Air Leakage Test Report

ingenieursbureau Van der Kleij

Buitink Zeilmakerij Duiven B.V.
Typograaf 1
NL-6921 VB Duiven
The Netherlands

Tel: +31 (0)316-250830
Fax: +31 (0)316-283954
info@buitink-technology.com
www.buitink-technology.com

KvK Arnhem: 09098432
BTW / VAT: NL819078244B02

Address:	Typograaf 1 6921 DV Duiven
Performed for:	Buitink Technology
Performed by:	ir. P.S. van der Kleij ingenieursbureau Van der Kleij Boccherinistraat 2 6815 GX Arnhem
Test date:	2021-09-07
Associated Test file:	Buitink Technology
Report Number:	21.344

Object to test

The object to test is a chimney valve, consisting of three bags mounted in a tube with a diameter of 4 m. The questions to be answered are:

- How much does the valve leak
- Where does it leak

The test

The test was performed as follows (see pictures at page 4):
In the opening in the tube we mounted a Retrotec fan (blowerdoor), type 300. This is a calibrated ventilator which can measure flow at various set pressures.
A Retrotec DM32 is installed to measure the pressure outside and inside the chimney. This device also controls the fan. It sets the pressure difference and shows the measured flow. First we did run the fan at a pressure difference of 110 Pa to get an idea of how much it leaked air. We blew smoke through the fan into the chimney (see pictures on the next page) to see where the valves leaked air. This was all done to see if any improvements were necessary.
Finally we ran the fan at eight different pressures between 50 and 250 Pa to get an accurate result of the leakage flow. The results were put in the Retrotec software (Fantastic). The outcome you can see on the next pages. One of the things the software calculates is the 'effictive leakage area', which gives an idea of how big a hole would be that leaks the same amount of air.

Pressure to be tested

We did calculate the pressure that will occur under the valve at **maximum 110 Pa**, with the following assumptions:

- Outside air temperature 15 °C
- Maximum temperature in the chimney, under the valve 150 °C
- Level of the bottom of the valve 18 m

- Summary of the input and the results

retrotec **FanTestic**	version: **5.12.6**	licensed to: **ingenieursbureau Van der Kleij**
Test date: **2021-09-07**	By: **ir. P.S. van der Kleij** **ingenieursbureau Van der Kleij** **Boccherinistraat 2** **6815 GX Arnhem**	
Customer:	**Buitink Technology**	
Project Number:	**21.344**	
Building address:	**Typograaf 1** **6921 DV Duiven**	

Building and Test Information	
Test file name:	**Test Buitink Technology 2021-09-07**
Volume [m³]:	**75**
Envelope Area [m²]:	**-**
Floor Area [m²]:	**12.6**
Height (from ground to top) [m]:	**6**
Altitude [m]:	**10**
Number of storeys:	**1**

Results	
Air flow at 50 Pa, [m³/h]	**19.33**
Air flow at 110 Pa, [m³/h]	**42.0**
Effective leakage area at 50 Pa, [cm²]	**5.9**

The air flow at 110 Pa pressure difference is approximately 42.0 m^3/h. This value is taken from the graph in the software and measured during the test as well.

In the software the results are put in a graph with both axis a logarithmic scale. There is a lot of (statistic) calculation taking place in the software to get a value for the accuracy of the testresults. The software draws a straight line through the measured points, as the relation between pressure and flow is logarithmic. How far the points are off the line gives a value for the correlation and uncertainty of the result (see page 5). These values depend on the testconditions (e.g. wind), the tested envelope and how well the test was performed. It gives the tester a check of test.

If you look at the results at page 5 it seems that the uncertainty is 8.6%. However if you look at the first graph at page 7, you can see that the measured flows don't fully match with the straight line. To match the points the line should actually be curved downwards with increasing pressure. This means that the valve would performe better with increasing pressure.

