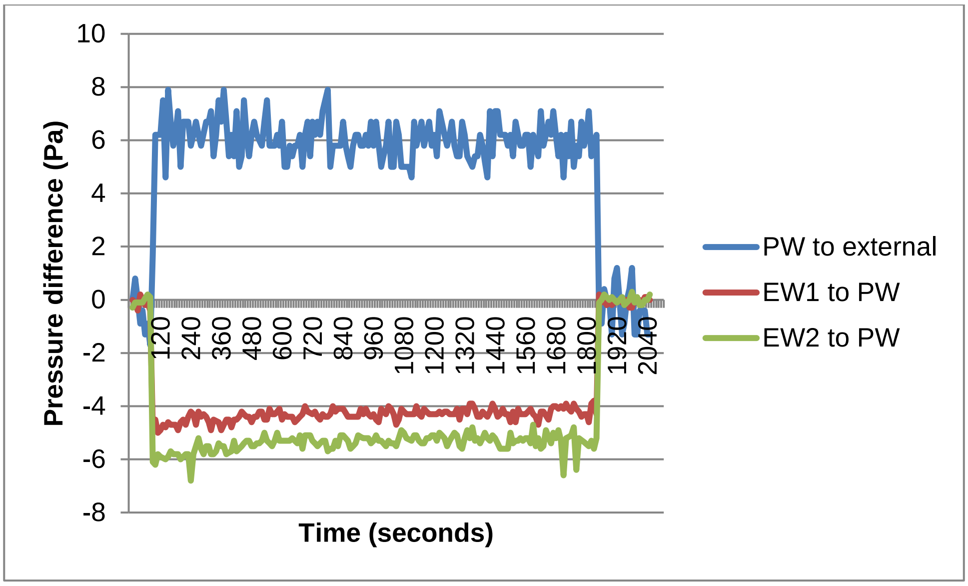

Figure 22 Test 2.5 Pressure differentials

Although this test procedure proved unsuitable for this study it provided an indication of the robustness of the ARC T-Barrier and the test rig itself, with Figure 22 displaying very similar values to that displayed in Figure 20 which had been undertaken the previous day.

3.1.2 75 mm Party Wall Cavity

Tests 3.6 to 3.8 and 4.9 to 4.13 (Table 2) were undertaken with the party wall cavity width set to 75 mm. Three sets of comparative tests were performed, with external wall cavity widths at 100 mm, 125 mm and 150 mm. The tests with the 100 mm external cavity (tests 3.6 to 3.8) were performed with an air input at a nominal 150 l/min; all subsequent tests were carried out with and increased air input to maximise the differences in performance between the products as edge seal solutions, with the rate of air input boosted to a nominal 250 l/min as indicated on the Steinel electronic hot air gun.

Test 3.6: Mineral wool + dpc

Figure 23 Test 3.6, mineral wool + dpc, 75 mm party wall, 100 mm external wall

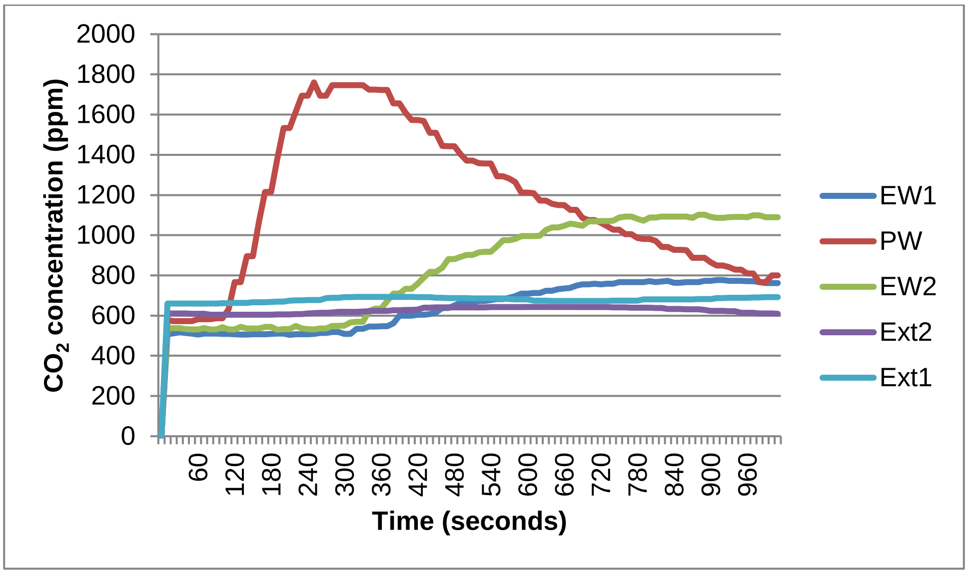

Figure 24 Test 3.6 CO_2 concentrations

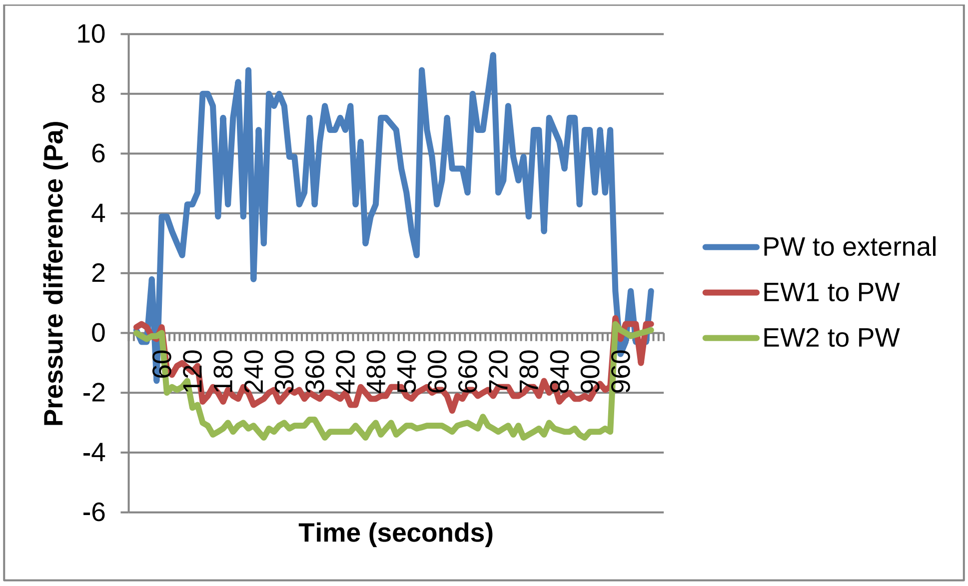

Figure 25 Test 3.6 Pressure differentials

Even with the test rig reset for the wider party wall cavity, the mean pressure differentials displayed in Figure 25 for both party wall cavity and external wall cavities resemble those obtained in test 1.3

(Figure 17) for the unsleeved mineral wool edge seal of the 50 mm party wall cavity with 50 mm external wall cavities.

Test 3.7: ARC T-Barrier

Figure 26 Test 3.7, ARC T-Barrier, 75 mm party wall, 100 mm external wall

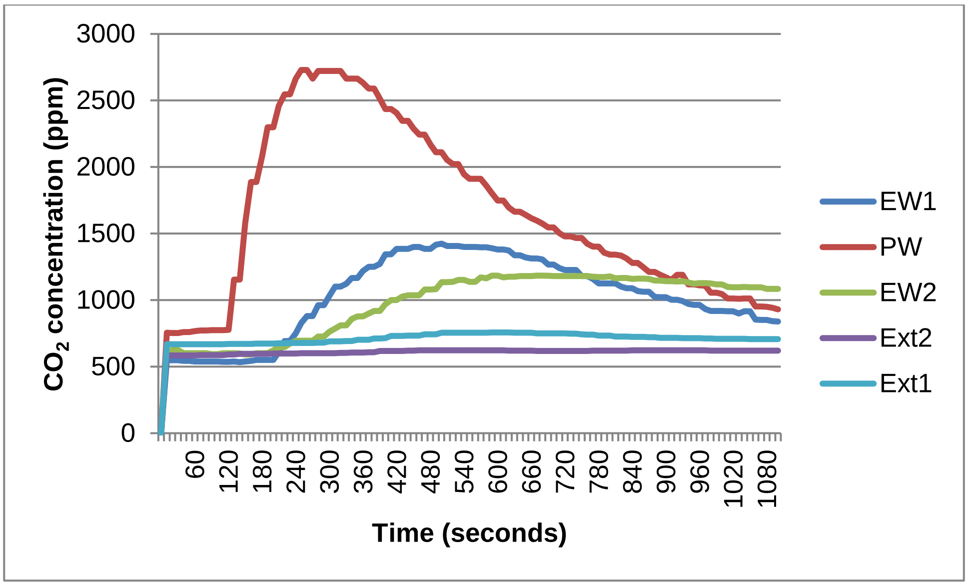

Figure 27 Test 3.7 CO_2 concentrations

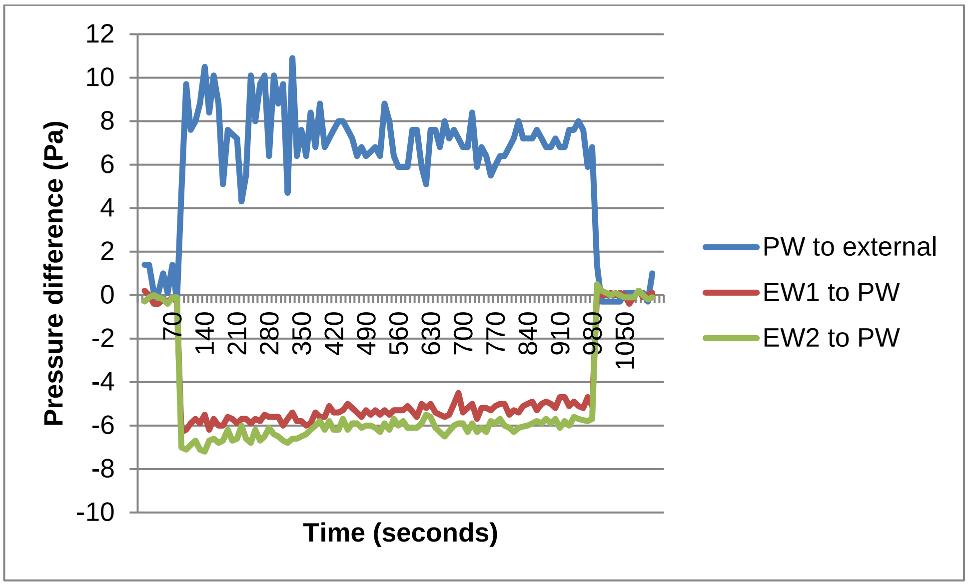

Figure 28 Test 3.7 Pressure differentials

As with the previous test, the mean pressure differentials displayed in Figure 28 resemble those obtained in test 1.4 (Figure 20) for the ARC T-Barrier with a 50 mm party wall cavity with 50 mm external wall cavities. There does appear to be some reduction in pressure differentials as the test progressed, it was envisaged that this could indicate a slight deterioration of the edge seal over the course of the test or might be an issue with the way the test was conducted with a reduction in the amount of air being forced into the party wall cavity. Additional Sugru™ was added to the injection point from that shown in Figure 6 to ensure that the seal around the air input to the party wall was improved for all subsequent tests (Figure 29)[1].

Figure 29 Original seal at the injection point and following the application of additional Sugru™ following test 3.7

[1] Apart from test 4.18, where the airtightness sealing tape developed a definite air leakage path that progressively deteriorated throughout the test, the phenomenon of the differential pressures decreasing as the test progressed was not observed on any subsequent tests.

