



Oldham Residence – Langley, WA



2015 WSEC RESULT:

0.149 CFM/ft²

WSEC Air Barrier Testing Report

Oldham Residence: 959 Woodside Lane | Langley, WA

Test Date: 12.23.2020

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Prepared for:

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Executive Summary

Soloveda performed air barrier testing at Oldham Residence in Langley, WA on 12/23/2020. The test was performed according to ASTM E779-15 and the 2015 Washington State Energy Code (WSEC).

Soloveda deployed 1 high-capacity fan to induce a series of pressure differentials across the building envelope. Once each target pressure stabilized, airflow from each fan was measured and averaged over a minimum of ten seconds. The averaged airflows across all fans were then added together to obtain a single aggregated airflow. The relationship between airflow and differential pressure (dP) was analyzed to estimate the envelope's leakage value and then compared to the allowable limit of 0.4 CFM/ft² at dP = 75 Pa defined in 2015 WSEC Section C402.5.1.2. These values are captured in the following table.

Table 1: Essential Compliance Results Summary

Parameter	Standard Leakage*	Allowable	Result
Leakage per ft ²	0.149 CFM/ft ²	0.4 CFM/ft ²	PASS
Total Leakage at 75 Pa	1,422 CFM	3,832 CFM	PASS

*Leakages are adjusted to standard references such that results are comparable to other buildings with different test conditions.

Stack effect, correlation coefficients, and pressure exponents: Based upon ASTM E779-15 and the 2015 WSEC requirements, the test procedure was valid relative to stack effect, correlation coefficients, and pressure exponents. These are described in the following tables and figures.

Equivalent leakage area (ELA): ELA is equivalent to all unintentional leaks of the building envelope combined into a single square-shaped hole given a pressure difference of 75 Pa. While the ELA has no defined limit, it is made available for an alternative interpretation of the results. This building's ELA at 75 Pa is estimated as 0.647 ft² compared to a building envelope of 9,580 ft².

Confidence intervals: To capture statistical uncertainty, each estimated value has a lower-bound and an upper-bound called a *confidence interval*. For example, the equivalent leakage area has a 95% confidence interval between 0.643 ft² and 0.651 ft². If we repeated this test 100 times under varying conditions, approximately 95 of the tests should have confidence intervals capturing the real value which we report as 0.647 ft².

Volume CF	Measured Leakage @ 50 Pa	ACH 50 Result	Result
52163 CF	1163 CFM	1.33	Pass



Table 2: **Comprehensive** Test Results - (Positive and Negative Pressure) With Confidence Intervals

Parameter	Low	Mid.	High	Limit	Test
Total Leakage @ 75 Pa	0.148 CFM/ft ²	0.148 CFM/ft ²	0.149 CFM/ft ²	< 0.4 CFM/ft ²	PASS
Pressure Exponent, <i>n</i>	0.683	0.701	0.718	0.45 < <i>n</i> < 0.85	PASS
Leakage Coefficient, <i>C</i> ₀	66.32	70.54	74.76	---	---
ELA @ 75 Pa	0.643 ft ²	0.647 ft ²	0.651 ft ²	---	---

ASTM E779-15 Test Procedure

ASTM E779-15 defines a *power-law model* relating differential pressure across a building envelope (*dP*) induced by fans with the corresponding airflow (*Q*) through an orifice with a *leakage coefficient C* and *pressure exponent n*:

$$Q = C (dP)^n$$

Ideally, a test consists of pressurizing and depressurizing a building with fans at differential pressures from 30 Pa to 75 Pa. Zero-airflow measurements before and after the test adjust measured *dP* to correct for any bias pressures detected (Wind, stack effect, etc).

Pressurization airflow measurements *Q* are converted to volumetric *standard* airflows *Q*₀ of the inside air by correcting for temperature and barometric pressure. Likewise, depressurization test measurements are corrected for outside air temperature and pressure. Measured pressure differences are averaged, and airflows for fans running simultaneously are summed.

An unweighted regression estimates the model parameters *C* and *n* based on converted volumetric airflows *Q*₀. The leakage coefficient *C* is "corrected" and renamed to *C*₀ to adjust for standard reference conditions: sea-level pressure and a 68 degrees Fahrenheit temperature. The pressure exponent *n* is a measure of air turbulence, and must fall within a small limit to ensure model validity according to regulations. The regression's correlation coefficient *r*² must be sufficiently close to 1.0 to indicate a proper agreement between the measured data and the power-law model:

$$Q_0 = C_0 (dP)^n$$

Standard volumetric airflow estimates *Q*₀ can now be computed for any given *dP* and compared to other building sites given the leakage coefficient correction *C*₀.

Soloveda follows the E779-15 guidelines both for computing small sample-size confidence intervals using the T-distribution, and for combining parameters and their confidence intervals from pressurization and depressurization data.



