

Laboratory Testing of Aereco Air Inlets

Final Report

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1. Introduction

The number of households with natural gas supply has significantly increased in Hungary over the past decades. Most of the gas appliances are open combustion chamber gas boilers with no outlet or with an outlet connected with the chimney (Type A and B boilers according to Hungarian standard MSZ CR 1749). Gas appliances with a closed combustion chamber (Type C) have recently started to gain ground.

In the case of type A gas appliances that emit flue gas into the air of the room, ventilation air flow is to be determined starting out from the condition that pollution concentration should not exceed certain threshold limit values.

In the case of type B gas appliances, combustion air needed for the operation of the appliance and air that leaves through the flue-gas connection has to be supplied in appropriate quantities.

Considering that today the necessary ventilation air flow cannot be supplied through unsealed windows and doors – due to energetics requirements, modern windows and doors have become rather airtight –, it is now desirable to install devices through which sized ventilation air flow can enter the room with the gas appliance.

This is exactly the task that the window- or wall-mounted Aereco air inlets perform. Their characteristic curve is known and they have been certified by an accredited laboratory. (In Hungary the air inlets have acquired the A-893/1999. technical licence for building industry, which is regularly renewed.)

In order to enhance the use of these air inlets in Hungary, the laboratory testing of their application was considered expedient. Testing was carried out in the measurement chamber built at the Department of Building Service Engineering. The chamber is equipped with an airtight door and suited for the operation of various gas boilers.

Based on these considerations, Aereco Légtechnikai Kft. commissioned the Department to carry out laboratory testing that would demonstrate the Aereco air inlets' applicability in providing for the air supply of rooms with a gas appliance.

The following air inlet types were tested:

air inlets EMM-916 HU, EHA-753 HU, EHA-755 HU, and EFA-581 HU,

and

wall inlets EHT-957 HU, EHT-022 HU, and EFT-026 HU.

2. Why air inlets are necessary?

In Hungary, the air supply of the rooms with a given gas appliance type was for decades planned and realised according to the principles and methods laid down in the Gas- and Oil Industry Technical Safety Code (*Gáz- és Olajipari Műszaki Biztonsági Szabályzat – GOMBSz*). The body of knowledge and technical environment of this safety code was based on circumstances present decades ago. Due to technological development, the technical circumstances have profoundly changed, especially with respect to the decrease in energy consumption and the use of building structures and materials. Yet, the code did not follow these changes. The new application and management code corresponding to the modern technical environment is being elaborated at present.

Concerning the air supply of the gas boilers with an open combustion chamber and connected with the chimney, the above mentioned *GOMBSz* established the principle that „. . . in the case of gas appliances connected with the chimney, air is to be supplied at a rate as to ensure the air flow necessary for the combustion and to substitute for the air that leaves the room via the draught diverter.” The code did not require the calculation of this air supply. Instead, it connected the verification of proper air supply to the value of specific heat load relating to the volume of the room (hereinafter specific load).

Specific load caused by the gas appliance in a given room can be calculated as

$$\frac{e \cdot \dot{Q}_H}{V}$$

where

\dot{Q}_H – is the heat load of the gas appliance [W],

e – is the simultaneity coefficient of the appliance's use,

V – is the volume of the room [m³].

The code set the adequacy of air supply in function of certain specific load values. Accordingly, if the calculated specific load exceeds a certain value, that is, the volume of the room is smaller than the minimum value corresponding to the size of an appliance, such an appliance cannot be installed in the room. If the specific load remains below this limit but exceeds another value specified in the code, ventilation between this room and another is to

be ensured in accordance with certain conditions. In the case of lower specific load, the gas appliance can be safely installed in the room as its air supply is considered appropriate.

Evidently, the elaborators of the code started out from the fact that the air of the specified room volume would provide for the combustion air needed for the operation of the gas appliance and make up for the air that leaves via the flue-gas connection – the draught diverter – for a given amount of time. Furthermore, they assumed that the fresh air entering the room through the unsealed windows and doors can ensure the air supply. It is for this reason that the code specifies the requirement of a window surface of min. 1.3 m².

Amongst today's technical circumstances, this assumption is not valid any more: the air permeability in the low differential pressure range of modern windows developed with an eye to energy saving is virtually zero.

The principle laid down in the code is correct: air is to be supplied to ensure combustion air and make up for the air that leaves the room via the flue-gas connection – the draught diverter. **Figure 1** illustrates the process to be followed in the calculation, the initial characteristics and the ones to be calculated.

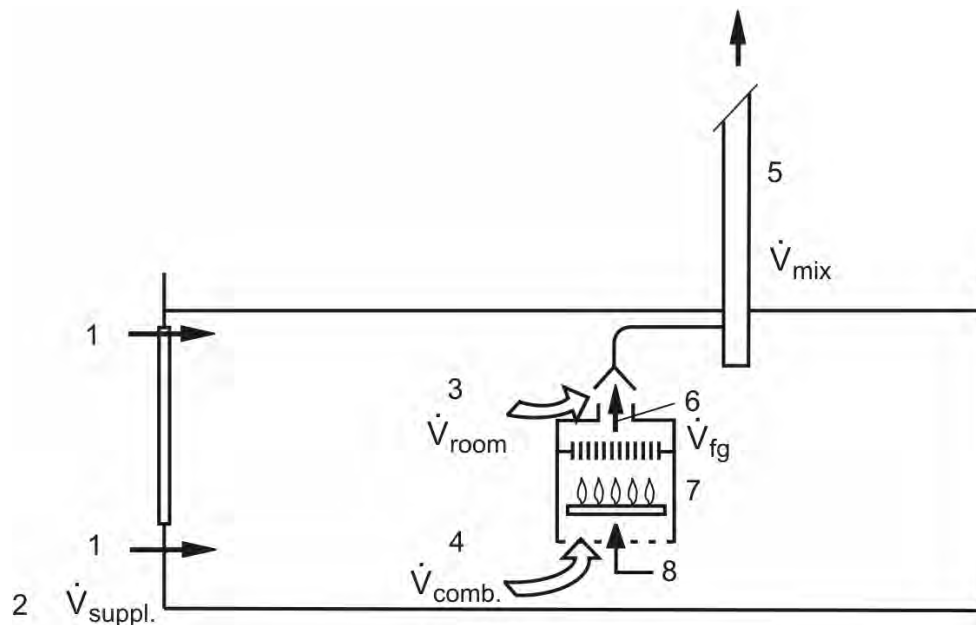


Figure 1. Model of open combustion chamber gas appliance connected with the chimney and its room