Test 3.8: Protect membrane

Figure 30 Test 3.8, Protect membrane, 75 mm party wall, 100 mm external wall

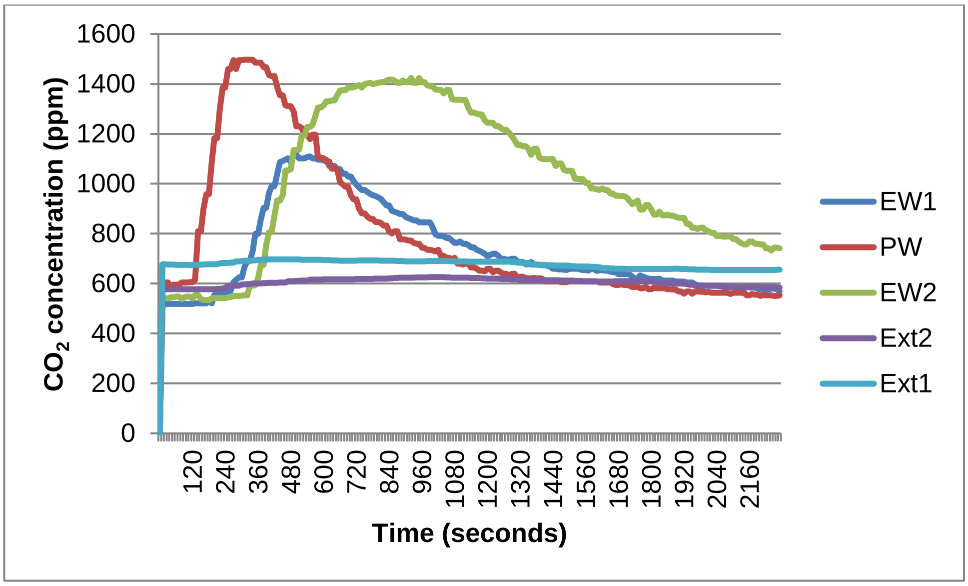

Figure 31 Test 3.8 CO_2 concentrations

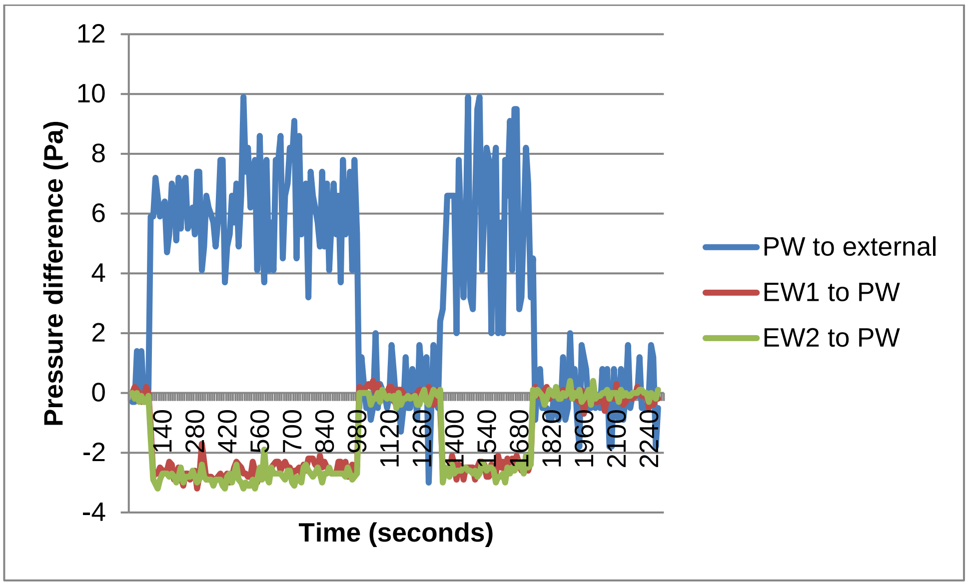

Figure 32 Test 3.8 Pressure differentials

Test 3.8 was conducted using a breather membrane (Protect FCM750) taped to the internal surfaces of both EW1 and EW2 and to the floor and top inspection window (Figure 30). This test was conducted for the 15 minute time period (test procedure 3) then air input into the party wall cavity was resumed following a 5 minute to observe whether the pressure differentials achieved for the test period was repeatable; this proved to be the case. An unexpectedly high CO_2 concentration was observed in one external wall cavity (EW2) which cannot be explained.

Test 4.9: Protect Membrane

Figure 33 Test 4.9, Protect membrane, 75 mm party wall, 125 mm external wall

Test 4.9 varied from test 3.8 in terms of test procedure used and external cavity wall width, the membrane covering of the party wall cavity junction was left untouched between the two tests. A smoke test prior to this test, to attempt to detect any air movement pathways between the chambers and explain the differing CO_2 concentrations shown in Figure 31, resulted in the initial CO_2 levels being slightly higher than the background levels on commencement of the test.

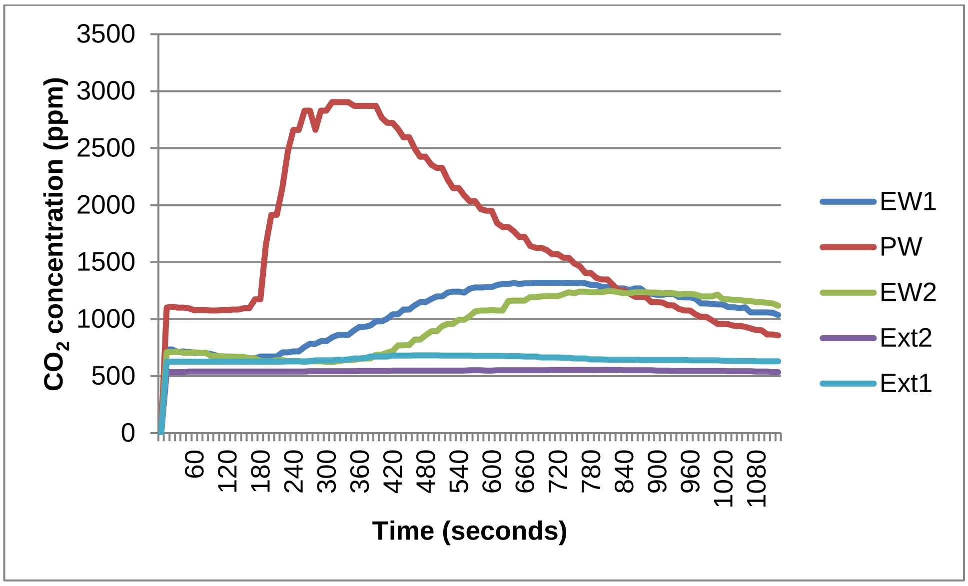

Figure 34 Test 4.9 CO_2 concentrations

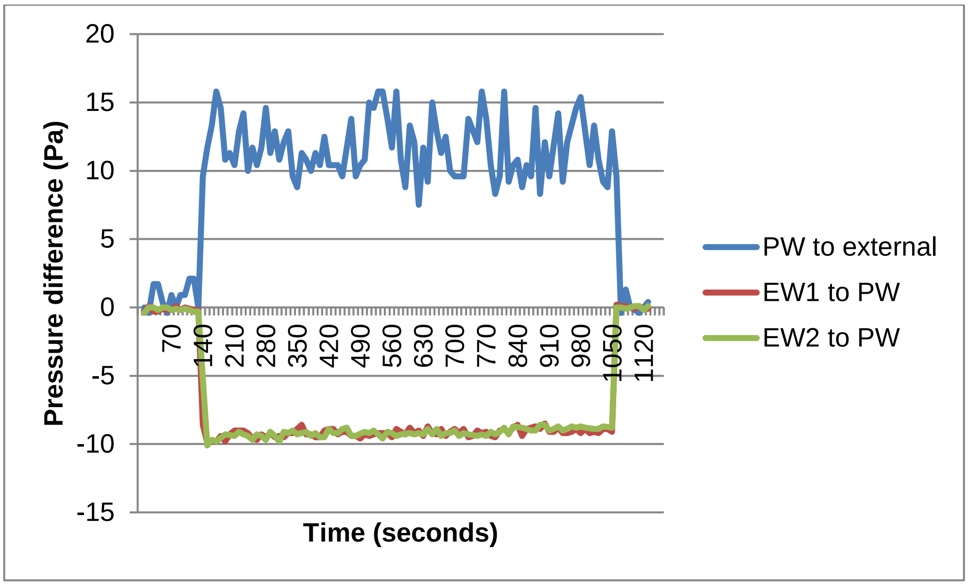

Figure 35 Test 4.9 Pressure differentials

Figure 34 shows similar CO_2 levels achieved in both EW1 and EW2, which is what would be expected given that there was no barrier between the two chambers (unlike Figure 31), similarly Figure 35 shows both the external wall cavities at the same pressure differentials for the course of the test. The increased rate of air input used in test procedure 4 resulted in a doubling of the party wall to external environment pressure difference over that obtained in the previous test.

Test 4.10: ARC T-Barrier

Figure 36 Test 4.10, ARC T-Barrier, 75 mm party wall, 125 mm external wall

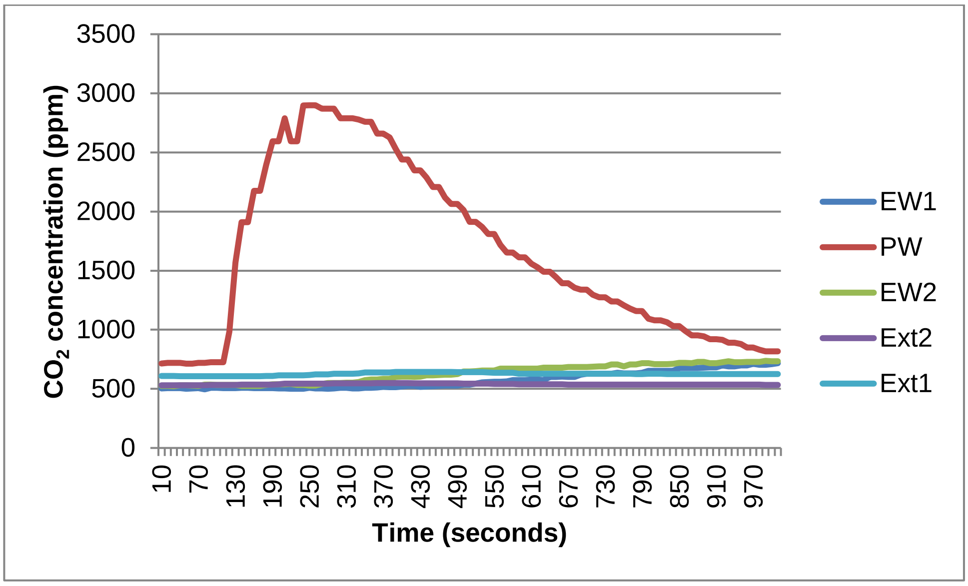

Figure 37 Test 4.10 CO_2 concentrations

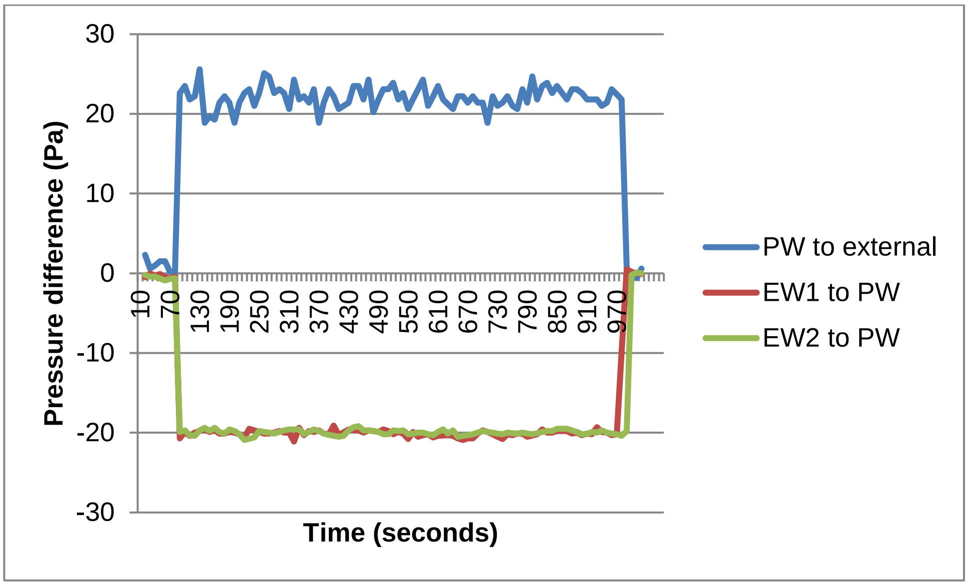

Figure 38 Test 4.10 Pressure differentials

At the higher air input rate used in test procedure 4 (250 l/min compared to the previous input rate of 105 l/min) far greater pressures were achieved in the party wall cavity. The pressure differentials illustrated in Figure 38 remained constant throughout the entire test, suggesting that the deterioration observed in test 3.7 (Figure 28) may have been due to degradation of the seal at the air injection point rather than a developing fault of the edge seal itself.

