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MORE-CONENCT 2nd training module

Building air tightness

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Duration: 4 hours

Type: self-learning 2h and class room lectures – 2 hours

Introduction

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- Air-tightness became an actual issues since mid90ies. All new modern buildings as well as renovated buildings should fulfill strict requirements for building envelope air-tightness level. MORE-CONNECT retrofitting approach deals with prefabricated panels. The air-tightness of panels' joints and connection between existing wall and panels plays significant role in overall building energy efficiency. Thus, correct blowerdoor test should be performed before and after building retrofitting in order to define weak points and to make all necessary improvements during the modular retrofitting process.
- In scope of this module the theoretical and practical aspects of building's air tightness will be presented. Participants will learn how to identify critical air leakage points and to perform real measurements using simulator trainer for building. During the learning module attendees will get information on building preparation and blowerdoor unit set procedures to perform high quality airtightness test.
- After completing this module individuals will be able to set up blowerdoor units un to perform real airtightness measurements using manufacturer automatic setting.

self-learning

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- Single Family Residential Air Leakage Testing - https://www.youtube.com/watch?v=PgR5a8IpVNY ;
- Peformance Testing for Homes with Suspect Conditions - https://www.youtube.com/watch?v=HXNGgARjhLo ;
- FanTestic Pro Multiple fan Webinar - https://www.youtube.com/watch?v=qPIGDqG-jwo&feature=youtu.be ;
- Practical experience - http://irbest.eu/lv/galereya/video

https://www.youtube.com/watch?v=BTvPdIcuSC4

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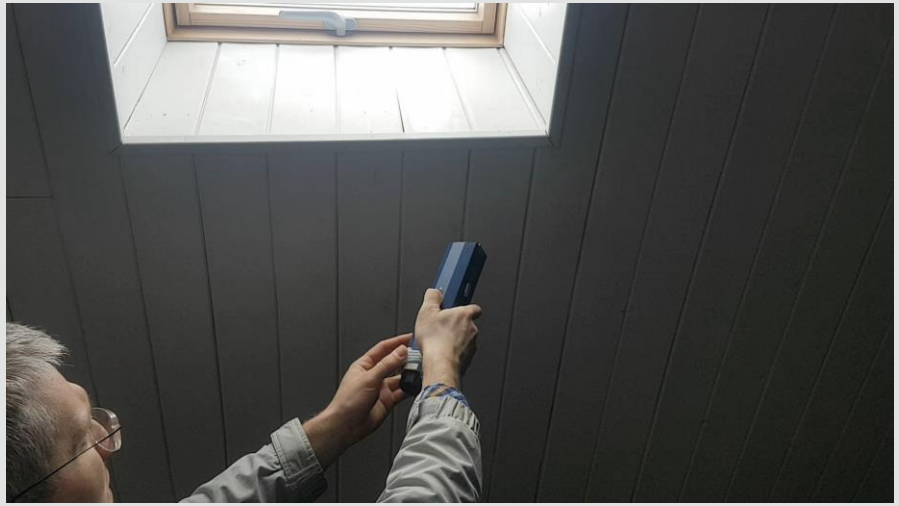
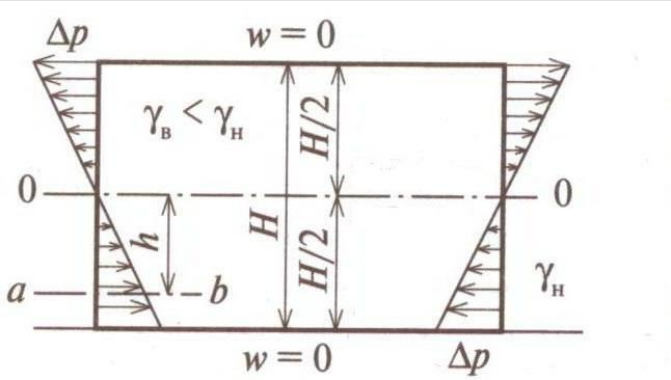


The stack effect

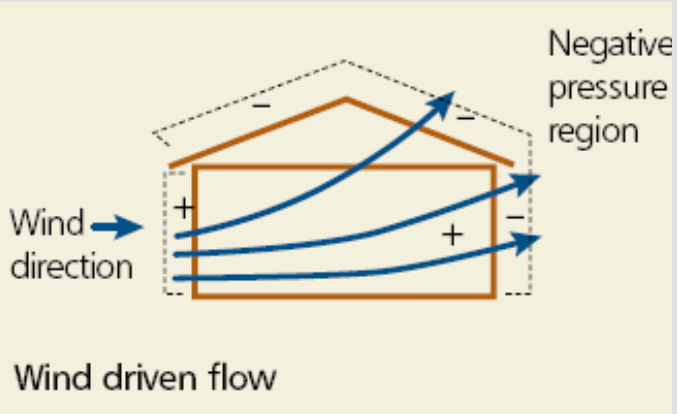


$$\Delta p = gh(\rho_e - \rho_i), Pa$$

- ✓ p_e – outdoor air density, kg/m³;
- ✓ p_i - indoor air density, kg/m³;

$$\rho = \frac{\rho_0}{1 + \frac{t}{273}}(kg/m^3) \quad or \quad \rho = \frac{353}{273 + t}(kg/m^3)$$