(1 – air inlet; 2 – supply air; 3 – room air; 4 – combustion air; 5 – chimney; 6 – flue gas;
7 – gas appliance; 8 – gas)

Accordingly, the planner's task is:

- to define *combustion air volume flow rate*,
- to calculate the *volume flow rate of the room air entering the flue-gas connection* – also known as diluting air,
- to plan how to create *differential pressure* that would provide for the substitution of slate air and the air leaving the room; and to *select devices through which air can enter the room*.

Aereco air inlets are hygrocontrolled, that is, they control air inflow in function of the relative humidity of the room. Air inlets with limitable minimum air flow (that cannot be shut off) and those with enhanced air flow can be used to provide for the air supply in rooms with a gas appliance. The present testing included the types listed in the introduction. Every tested air inlet has been certified by an accredited laboratory. Their certificate contains their respective characteristic curves.

The purpose of the present testing was to verify the applicability of the currently available selection of air inlets (as enumerated in the introduction) and to demonstrate their applicability in providing for the air supply of airtight rooms with gas appliances, record the findings, and elaborate recommendations.

Next, the conditions of measurement and the measurement results will be presented, followed by the conclusions and recommendations.

3. Conditions of measurement and the measurement results

The measurement chamber that we used for the testing was built at the Department of Building Service Engineering in the framework of a diploma project. In designing the chamber it was essential requirement that its volume should exceed the basic value as defined in *GOMBSz*.

We planned the test with two kinds of gas appliances in the chamber. One is an older type, a frequently used FÉG V4 wall mounted water heater. According to catalogue data, its nominal heat load is 27.3 kW.

The other is a modern wall mounted Vaillant boiler. According to its data plate: Type VU INT 180/1-XE, its heat load can vary between 9.6 and 20 kW.

In the case of boilers with open combustion chamber and connected with the chimney, *GOMBSz* stipulates that the maximum specific load cannot exceed 3140 W/m^3 . Accordingly, the minimum volume of the room in the case of the V4 type water heater is:

$$V_a = \frac{27300 \text{ W}}{3140 \text{ W/m}^3} = 8.7 \text{ m}^3$$

Since the height of the gas technical laboratory is 3.41 m, the smallest permissible chamber area is $8.7/3.41 = 2.55 \text{ m}^2$.

Considering the local conditions, we developed the chamber as illustrated in **Figure 2**.

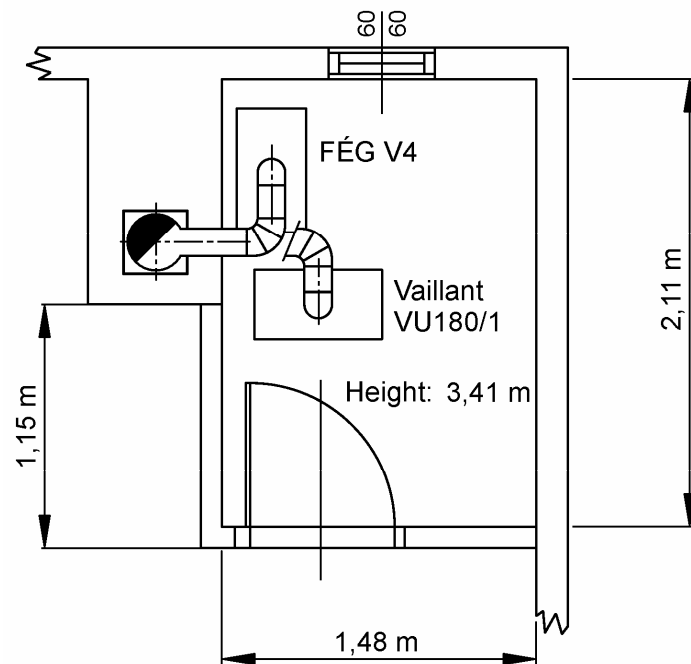


Figure 2. Layout with principal dimensions

The *combustion air volume flow rate* was defined with the equation:

$$\dot{V}_{\text{égési lev.}} = \lambda \cdot V_{\text{lev,elm}} \cdot \frac{\dot{Q}_H}{H_a} \cdot 3600, \quad \text{m}^3/\text{h}$$

where

λ – coefficient of excess air, its value was established at 1.4, as customary in the case of atmospheric gas appliances;

$V_{\text{air, th}}$ – theoretical air volume, for natural gas H its value is about 9.5 m³ air/m³ gas;

\dot{Q}_H – heat load of the gas appliance, for type V4 it is 27.3 kW;

H_a – heat value of natural gas; for natural gas H that supplies the gas technical laboratory, its value in the gas technical normal state is about 34,000 kJ/m³.

The combustion air mass flow is about 38.4 m³/h.

The *air flow of the room air entering the flue-gas connection*, which amounts to at least 30% of the flue gas volume flow rate, is

$$\dot{V}_{\text{hígító lev.}} = 0,3 \cdot [V_{\text{ét,elm}} + (\lambda - 1) \cdot V_{\text{lev,elm}}] \cdot \frac{\dot{Q}_H}{H_a} \cdot 3600, \quad \text{m}^3/\text{h}$$

where

$V_{\text{fg,th}}$ – theoretical (pertaining to $\lambda = 1$) flue gas quantity, for natural gas H it can be established as about 8.5 m³ flue gas/m³ natural gas.

