Airtightness Testing Report

Prepared for:

Larch Corner
Warwickshire

On behalf of:

Mick Woolley

Author:

Paul Jennings

Date:

21st April 2019

Reference:

P3727-03

DOCUMENT HISTORY

Role	Name	Date
Author	Paul Jennings	21st April 2019
Checked & Authorised	Alex Baines	21st April 2019

Design recommendations and specifications provided in this report are based on the best professional endeavours of the authors. All calculations are based on the best information available to us at the time of report production. Where third party equipment is referred to Aldas rely on manufacturer performance statements, guarantees, and warranties. We are not liable for any errors in calculations or omissions resulting from data provided by the customer or third parties.

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EXECUTIVE SUMMARY

The results achieved in the acceptance Airtightness Testing of the newbuild detached bungalow called Larch Corner, in Warwickshire, which was carried out on the 29th March 2019, are detailed in the table below:

Testing carried out by:	**Test Engineer: Paul Jennings, Aldas**
Target Air Changes, AC/hr @ 50 Pa:	**≤ 0.6 AC/hr @ 50 Pa (Passivhaus)**
Achieved Air Changes, AC/hr @ 50 Pa:	**0.048**
Achieved Air Permeability, $m^3/hr/m^2$ @ 50 Pa:	**0.041**
Data consistency, r^2 (requirement, $r^2 > 0.98$):	**0.995**
Slope, n (requirement, $0.5 < n < 1.0$):	**0.89**

This result demonstrates that Larch Corner is extremely well sealed and readily meets the newbuild Passivhaus airtightness target. To the best of our knowledge, it is the most airtight dwelling ever completed in the UK, and possibly even in the world. A remarkable achievement by the design & construction team.
No significant areas of air leakage could be identified during the testing. Some minor leakage was found in the base of a service void in one bathroom, but this could not be pinpointed to enable it to be rectified.

Full information on the test set-up and procedure is detailed in Appendix I and the test data for the depressurisation and pressurisation tests carried out is provided in Appendices II & III. The envelope area and volume measurements, with associated calculations, prepared by Mark Siddall of LEAP, are detailed in Appendix IV. An Air Leakage Certificate is included as Appendix V.

1.0 INTRODUCTION

This report documents acceptance air leakage testing and leakage investigations undertaken by Aldas for Mick Woolley at the newbuild detached bungalow called Larch Corner, in Warwickshire, which was carried out on the 29th March 2019. We present direct observations from what was noted during our attendance on site, together with recommendations for what to do next, in terms of both investigative and/or remedial work, if required.

The purpose of this report is to:

- Detail the measurements recorded and the test procedures followed
- Provide a photographic record of the test configuration, including any temporary sealing undertaken, and pictures of any significant leakage issues identified
- Confirm the air tightness result achieved
- Identify typical and atypical airtightness faults that did or may impede successful delivery of the required airtightness standard
- Detail the envelope area and volume measurements and calculations that underpin the results achieved
- Provide air leakage certificates for buildings where conforming airtightness tests were completed

2.0 TEST SET-UP AND PROCEDURES

2.1 Set-up

Acceptance air leakage testing of the newbuild detached bungalow called Larch Corner, in Warwickshire, was carried out on the 29th March 2019. Testing was carried out using a Retrotec 300 DucTester fan. This was mounted in a window board positioned in the front bedroom window. Testing was carried out in accordance with the requirements of BS EN 13829 and the ATTMA Quality Procedure, in conformance with the standards ATTMA TSL1 (2016) and ATTMA TSL4 (2018), in compliance with Method A (acceptance testing). The additional requirements of the Passivhaus Institute when testing building aiming for Passivhaus certification were also complied with. Any queries or complaints about this test should be addressed in the first instance to the test engineer and in the second instance to the scheme manager at ATTMA.

ATTMA contact details:	Scheme Manager, ATTMA, St Mary's Court, The Broadway, Amersham HP7 0UT e-mail: manager@attma.org	www.attma.org

All external doors and windows, other than that where the test equipment was mounted, were shut for the duration of testing, whilst internal doors were kept open for the duration of testing so free movement of air within the property was assured.

2.2 Measurement procedures

Test procedures in accordance with the following standards: ATTMA TSL1, 2016 and ATTMA TSL4, 2018, Method A. After a preliminary single- point depressurisation test and initial leakage check of the dwelling, full multi-point pressurisation testing was carried out. As required by the PHI for Passivhaus certification a full multi-point depressurisation test was then undertaken.

Measurements Recorded

Averages of zero flow pressure differentials were recorded before and after the test, as were internal and external temperatures, windspeed and the barometric pressure.

2.3 Dwelling air volume

A detailed survey of the as-built dwelling was carried out by the Architect and Passivhaus Consultant, Mark Siddall of LEAP, immediately before the test. This was then used to calculate a volume in compliance with Passivhaus Institute requirements, as well as values for the envelope area and the volume in accordance with ATTMA TSL1 (2016) and ISO9972 (2015). This process was reviewed and agreed with the test engineer and the representative of ATTMA attending the test, and several calculations of envelope area and volume then undertaken. These are summarised in the table below and the full survey information and calculations are detailed in Appendix IV.

Volume under test:	**Larch Corner, Hill Lane, Upper Quinton, near Stratford-upon-Avon, Warwickshire CV37 8TB**	
	Volume (m^3)	**Envelope area (m^2)**
PHI conventions:	423.25	n/a
ATTMA TSL1 conventions:	471.21	504.69
ISO 9972 conventions:	457.71	493.10
External measurement:	721.06	621.67

Current TSL1 conventions require measurements to be taken to the airtightness layer, which in this case is the outside of the CLT (cross-laminated timber) forming the walls and roof of the dwelling. However, those attending the test agreed that it was more appropriate to calculate the airtightness envelope area and volume to the inside of the CLT walls and roof, in accordance with ISO 9972 conventions. Hence an envelope area of 493.1 m^2 was used in calculating the air permeability alongside the volume of 423.25 m^3 used to calculate the Air Change Rate in conformance with the requirements of the Passivhaus Institute.

2.4 Equipment Calibration

All test equipment and accessories are calibrated. The table below provides details of the equipment and the calibration validity for each:

Equipment	Serial No.	Calibration expiry date
Retrotec DM-2A Digital Gauge	Serial No: 205393	Expires 18th March 2020
Retrotec 300 DucTester	Serial No: 3LFT00000383	Expires 18th March 2020
Testo 511 Digital Barometer	Serial No: 39109073/311	Expires 18th March 2020
Testo 110 Digital Thermometer	Serial No: 33955502/310	Expires 18th March 2020

Full calibration data for the above set of equipment is lodged with ATTMA.