Pictures

The tester

Blowing smoke through the fan

Buitink Zeilmakerij Duiven B.V.
Typograaf 1
NL-6921 VB Duiven
The Netherlands

Tel: +31 (0)316-250830
Fax: +31 (0)316-283954
info@buitink-technology.com
www.buitink-technology.com

KvK Arnhem: 09098432
BTW / VAT: NL819078244B02

Results

Combined Test Data (Tested in one direction only)

	Results	95% Confidence Interval		Uncertainty
Air flow at 50 Pa, [m³/h]	19.330	17.740	21.060	+/-8.6%
Air changes at 50 Pa, n_{50} [/h]	0.26	0.2355	0.2800	+/-8.6%
Specific leakage rate (envelope) at 50 Pa, [m³/h/m²]	-	-	-	-
Specific leakage rate (floor) at 50 Pa, [m³/h/m²]	-	-	-	-
Effective leakage area at 50 Pa, [cm²]	5.890	5.405	6.420	+/-9.0%

Air Leakage Test Data Appendix

Pressurize Data Set

Test Dataset Date: 2021-09-07
Start time: 14:15:00
Finish Time: 14:30:00

Environmental Conditions		
Wind speed:	2: Light breeze	
Operator Location:	Outside	
Greatest Baseline Pressure Point	-2.5 Pa	
Initial Bias Pressure:	-2.50 Pa	
Final Bias Pressure:	-2.50 Pa	
Average Bias Pressure:	-2.5 Pa	
Initial Temperature:	indoors: 24 C	outdoors: 22 C
Final Temperature:	indoors: 24 C	outdoors: 22 C
Barometric Pressure	101.500 kPa	from Direct measurement

Pressurize Test Analysis				
Correlation, r [%]:	99.188			
Coefficient of Determination, r^2	0.99188			
	Mean	95% confidence limits		Uncertainty
		Lower	Upper	
Slope, n:	0.948	0.87092	1.02412	
Air leakage coefficient, C_{env} [m³/h/Pa^n]:	0.47497	0.3253	0.6936	
Air leakage coefficient, C_L [m³/h/Pa^n]:	0.47468	0.3251	0.6932	
Air flow at 50 Pa, [m³/h]	19.329	17.74	21.06	+/-8.6%
Effective leakage area at 50 Pa, [cm²]	5.892	5.407	6.420	+/-9.0%

Buitink Zeilmakerij Duiven B.V.
Typograaf 1
NL-6921 VB Duiven
The Netherlands

Tel: +31 (0)316-250830
Fax: +31 (0)316-283954
info@buitink-technology.com
www.buitink-technology.com

KvK Arnhem: 09098432
BTW / VAT: NL819078244B02

Measured pressure [Pa]		50.0	75.0	100.0	125.0	150.0	175.0	200.0	225.0	250.0
Induced Pressure [Pa]		52.5	77.5	102.5	127.5	152.5	177.5	202.5	227.5	252.5
	Flow [m3/ hr]	18,6	30	39,5	48,8	57,5	64	72,3	78,3	84,5
Total Flow, q_r [m³/h]		18.6000	30.0000	39.5000	48.8000	57.5000	64.0000	72.3000	78.3000	84.5000
Measured Flow, q_m [m³/h]		18.6065	30.0105	39.5138	48.8171	57.5202	64.0224	72.3253	78.3274	84.5296
Flow through envelope, q_{env} [m³/h]		18.733	30.214	39.782	49.148	57.910	64.456	72.815	78.858	85.102
Error [%]		-7.5%	3.1%	4.2%	4.7%	4.1%	0.3%	0.0%	-3.0%	-5.1%

Average Baseline, ΔP: -2.5 Pa
Greatest Baseline Pressure Point: -2.5 Pa

Static Pressure Averages:			
Average Baseline [Pa]	ΔP -2.5		
initial [Pa]	ΔP01 -2.50	ΔP01- -2.50	ΔP01+ 0.00
final [Pa]	ΔP02 -2.50	ΔP02- -2.50	ΔP02+ 0.00