According to our calculations, the air flow of the room air entering the flue-gas connection is at least 10.7 m³/h.

In view of all this, we selected the air inlets for a minimum 49 m³/h air flow, based on the catalogue of the manufacturer.

Accordingly, we installed the following quantities from the given types.

Window air inlets types

EMM-916 HU: 4 pcs air flow with differential pressure 10 Pa: min. 4 x 11 = 44 m³/h

EHA-753 HU: 4 pcs air flow with differential pressure 10 Pa: min. 4 x 11 = 44 m³/h

EHA-755 HU: 3 pcs air flow with differential pressure 10 Pa: min. 3 x 22 = 66 m³/h

EFA-581 HU: 2 pcs air flow with differential pressure 10 Pa: 2 x 35 = 70 m³/h

Wall air inlets

EHT-957 HU: 4 pcs air flow with differential pressure 10 Pa: min. 4 x 13 = 52 m³/h

EHT-022 HU: 3 pcs air flow with differential pressure 10 Pa: min. 3 x 17 = 51 m³/h

EFT-026 HU: 2 pcs air flow with differential pressure 10 Pa: 2 x 35 = 70 m³/h

The airtightness of the chamber was examined prior to the measurements. Within the chamber, we brought about pressure lower than the ambient pressure with an insulated flue gas connection and a fan of multiple rpm options. The air flow removed with the fan defines the airtightness of the chamber. **Figure 4** illustrates the measurement results.

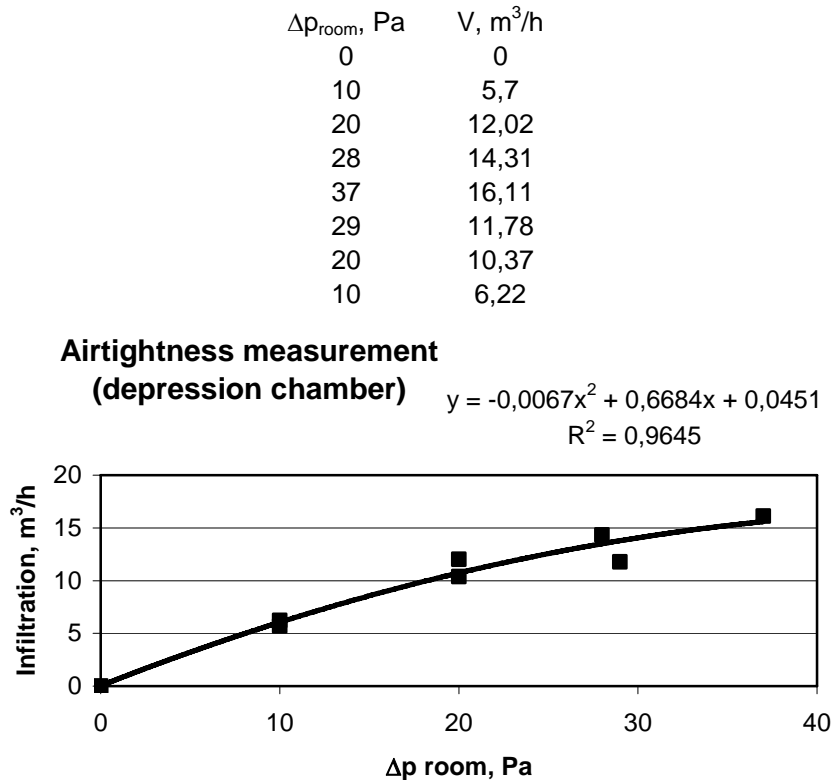


Figure 4. Results of the airtightness measurement, trend line and regression function

When the pressure differential is 10 Pa, the infiltration of the chamber obtained with the selected air inlets is 8–13% of the obtainable air flow, which is acceptable for the demonstration of the operation of the air inlets.

The air flow entering via the air inlets was measured with measurement sections fastened to the inlets. The measurement sections and their number was established in accordance with Hungarian standard MSZ 21853-2:1998.

In the case of the circular measurement section we divided the diameter into 3 equal parts, in the case of the flat measurement section of the window air inlets we divided the diameter into 5 equal parts. Since the areas belonging to the measurement points are equal and, based on the measured values, the velocity distribution could be considered almost constant. The average velocity relative to the measurement diameter is, according to the above

mentioned standard, the arithmetic average of the velocities determined (c_i) in the given measurement points:

$$c_{\text{ave}} = \frac{\sum_{i=1}^n c_i}{n}$$

Testovent 4100 hot-wire anemometer was used for the measurement of the air flow velocity. The static differential pressure between the chamber and the ambient was determined with a Lambrecht inclined manometer. Besides, the following parameters were measured: outdoor temperature, temperature of the gas technical laboratory regarded as ambient temperature, room temperature in the chamber, relative humidity, barometric pressure, several gas parameters (undiluted flue gas temperature, air-flue gas mixture temperature, gas consumption, gas pressure at the appliance), and, for the description of the operational condition of the gas appliance, the water temperature in the supply and the return lines.

Figure 5 illustrates the outline of the measurement with the measured values and the measurement instruments. **Annex 1** includes a few photographs on the chamber, the measurement instruments, and the installed air inlets.