3.0 LEAKAGE OBSERVATIONS

Leakage sites identified in the building tested are grouped into categories and described in detail below. Photographs, including thermographic images where applicable, are provided for key leakage sites where possible.

3.1 Leakage identified during testing

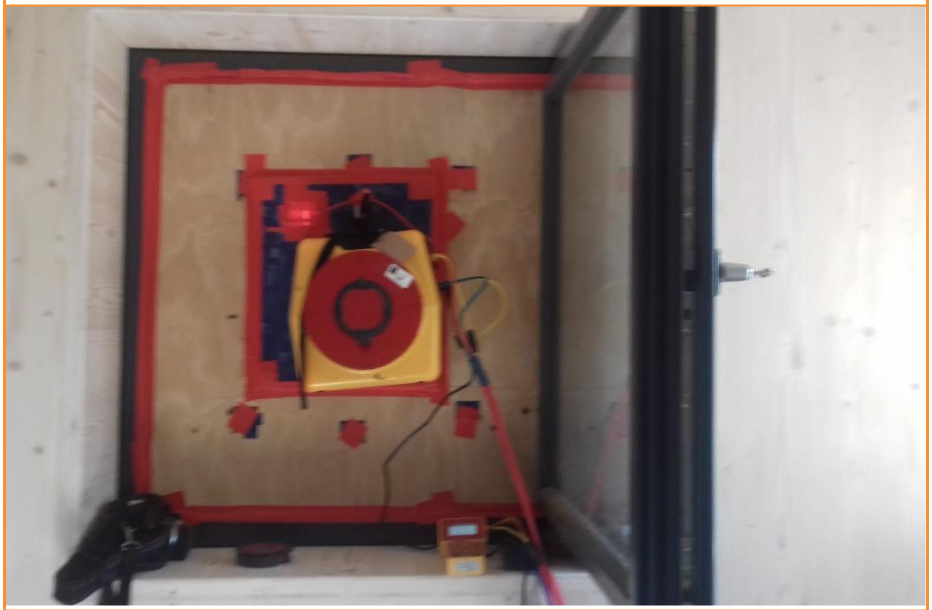
Unsurprisingly, given the results achieved, very little leakage was identified during the testing. The minor leakage found in the family bathroom could not be eliminated without substantial further investigation and disruption, which was not warranted. The leakage measured in the pressurisation test was 1.23 cm^2 ELA and in the depressurisation test 2.70 cm^2 ELA. It appears likely that the major part of this difference is due to the draughtseals fitted to the inward-opening windows and doors (supplied by the Green Building Store) operating more effectively when the dwelling was pressurised. However, it is rare that a building is so airtight that this difference can be detected.

3.1.1 Minor leakage was found near the base of the waste pipe, below the admittance valve shown above. Initially this was thought to be on a joint in the plumbing waste, then perhaps around the waste pipe where it penetrated the floor. Another theory was that the leakage was occurring laterally beneath the internal panel, connecting with the base of the external wall approximately 2 metres away. However, the location of the leakage could not be pinpointed and therefore remedial sealing could not be carried out.

APPENDIX I - Set-up images

Site Address: Larch Corner
Warwickshire

A1.1) External view of test equipment mounted in front Bedroom window



A1.2) Internal view of test equipment mounted in front Bedroom window

A1.3 MVHR grilles sealed externally

A1.4 Admittance valve in family bathroom temporarily sealed for duration of testing. A second admittance valve in a WC was also sealed

A1.5 Dry trap on condensate drain from MVHR

A1.6 Dry trap temporarily sealed for duration of testing

APPENDIX II – Negative Pressure Differential vs Airflow Data Set

Site Address: Larch Corner, Warwickshire

Date:	**29th March 2019**	Time:		**14.05**	to	**14:35**	
Environmental Conditions:							
Barometric Pressure:		**102.2**	**kPa**	Wind speed:		**0.2**	**m/s**
Temperatures, initial:	Indoors:	**21.0**	**°C**	Outdoors:		**16.3**	**°C**
Temperatures, final:	Indoors:	**21.0**	**°C**	Outdoors:		**16.3**	**°C**

Test Data:

At least **10** static pressures taken for **10** secs each.
A minimum of **10** induced pressures taken for >**20** sec each.

Existing Pressure Differentials (Static pressure):

Baseline, initial [Pa]	**3.5**	**3.3**	**2.4**	**2.4**	**2.7**	**2.6**	**3.3**	**3.1**	**2.1**	**1.7**
Baseline, final[Pa]	**1.1**	**1.1**	**1.0**	**0.7**	**0.6**	**0.5**	**0.4**	**0.7**	**1.2**	**1.3**