Figure 37 shows very little movement of CO_2 from the party wall cavity into either of the external wall cavities, indicating that the movement of CO2 out of the party wall cavity was into the external environment and not into the external wall cavities EW1 and EW2.

Test 4.11: Mineral wool + dpc

Figure 39 Test 4.11, Mineral wool + dpc, 75 mm party wall, 125 mm external wall

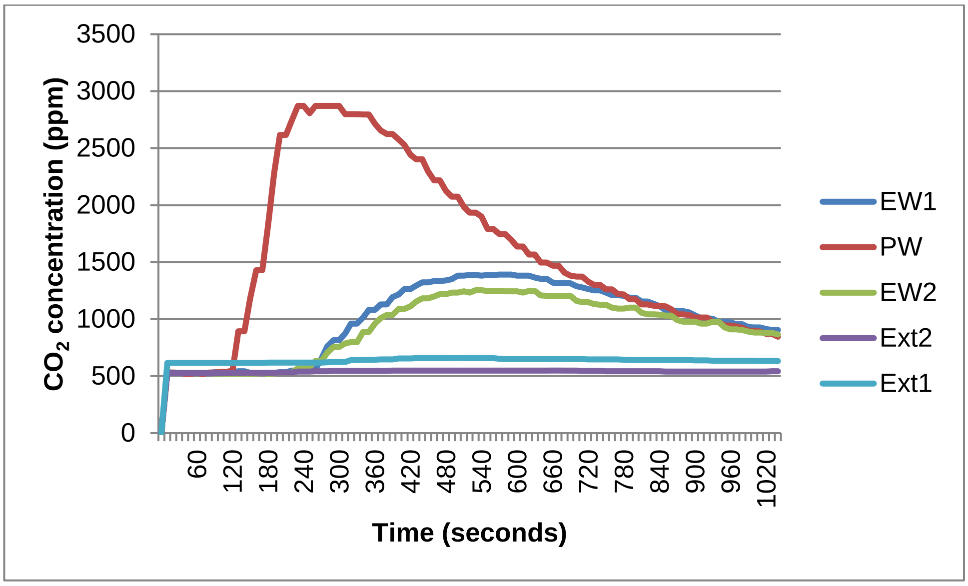

Figure 40 Test 4.11 CO_2 concentrations

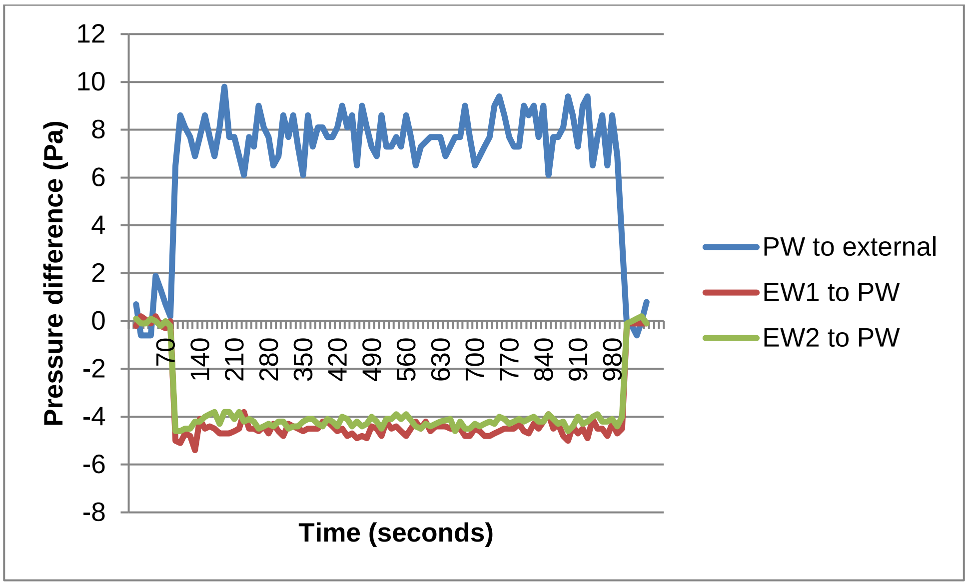

Figure 41 Test 4.11 Pressure differentials

Significantly lower pressure differentials and increased CO_2 transfer from the party wall cavity to the external wall cavities were observed with the mineral wool edge seal than were observed in the previous test (test 4.10) where the ARC T-Barrier was installed for the test rig set to the same dimensions and the same test procedure employed.

