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Blower Door Measurements (EN 13829) and Results of 5 large Buildings - with one or more Blower Systems

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Introduction

In Germany the blower door system has been used to measure the air tightness of
- single-family houses since 1989,
- apartment buildings (multiple dwellings) since 1991,
- large administration and industrial buildings since 2002

Proof of airtightness was required in
- Low Energy House Standards (in some German countries, beginning in 1989)
- DIN 4108-7 (1996 and 2001)
- Energy Saving Directive EnEV (2002)

Reasons and objectives:
- saving energy
- guarantee effective function of the ventilation system
- avoidance of convection-related building damage
- protection against allergens in the home
- quality assurance
- sealing of clean rooms
- fire protection

Level of air tightness required in accordance with EN 13829 (2000)

Airtightness specification (EnEV, DIN 4108-7):

air change rate per hour at a 50 Pa pressure difference:
n_{50} = air leakage rate at 50 Pa / internal volume

buildings with natural ventilation: $n_{50,\ max} = 3\ h^{-1}$

buildings with mechanical ventilation systems: $n_{50,\ max} = 1.5\ h^{-1}$

Additional specification (DIN 4108-7):

air permeability at 50 Pa:
q_{50} = air leakage rate at 50 Pa V_{50} / envelope area A_E

all buildings $q_{50,\ max} = 3\ m^3/(h \cdot m^2)$

Level of air tightness required for passive houses:
(PHI - Passiv Haus Institut, Darmstadt, Dr. Wolfgang Feist) $n_{50,\ max} = 0.6\ h^{-1}$

Methodology

We were commissioned to carry out a blower door measurement in accordance with EN 13829 and to determine the n_{50} (air change rate per hour at a 50 Pa pressure difference).
The tests were carried out with 1- 7 Minneapolis Blower Door units (model 3, 4).

The number of blower door systems required was determined as follows:

Allowed air flow rate at 50 Pa = Volume x $n_{50\ max}$.

Nº. of blower systems = allowed air flow at 50 Pa / max. blower door capacity

Example – Building A (uncorrected volume advised by the client):

35,000 m³ x **1.5 h^{-1}** = 52,500 m³/h

52,500 m³/h / 7,200 m³/h at 50 Pa = **7.3 blower door systems**

(If the building is leakier than planned, i.e. the $n_{50\ max}$ figure is exceeded, the 50 Pa pressure difference cannot be created with the calculated number of fans.
Some of the buildings were more tight than planned: a number of fans could be switched off and closed after completed preparation of the building (i.e. shut all windows).)

Example, Building A: Care Centre in Karlsruhe, Baden-Württemberg

built 2004,
proof of tightness required
in accordance with EnEV 2002
(building with ventilation system):
$n_{50\ max.} = 1.5\ h^{-1}$

Volume (internal): 27,400 m³
7 blower door systems installed

Results:
Measured air flow rate:
45,111 m³ / h
$n_{50} = 1.6\ h^{-1}$

Proof of tightness in accordance with EnEV not achieved: built using traditional methods of construction without special regard for air tightness.

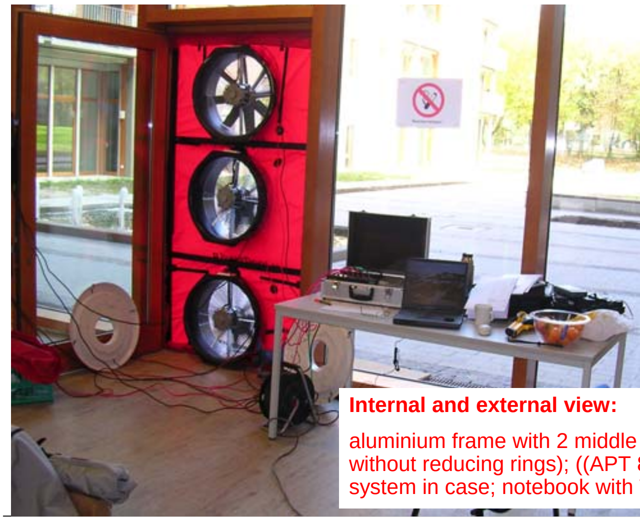
Building A: Installation of 5 blower door units

External view of building A, installation of 5 (out of 7) blower door systems:

Either 2 or 3 units were installed per external door opening using an aluminium frame and special panels (2 or 3-hole panels).

