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Passive house for Latvia

Energy efficiency and technical-economic aspects

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Thesis for the Degree of Master of Science

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Abstract

The growing energy prices and energy consumption caused the interest about buildings with low energy consumption such as Passive house. Energy demand in households accounts for around one forth of the final energy needs in the EU (Intelligent Energy Europe 2006), and it is a potential for energy demand reduction. At the same time, environment protection with a reduction of CO_2 emissions nowadays is becoming a requirement for new built buildings. European Union tends to implement Passive house standard in 2016. And in many countries, including Scandinavian countries, there is a good experience of Passive house whereas in Latvia this concept is new at this moment.

The main objective of this work is to explore what a Passive house is, to find out the energy efficiency requirements for it and to study technical-economic aspects of it. Another objective, as a personal input into this work, is to design ventilation system for Passive house in Latvia and to compare annual costs for heating for Passive house and standard Latvian house.

Theoretical part of the work is based on available literature that includes study of articles, publications and thesis works that are carried out in field of Passive house. In addition, to deepen literature study, consulting with specialists and researchers working with this issue is done. In practical part, all calculations are done with traditional calculation methods and calculated in Excel software, in order to see it in detail. No design software, such as CADvent or MagiCAD, is used.

At the beginning of the theoretical part of the work, the concept and definition of the Passive house are described, the late history of Passive house is presented, the overview of other low energy building types are done and the benefits of Passive house are studied. Afterwards, the view of energy efficiency requirements for building envelope, heating system, domestic hot water, ventilation and air conditioning, lightening and equipment, location of the building, indoor climate and energy use of Passive house is done. This part includes also maintenance, standard and examples of Passive house. In the last part of the theoretical work the technical-economic aspects of Passive house are studied.

In the practical part of the work, ventilation system for Passive house in Latvia is designed. The heat losses of the building are calculated and added to ventilation system in order to obtain heating with ventilation system. Principles of Passive house are applied for one specific building as an alternative of standard applications. Building is not designed as Passive house initially. Additional part of practical work is calculation and comparison of annual costs for heating for Passive house and standard Latvian house.

The overall conclusions of this work, on the introduction of Passive house in Latvia, are that Passive house is specific type of the building that requires proper planning, design and construction. From economic point of view, Passive house justification is influenced by many factors, mainly by energy price; Passive house usually do not have active heating system, instead ventilation system is equipped with function of preheating supply air. Ventilation system of Passive house is more complicated and very important in design compared with standard building.

Contents

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Lastly, I want to say warm thank you to my parents, my little brother, my best friends and Jacopo who were with me and encouraged me to the success of this work.

1. Introduction

1.1. Background & problem description

The growing energy prices and energy consumption caused the interest about buildings with low energy consumption such as Passive house. Energy demand in households accounts for around one forth of the final energy needs in the EU (Intelligent Energy Europe 2006), and it is a potential for energy demand reduction. At the same time, environment protection with a reduction of CO_2 emissions nowadays is becoming a requirement for new built buildings. And choice for environment friendly appliances usually are less economic attractive.

Latvian architects seem to be more advanced in this field and some theses about Passive houses are already performed at Riga Technical University by architecture students. Therefore it is important to be aware also for building service students what exactly a Passive house concept is, what are the requirements to meet energy efficiency and technical-economic aspects, in order to be prepared for incoming innovation in the building sector.

European Union tends to implement Passive house standard in 2016. In many countries, including Scandinavian countries, there is a good experience of Passive house whereas in Latvia this concept is new at this moment. Economical justification could be a barrier for Passive house implementation in Latvia, especially when it comes to a private building sector.

1.2. Purpose

The purpose of the work is to become more competent about the issue of Passive house - energy efficiency, economical point of view and particularities of Passive house ventilation system design. The purpose of this work does not include a question whether is it profitable to build a Passive house in Latvia or not.

1.3. Objectives

The main objective of this work is to explore what a Passive house is, to find out the energy efficiency requirements for it and to study technical-economic aspects of it. Another objective, as a personal input into this work, is to design ventilation system for an ordinary residential building in Latvia, which has been rebuilt and adapted to Passive house standards. The next step is to compare annual costs for heating the Passive house as above with equivalent costs of an ordinary house.

1.4. Methods

Theoretical part of the work is based on available literature that includes study of articles, publications and thesis works that have been carried out in field of Passive house. In addition, to deepen literature study, consulting with specialists and researchers working with this issue is done. In practical part, in order to see all calculations in detail, traditional calculation methods are used and handled by the Excel software. No design software, such as CADvent or MagiCAD, is used.