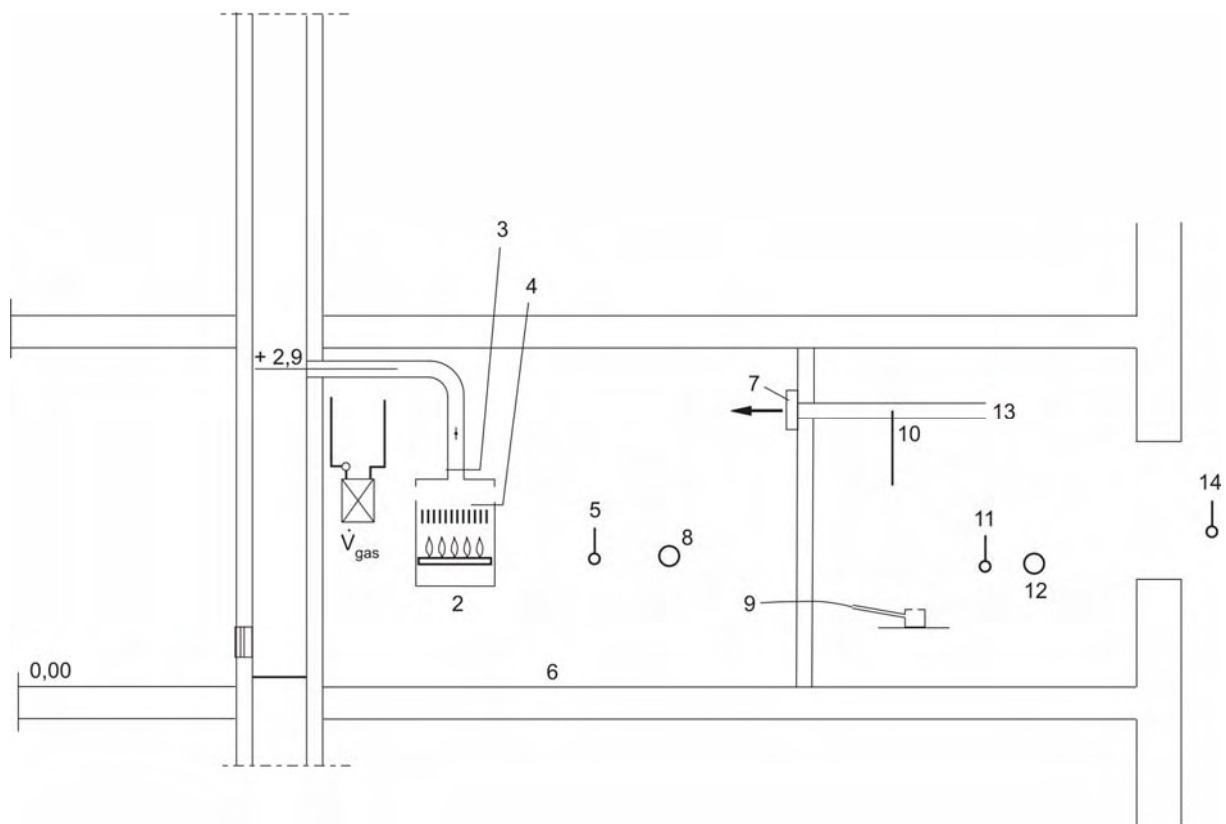


Figure 5. The outline of the measurement with the measured values

In the fig. 5: 1 – gas meter; 2 – gas appliance; 3 – measurement point of air-flue gas mixture temperature; 4 – measurement point of flue gas temperature; 5 – room temperature; 6 – measurement chamber; 7 – air inlet; 8 – measurement point of relative humidity; 9 – pressure difference in room; 10 – measuring of air velocity; 11 – ambient temperature; 12 – barometric pressure; 13 – measurement tube; 14 – outdoor temperature.

4. Measurement results and their evaluation

The measurements were conducted between June 25 and July 15, 2004, with varying outdoor weather conditions, with the planned two gas appliances and, without them, with the natural draught of the chimney. Given the error of the measurement instruments and their inaccuracies not conforming to the rather small differential pressure, we could not use the results of some of the days. Since we installed several pieces (2-4) from a certain type of air inlet, we examined how depression changed within the chamber and how the air mass flow entering via the open ones changed upon the closing of certain inlets.

The measurement results and the calculated parameters are presented in **Annexes 2–9**, with

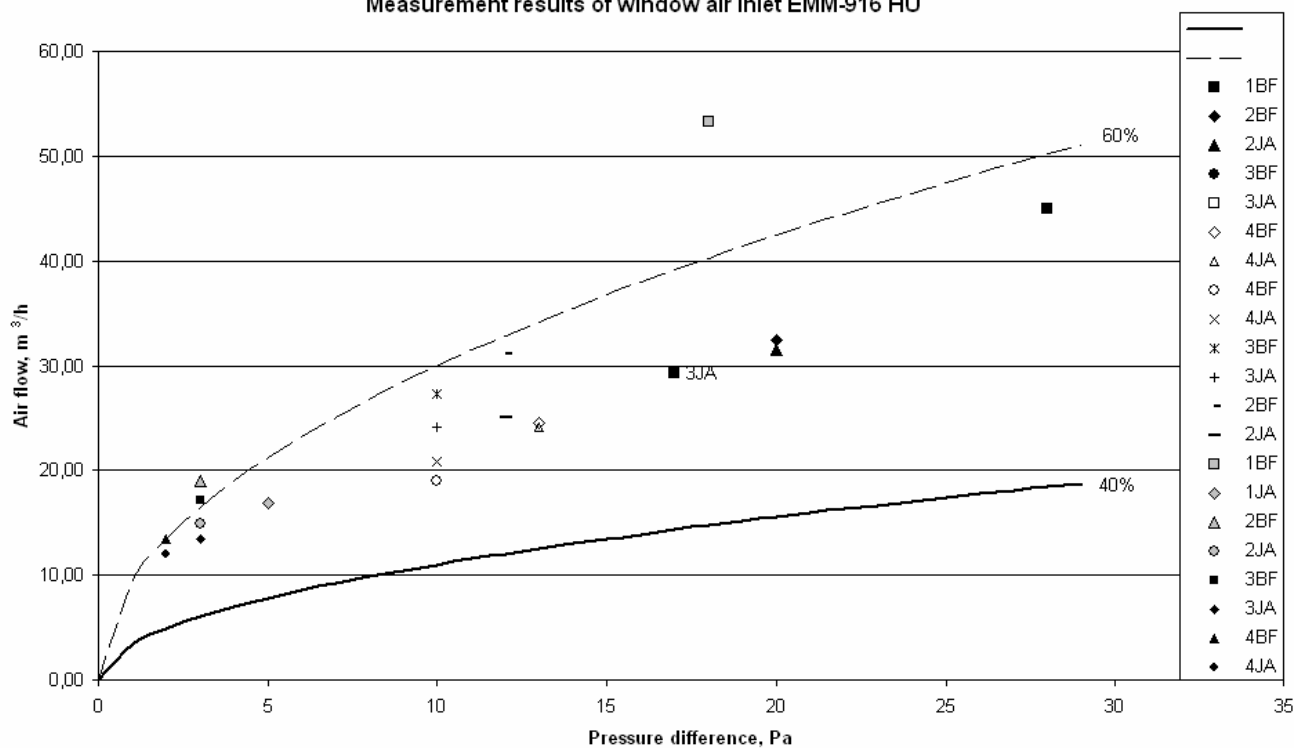
- Annexes 2, 3, 4, and 5 presenting the measurement results of window air inlets,
- and Annexes 6, 7, and 8 presenting the measurement results of wall air inlets.