Individual Test Compliance Results

The following tables list the separate pressurization and depressurization statistical parameters and compliance results with their confidence intervals used to compute values in Table 2.

Table 3: *Pressurization Test Compliance Results - Confidence Intervals*

Parameter	Low	Mid.	High	Limit	Test
Total Leakage @ 75 Pa	0.159 CFM/ft ²	0.160 CFM/ft ²	0.161 CFM/ft ²	< 0.4 CFM/ft ²	PASS
Pressure Exponent, n	0.654	0.667	0.679	$0.45 < n < 0.85$	PASS
Leakage Coefficient, C_0	81.87	86.14	90.64	---	---
ELA @ 75 Pa	0.695 ft ²	0.698 ft ²	0.700 ft ²	---	---
Correlation Coefficient, r^2	---	0.99964	---	> 0.98	PASS

Table 4: *Depressurization Test Compliance Results - Confidence Intervals*

Parameter	Low	Mid.	High	Limit	Test
Total Leakage @ 75 Pa	0.135 CFM/ft ²	0.137 CFM/ft ²	0.139 CFM/ft ²	< 0.4 CFM/ft ²	PASS
Pressure Exponent, n	0.702	0.735	0.767	$0.45 < n < 0.85$	PASS
Leakage Coefficient, C_0	48.20	54.94	62.62	---	---
ELA @ 75 Pa	0.590 ft ²	0.597 ft ²	0.604 ft ²	---	---
Correlation Coefficient, r^2	---	0.99804	---	> 0.98	PASS



Test Data

The following sections list the model's corrected data inputs for pressurization and depressurization tests alongside figures plotting power-law model trendlines along with corrected data (see Test Procedure Section).

Table 5: *Pressurized Airflow Data*

Target dP (Pa)	Corrected dP	Measured Airflow (CFM)	Leakage (CFM)
75.0	76.0	1,515	1,548
70.0	70.8	1,444	1,476
65.0	65.5	1,364	1,393
60.0	60.7	1,301	1,330
55.0	55.8	1,237	1,264
50.0	50.7	1,154	1,179
45.0	45.6	1,075	1,098
40.0	40.8	1,000	1,021

Table 6: *Depressurized Airflow Data*

Target dP (Pa)	Corrected dP	Measured Airflow (CFM)	Leakage (CFM)
-75.0	-74.5	1,346	1,317
-70.0	-69.2	1,272	1,245
-65.0	-64.0	1,209	1,183
-60.0	-59.3	1,126	1,102
-55.0	-54.2	1,060	1,037
-50.0	-49.3	984	963
-45.0	-44.2	907	888
-40.0	-39.3	849	831