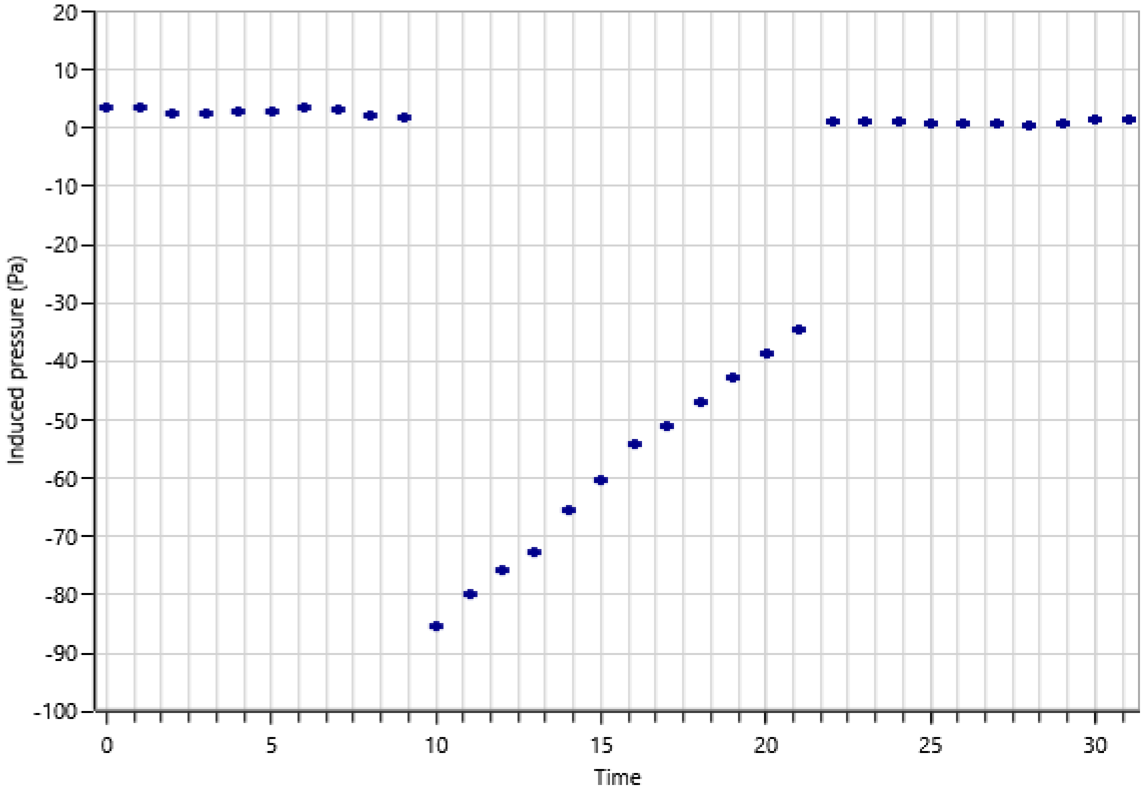
Static Pressure Averages:	**initial [Pa]**	ΔP_{01}	**2.71**	ΔP_{01-ve}	**0.00**	ΔP_{01+ve}	**2.71**
	final[Pa]	ΔP_{02}	**0.86**	ΔP_{02-ve}	**0.00**	ΔP_{02+ve}	**0.86**

Results:

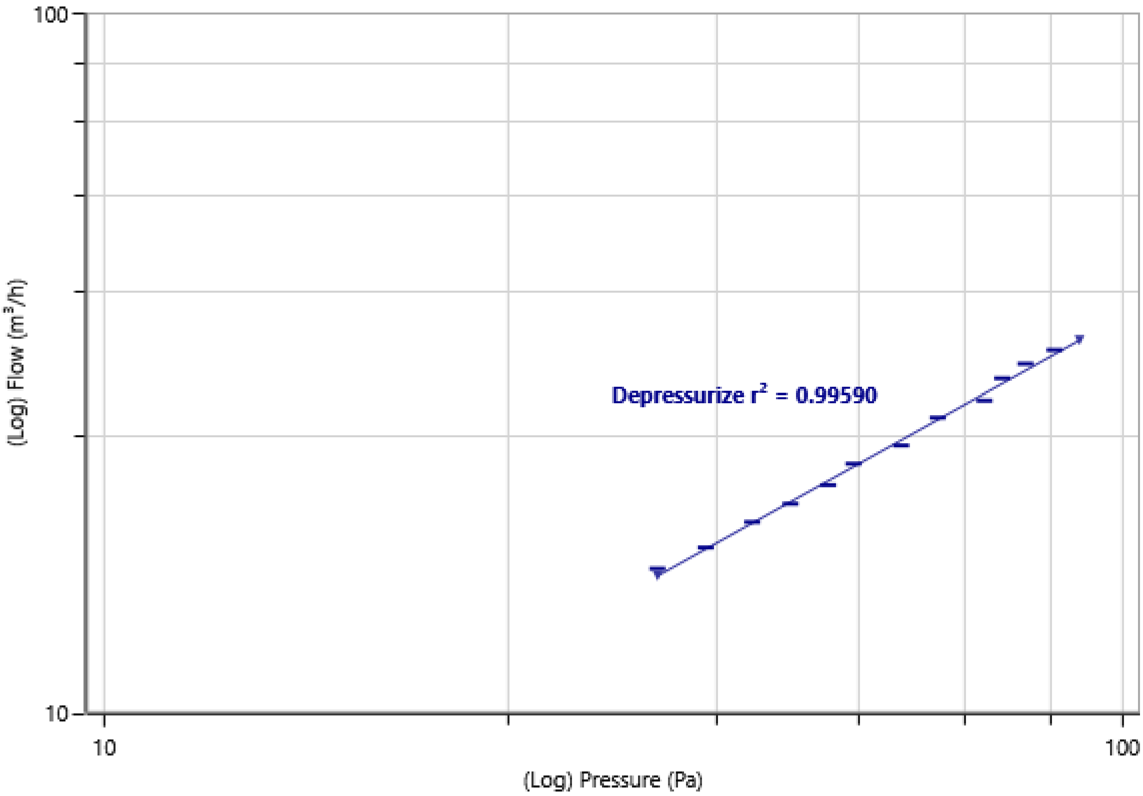
All results are compared to the standards set in Building Regulations 'Approved Document L1A – Conservation of fuel and power in new dwellings (2010)'. Results are calculated using the formulae set out in ATTMA TSL1 (Appendix A). Readings collected are detailed below:

Reading	1	2	3	4	5	6	7	8	9	10	11	12
Induced Pressure [Pa]	-83.6	-78.2	-74.1	-71.1	-63.8	-58.6	-52.4	-49.4	-45.2	-41.3	-37.0	-33.0
Total flow, Q_r [m³/h]	33.8	32.3	30.8	28.7	27.1	24.7	23.3	21.7	20.4	19.2	17.7	16.5
Corrected flow, Q_{env} [m³/h]	33.1	31.6	30.1	28.0	26.5	24.2	22.8	21.2	20.0	18.8	17.3	16.1
Error [%]	1.1%	1.8%	1.4%	-2.6%	0.3%	-2.1%	0.7%	-1.7%	-1.0%	0.0%	0.1%	2.1%

G1: Graph of imposed pressure differentials, Depressurisation, Larch Corner:



G2: Graph of imposed pressure differential against airflow, Depressurisation, Larch Corner:



Depressurisation Test Results – Larch Corner

	Results				Results	Uncertainty
Correlation, r^2	**0.996**	95% confidence limits		Air flow at 50 Pa, Q_{50} [m^3/h]	**21.3**	**+/-1.1%**
Intercept, C_{env} [$m^3/h.Pa^n$]	**0.89**	**0.77**	**1.04**	Permeability at 50 Pa, AP_{50} [$m^3/h.m^2$]	**0.043**	**+/-1.3%**
Slope, n	**0.81**	**0.77**	**0.85**	Equivalent leakage area at 50 Pa [cm^2]	**2.70**	**+/-1.1%**
				Air changes, n_{50}	**0.050**	**+/-1.2%**

APPENDIX III - Positive Pressure Differential vs Airflow Data Set

Site Address: Larch Corner, Warwickshire

Date:	**29th March 2019**	Time:	**13:00**		to	**13:25**	
Environmental Conditions:							
Barometric Pressure:		**102.2**	**kPa**	Wind speed:		**0.2**	**m/s**
Temperatures, initial:	Indoors:	**21.0**	**°C**	Outdoors:		**16.1**	**°C**
Temperatures, final:	Indoors:	**20.7**	**°C**	Outdoors:		**16.1**	**°C**

Test Data:

At least **10** static pressures taken for **10** secs each.
A minimum of **10** induced pressures taken for >**20** sec each.