For the sake of clarity, Annex 9 presents the values recorded in data loggers for undiluted flue gas, diluted flue gas (flue gas and air mixture), and air temperature (outdoor temperature and room temperature within the chamber) in diagrams.

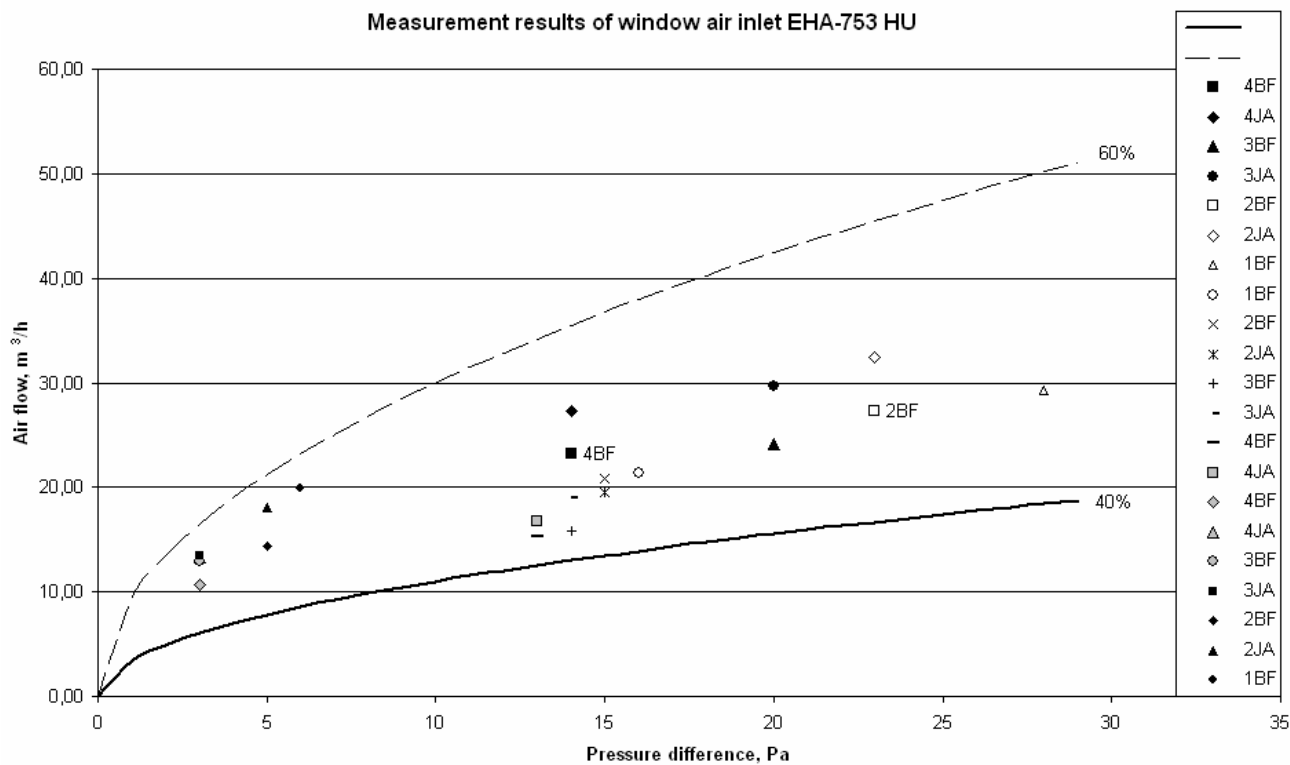
The calculated related differential pressure and supply air mass flow values were compared with the characteristic curves that the commissioning company provided in Excel format. They were represented in a diagram that, besides the characteristic curve, contained the measurement points as well. The measurement points were marked with a number and position of the air inlets [upper left (bal felső – BF), upper right (jobb felső – JF), lower left (bal alsó – BA), and lower right (jobb alsó – JA)]. The only exception was model EHT-957 HU, where we did not apply this method because of the great number of measurements and concurrent measurement points. The measurement points can easily be identified with the help of the summary tables in the Annex.

The diagrams illustrating the measurement points for the seven tested air inlet types are as follows.