The wind pressure



$$p = \frac{v^2 \rho}{2}$$

Pressure difference in high-rise buildings

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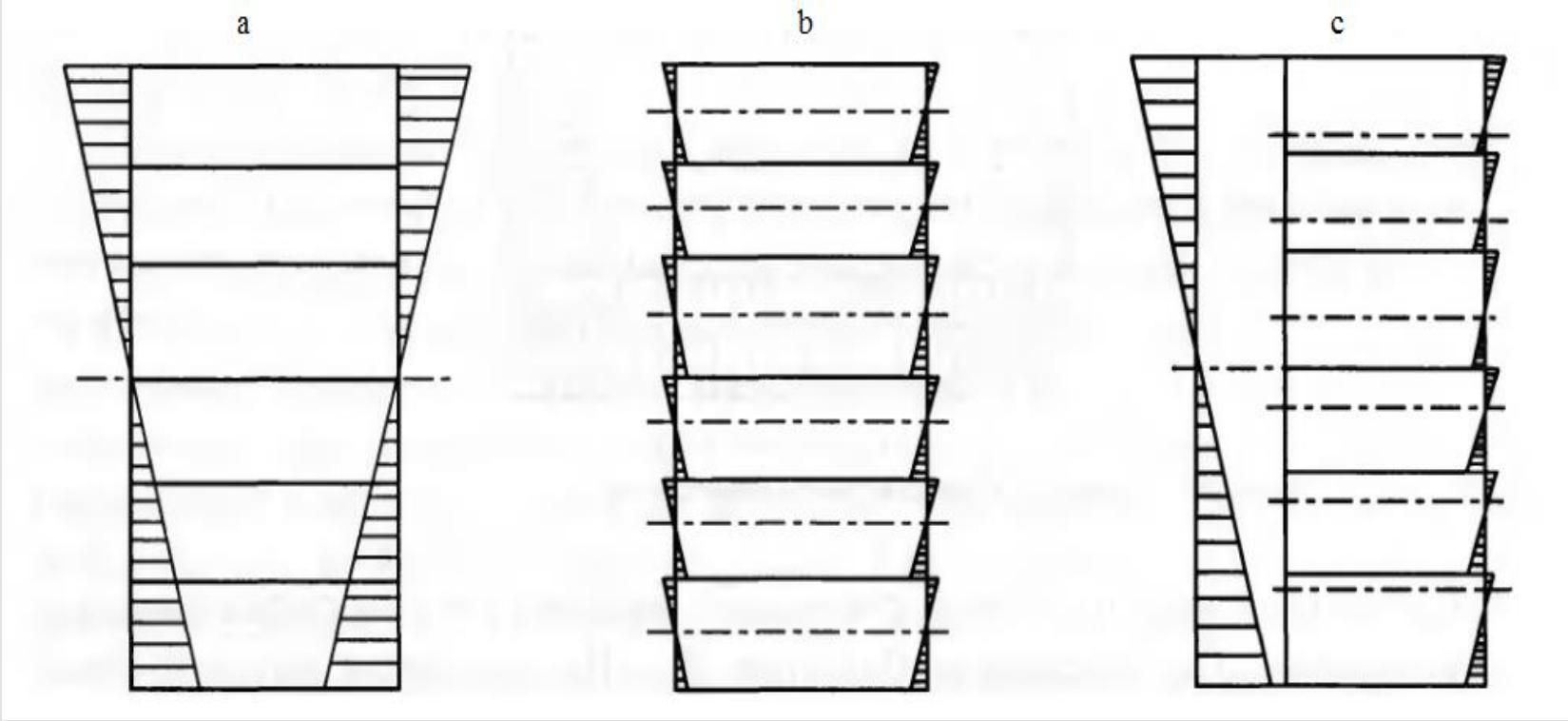
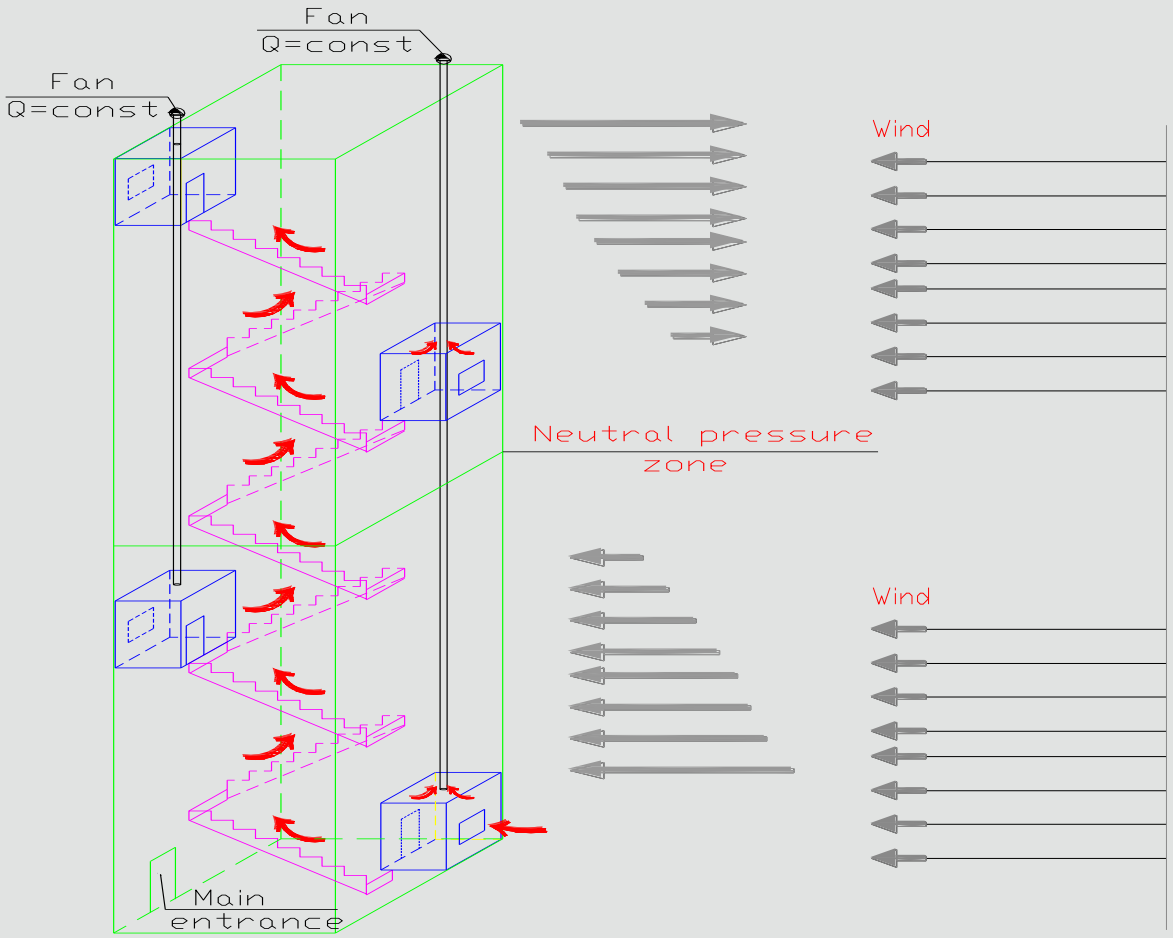


a –free air circulation between floors;
b – mutually isolated floors;
c – under real conditions;

Total pressure difference



$$\Delta p = 0.8[\pm g(\rho_e - \rho_i)H \pm 0.6\frac{(n\upsilon)^2 \rho_e}{2}], Pa$$