Existing Pressure Differentials (Static pressure):

Baseline, initial [Pa]	**-0.6**	**-0.5**	**-0.4**	**0.0**	**-0.1**	**-0.3**	**-0.9**	**-0.7**	**-0.5**	**-0.8**
Baseline, final[Pa]	**1.8**	**2.7**	**1.1**	**0.8**	**1.6**	**0.4**	**0.0**	**0.7**	**1.7**	**0.7**

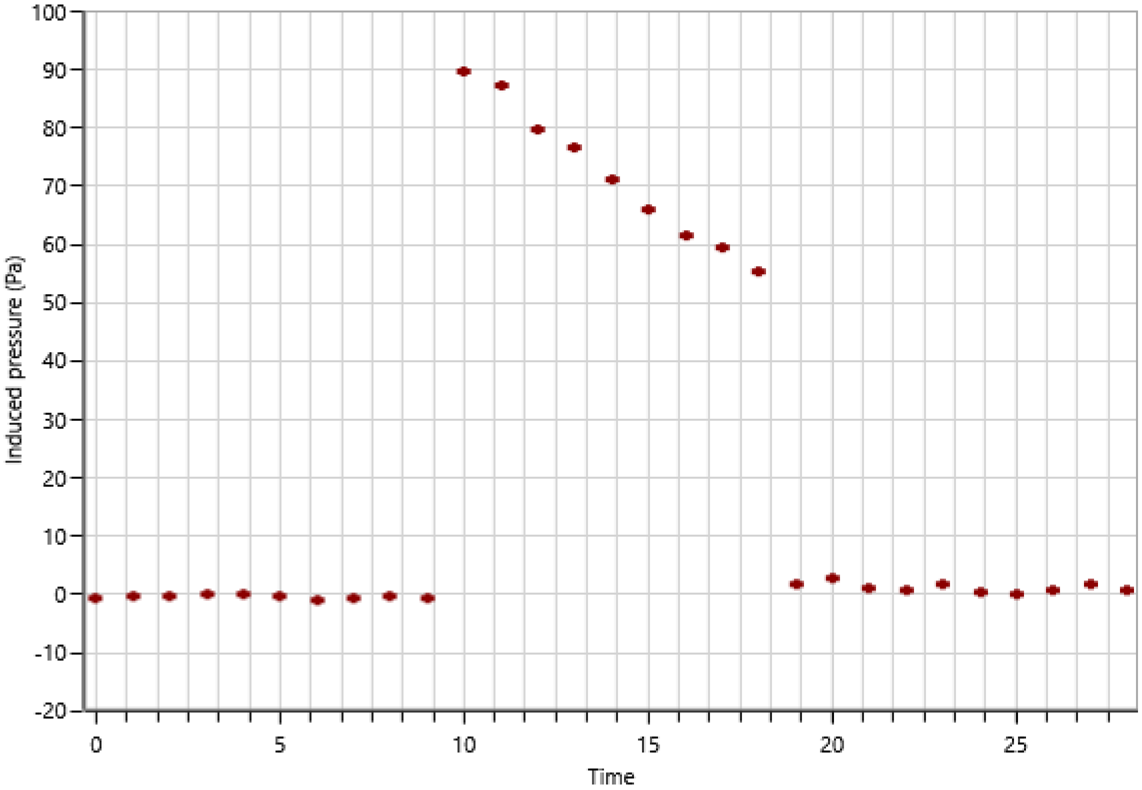
Static Pressure Averages:	**initial [Pa]**	ΔP_{01}	**-0.48**	ΔP_{01-ve}	**-0.53**	ΔP_{01+ve}	**0.00**
	final[Pa]	ΔP_{02}	**1.15**	ΔP_{02-ve}	**0.00**	ΔP_{02+ve}	**1.15**

Results:

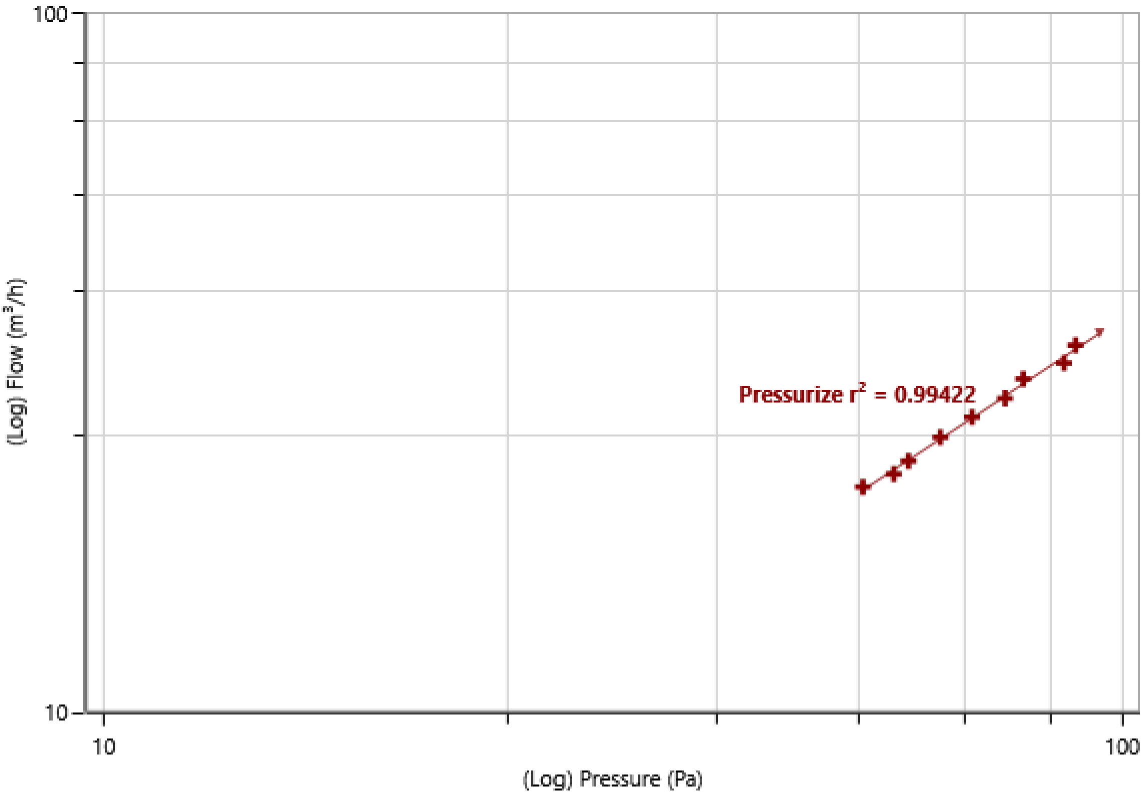
All results are compared to the standards set in Building Regulations 'Approved Document L1A – Conservation of fuel and power in new dwellings (2010)'. Results are calculated using the formulae set out in ATTMA TSL1 (Appendix A). Readings collected are detailed below:

Reading	1	2	3	4	5	6	7	8	9
Induced Pressure [Pa]	89.9	87.6	79.9	76.7	71.2	66.3	61.7	59.7	55.7
Total flow, Q_r [m^3/h]	33.8	31.9	30.3	28.4	26.7	25.0	23.1	22.2	21.2
Corrected flow, Q_{env} [m^3/h]	33.6	31.7	30.1	28.3	26.6	24.9	23.0	22.0	21.1
Error [%]	1.3%	-2.1%	1.6%	-0.7%	0.3%	0.5%	-0.3%	-1.4%	1.0%

G3: Graph of imposed pressure differentials, Pressurisation, Larch Corner:



G4: Graph of imposed pressure differential against airflow, Pressurisation, Larch Corner:



Pressurisation Test Results – Larch Corner						
	Results				Results	Uncertainty
Correlation, r^2	**0.994**	95% confidence limits		Air flow at 50 Pa, Q_{50} [m^3/h]	**19.0**	**+/-2.5%**
Intercept, C_{env} [$m^3/h.Pa^n$]	**0.44**	**0.33**	**0.58**	Permeability at 50 Pa, AP_{50} [$m^3/h.m^2$]	**0.039**	**+/-2.5%**
Slope, n	**0.96**	**0.90**	**1.03**	Equivalent leakage area at 50 Pa [cm^2]	**1.23**	**+/-2.5%**
				Air changes, n_{50}	**0.045**	**+/-2.6%**

APPENDIX IV- Dimensioned drawings & envelope and volume calculations

Dimensioned ground floor plan – PHI compliant

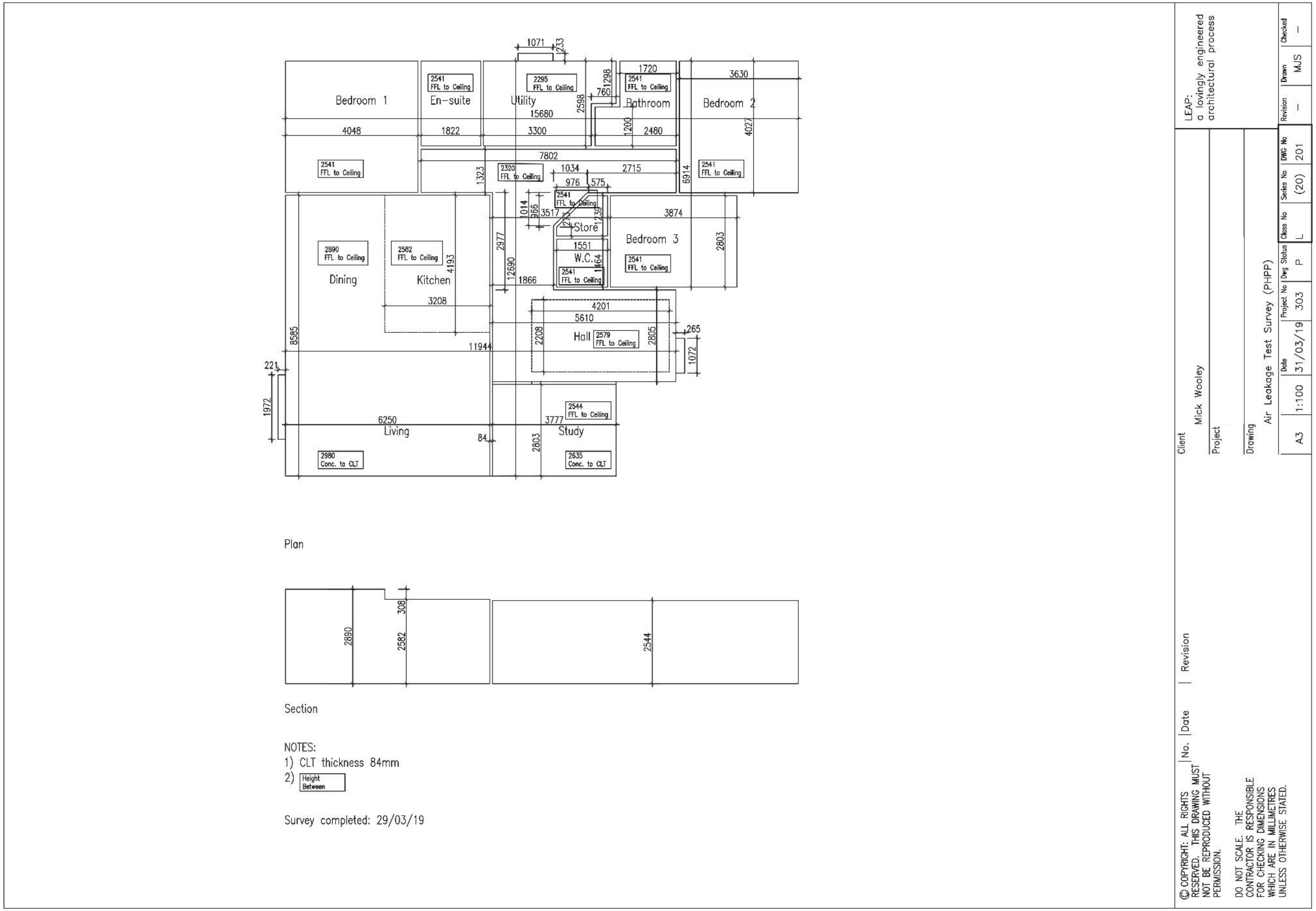
Dimensioned ground floor plan – ATTMA TSL1 (2016)