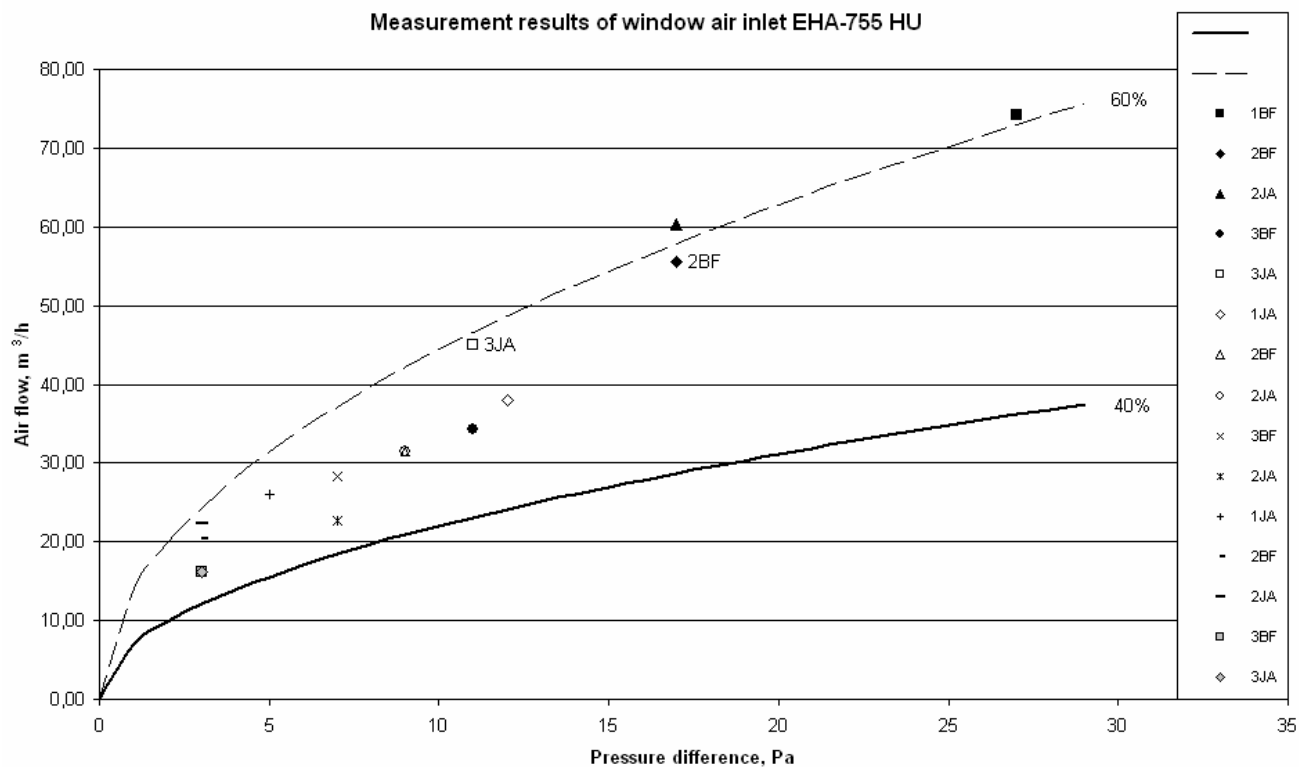
Measurement results of window air inlet EMM-916 HU



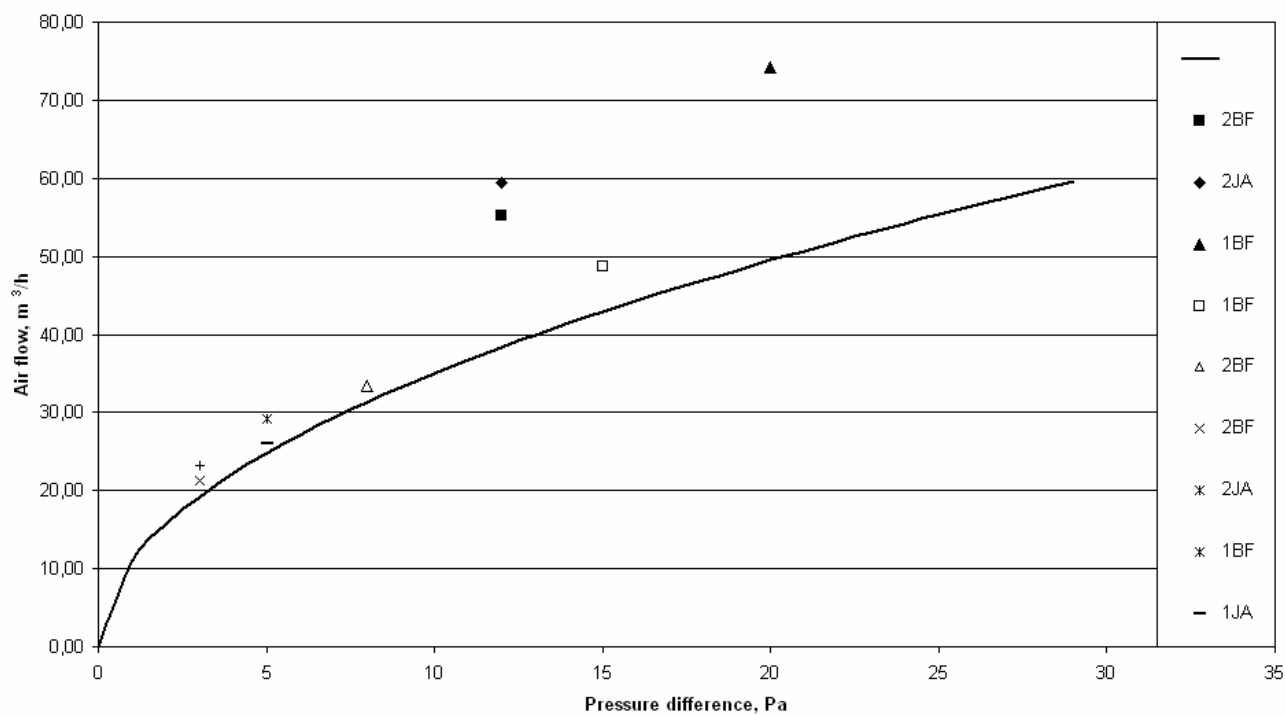
Measurement results of window air inlet EHA-753 HU