Test 4.12: ARC T-Barrier

Figure 42 Test 4.12, ARC T-Barrier, 75 mm party wall, 150 mm external wall

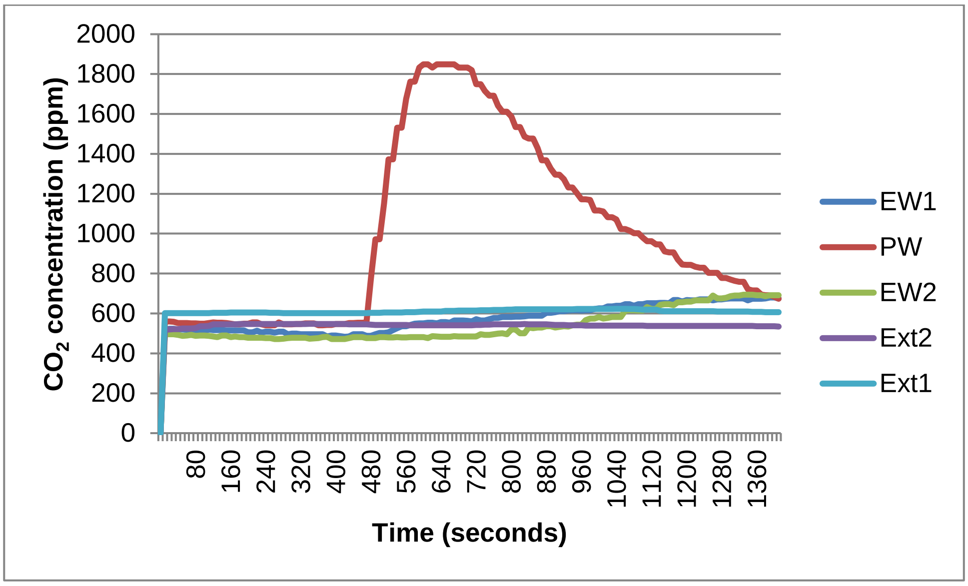

Figure 43 Test 4.12 CO_2 concentrations

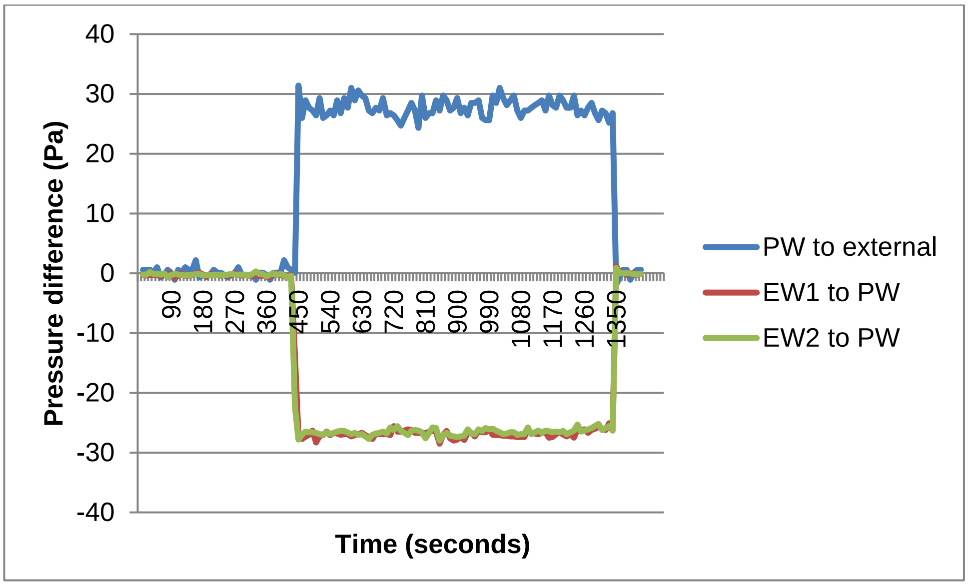

Figure 44 Test 4.12 Pressure differentials

Test 4.13: Mineral wool + dpc

Figure 45 Test 4.13, Mineral wool + dpc, 75 mm party wall, 150 mm external wall

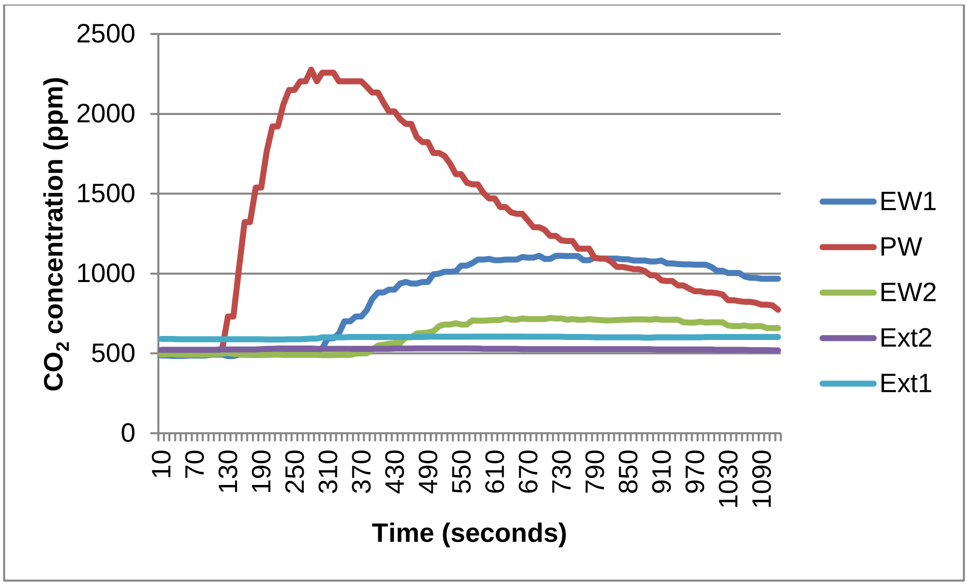

Figure 46 Test 4.13 CO_2 concentrations

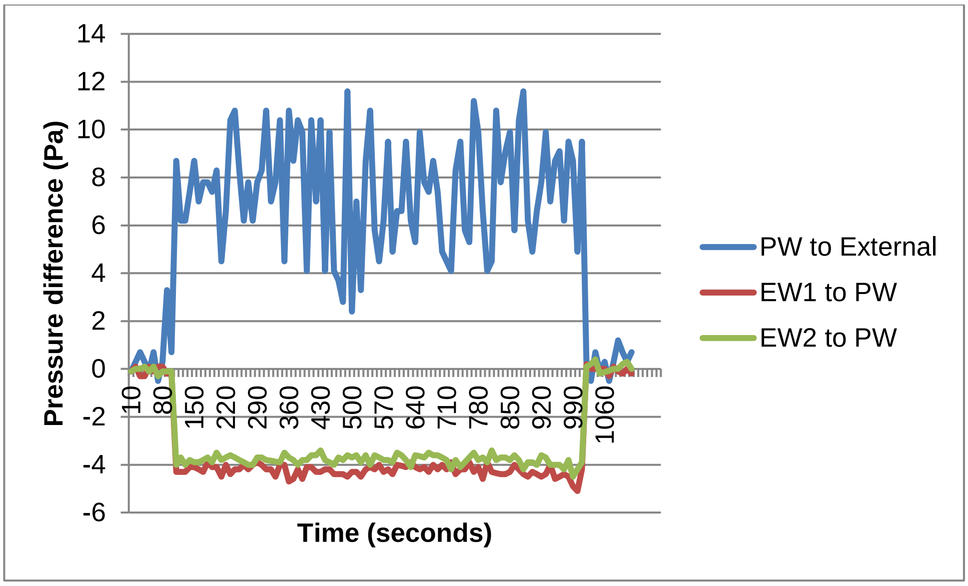

Figure 47 Test 4.13 Pressure differentials

With the external wall cavity extended from 125 mm to 150 mm the pressure differentials recorded with the ARC T-Barrier in position actually increased (test 4.12 compared to test 4.10) but the shape of the CO_2 concentration curves were very similar, suggesting that with the wider external wall cavity the ARC T-Barrier proved to be an even more effective edge seal. With the mineral wool (tests 4.13 and 4.11) both the pressures recorded and CO_2 distributions were essentially identical at both external wall cavity widths. At both cavity widths the ARC T-Barrier outperformed the mineral wool in its effectiveness as an edge seal, with the Protect breather membrane providing results somewhere between the two (for the 125 mm external wall cavity).

3.1.3 100 mm Party Wall Cavity

Tests 4.14 to 4.20 (Table 2) were undertaken with the party wall cavity width set to 100 mm. Three sets of comparative tests were performed, with external wall cavity widths at 100 mm, 125 mm and 150 mm. As no changes to either the test rig or the test procedure was implement for these tests they provide possibly the most persuasive direct comparisons between the edge seal solutions employed. Additional taping and sealing around the test rig was undertaken for these tests to try to ensure that any air leakage around the party wall cavity itself was kept as consistent as possible for the duration of all the tests with the 100 mm party wall cavity.

Test 4.14: Mineral wool + dpc

Figure 48 Test 4.14, Mineral wool + dpc, 100 mm party wall, 150 mm external wall

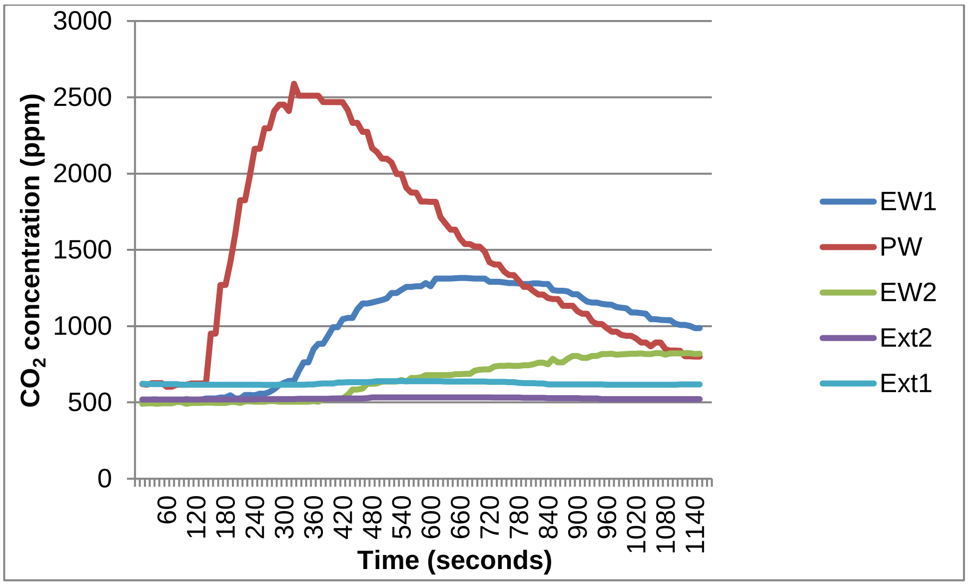

Figure 49 Test 4.14 CO_2 concentrations

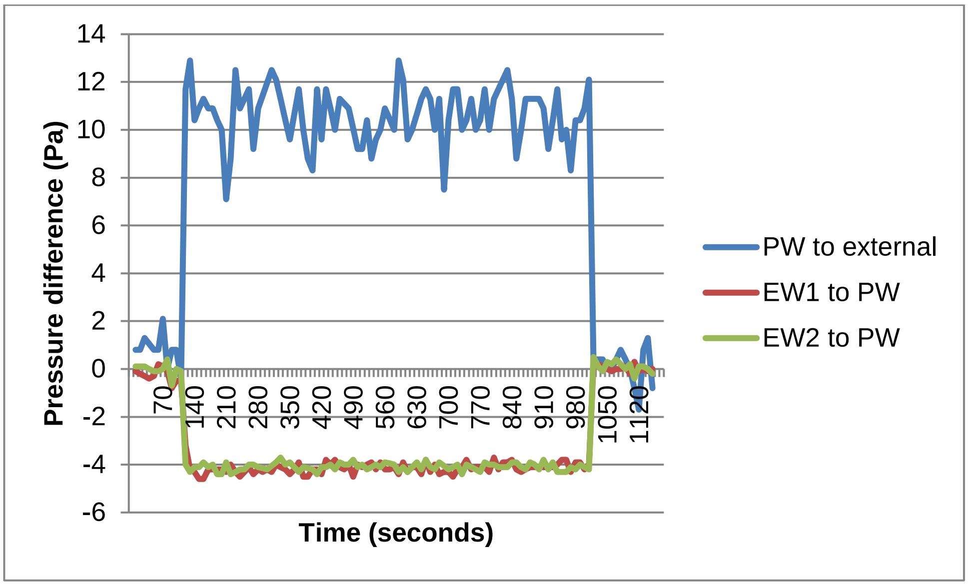

Figure 50 Test 4.14 Pressure differentials

Test 4.15: ARC T-Barrier

		

Figure 51 Test 4.15, ARC T-Barrier, 100 mm party wall, 150 mm external wall

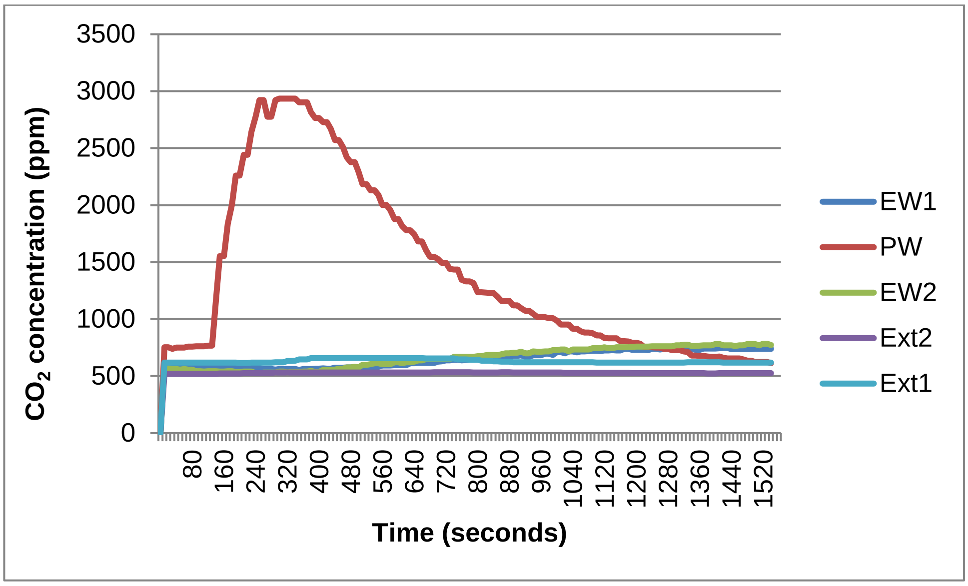

Figure 52 Test 4.15 CO_2 concentrations

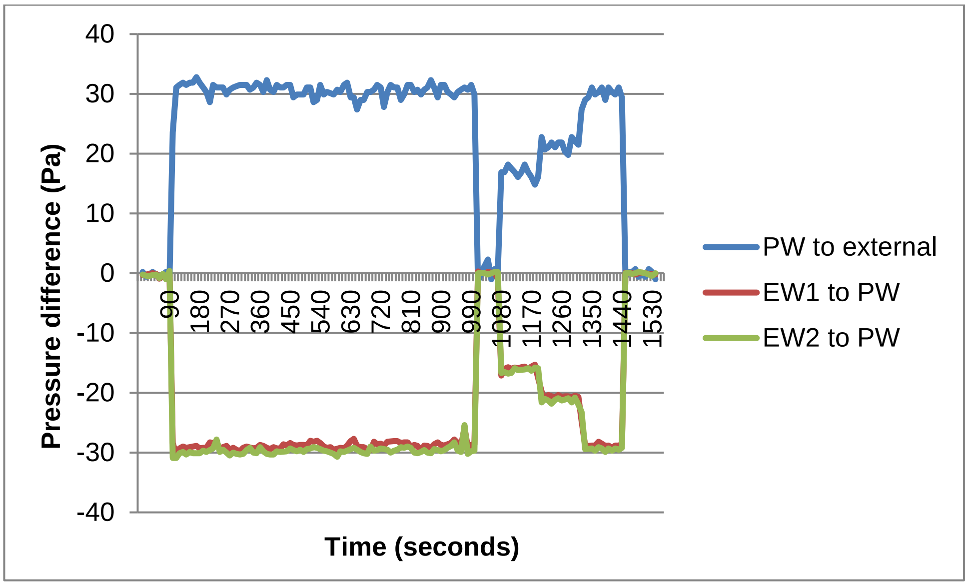

Figure 53 Test 4.15 Pressure differentials

Following completion of test 4.15 the hot air gun was re-applied to the injection point at a number of different flow rates to test the repeatability of the test. Figure 53 shows the pressure differentials achieved at increasing nominal input flow rates of 150 l/min, 200 l/min and 250 l/min following the 15 minute test period. The pressure differentials realised at the 250 l/min input rate after the test are the same as those obtained during the test with the same input rate, indicating that the ARC T-Barrier provided a robust edge seal for the entire duration of this experiment.