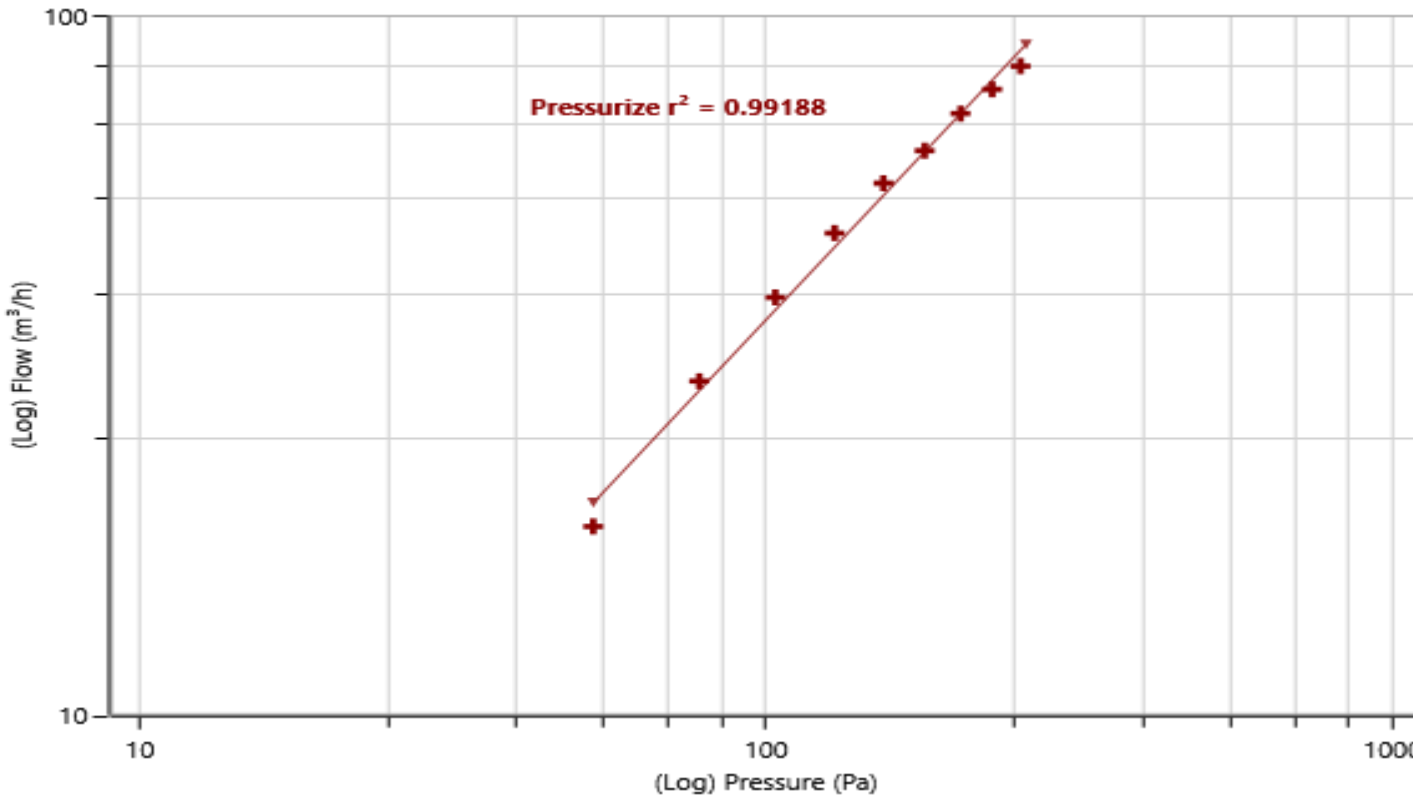
Baseline, initial [Pa]	-2.50											
Baseline, final [Pa]	-2.50											