Figure 1: Graph of Standard Airflow vs Differential Pressure

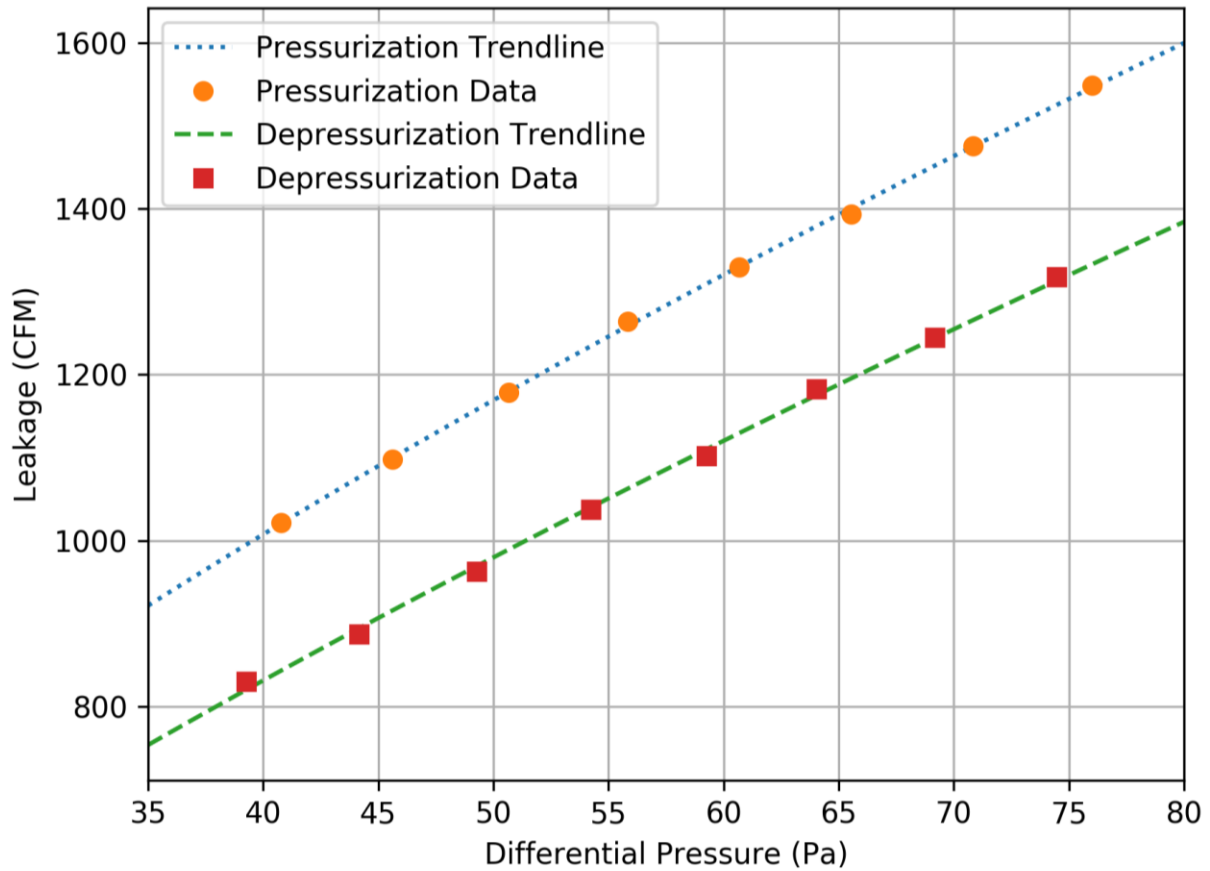


Table 7: General Building and Environment Measurements

Parameter	Value
Site Elevation	135.0 ft
Building Height	40.0 ft
Building Envelope Area	9,580 ft ²
Building Volume	55,163 ft ³
Inside Temperature	55.0 degrees F
Outside Temperature	44.0 degrees F
Windspeed	2.0 mph
Zero-flow Pressure Difference	-0.7 Pa
Stack Effect Validity	PASS



Test Equipment and Building Test Preparation Procedures

Testing was conducted by deploying 1 high-capacity Retrotec 3000SR orifice blower door fan, installed in an exterior entry door off the garage. Below is an outline of the measures taken to ensure only legitimate leakage through the envelope was measured.

- Isolated exhaust fans
- closed windows doors and trickle vents
- drains filled with water

Upon successful installation of the fans, the building was pressurized sampling differential pressure in 5 Pa increments. Before and after each test, zero-flow baseline pressures were taken and used to correct the final pressure measurements. The resulting pressure and flow data points were then plotted to determine their correlation and identify the pressure exponent and leakage coefficient which are indicative of the building's leakage characteristics.

Report Conclusion

ASTM E779-15 testing performed by Soloveda indicates that the building enclosure air tightness capabilities meet or exceed the formal performance requirements set forth in 2015 WSEC Section C402.5.1.2.

Congratulations on a successful test!

Regards,

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This report was prepared for Soloveda's client and contains findings, comments, and observations made by a qualified representative of Soloveda. The report is intended to serve as a Quality Assurance tool, and is provided in a timely manner so that remedial action can be undertaken as necessary. Note that the testing conducted was not inclusive of all specimens present and is therefore limited in nature. Accordingly, Soloveda's statements contained herein do not constitute approval, disapproval, certification, acceptance of performance of products materials, or endorsement by this laboratory/ testing agency. The report is the exclusive property of our client, and relates solely to the specimens tested.



Report Glossary

air-leakage*, n - the movement/flow of air through the building envelope, which is driven by either or both positive (infiltration) and negative (exfiltration) pressure differences across the envelope.

air-leakage rate*, n - the volume of air movement/unit time across the building envelope including airflow through joints, cracks, and porous surfaces, or a combination thereof driven by mechanical pressurization and depressurization, natural wind pressures, or air temperature differentials between the building interior and the outdoors, or a combination thereof.

building envelope*, n - the boundary or barrier separating different environmental conditions within a building and from the outside environment.

effective leakage area*, n - the area of a hole, with a discharge coefficient of 1.0, which, with a 75 Pa pressure difference, leaks the same as the building, also known as the sum of the unintentional openings in the structure.

flow coefficient, n - the constant parameter of the power law equation that relates flow to differential pressure across a building envelope. It represents the theoretical flow rate that exists at a differential pressure of 1 Pa.

pressure exponent, n - the exponent applied to the pressure parameter of the power law equation that relates flow to differential pressure across a building envelope. The exponent is a value between 0 and 1 that is indicative of how turbulent the air flow is. A value of 1 represents totally laminar flow.

* Definition as given in ASTM E779-15 Standard Method for Determining Air Leakage Rate by Fan Pressurization.