Test 4.16: ARC T-Barrier

Figure 54 Test 4.16, ARC T-Barrier, 100 mm party wall, 125 mm external wall

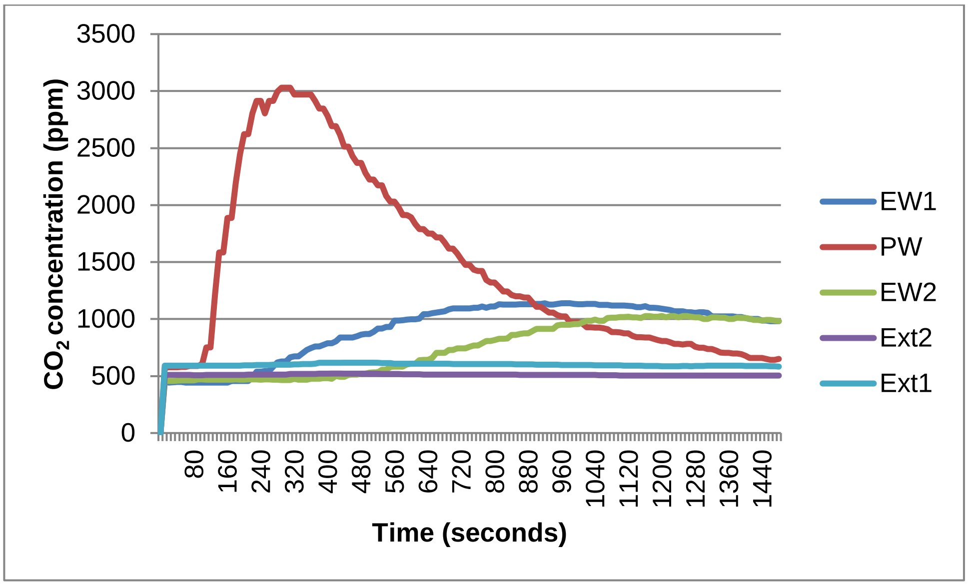

Figure 55 Test 4.16 CO_2 concentrations

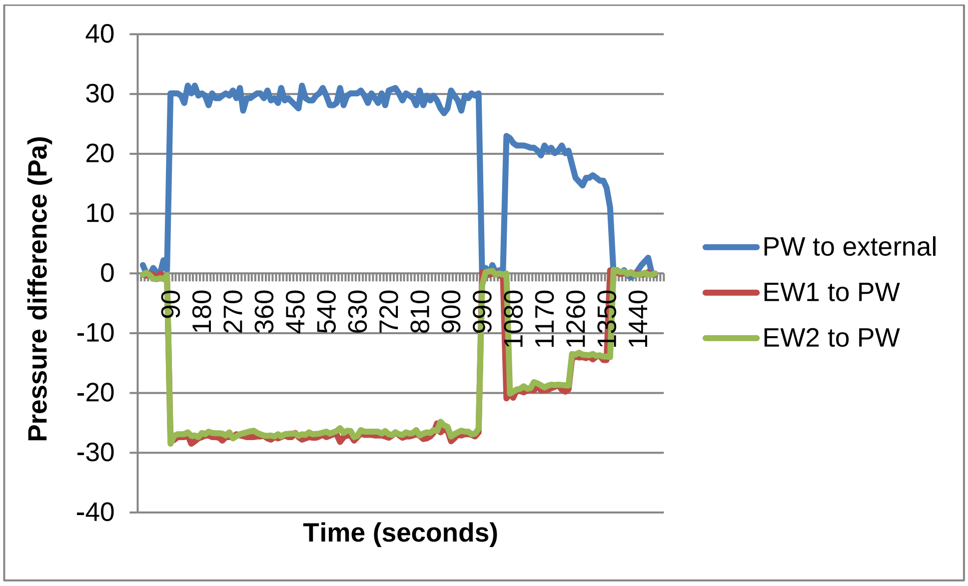

Figure 56 Test 4.16 Pressure differentials

As with test 4.15, forced air input was repeated following this test. The reduction in external cavity width (from 150 mm to 125 mm) had a negligible effect on the pressure differentials developed between test 4.15 and 4.16), not only at the test input rate of 250 l/min, but also at the reduced flow rates of 200 l/min and 150 l/min.

Test 4.17: Mineral wool + dpc

Figure 57 Test 4.17, Mineral wool + dpc, 100 mm party wall, 125 mm external wall

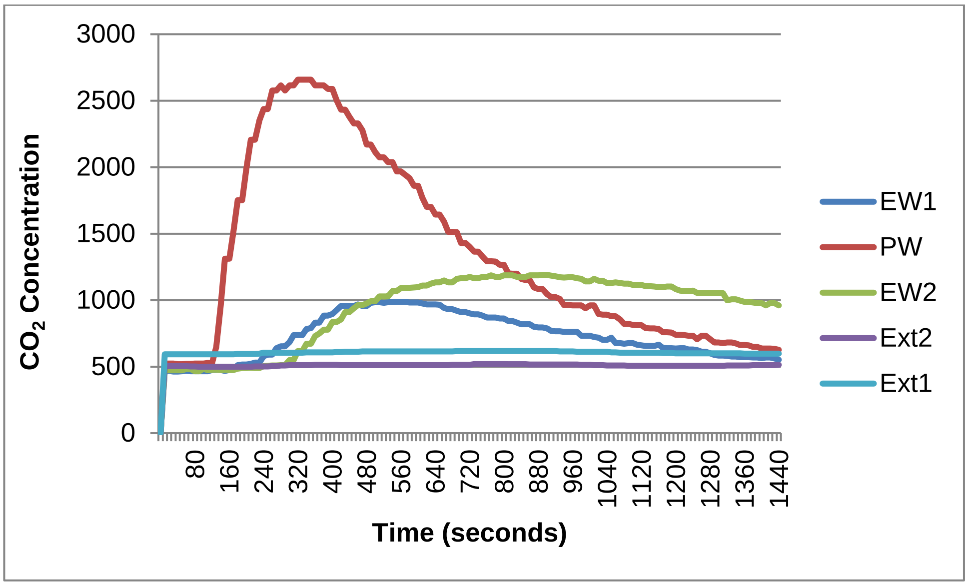

Figure 58 Test 4.17 CO_2 concentrations

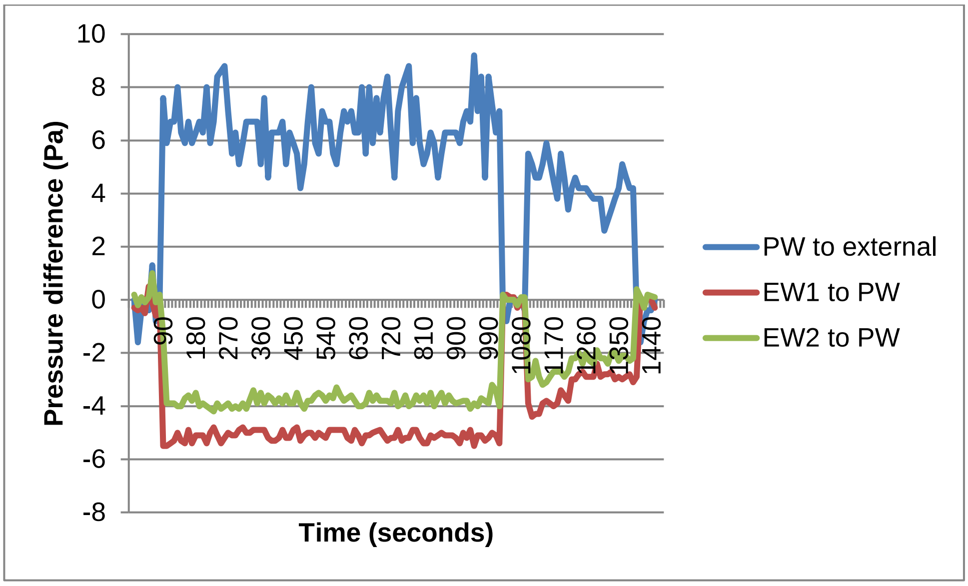

Figure 59 Test 4.17 Pressure differentials

The re-pressurising of the party wall cavity following this test showed the same stepped reductions in recorded pressure differentials as observed for the ARC T-Barrier in tests 4.15 and 4.16, albeit at much lower pressures commensurate with its less effective edge sealing performance.

Test 4.18: DuctMask™ airtightness sealing tape

Figure 60 Test 4.18, DuctMask™, 100 mm party wall, 100 mm external wall

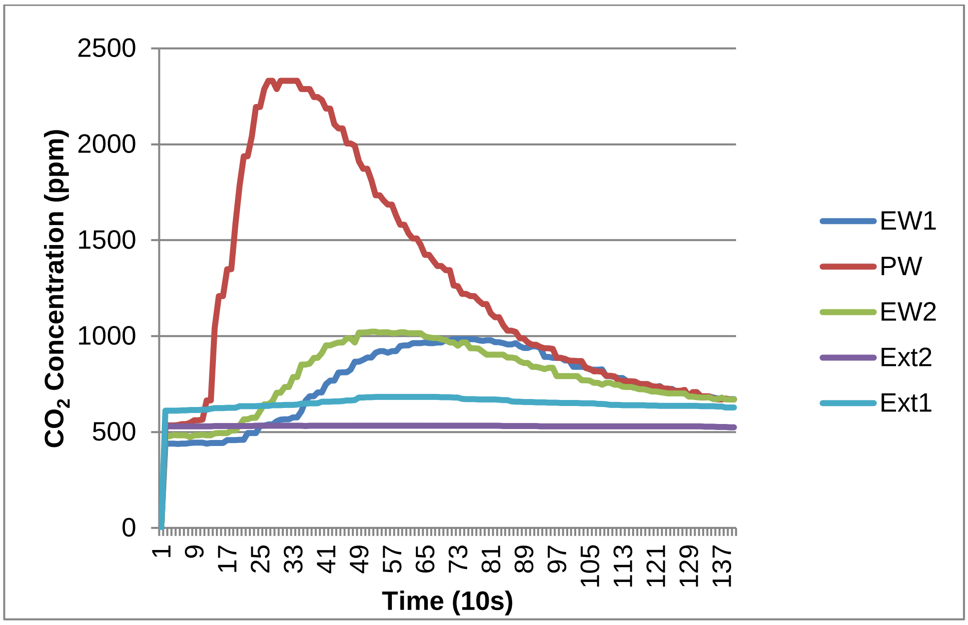

Figure 61 Test 4.18 CO_2 concentrations

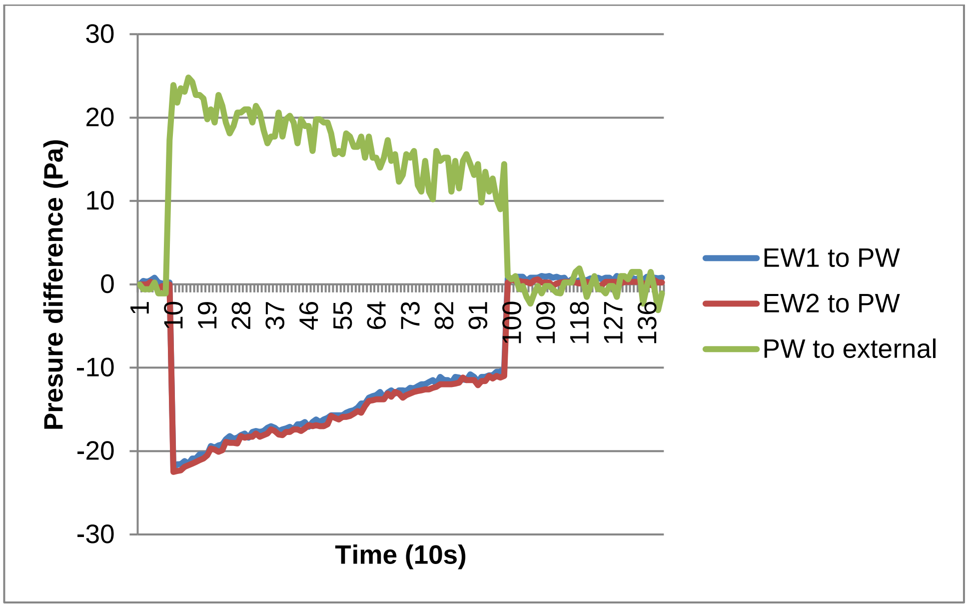

Figure 62 Test 4.18 Pressure differentials

An airtightness test sealing tape was used for test 4.18, the test began well but this proved not to be a robust solution. Although the DuctMask™ produced a high pressure differential upon commencement of the test (peaking at 24.8 Pa after 1 minute) this steadily dropped away to a much lower pressure near the end of the test (minimum 9.0 Pa after 14½ minutes) as shown in Figure 62. This was due to the airtight seal failing at the junction of the test rig wall and top inspection window, and getting progressively worse as the test proceeded (shown circled in Figure 63). Figure 61 shows the CO_2 concentrations reached the same levels in both external wall cavities due there being no separation between them.