Buitink Zeilmakerij Duiven B.V.
Typograaf 1
NL-6921 VB Duiven
The Netherlands

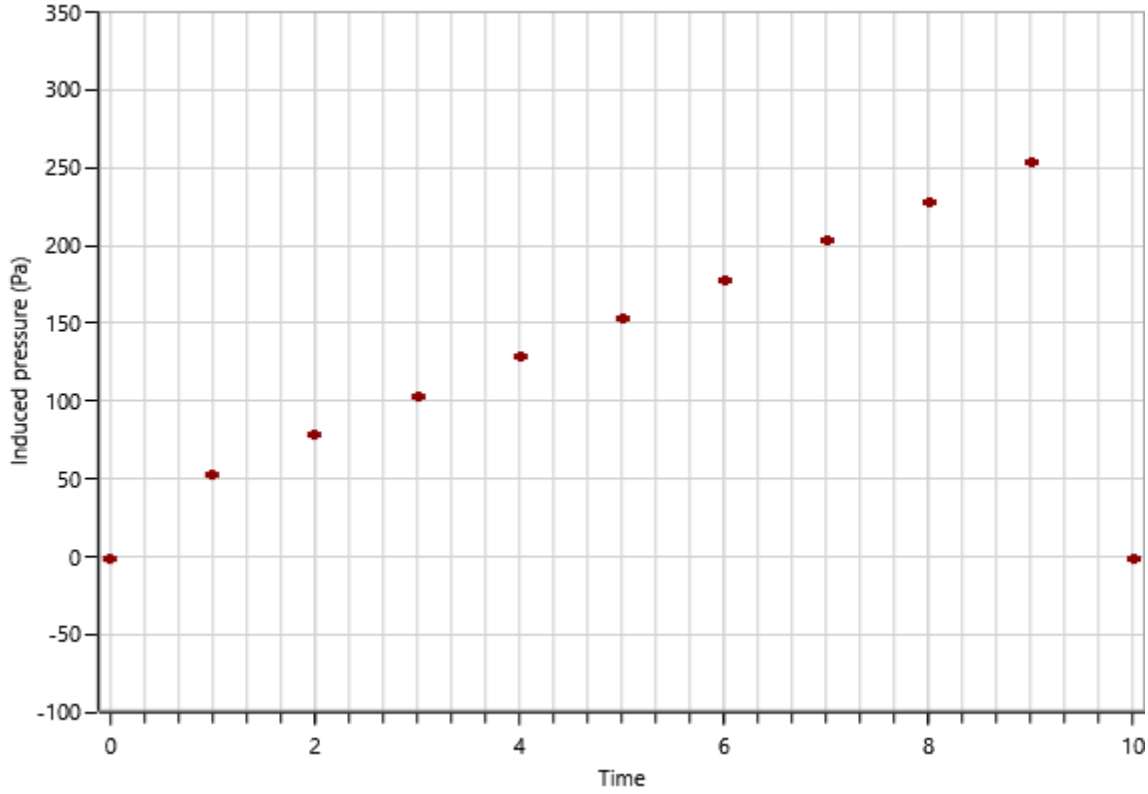
Tel: +31 (0)316-250830
Fax: +31 (0)316-283954
info@buitink-technology.com
www.buitink-technology.com

KvK Arnhem: 09098432
BTW / VAT: NL819078244B02

Flow vs Induced Pressure (Pressurize Set)



Building Gauge Pressure (Pressurize Set)



Buitink Zeilmakerij Duiven B.V.
Typograaf 1
NL-6921 VB Duiven
The Netherlands

Tel: +31 (0)316-250830
Fax: +31 (0)316-283954
info@buitink-technology.com
www.buitink-technology.com

KvK Arnhem: 09098432
BTW / VAT: NL819078244B02

Test Equipment

The following test equipment was used in the performance of the air leakage tests.

	Fan	Fan serial	Fan location	Gauge	Gauge serial	Gauge Calibration
#1	Retrotec 300	3xlf00723		DM32	405437	2020-01-23

Fan Calibration Certificate Retrotec 300:

Retrotec 300 3xlf00723 Fan last calibrated: 2021-03-19. Flow Equation Parameters - Retrotec: 202103181706-3XLF00723. m³/h							
Range	**n**	**K**	**K1**	**K2**	**K3**	**K4**	**MF**
Open	0,49626744	53,66516984	0	0,4	0	1	20
102	0,5887045	19,21636965	0	0,4	0	1	100
74	0,49900243	12,92228043	0	0,25	0	1	15
47	0,50154644	5,48439503	0	0	0	1	10
29	0,51115059	1,8934728	0	0	0	1	20
18	0,499	0,77644794	0	0,25	0	1	25
11	0,48	0,35339425	0	0,25	0	1	25
7	0,5	0,12198898	0	0,11	0	1	25

Fan Pressure (FP) is the measured fan pressure when using a self-referenced fan or when Room Pressure (RP) is negative. If using a fan which is not self-referenced, and Room Pressure is positive, Fan Pressure is calculated by subtracting the measured Room Pressure from the Absolute Value of the Fan Pressure.

If PrA>0 and fan is not self-referencing: FP = |PrB|-PrA
If PrA<0 or fan is self-referencing: FP = PrB

Flow calculations are not valid if Fan Pressure is less than either MF or (K2 x |RP|).

Flow in m³/h using the above coefficients is calculated as follows for standard Ranges:

$$flow = \left(FP - (|RP| \times K1)\right)N \quad + \ (K + (K3 \times \ FP))$$

Buitink Zeilmakerij Duiven B.V.
Typograaf 1
NL-6921 VB Duiven
The Netherlands

Tel: +31 (0)316-250830
Fax: +31 (0)316-283954
info@buitink-technology.com
www.buitink-technology.com

KvK Arnhem: 09098432
BTW / VAT: NL819078244B02