Dimensioned ground floor plan – ISO 9972 (2015)

Dimensioned ground floor plan – External dimensions

Summary Table & Notes

Calculation spreadsheets (4)


Bedroom 1
En-suite
Utility
Bathroom
Bedroom 2
Store
W.C.
Bedroom 3
Dining
Kitchen
Hall
Living
Study
Plan
Section
NOTES:
1) CLT thickness 84mm
2) Height Between
Survey completed: 29/03/19
LEAP: a lovingly engineered architectural process
Client
Mick Wooley
Project
Drawing
Air Leakage Test Survey (PHPP)
A3
1:100
31/03/19
303
P
L
(20)
201
MJS
No.
Date
Revision
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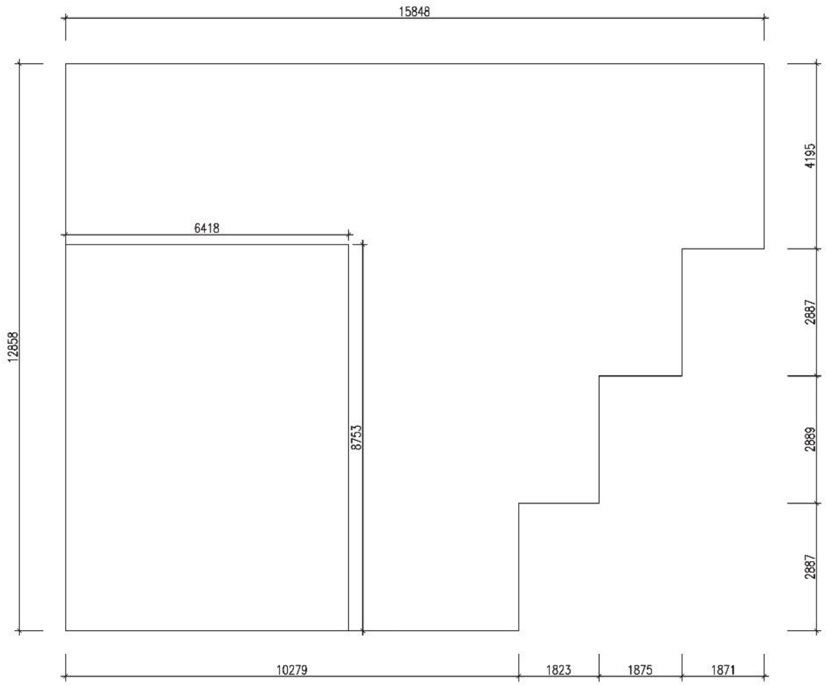
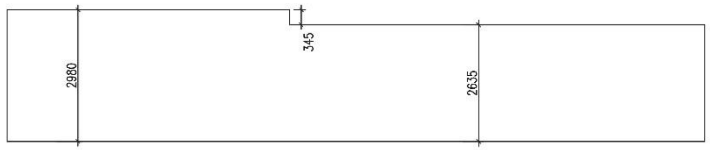


Plan



Section

NOTES:
1) CLT thickness 84mm
2) Height Between

Survey completed: 29/03/19

LEAP:
a lovingly engineered
architectural process

Client
Mick Wooley

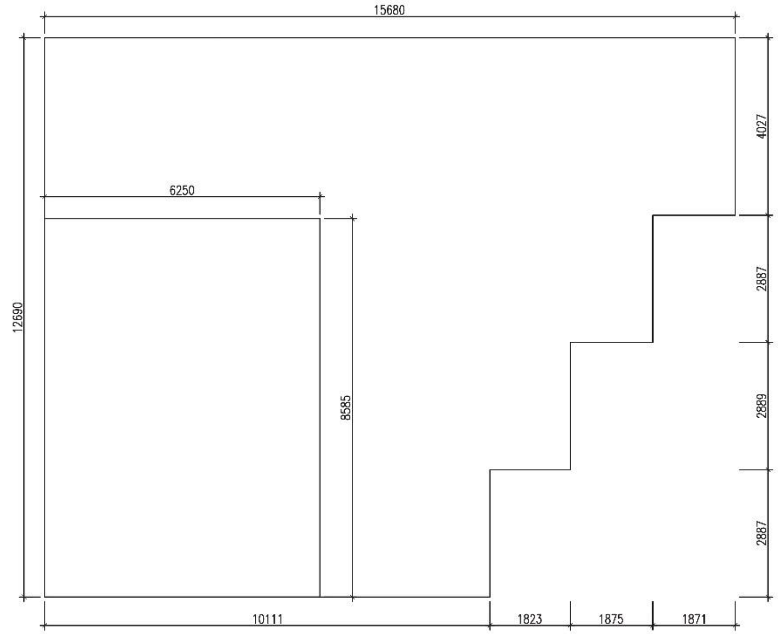
Project

Drawing
Air Leakage Test Survey (ATTMA)

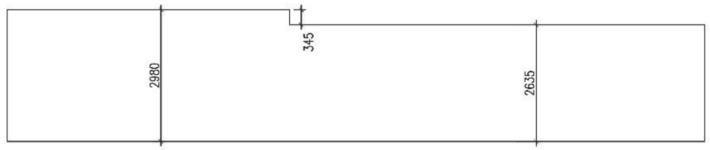
	Date	Project No	Dwg Status	Class No	Series No	DWG No	Revision	Drawn	Checked
A3 1:100	31/03/19	303	P	L	(20)	202	–	MJS	–

No. | Date | Revision

DO NOT SCALE. THE CONTRACTOR IS RESPONSIBLE FOR CHECKING DIMENSIONS WHICH ARE IN MILLIMETRES UNLESS OTHERWISE STATED.



Plan



Section

NOTES:
1) CLT thickness 84mm
2) Height Between

Survey completed: 29/03/19

DO NOT SCALE. THE CONTRACTOR IS RESPONSIBLE FOR CHECKING DIMENSIONS WHICH ARE IN MILLIMETRES UNLESS OTHERWISE STATED.