Air permeability of building materials

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Air permeability resistance:

$$R_{g.c} = \frac{d}{i}, [m^2 \cdot st \cdot Pa / kg]$$

Air permeability :

$$W = \frac{\Delta P}{\sum R_{g.c.}}, [kg / (m^2 \cdot st)]$$

Concrete panels with mineral wool and external concrete finishing:

$$R_{\text{inf}} = R_{\text{inf}}^{betons} + R_{\text{inf}}^{iizolāizol} + R_{\text{inf}}^{ārējaisslānis}, m^2 hPa / kg \qquad R_{\text{inf}} = 39242 m^2 hPa / kg$$

СП 23-101-2004. Проектирование тепловой защиты зданий. – Москва, 2008

Jacques Rousseau(Project Manager:)Research *Report: Air Permeance of Building Materials*, 1998 http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/98109.htm 4

Air tightness of Windows

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EN 12207

Class	Reference air permeability at 100 Pa		Maksimālais pārbaudes spiediens
	Reference air permeability related to joints length m3/hm	Reference air permeability related to overall area, m3/h·m2	
1	12,5	50	150
2	6,75	27	300
3	2,25	9	600
4	0,75	3	600

LBN002 – 15 requirements

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Maximum air permeability at the pressure difference of 50 Pa:

- ✓Building with natural ventilation – $q_{50} \leq 3\ m^3/(m^2 \cdot h)$;
- ✓Buildings with mechanical ventilation– $q_{50} \leq 2\ m^3/(m^2 \cdot h)$;
- ✓Buildings with mechanical ventilation equipped with exaust air heat recovery units – $q_{50} \leq 1{,}5\ m^3/(m^2 \cdot h)$;
- ✓Industrial buildings (q_{50}) $\leq 4\ m^3/(m^2 \cdot h)$.

LBN002 – 15 requirements

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- EN 13829 (thermal performance of buildings. Determination of air permeability in buildings. Fan pressurization method)

- **ISO 9972:2015 -** Thermal performance of buildings -- Determination of air permeability of buildings -- Fan pressurization method

Air permeability q50

$$q_{50}=V_{50}/A_E,\ m^3/(h\cdot m^2)$$

- ✓ V_{50} – izmērītā gaisa plūsma cauri konstrukcijai ar spiediena starpību 50Pa;
- ✓ A_E – ēkas ierobežojošo konstrukciju laukums;

Air change rate coefficient n50 (h-1)

$$n_{50}= V_{50}/V$$

- V_{50} – izmērītā gaisa plūsma cauri konstrukcijai ar spiediena starpību 50Pa;
- V – ēkas tilpums.

Measurement procedure

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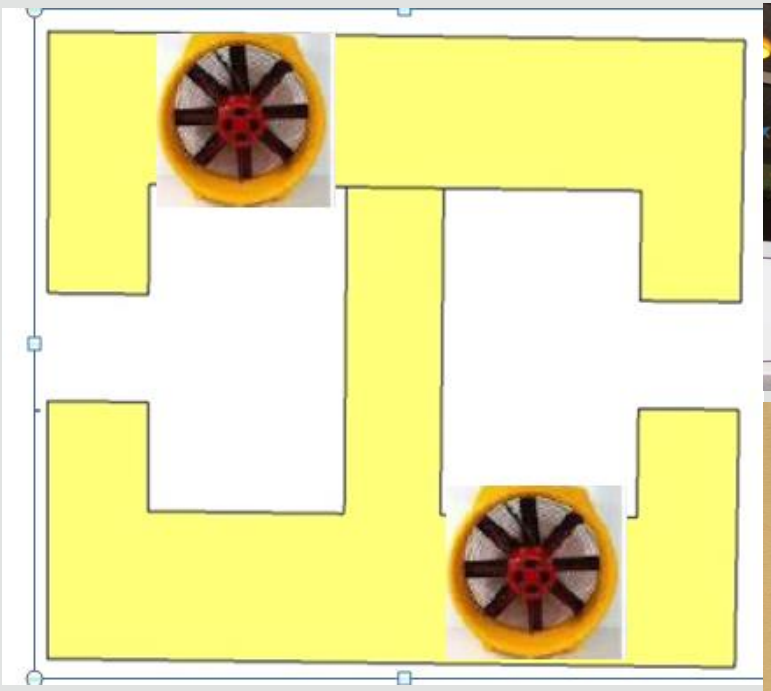
Equipment



Measurements

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Methods

- Method A (test of a building in use): The condition of the building envelope should represent its condition during the season in which heating or cooling systems are used.
- **Method B (test of the building envelope): Any intentional opening in the building envelope shall be closed or sealed.**
- Method C (test of the building in use): Automatically regulating, externally mounted air transfer devices are sealed, other openings are handled in the same way as for method A.

ISO 9972:2006(E)

Measurements

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Limitations

- ✓indoor/outdoor air temperature difference;
- ✓wind speed ;

ISO 9972:2006(E)