If internal doors create a pressure drop within the building, the blower systems have to be distributed around the building shell. The measurement then has to be carried out by a number of people who can communicate with each other by mobile phone. In other cases, the blower door systems can be installed at a single point and operated by just one person.

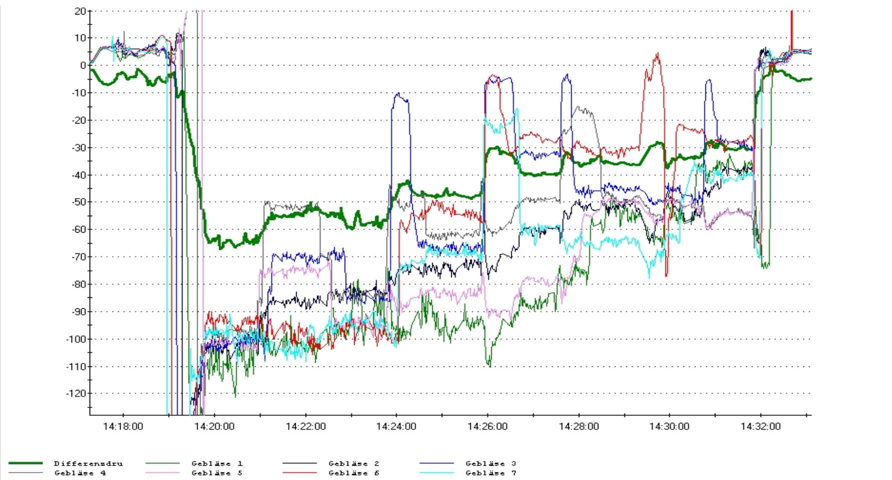
Building A, in detail : Installation of 3 blower door units in one external door



Internal and external view:

aluminium frame with 2 middle cross bars; 3 blower door units (open, without reducing rings); ((APT 8 - Automated Performance Testing system in case; notebook with TECLOG and BlowerDoor plus))

Building A: pressure difference sequence (software TECLOG)



measurements of zero-flow and indoor-outdoor pressure difference -65 untill -30 Pa / fan pressure difference

Building A: results of **depressurization** (software BlowerDoor plus)

Calculated fan pressure and air leakage rate of all 7 fans

Blower door			1	2	3	4	5	6	7	8		
Number			1	2	3	4	5	6	7	8		
Model:	3 or 4		4	4	4	3	4	4	4			
Fan Configuration:	0, A, B, C, D, E		0	0	0	0	0	0	0			
Fan Configuration coefficient:	C [m³/hPa]		682.73	682.73	682.73	818.24	682.73	682.73	682.73			
Fan Configuration exponent:	n		0.4993	0.4993	0.4993	0.4947	0.4993	0.4993	0.4993			
Readings Building		**Readings BlowerDoor**									**Summary** V_{Fan}	Δp_{Fan}
zero flow Δp_0	-4.7	--	--	--	--	--	--	--	--	--	--	--
Δp_1 [Pa]	-64.4	$\Delta p_{Fan,i}$ [Pa]	108.6	102.4	102.0	98.1	101.5	94.0	98.0		--	--
	--	$V_{Fan,i}$ [m³/h]	7091.5	6886.4	6872.9	7909.7	6856.1	6598.3	6737.0		48952	5202.9
Δp_2 [Pa]	-53.7	$\Delta p_{Fan,i}$ [Pa]	102.1	86.4	70.5	52.3	74.9	99.2	101.9		--	--
	--	$V_{Fan,i}$ [m³/h]	6876.3	6326.3	5715.4	5794.6	5890.8	6778.1	6869.6		44251	4250.4
Δp_3 [Pa]	-57.1	$\Delta p_{Fan,i}$ [Pa]	89.1	82.9	85.3	84.5	94.3	97.1	94.4		--	--
	--	$V_{Fan,i}$ [m³/h]	6424.3	6197.0	6286.0	7346.8	6608.8	6706.1	6612.3		46181	4629.8
Δp_4 [Pa]	-47.5	$\Delta p_{Fan,i}$ [Pa]	93.9	74.0	66.6	61.6	83.4	52.8	68.4		--	--
	--	$V_{Fan,i}$ [m³/h]	6594.8	5855.4	5555.3	6283.3	6215.7	4947.2	5629.8		41081	3662.5
Δp_5 [Pa]	-35.7	$\Delta p_{Fan,i}$ [Pa]	54.4	51.3	45.0	47.4	49.9	31.3	64.3		--	--
	--	$V_{Fan,i}$ [m³/h]	5021.5	4876.5	4567.7	5519.4	4809.6	3810.4	5458.7		34064	2516.8
Δp_6 [Pa]		$\Delta p_{Fan,i}$ [Pa]									--	--
	--	$V_{Fan,i}$ [m³/h]									0	0.0
Δp_7 [Pa]		$\Delta p_{Fan,i}$ [Pa]									--	--
	--	$V_{Fan,i}$ [m³/h]									0	0.0
Δp_8 [Pa]		$\Delta p_{Fan,i}$ [Pa]									--	--
	--	$V_{Fan,i}$ [m³/h]									0	0.0
zero flow Δp_0	-4.5	--	--	--	--	--	--	--	--	--	--	--