Figure 63 Progressive failure of seal of DuctMask™ as test progressed

Test 4.19: ARC T-Barrier

Figure 64 Test 4.19, ARC T-Barrier, 100 mm party wall, 100 mm external wall

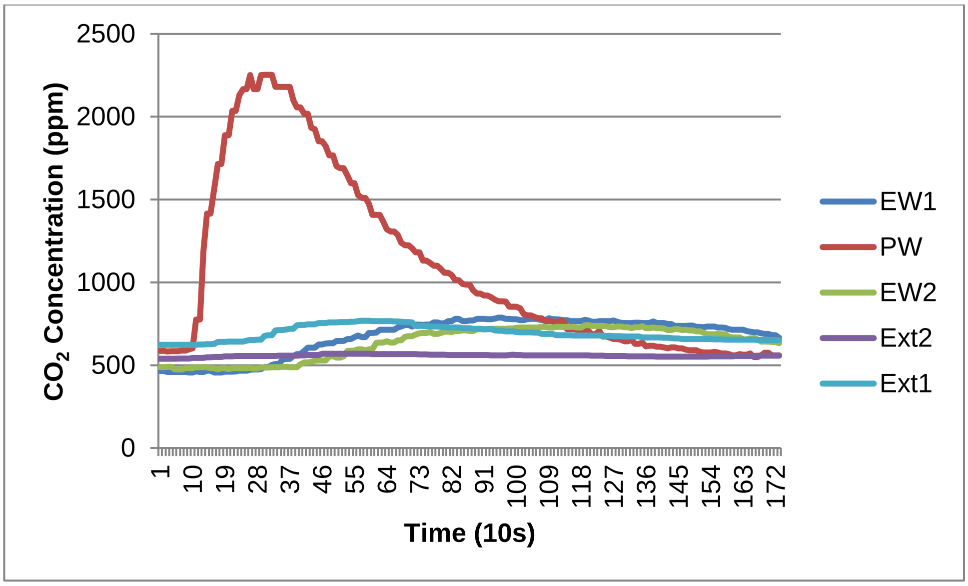

Figure 65 Test 4.19 CO_2 concentrations

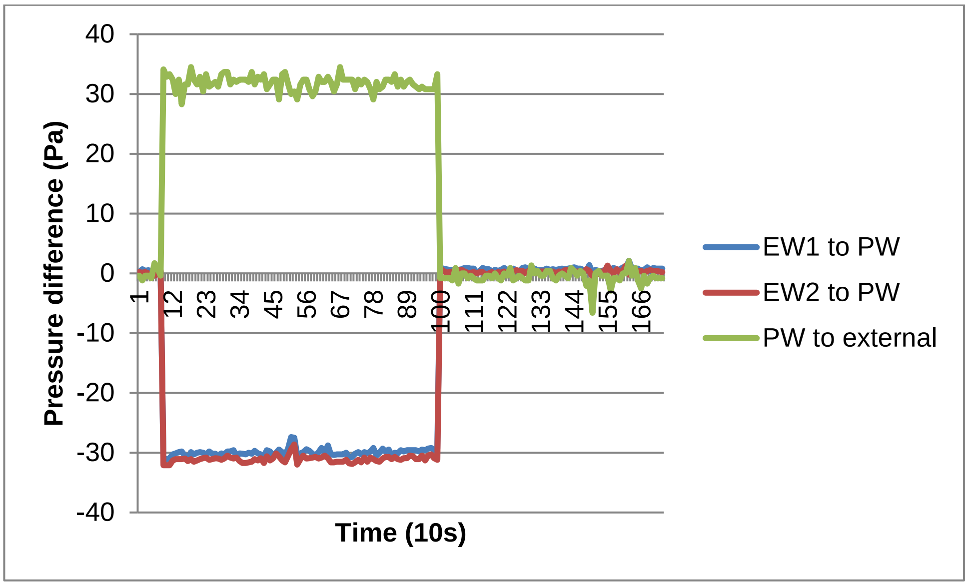

Figure 66 Test 4.19 Pressure differentials

Test 4.19 showed little variation between the other tests for the ARC T-Barrier with the 100 mm party wall cavity (tests 4.15 and 4.16), both in terms of pressure differentials generated and with the movement of CO_2 between the party wall cavity and the external wall cavities. This was perhaps unsurprising as every effort had been made to ensure that the air leakage from the party wall to the external environment was consistent throughout the tests of the 100 mm party wall cavity.

Test 4.20: Mineral wool + dpc

Figure 67 Test 4.20, Mineral wool + dpc, 100 mm party wall, 100 mm external wall

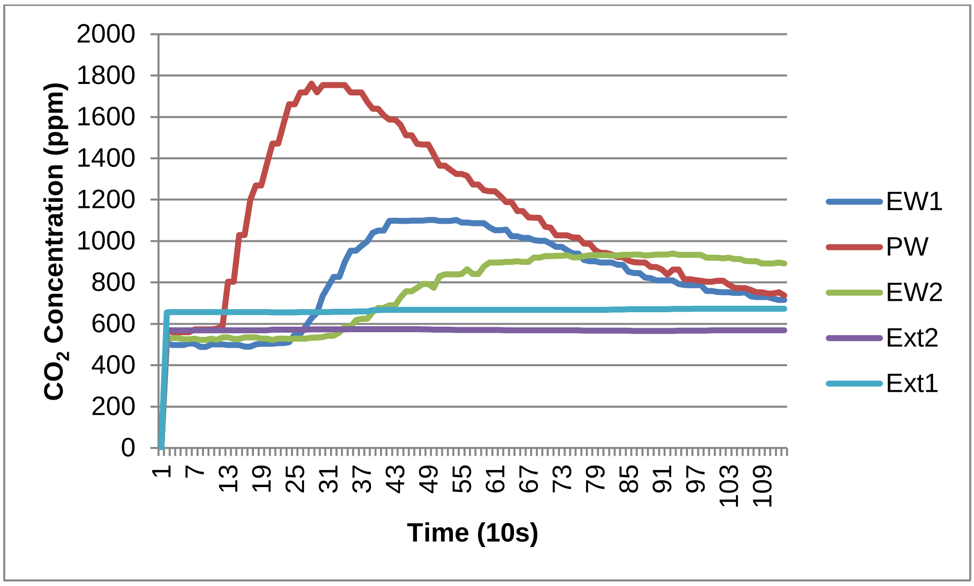

Figure 68 Test 4.20 CO_2 concentrations

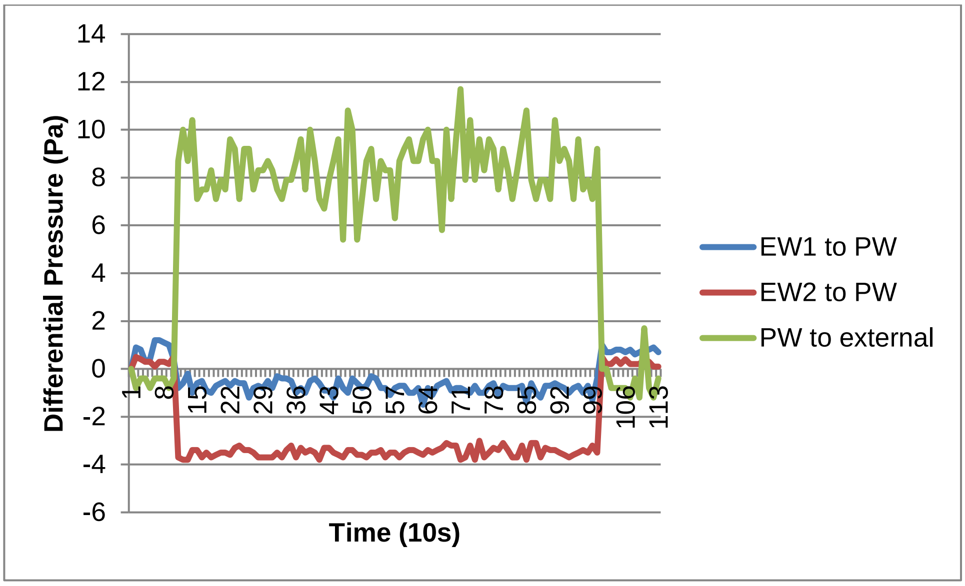

Figure 69 Test 4.20 Pressure differentials

As commented on with the previous test, Test 4.20 showed little variation between the other tests for the mineral wool edge seal with the 100 mm party wall cavity (tests 4.14 and 4.17), both in terms of pressure differentials generated and with the movement of CO_2 between the party wall cavity and the external wall cavities.

3.2 Pressure Differentials

With the first sets of tests (test procedures 1 to 3) conducted at pressures representative of those normally experienced at this junction in real buildings, and subsequent tests (test procedure 4) carried out at higher induced pressures, it is not possible to directly compare the pressure differentials generated by the differing test procedures. In addition, for the testing of the 100 mm party wall cavity (tests 4.14 to 4.20) some further sealing around the outside of the test rig was carried out during the smoke testing following test 4.13, resulting in the test rig itself being more airtight for these later tests. However, it is possible to compare the relative performance of each edge seal solution tested under the same protocol and test conditions and these are illustrated in

Figure 70, Figure 71 and Figure 72, where the pressure differentials achieved in each of the edge seal tests have been grouped together to allow fair comparisons to be made. In each of the following plots, the red bar represents the pressure differential generated in the party wall cavity with respect to the external environment, a measure of how effective an edge seal of the party wall the solution employed is. The negative differentials are those between the party wall cavity and the two external wall cavities, the greatest negative values indicating the least communication between the cavities.