Measurements

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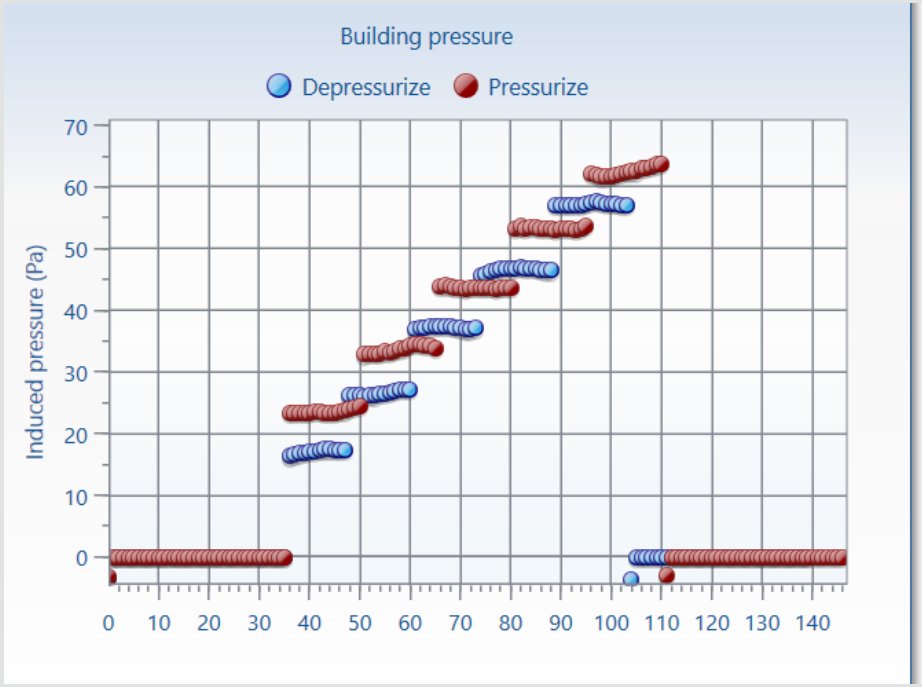
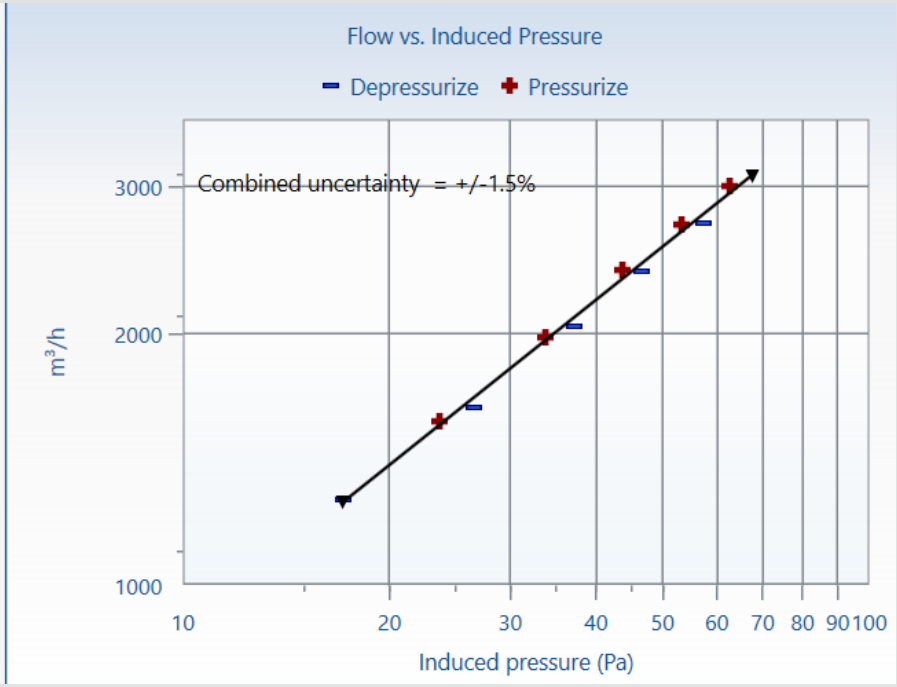
- Initial base line;
- Pressure in buildings
- Final base line;





ISO 9972:2006(E)

Measurements

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Results

Correlation, r [%]	**99.95**	Confidence Limit 95%	
Intercept, C_{env} [m³/h·Pa^n]	**205.30**	**179.6**	**234.7**
Intercept, C_L [m³/h·Pa^n]	**208.44**	**182.3**	**238.3**
Slope, n	**0.637**	**0.59915**	**0.67461**

	Results	95% Confidence Interval		Uncertainty
Air flow at 50 Pa, V_{50} [m³/h]	**2517.7**	**2464**	**2573**	**+/-2.2%**
Air changes at 50 Pa, n_{50} [/h]	**4.341**	**4.246**	**4.435**	**+/-2.2%**
Permeability at 50 Pa, q_{50} [m³/h·m²]	**4.7415**	**4.638**	**4.845**	**+/-2.2%**
Specific leakage at 50 Pa, w_{50} [m³/h·m²]	**11.6562**	**11.4025**	**11.9098**	**+/-2.2%**
Effective leakage area at 50 Pa, $EfLA_{50}$ [cm²]	**767.4**	**750.9**	**784.3**	**+/-2.2%**
Equivalent leakage area at 50 Pa [cm²]	**1258**	**1231**	**1286**	**+/-2.2%**
Normalized leakage area at 50 Pa, NLA_{50} [cm²/m²]	**1.445**	**1.414**	**1.477**	**+/-2.2%**