Building B: Industrial building in Cloppenburg, Lower Saxony

built 2004,
proof of tightness required
to guarantee effective function
of ventilation system:
$n_{50\ max.} = 1.5\ h^{-1}$

Volume (internal): 17,100 m³
3 blower door systems installed

Results:
Measured air flow rate:
22,260 m³ / h
$n_{50} = 1.3\ h^{-1}$

The building is used for producing special cables and is equipped with an ultramodern ventilation system. Adequate air tightness of the building envelope – as the precondition for correct performance of the ventilation system – could be successfully proved.

Building C: Office building in Hamm, North Rhine-Westphalia

built 2003,
quality assurance of the air barrier at the construction phase
(building with natural ventilation):
$n_{50\ max.} = 3\ h^{-1}$

Volume (internal): 31,500 m³
3 blower door systems installed

Results:
Measured air flow rate:
6,742 m³ / h (1 blower door)
$n_{50} = 0.21\ h^{-1}$

measured with just one blower door unit, achieved excellent results – because of a very good air tightness design concept. The air tightness construction details were examined by the author at the design stage and suggestions for improvement were made.

Building D: Industrial building in Brunswick, Lower Saxony

built 2002,
proof of tightness required in accordance with passive house standard ("zero emission building", with ventilation system):
$n_{50\ max.} \leq 0.6\ h^{-1}$

Volume (internal): 46,500 m³
4 blower door systems installed

Results:
Measured air flow rate:
10,089 m³ / h (2 blower doors)
$n_{50} = 0.22\ h^{-1}$

A preliminary measurement of the air barrier was carried out during the construction phase because, besides the thermal insulation, the air tightness of the building is an essential factor in ensuring high energy efficiency. The planned ventilation with heat recovery can only achieve its aim if the air exchange for provision of the required clean, fresh air actually takes place via the heat exchanger and not through joints and cracks.

Building D, in detail : Installation of 4 blower door units in two external doors

Following remedial works, two of the four blower door units could be switched off during the course of the measurement – the final measurement was carried out with just two blower door systems.

Building E: Industrial warehouse in Marl, North Rhine-Westphalia

built 2004,
proof of tightness for fire prevention system (by injection of nitrogen) required:
$\mathbf{n_{50\ max.} \leq 0.02\ h^{-1}}$

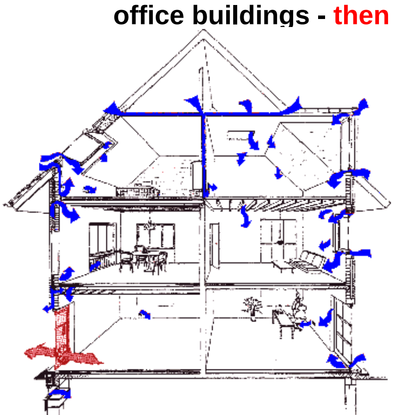
Volume (internal): 191,000 m³,
1 blower door installed

Results:
Measured air flow rate:
2,613 m³ / h (1 blower door, ring A)
$\mathbf{n_{50} = 0.014\ h^{-1}}$

By injecting nitrogen, this system reduces the oxygen content in the warehouse to such an extent that a fire is no longer possible. As a result, no sprinkler system is required. Instead, under the terms of the contract, extremely demanding requirements are imposed with regard to air tightness (facade made from mineral fibre sandwich panels).

Conclusion

The Blower Door test should be included in any national regulation - for small dwelling houses as well as for large office buildings - then the quality will become high!



And only airtight houses save energy because in good insulated buildings

Losses by convection

(through joints and gaps)

are bigger than

Losses by heat transmission

(through walls and roofs)

You are invited to our European BlowerDoor Symposium: 16+17.6.2006 in Freiburg!