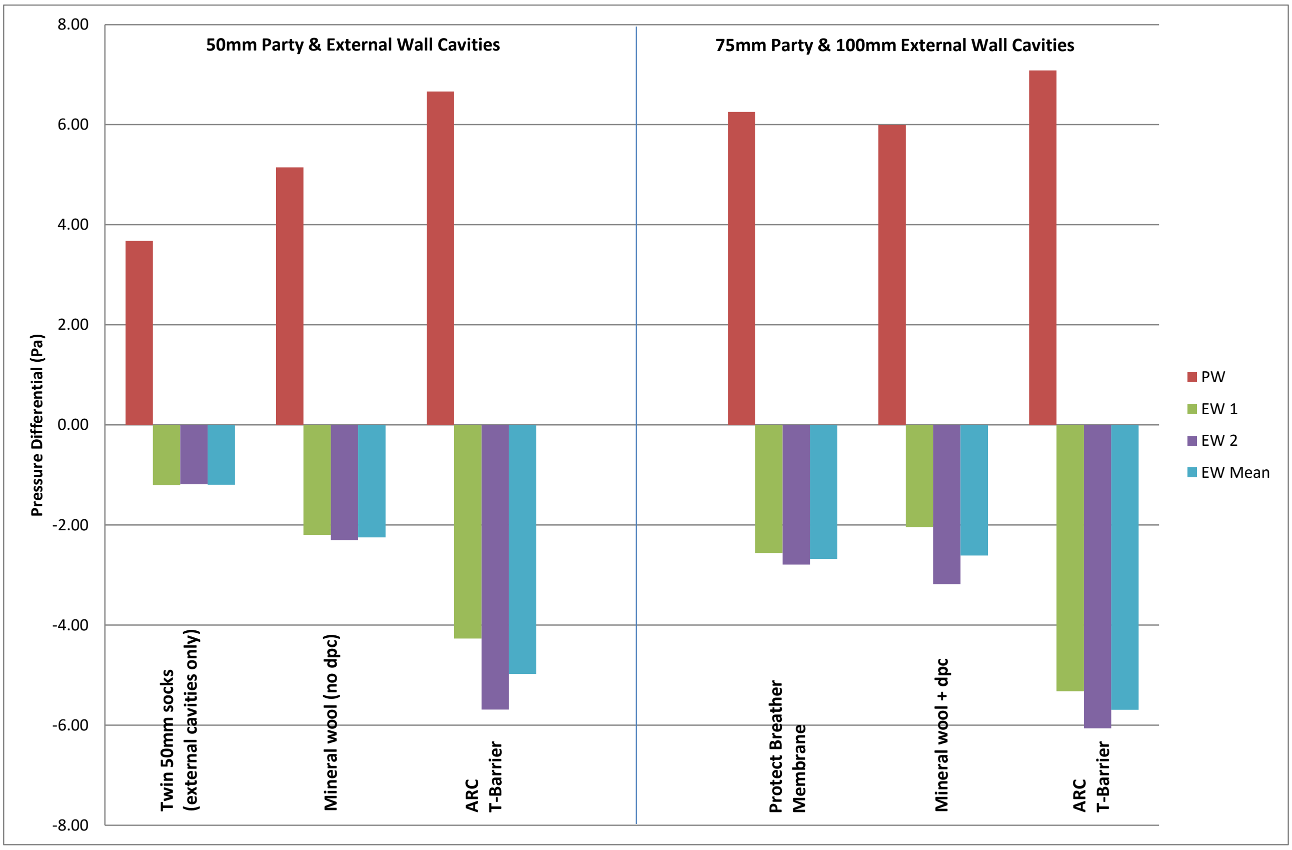

Figure 70 Pressure differentials: 50 mm & 75 mm party wall cavity at 150 l/min air input

Of the tests conducted using test procedure 1 (50 mm party wall cavity) and test procedure 3 (75 mm party wall cavity), the ARC T-Barrier produced the greatest pressure in the party wall cavity and the greatest negative pressure differential between the party wall cavity and the external wall cavities, as can be seen in Figure 70. With the air input rate of 150 l/min, the ARC T-Barrier displayed similar results for both party/external wall configurations; the mineral wool edge seal also displayed similar results for both configurations, albeit at lower pressure differentials to the ARC T-Barrier.

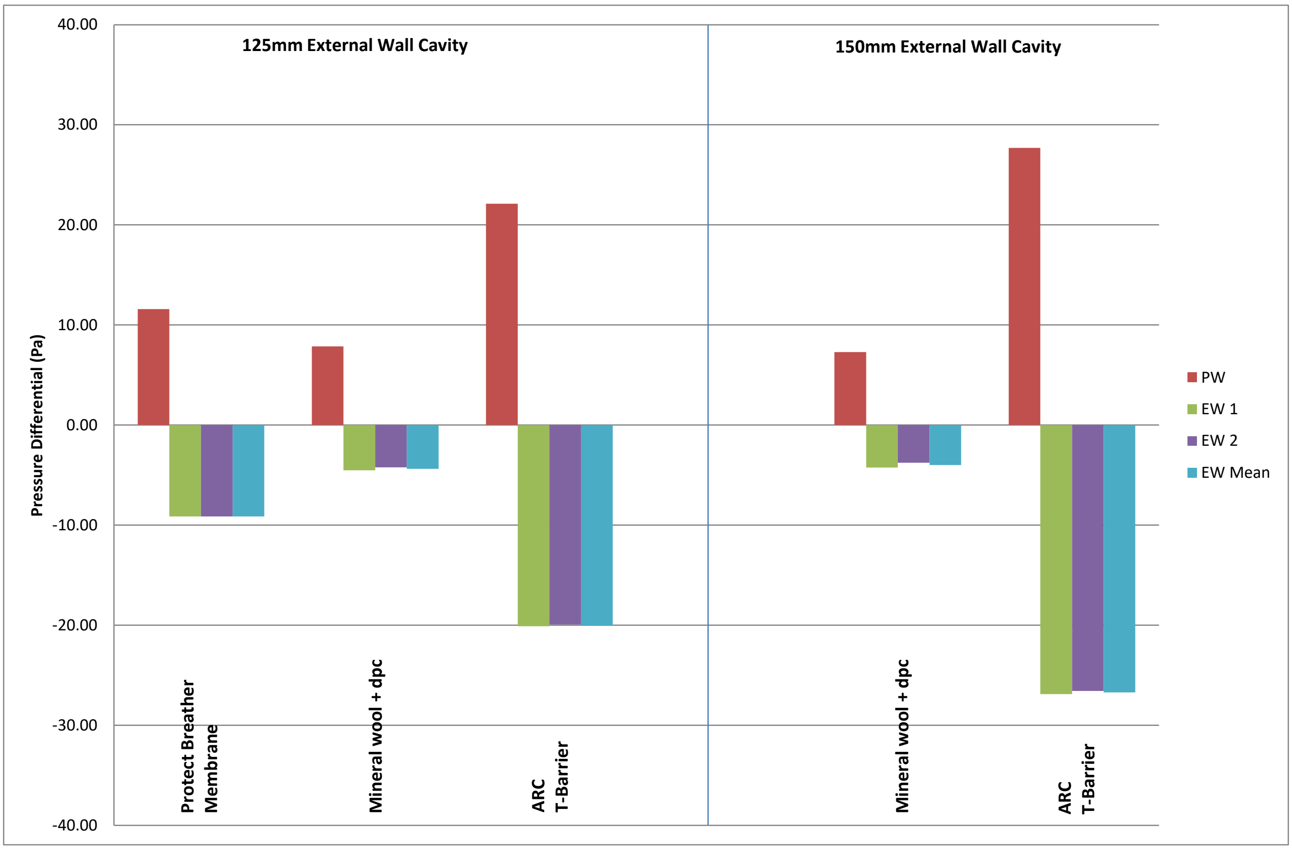

Figure 71 Pressure differentials: 75 mm party wall cavity at 250 l/min air input

Tests 4.9 onwards all used a higher air input rate of 250 l/min, this increased the pressure differentials measured and placed a greater strain on the edge barrier being tested. Figure 71 shows the comparison of the 125 mm and 150 mm external wall cavity results for different products tested, both with a 75 mm party wall cavity. Whilst the mineral wool edge seal pressure differentials only increased slightly with the increased airflow, the results for the Protect FCM750 doubled and those for the arc T-barrier more than trebled. This suggests that at the higher pressure differentials the mineral wool barrier shows only a slightly greater resistance to air movement, whereas the ARC T-Barrier exhibits a far greater resilience as the conditions become more extreme.

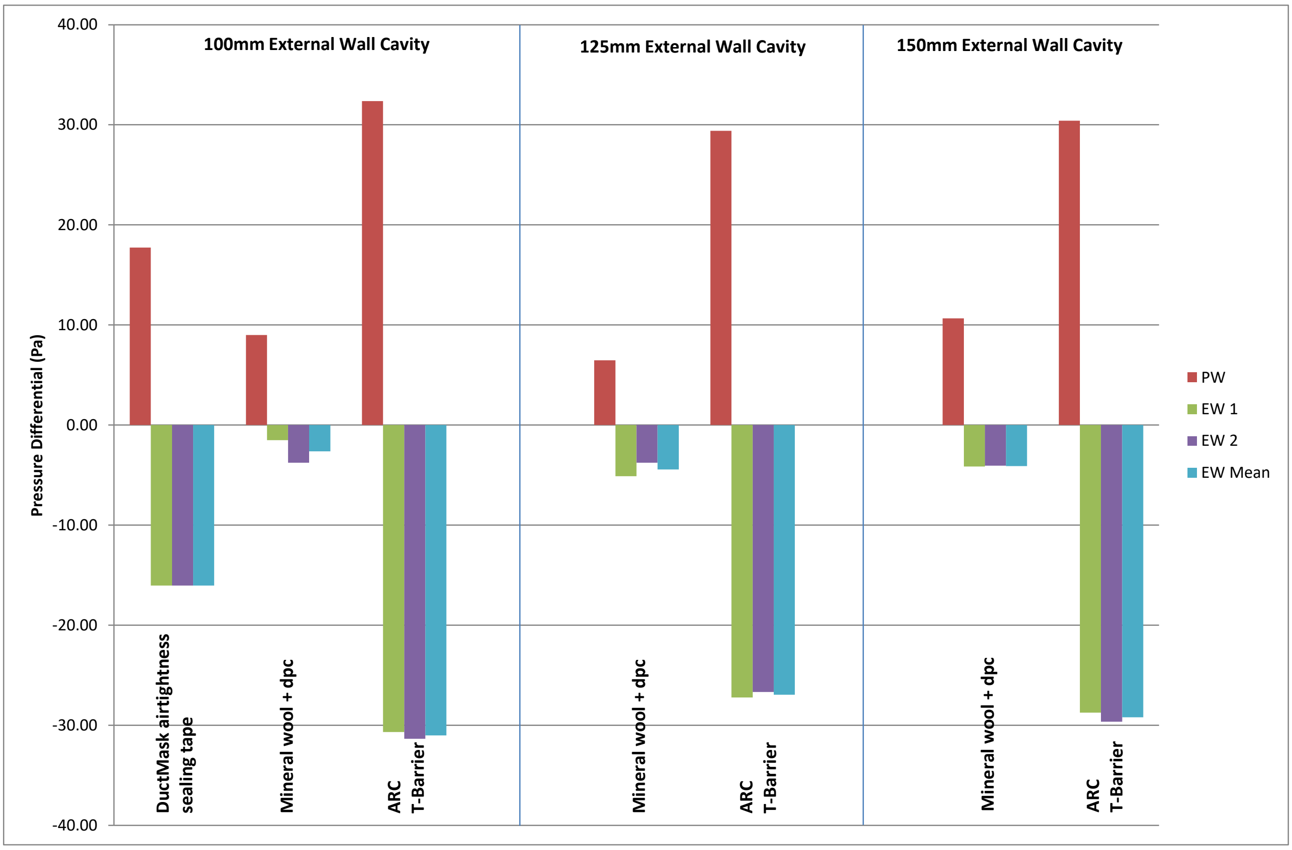

Figure 72 Pressure differentials: 100 mm party wall cavity at 250 l/min air input

Tests 4.14 onwards all used a 100 mm party wall cavity, with additional sealing tape applied to many of the external junctions of the test rig to minimise air leakage from the party wall cavity to the external environment, thus maximising the pressure differentials measured and logged, these are shown graphically in Figure 72. The results for the ARC T-Barrier are remarkably consistent for all external wall cavity widths, where it reliably outperformed the other edge seal solutions by a significant margin. The additional sealing applied to the test rig increased the airtightness of the party wall cavity; this can be seen in the results for the ARC T-Barrier in Figure 72 both in terms of the pressure differentials measured for the party wall cavity and those between the party wall and external wall cavities, which (although opposite in terms of measurement) are of very similar magnitudes. However, with the mineral wool edge seals the pressure differentials between the party and external wall cavities is noticeably lower than the pressures achieved in the party wall cavity with respect to the external environment, suggesting air movement permeating through the mineral wool is a much greater issue as the pressure differentials increase, with the ARC T-Barrier this issue does not arise.