$$q_n = C_{env} \cdot P_n^{n,slope}, \text{ m}^3/(\text{m}^2 \cdot \text{h});$$

$$q_n = C_{env} \cdot P_n^{n,slope}, \text{ m}^3/(\text{m}^2 \cdot \text{h});$$

Sealing of the opening

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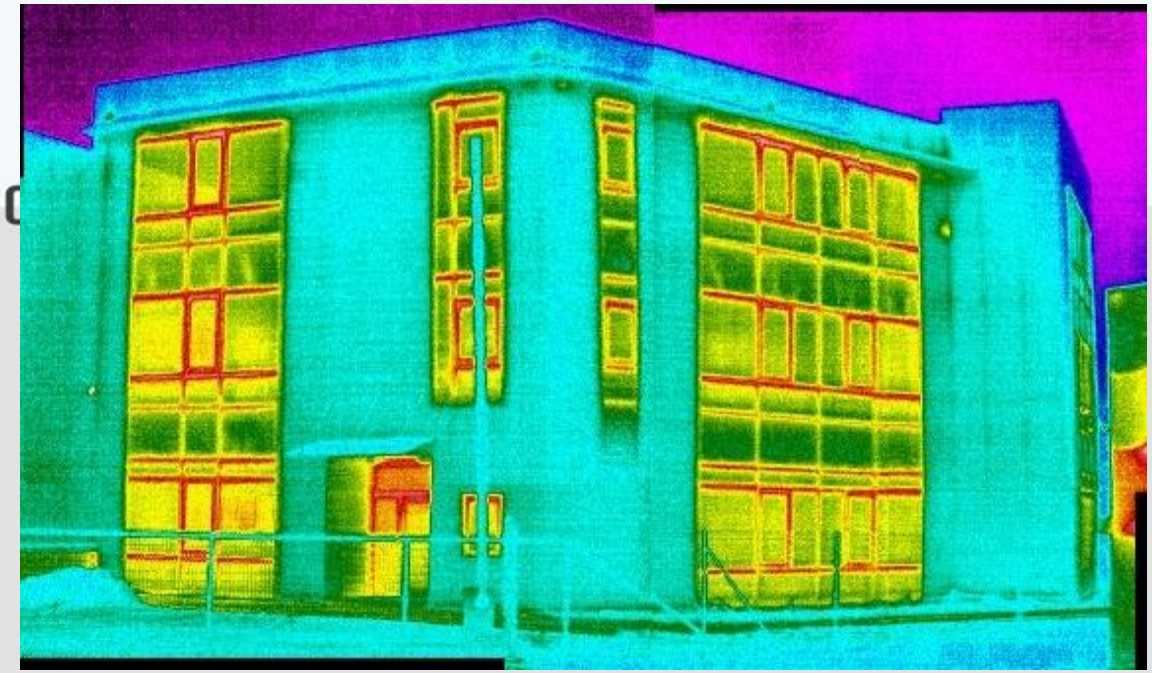
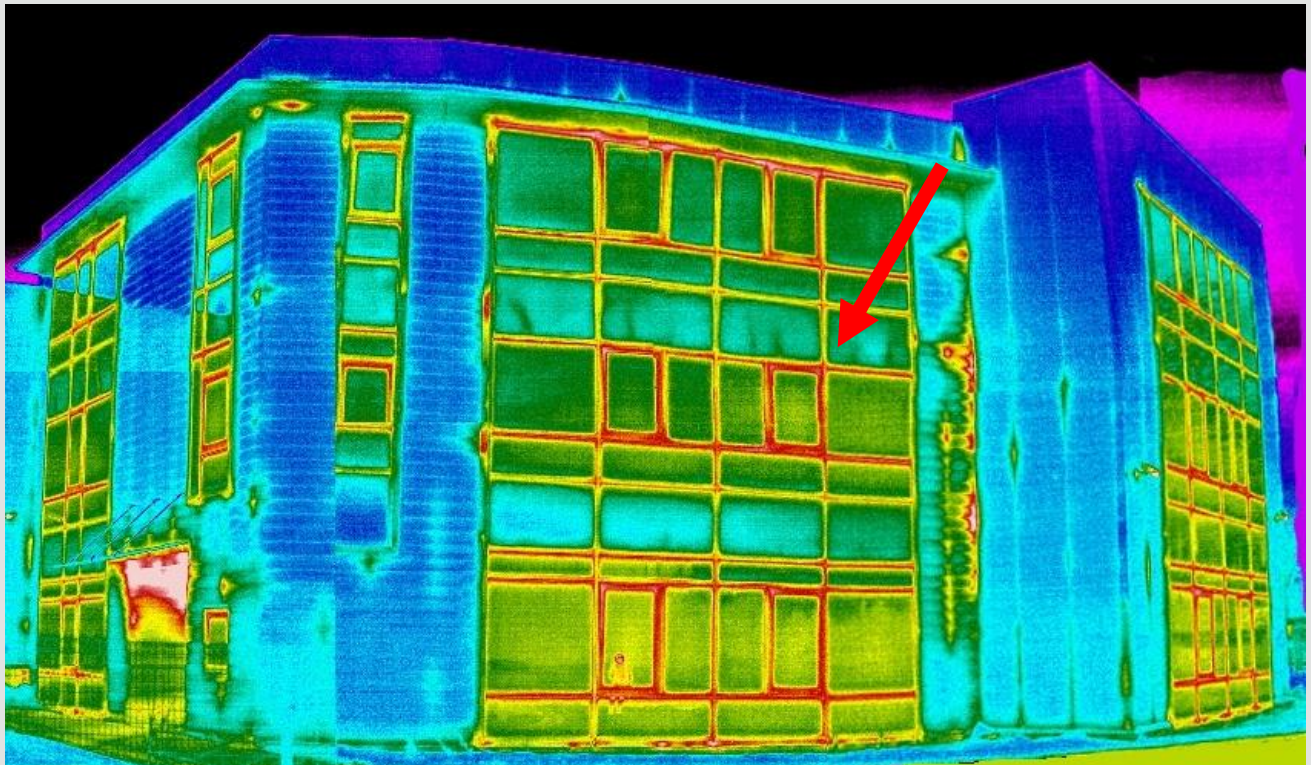


0 Pa

+50 Pa



www.irbest.lv

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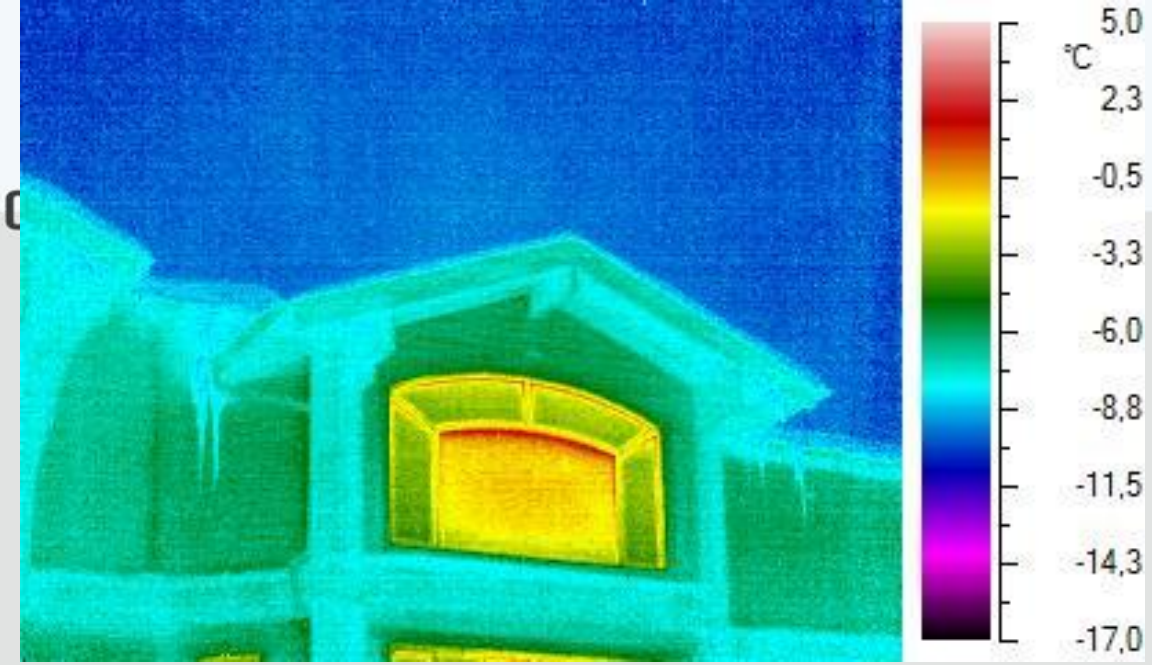
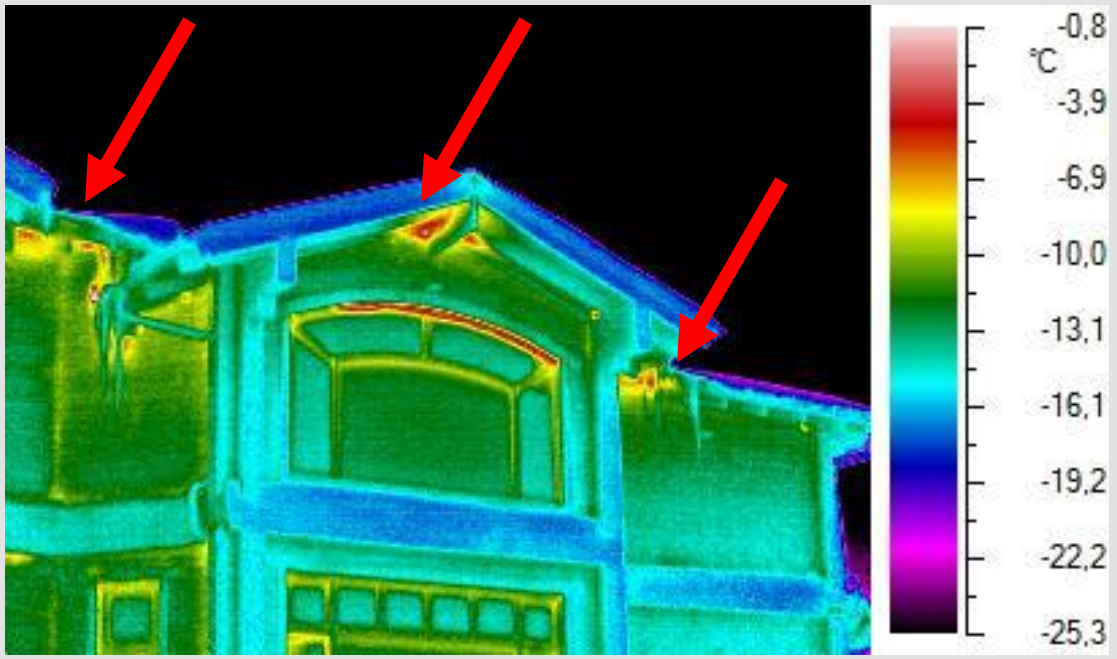