No.	Date	Revision

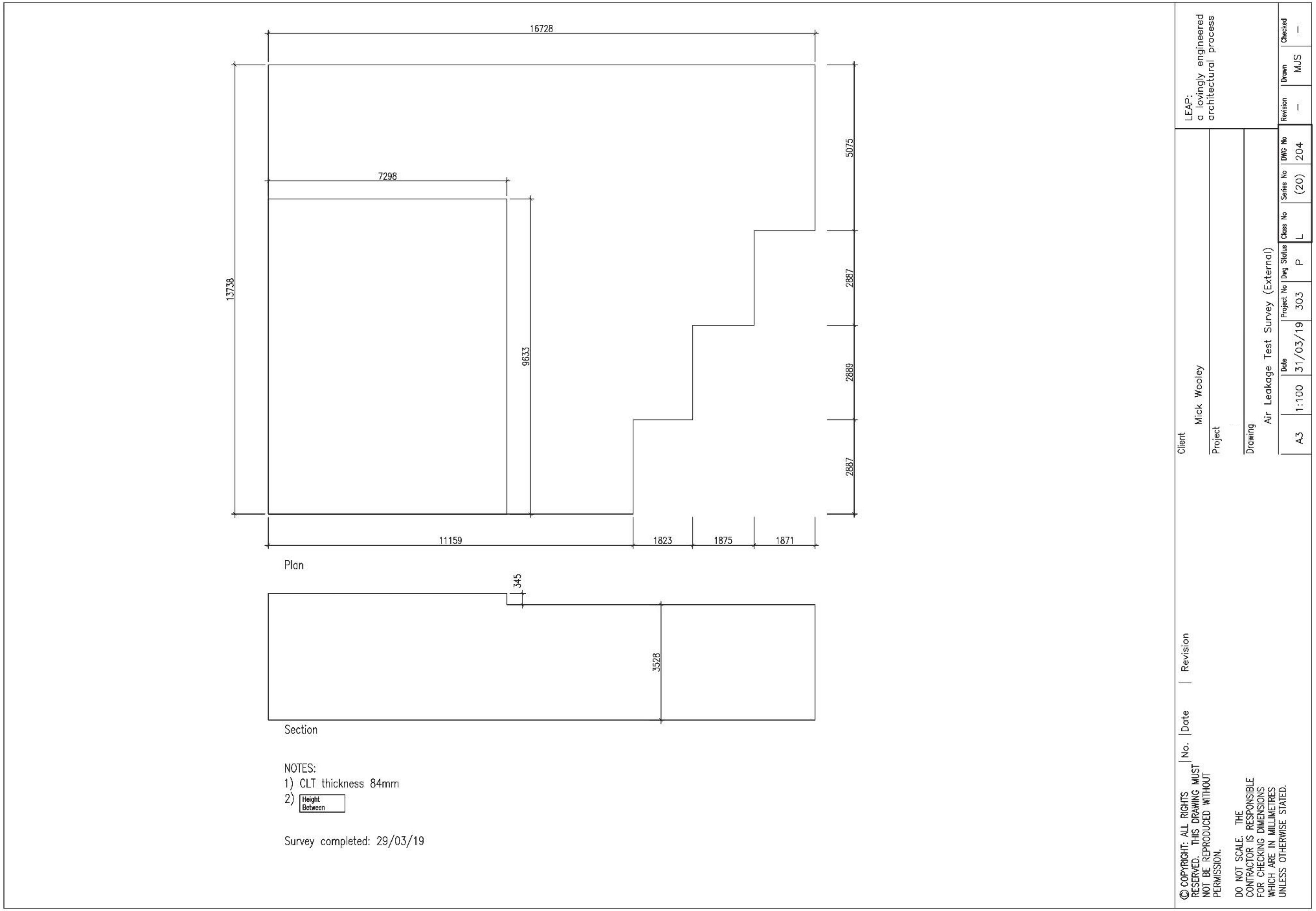
LEAP:
a lovingly engineered architectural process

Client: Mick Wooley

Project

Drawing: Air Leakage Test Survey (ISO)

	Date	Project No	Dwg Status	Class No	Series No	DWG No	Revision	Drawn	Checked
A3 1:100	31/03/19	303	P	L	(20)	203	–	MJS	–


16728
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13738
9633
5075
2887
2889
2887
11159
1823
1875
1871
Plan
345
3528
Section
NOTES:
1) CLT thickness 84mm
2) Height Between
Survey completed: 29/03/19
LEAP:
a lovingly engineered architectural process
Client
Mick Wooley
Project
Drawing
Air Leakage Test Survey (External)
A3
1:100
Date
31/03/19
Project No
303
Dwg Status
P
Class No
L
Series No
(20)
DWG No
204
Revision
–
Drawn
MJS
Checked
–
No.
Date
Revision
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Notes on envelope area and volume calculations, prepared by Mark Siddall of LEAP

SUMMARY TABLE

	Area	Volume	Depressurisation airflow	Pressurisation airflow	Average airflow		
	m^2	m^3	m^3/hr @ 50 Pa	m^3/hr @ 50 Pa	m^3/hr @ 50 Pa	q50	n50
Passivhaus		423.25	21.294	18.960	20.127		0.048
ATTMA							
TSL1	504.69	471.21	21.294	18.960	20.127	0.040	0.043
ISO 9972	493.10	457.71	21.294	18.960	20.127	0.041	0.044
External	621.67	721.06	21.294	18.960	20.127	0.032	0.028

NOTES:

1) ATTMA TSL1:2016 (as well as BC Housing:2017, Canada) requires measurement along the line of the component being relied upon for air sealing. This applies to the calculation of volumes and areas.
2) ISO 9972:2015 (as well as Resnet/ICC380, USA) requires the gross dimensions to be measured along the line of the internal surface, but through interrupting internal walls/floors i.e. no subtractions. This applies to the calculation of volumes and areas. Plane of internal surface resistance (Rsi).
3) When measuring the internal volume BE EN 13829:2001 requires the net area (excluding the volume of interrupting internal walls/floors) to be multiplied by the net-mean height. The measurement of areas follows the method outlined in item 2 above.
4) External area measured to plane of external surface resistance (Rse).