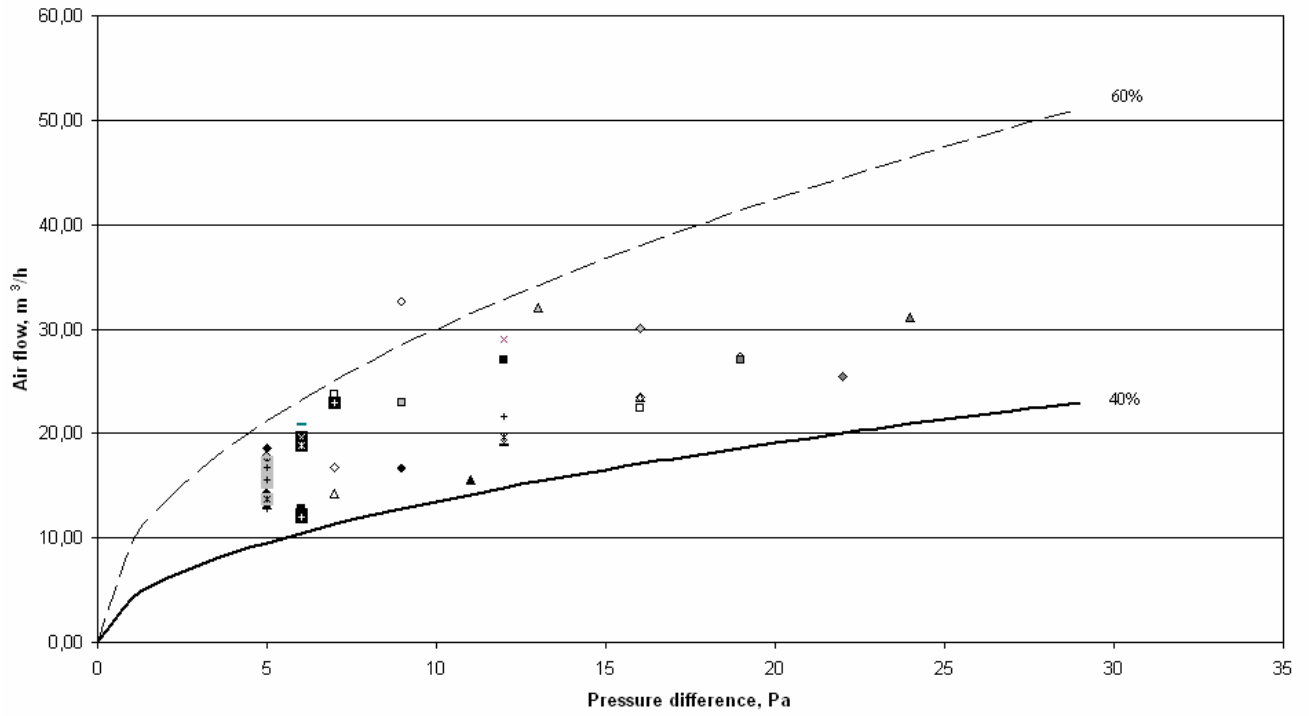
Measurement results of window air inlet EHA-755 HU



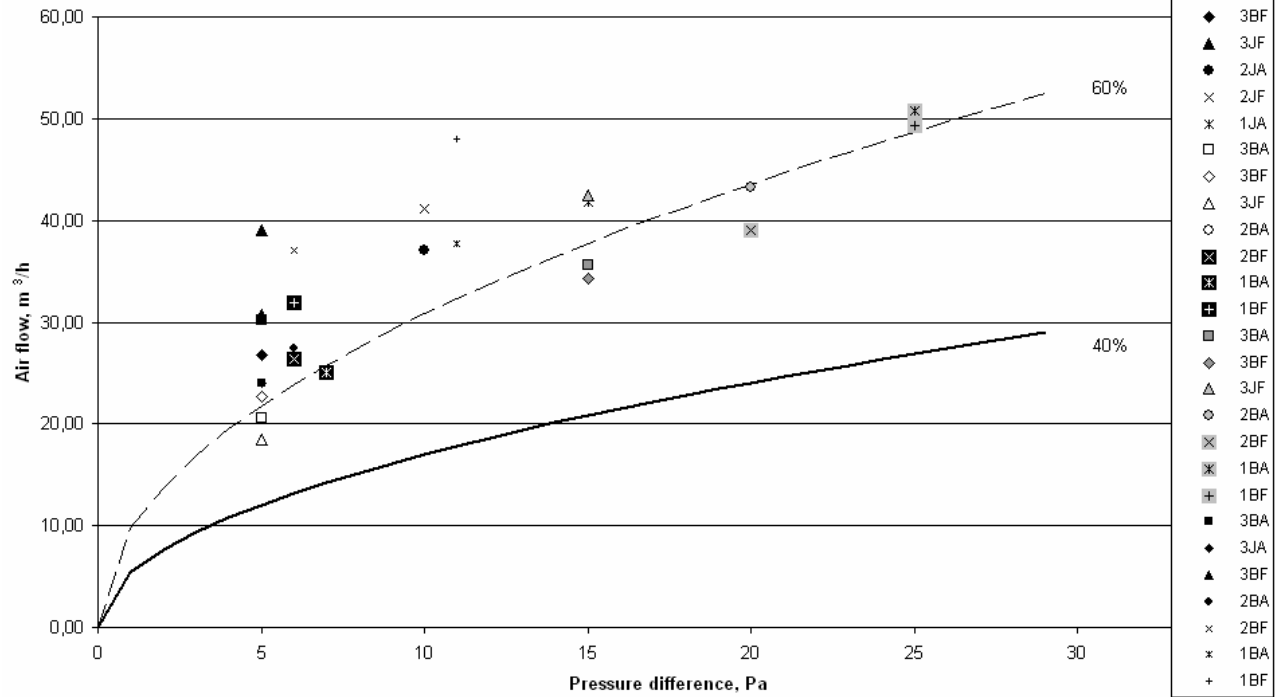
Measurement results of window air inlet EFA-581 HU