+3 Pa

+15 Pa



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MORE-CONNECT challenge

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- ✓ Panel joints;
- ✓ Windows/wall joints;
- ✓ Panel/wall connection;

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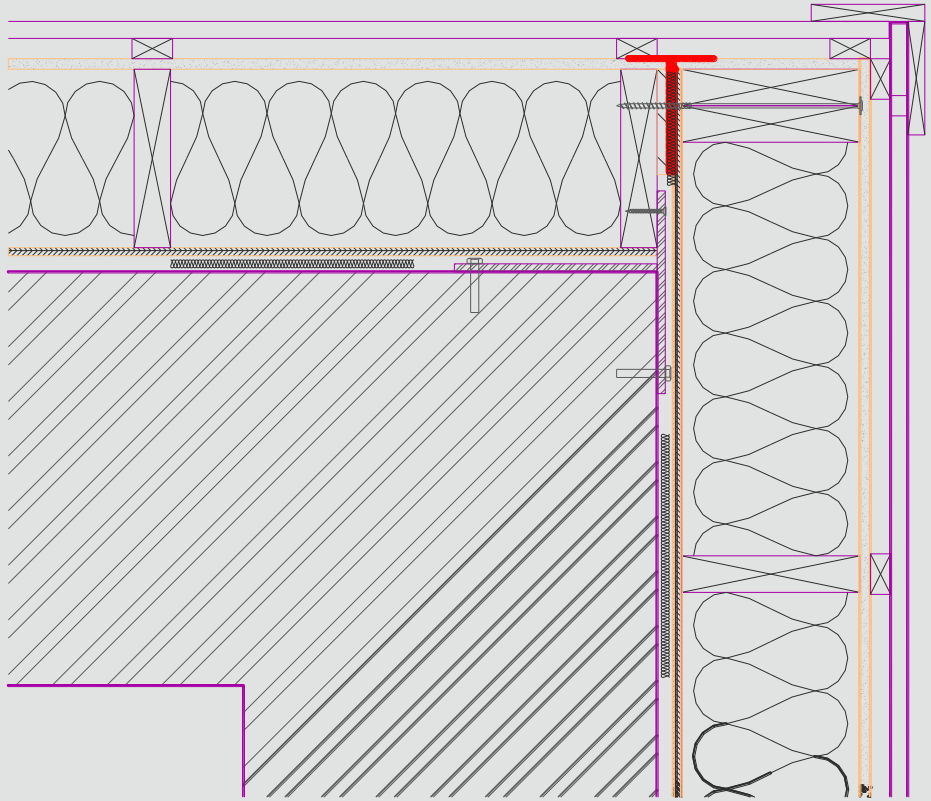