References:

ANSI/Resnet/ICC380, Standard for Testing Airtightness of Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems, USA, 2016

ATTMA TSL1 (2016) Technical Standard L1: Measuring Air Permeability in The Envelopes of Dwellings, ATTMA, September 2016

ATTMA TSL4 (2018) Technical Standard L4: Measuring Air Permeability in Passivhaus and Low Energy Buildings, May 2018

BC Housing (2017) Illustrated Guide: Achieving Airtight Buildings, BC Housing, September 2017

ISO 9972 (2015) Thermal performance of buildings — Determination of air permeability of buildings — Fan pressurization method

BE EN 13829 (2001) Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method, BSI, 2015

Passivhaus: n50 Volume Calculation (based upon BS EN 13829)

	Width (m)	Length (m)	Area (m2)	TFA?	TFA	height (m)	Volume
Kitchen/Dining/Living	6.25	8.59	53.66	Y	53.66	2.89	155.07
Living Room Door	0.22	1.97	0.44	Y	0.44	2.20	0.96
Kitchen (ceiling downstand)	3.21	4.19	13.45			0.31	-4.14
Utility	3.30	2.60	8.57	Y	8.57	2.30	19.68
Utility	0.76	1.30	0.99	Y	0.99	2.30	2.26
Utility Back door	0.22	1.07	0.24	Y	0.24	2.30	0.55
Store	0.97	0.58	0.56	Y	0.56	2.54	1.41
Store	0.98	0.97	0.47	Y	0.47	2.54	1.20
Store	1.55	0.27	0.42	Y	0.42	2.54	1.08
WC	1.55	1.46	2.27	Y	2.27	2.54	5.77
Study	2.80	3.78	10.59	Y	10.59	2.54	26.93
Entrance / Hall	7.80	1.32	10.32	Y	10.32	2.32	23.95
Entrance / Hall	2.98	1.87	5.56	Y	5.56	2.32	12.89
Entrance / Hall	2.81	5.61	15.74	Y	15.74	2.32	36.51
Entrance / Hall	1.01	1.03	0.52	Y	0.52	2.32	1.22
Entrance (ceiling recess)	2.21	4.20	9.28			0.26	2.40
Entrance Front door	0.27	1.07	0.28	Y	0.28	2.20	0.62
Bed 1	4.05	4.03	16.29	Y	16.29	2.54	41.38
En Suite	1.82	2.60	4.73	Y	4.73	2.54	12.03
Bed 2	3.63	4.03	14.62	Y	14.62	2.54	37.14
Bed 3	2.80	8.74	10.86	Y	10.86	2.54	27.59
Bathroom	1.72	2.60	4.47	Y	4.47	2.54	11.35
Bathroom	1.20	0.76	0.91	Y	0.91	2.54	2.32
Floor Finish Correction			162.50			0.02	3.09
					162.50		423.25

TFA	**162.50**
Total volume (Vn50)	**423.25**

ATTMA TSL1: AIR BARRIER SURFACE AREA

	Perimeter	height		
GF	57.41	2.64	151.28	
K/L/D upstand	30.34	0.35	10.47	
			161.75	m^2

Plan		
GF	171.47	m^2
Roof	171.47	m^2

TOTAL SURFACE AREA OF AIR BARRIER:	**504.69**	**m^2**

ATTMA TSL1: AIR BARRIER VOLUME

	area	height		
GF Area	171.47	2.64	451.83	
K/L/D upstand	56.18	0.35	19.38	
			471.21	m^3

ISO 9972: INTERNAL SURFACE AREA

	Perimeter	height		
GF Perimeter	56.74	2.64	149.51	
upstand	29.67	0.35	10.24	
			159.75	m^2

Plan		
GF	166.68	m^2
Roof	166.68	m^2

TOTAL SURFACE AREA OF AIR BARRIER:	**493.10**	**m^2**

ISO 9972: INTERNAL VOLUME

ATTMA (INT)

	area	height		
GF Area	166.68	2.64	439.20	
K/L/D upstand	53.66	0.35	18.51	
			457.71	m^3

EXTERNAL SURFACE AREA (to surface resistance)

	Perimeter	height		
GF Perimeter	60.93	3.53	214.97	
upstand	33.86	0.35	11.68	
			226.65	m^2

Plan		
GF	197.51	m^2
Roof	197.51	m^2
TOTAL SURFACE AREA OF AIR BARRIER:	**621.67**	**m^2**

ISO 9972: INTERNAL VOLUME

ATTMA (INT)

	area	height		
GF Area	197.51	3.53	696.81	
K/L/D upstand	70.30	0.35	24.25	
			721.06	m^3

APPENDIX V - Air Leakage Certificate

Air Leakage Certificate

In accordance with BS EN 13829, ATTMA TSL1 (2016) & TSL4 (2018) & the requirements of the Passivhaus Institute

Building Tested:		Larch Corner, Warwickshire
Test Date:		29th March 2019
Test Engineer:		Paul Jennings, Aldas
Certificate No:		P3727-C01

This is to certify that the above-named dwelling has been tested for air leakage in accordance with the BS EN 13829:2001 methodology and the requirements of ATTMA as specified in TSL1 (2016) and TSL4 (2018). The additional requirements of the Passivhaus Institute when Passivhaus Certification is required were also met. The average Leakage Characteristics of the dwelling were recorded as follows:

Airflow @ 50 Pa:		20.13 m^3/hr
Air Permeability @ 50 Pa:		0.041 m^3/ (hr.m^2)
Air Change Rate @ 50 Pa:		0.048 AC/hr
Data consistency, r^2 (requirement, r^2 > 0.98):		0.995
Slope, n (requirement, 0.5 < n < 1.0):		0.89
Intercept, C_{env}:		0.667 m^3/ (hr.Pa^n)
Test Parameters		
Envelope, A_E:		493.1 m^2
Volume, V:		423.3 m^3
Env. Calc. prepared by:		Mark Siddall, LEAP

Initial Offset Pressure	-0.48 Pa	Final Offset Pressure:	0.86 Pa
Initial Inside Temperature:	21.0°C	Final Inside Temperature:	21.0°C
Average Outside Temperature:	16.2°C	Barometric Pressure:	102.2 kPa

This certificate should be read in conjunction with the full airtightness test report P3727-03 and associated test method statement.

Signed: Paul Jennings Name: Paul Jennings Date Issued: 22nd April 2019

Position: Air Leakage Specialist

Deviations from TSL1 & TSL4 methodology: None

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