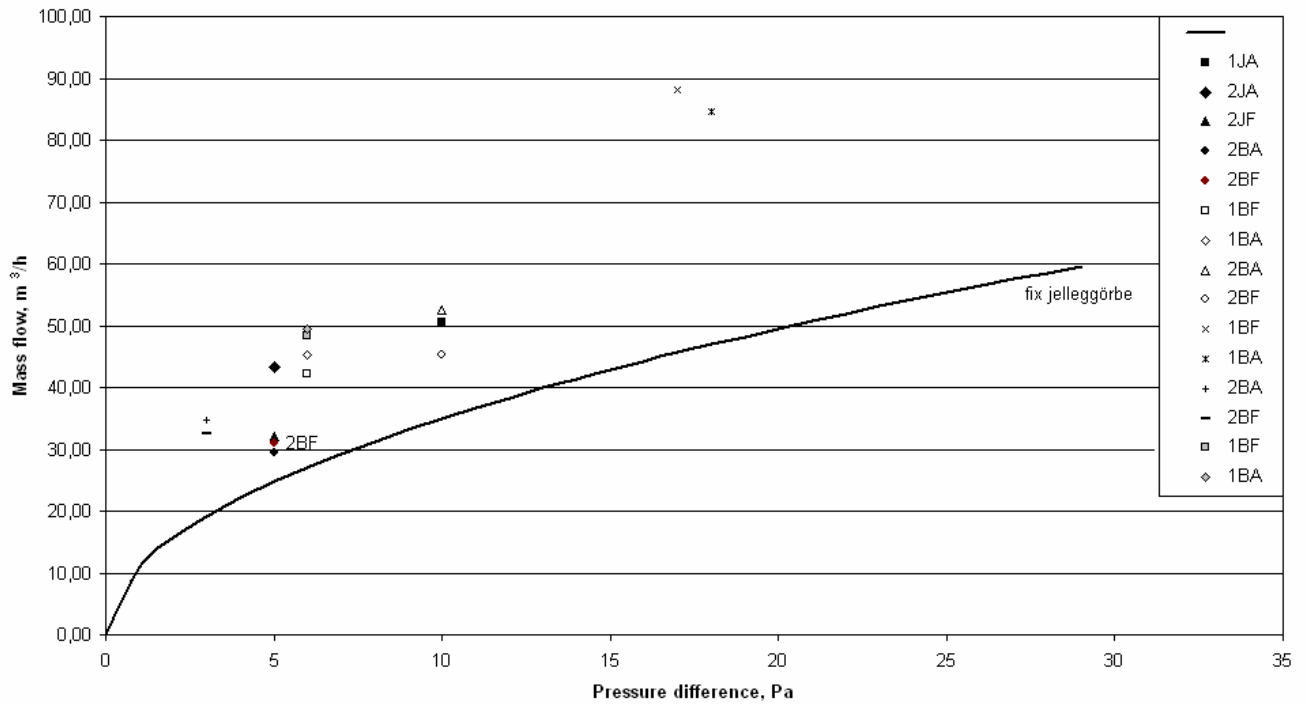
Air flow of wall air inlet EHT-957 HU



Air flow of wall air inlet EHT-022 HU



Air flow of wall air inlet EFT-026 HU



Based on the evaluation of the measurement results, it can be concluded that the measurements carried out amongst laboratory conditions but with operational preciseness, revealed greater air flow rates than the ones presented in the characteristic curves prepared on the basis of the qualification measurements. Some measurement points perceptibly stand out as compared with the characteristic curve or its range, which can be explained by the slight changes in the pressure conditions in the environment of the gas technical laboratory. The wind conditions had a palpable influence on the read values; yet, the evaluated air flow results always proved to be higher than the data of the characteristic curve, which, given that this enhances security, is reassuring from the point of view of the air inlets' application.

5. Conclusion, recommendations

The tests have clearly proved that Aereco window and wall air inlets can safely be used to provide for the air supply in rooms with gas appliances.

The tests aimed at demonstrating not only the operation of the air inlets but also, with respect to the preparation of the testing, the method to be followed by planners when selecting the appropriate air inlet type.

It is to be emphasised that these tests did not seek to verify either the certified measurements relative to these air inlets carried out by an accredited institution or the characteristic curves drawn up on their basis. However, the measurements of operational nature expressly confirmed that the air inlets safely provide for the air flow as revealed by the characteristic curves, and their operation is stable even in the case of low differential pressure values.

Based on our experiences, when it comes to planning the air supply of boilers we suggest the application of the air inlet selection method presented here. It is essential that the air needed for the operation of the appliance has to be continuously supplied. Accordingly, not only the appropriate room volume has to be ensured but also ventilation air mass flow. This is especially true in the case of small room volumes typical in Hungary.

The air inlet selection of Aereco Légtechnikai Kft. can be, given their limitable minimum air flow, safely used to provide for the air supply of rooms with gas appliances. Furthermore, due to the fortunate design of these air inlets, they present so favourable air flow characteristics that the necessary supply air flow can be easily obtained with only a few inlets.

6. References

- Gas- and Oil Industry Technical Safety Code (*Gáz- és Olajipari Műszaki Biztonsági Szabályzat – GOMBSz*). Annex 2 of Order No. 1/1977 (04. 06.) NIM
- Németh, Sz. L.*: Investigation of Gas Appliances in Non Steady State Conditions. Final Project Work, BUTE Department of Building Service Engineering, 2004
- Barna L.*: Sizing of Air Supply in the Room of Gas Appliances. 1st Part: A Type Gs Appliances, 2nd Part: B Type Gas Appliances, Magyar Épületgépészet – Haustechnik, 2004/3 and 2004/8

Contents of Annexes

- Annex 1: Photos of the measurement chamber and the measuring instruments
- Annex 2: Measurement Report of window air inlet EMM-916 HU
- Annex 3: Measurement Report of window air inlet EHA-753 HU
- Annex 4: Measurement Report of window air inlet EHA-755 HU
- Annex 5: Measurement Report of window air inlet EFA-581 HU
- Annex 6: Measurement Report of wall air inlet EHT-957 HU
- Annex 7: Measurement Report of wall air inlet EHT-022 HU
- Annex 8: Measurement Report of wall air inlet EFT-026 HU
- Annex 9: values recorded in data loggers for undiluted flue gas, diluted flue gas (flue gas and air mixture), and air temperature