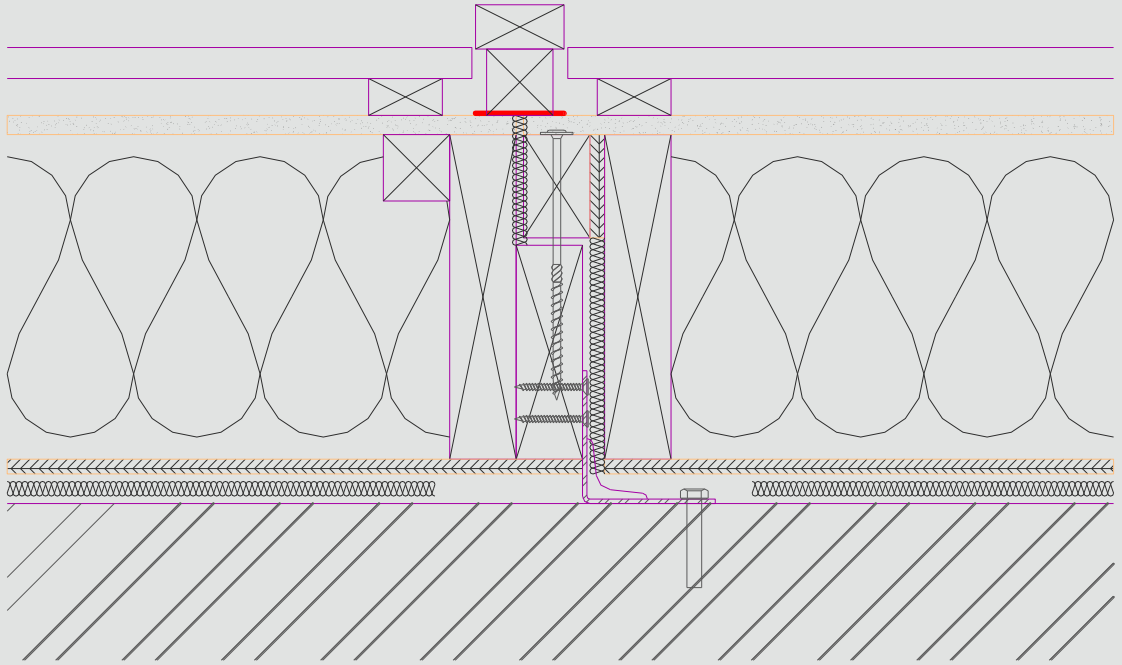

Latvian demo building

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Thermal imaging

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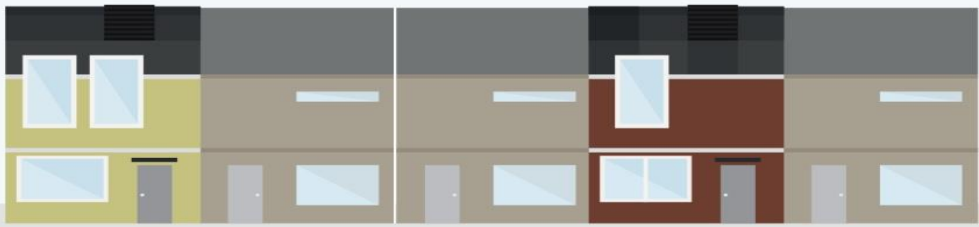

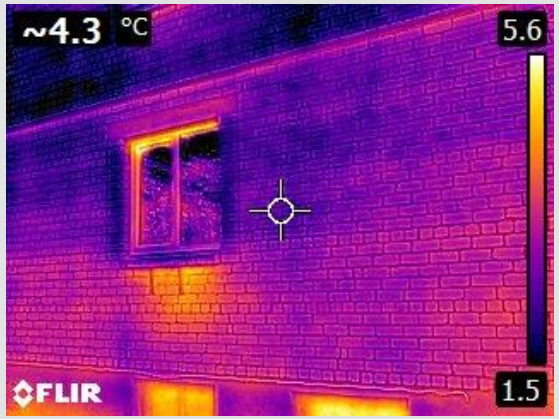

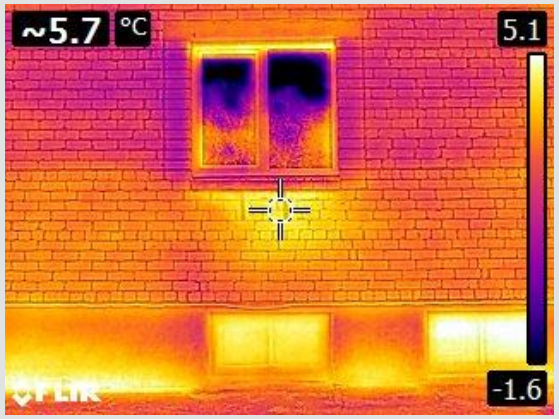

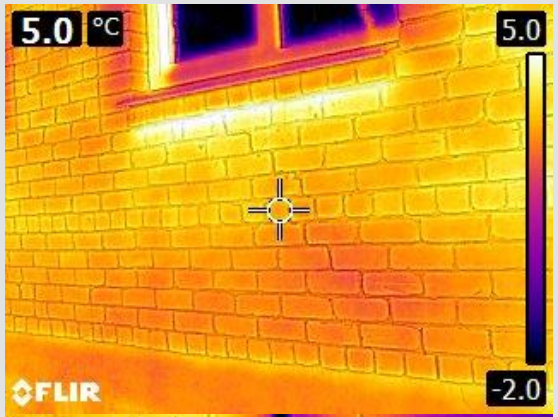

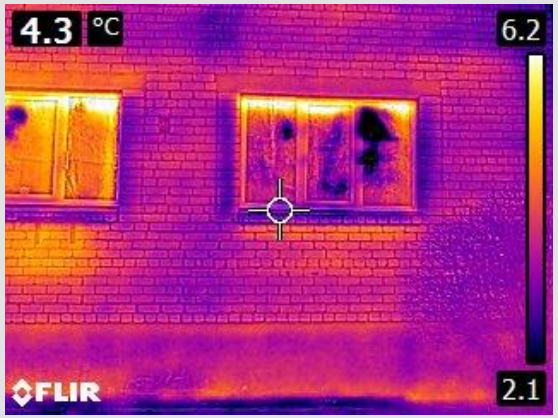

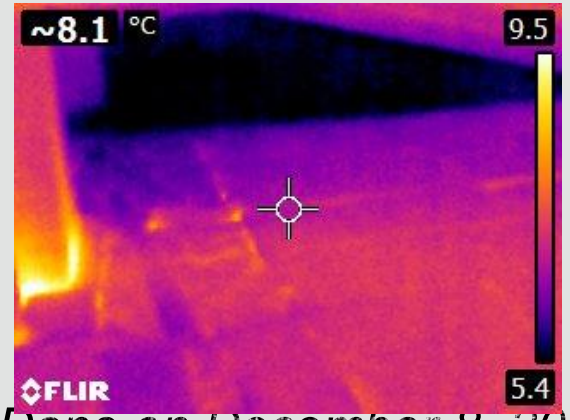

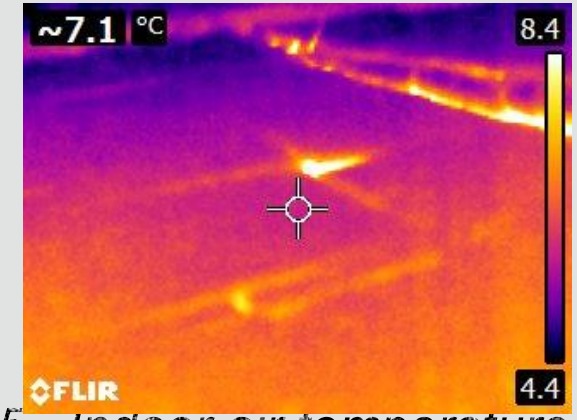

Done on December 8, 2015. Indoor air temperature +22°C, outdoor +3°C. Will be repeated under better conditions