3.3 Tracer Gas

Tests 1.1 to 3.8 were performed with air forced into the party wall cavity at a rate of 150 l/min; whilst this flow rate was selected originally as it reproduced the types of pressures normally experienced at this junction in real buildings, it was not felt that it provided conditions that allowed measureable differences between some of the edge seal solutions to be distinguished between clearly enough. The air input rate into the party wall was increased to 250 l/min for all of the subsequent tests, reducing the noise and allowing more direct comparisons between the measurements to be considered, both for pressure differentials and for the movement of the tracer gas (CO_2).

The CO_2 concentrations observed in each of the edge seal tests are shown in Table 3, where the figures presented for the external wall cavity are shown as a mean of those measured in EW1 and EW2. Also shown in Table 3 is the ratio of the mean maximum rise in CO_2 concentration in the external wall cavities compared to the rise in the CO_2 level in the party wall, expressed as a percentage.

Table 3 Summary of CO_2 concentrations measured

Test	Party Wall Cavity	External Wall Cavity	Edge Seal Measure Installed	Party Wall CO_2			Mean External Wall CO_2			Rise in EW as % of rise in PW
				Background	Peak	Max. Rise	Background	Peak	Max. Rise	
	mm	mm		ppm	ppm	ppm	ppm	ppm	ppm	
1.1	50	50	Single cavity sock	470	2660	2190	470	780	310	
1.2	50	50	Twin cavity socks	490	1960	1470	500	730	230	
1.3	50	50	Mineral wool	500	3280	2780	510	830	320	
1.4	50	50	T-Barrier	530	2300	1770	510	840	330	
2.5	50	50	T-Barrier	490	>5000		470	4620	4150	
3.6	75	100	Mineral wool + dpc	570	1760	1190	520	940	420	
3.7	75	100	T-Barrier	750	2730	1980	560	1300	740	
3.8	75	100	Protect membrane	550	1500	950	520	1270	750	
4.9	75	125	Protect membrane	860	2900	2040	640	1290	650	31.9
4.10	75	125	T-Barrier	710	2900	2190	510	730	220	10.0
4.11	75	125	Mineral wool + dpc	520	2870	2350	530	1420	890	37.9
4.12	75	150	T-Barrier	540	1850	1310	480	690	210	16.0
4.13	75	150	Mineral wool + dpc	510	2280	1770	490	1420	930	52.5
4.14	100	150	Mineral wool + dpc	600	2590	1990	500	1070	570	28.6
4.15	100	150	T-Barrier	610	2940	2330	540	770	230	9.9
4.16	100	125	T-Barrier	570	3030	2460	450	1090	640	26.0
4.17	100	125	Mineral wool + dpc	520	2660	2140	470	1090	620	29.0
4.18	100	100	Airtightness tape	540	2330	1790	460	1000	540	30.2
4.19	100	100	T-Barrier	550	2250	1700	460	770	310	18.2
4.20	100	100	Mineral wool + dpc	560	1760	1200	510	1020	510	42.5

For each party wall/external wall configuration tested at the 250 l/min air input rate, the ARC T-Barrier showed the lowest concentration increase in CO_2 in the external wall cavities when expressed as a percentage of the CO_2 concentration rise in the party wall cavity. For the CO_2 concentrations in the external wall cavities to rise above the background levels they must be receiving air from the party wall cavity, so the figures in Table 3 confirm that the ARC T-Barrier reliably provides a greater resistance to air exchange between the party wall and external wall cavities at the vertical junction than any of the other edge seal solutions investigated.

3.4 Thermal Imaging

On 8th June, following both tests 4.12 and 4.13, warmer air was forced into the party wall cavity for a 5 minute period and the resulting thermal images shown in Figure 73. The idea of performing this additional test was to investigate whether it was the part of the ARC T-Barrier that protrudes into the party wall cavity that was making the difference in performance between the ARC T-Barrier and the alternative edge seal solutions, or whether it was having a covering which was impervious to air movement through it.

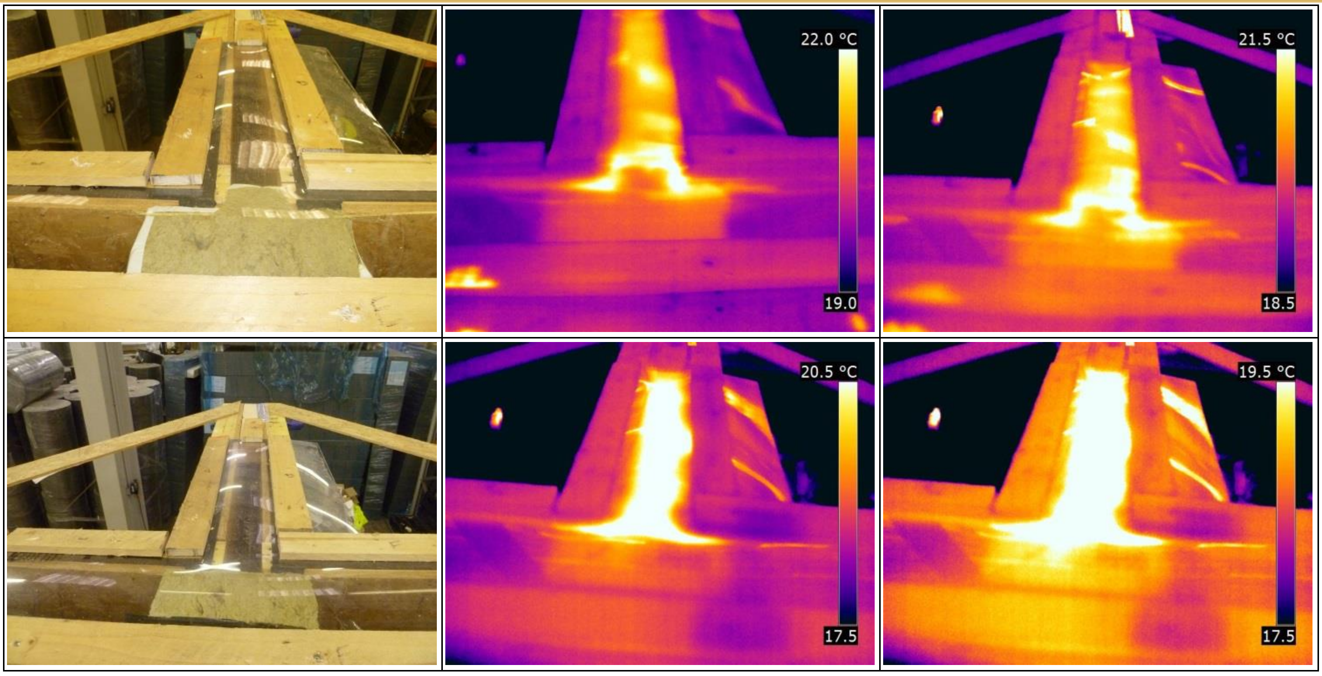

Figure 73 Thermal images captured following tests 4.12 & 4.13

Figure 73 shows the top inspection window heating up due to warmer air being introduced to the party wall cavity (250 l/min at ~40 ºC for 5 minutes); care was taken not to raise the cavity temperature too high to avoid compromising subsequent tests and to allow the test rig to revert to ambient temperatures quickly afterwards. What appears to be happening in Figure 73 is that hotter air can be seen deflecting around the ARC t-barrier and not breaching the covering of the barrier, whereas with the unsleeved mineral wool warmer air appears to be permeating into the barrier itself.

4.0 Discussions and Conclusions

4.1 Summary

It is recognised that currently there is no standard test available for quantitatively demonstrating the effectiveness of edge sealing of a vertical junction between a party wall cavity and an external wall cavity. This investigation introduced a method of comparing the effectiveness of recognised 'current practice' solutions against ARC Building Solutions Ltd.'s T-Barrier in this position for a number of different party wall and external wall cavity configurations. In addition to this comparative testing, this project may also assist in the development and application of a standardised 'Edge Seal Test' for which there is understood to be no specific precedent. Whilst the test rig utilised may not be fully representative of the actual construction of a party wall/external wall junction in situ, the results provide a pragmatic means of comparatively testing alternative solutions and offer insight as to how the performance of these products may compare in real building situations.

The test procedure evolved as the tests progressed. Variations between tests, such as changing the party wall width, appeared to have an impact on the airtight performance of the test rig. As such, each set of tests should be regarded as individual sets of tests, with direct comparisons only fully applicable between results obtained at each discrete party wall width. Comparisons between tests performed at different party wall widths should not be made without further, more sophisticated, analysis of the data.

From analysis of the test results, at each party wall width tested, the ARC T-Barrier appeared to outperform any of the other edge seal solutions tested both in terms of the differential pressure achieved (a metric for how effective the edge seal is) and in spread of CO_2 (a metric for movement of air between the party wall cavity and the 2 external wall cavities). The highest pressure differentials were achieved at the same party wall cavity widths and air flows using ARC T-Barrier as an edge seal. Monitoring of CO_2 in the 3 test chambers (PW, EW1 & EW2), showed that when similar amounts of CO_2 were released into the positively pressurised party wall cavity, significantly lower concentrations were detected in the external wall cavities when the ARC T-Barrier was used as an edge seal than detected with other edge seal solutions tested.

It appears that it is the protrusion of the ARC T-Barrier into the party wall cavity that creates the more airtight seal to the party/external wall junction of the test rig than the alternative solutions tested. It is envisaged that these results would be replicated should the same products be tested on-site, in actual buildings.

4.2 Recommendations for Further Work

Whilst this series of tests shows that the ARC T-barrier outperforms the other existing edge seal solutions tested in this test rig, development of a standardised test rig would allow a corporative test to be established which could be certified by a recognised compliance body.

The use of thermographic imaging (section 3.4) could be expanded upon to identify the heat loss and air movement paths at the test junction. This could indicate the combined benefits of the increase in the airtight sealing of the junction using ARC T-Barrier and any potential reduction in thermal bridging by recording surface temperatures and/or heat flux data.

5.0 References

Building Control Alliance. (2011) *Technical Guidance Note 12: Cavity Separating Wall Guidance for Part L 2010* [Online]. Available from:<http://www.buildingcontrolalliance.org/guidance/technical-guidance-notes/> [Accessed 28 January 2015].

HM Government. (2013) *Approved Document L1A: Conservation of Fuel and Power in New Dwellings*. The Building Regulations 2010. London: NBS.

Lowe, R.J., Wingfield, J., Bell, M. and Bell, J.M. (2007) *Evidence for heat losses via party wall cavities in masonry construction*. Building Services Engineering Research and Technology, Vol. 28, pp 161-181.

Wingfield, J., Bell, M., Miles-Shenton, D., South, T. and Lowe, R.J. (2011) *Evaluating the impact of an enhanced energy performance standard on load-bearing masonry domestic construction. Understanding the gap between designed and real performance: lessons from Stamford Brook.* Department for Communities and Local Government, HMSO.
Available from:< http://webarchive.nationalarchives.gov.uk/20120919132719/http:/www.communities.gov.uk/documents/corporate/pdf/2219033.pdf>[Accessed July 2015].

Party Wall Cavity Barrier Effective Edge Seal Testing for ARC Building Solutions Ltd

Authors

Testing conducted and Report prepared by:

Dominic Miles-Shenton
David Farmer

Leeds Sustainability Institute
Leeds Beckett University
A223, Broadcasting Place
Woodhouse Lane
Leeds
LS2 9EN

Tel:

0113 8121929
0113 8121938

Email:

d.miles-shenton@leedsbeckett.ac.uk
d.j.farmer@leedsbeckett.ac.uk

Acknowledgements:

Prof. David Johnston, for technical assistance regarding the design and operation of the test rig; and the staff at ARC Building Solutions Ltd for their helpfulness and understanding during the tests.

Leeds Beckett University
Enterprise Services
Old Broadcasting House
148 Woodhouse Lane
Leeds
LS2 9EN

T: 0113 812 1904
W: www.leedsbeckett.ac.uk/business