Air tightness

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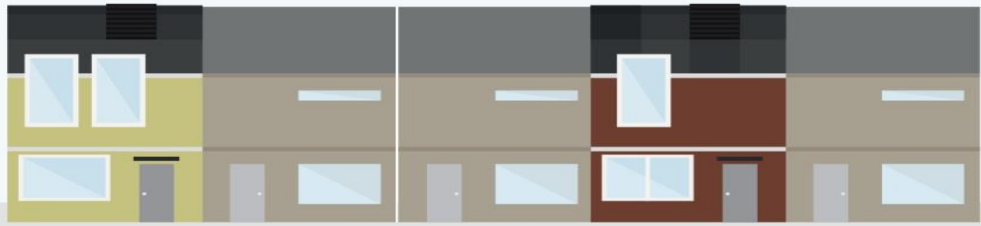
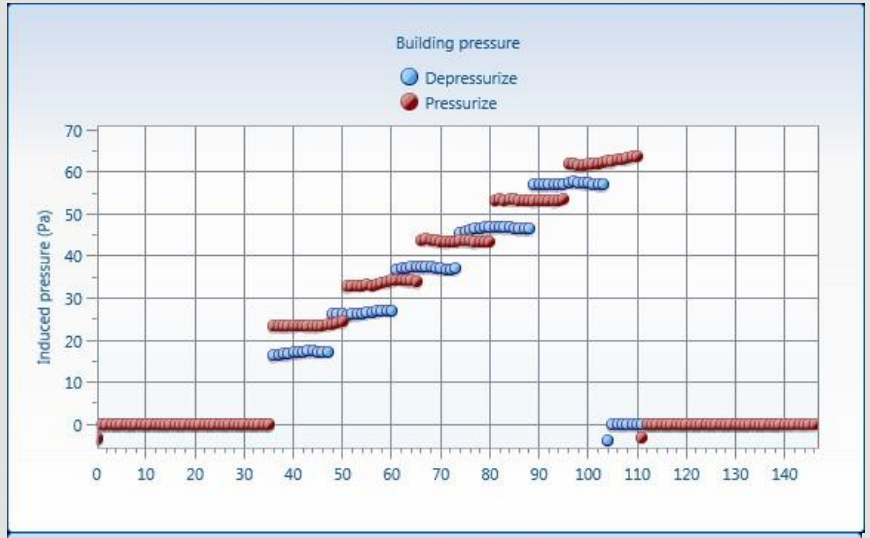
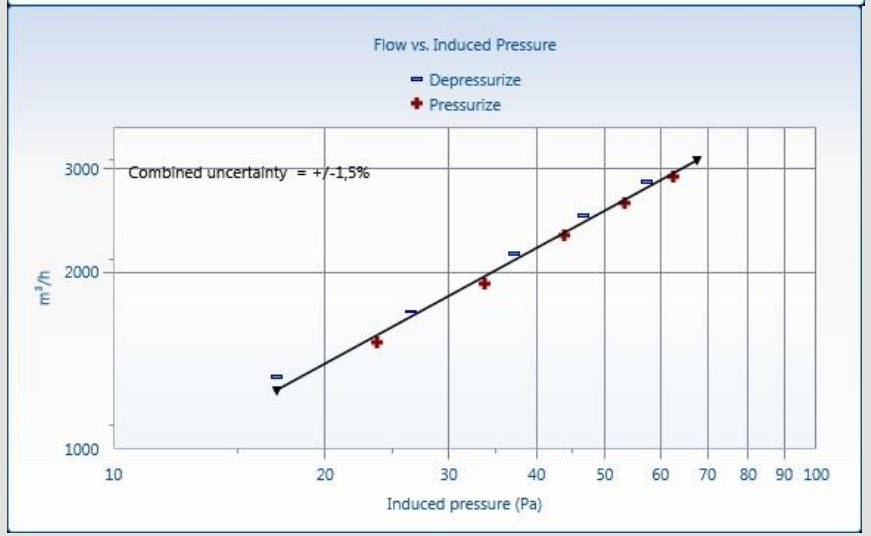


Demo building measurements

Results	
Air flow at 50 Pa, V_{50} [m³/h]	2550
Air changes at 50 Pa, n_{50} [/h]	4,40
Permeability at 50 Pa, q_{50} [m³/h/m²]	4,803
Specific leakage at 50 Pa, w_{50} [m³/h/m²]	11,808
Effective leakage area at 50 Pa, A_L [cm²]	777,5
Equivalent leakage area at 50 Pa, A_L [cm²]	1275
Normalized Leakage Area [cm²/m²]:	1,464





Practical task

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Simulator Trainer for Building tests

Quick Installation Guide

https://retrotec.com/sites/default/files/manual-guides-specs/QuickGuide-House%20and%20Duct%20Simulators-QG500.pdf

Practical task

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- Determine the total area of openings using the Blower Door method and compare results with the actual measured. Area;

- Use the Blower Door Simulator;
- Assume openings' sizes on you own;
- Measure the air permeability with respect to the "base line". The "base line“ measurement time is 30 seconds;
- Perform air flow measurements at six measuring points with an interval of 10Pa. The duration of each measurement is 30 seconds.

Practical task

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Opening	Size, m	Area, m^2
Left side		
Back side		
Right side		
Area of external building element (including floor), m^2		
Simulator volume, m^3		
	Total:	

Practical task

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Setup pressure, Pa	10	20	30	40	50	60
Induced Pressure [Pa]						
Total Flow, q_r [m^3/h]						
Measured Flow, q_m [m^3/h]						
Flow through envelope, q_{env} [m^3/h]						
Error [%]						

Practical task

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	Mean	95% confidence limits		Uncertainty
		Lower	Upper	
Slope, n:				
Air leakage coefficient, C_{env} [$m^3/h/Pa^n$]:				
Air leakage coefficient, C_L [$m^3/h/Pa^n$]:				
Air flow at 50 Pa, [m^3/h]				
Air changes at 50 Pa, n_{50} [/h]				
Specific leakage rate (envelope) at 50 Pa, [$m^3/h/m^2$]				
Specific leakage rate (floor) at 50 Pa, [$m^3/h/m^2$]				
Effective leakage area at 50 Pa, [cm^2]				
Specific effective leakage area (envelope) at 50				