1.5. Constraints

The theoretical part of the work is limited to Passive house experience in Europe from available literature sources. Practical part is limited to general ventilation system design methods and Passive house ventilation system principles adapted to Latvian climate. Concerning Passive house in Latvia, this work is limited to private house sector.
Prices used in house and energy costs calculations are only valid for the specific cases used in this study.

2. What is Passive house

2.1 Concept and definition

The basic idea of a Passive house is very good insulated and airtight building envelope with mechanical ventilation (Janson 2008). The concept of Passive house was presented in 1988: *"A passive house is a building in which a comfortable interior climate can be maintained without active heating and cooling systems"* (Passive House Institute 2010 after Adamson 1987 and Feist 1988). Janson (2008) writes that *"The Passive House concept is not an energy performance standard, but a concept to achieve high indoor thermal comfort conditions at low building costs."* Should be added, that low energy costs regards to annual energy costs; new build Passive house usually is more expensive compared with standard building. Golunovs (2009) (Riga Energy Agency) formulated the basic principles of Passive house concept:

1. Improved insulation of building envelope;
2. Reduced the influence of thermal bridges;
3. Triple glazing windows;
4. Air tightness of the building;
5. Mechanical ventilation with heat recovery.

As to definition, there is no one exact international and generally accepted definition of term "passive house" on this moment, but many papers refer to definition presented by one of main stakeholders on the field of Passive Houses nowadays, German Passive House Institute: "*A Passive House is a building for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to fulfill sufficient indoor air quality conditions (DIN 1946) - without a need for recirculated air*" (Feist 2006a). The important additional comment on this definition has been made by Feist (2006a): "*It does not need any numerical value and it is independent of climate. From this definition it is clear, that the Passive House is not an arbitrary standard enacted by somebody, but a fundamental concept. Passive Houses have not been "invented", but the conditions to use the passive principle had been discovered.*" Regarding the building type (Schnieders and Hermelink (2004) after Badescu and Sicre (2003) define Passive house as: *"A type of low-energy building; design is oriented to make maximum exploitation of passive technologies (eventually adopting also some active solar technology), assuring a comfortable indoor climate during summer and winter without needing any conventional heating or cooling system."*

For wider audience who is not involved in any construction, design or planning Feist (2007a) writes that Passive house is a building in which a comfortable indoor climate can be achieved with minimal energy consumption. Passive house is more demanding in regard to conception, design and exploitation.

2.2 History to nowadays

After the World War II cheap and easy transported oil became a main energy source in the world (Dzelzītis 2005). After Energy Crises in 1970’s and 1980’s, energy prices increased and energy became a matter of concern for proceeding in sustainable development.

For that reason in 1980's the low-energy building standard was already required for new buildings in Sweden and Denmark. Many elements reducing building energy consumption (for example: thick insulation, minimized thermal bridges, air tightness, insulated glazing and heat recovery ventilation) have been developed at that time. Referring to this the base concept of Passive house was developed by host Professor Bo Adamson, while he was doing research in the field of building construction at the Lund University, Sweden, in May 1988. Bo Adamson continued to develop his concept together with Dr. Wolfgang Feist until his retirement, see Figure 2.1 (Feist 2006b).

The theoretical proof for the feasibility of Passive houses was presented in the thesis "Passive Houses in Central Europe" (Feist 2006b after Feist 1993). Feist (2006b) writes that, it was quickly realized that the energy optimization for buildings should not be limited to heating energy only; all household energy consumption must be minimized.

Before the first Passive house in Kranichstein was built, a scientific working group had been formed for developing architectural drafts, improving efficiency of ventilation heat recovery, determining proper amount of ventilation for good air-quality, developing new highly thermally insulated window frames, designing different construction elements with only small losses due to thermal bridges, testing waste-water heat recovery concept (Feist 2006b).

The first Passive house four-unit building was built in 1991 in Darmstadt Kranichstein, Germany (Figure 2.2 and 2.3). The components of the house had to be handmade and it raised the costs compared with the conventional construction. Accordingly, it was not economical at that time. In order to evaluate its performance later, the house was equipped with highly precise data recording monitoring devices during construction (Feist 2006b).

Figure 2.1: Bo Adamson and Wolfgang Feist (Feist 2006b)

Figure 2.2: Germany, Darmstadt, Kranichstein


Figure 2.3: Passive house in Kranichstein - North side and southern facade (Feist 2006b)

Good results in this field had led to a formation of the working group named "economical Passive Houses", which played a key role in the transition between building physics and building practice. This group worked on simplified method of planning Passive houses - the Passive House Planning Package (PHPP). That has led to the broadening scope of the Passive House concept from1996 (Feist 2006b).

In 1996, the Passive House Institute (Passivhaus Institut, PHI) was founded by Dr. Feist in Darmstadt, Germany to promote and to control energy standard for Passive house building. Since that time, Passive House Institute holds annual international Passive House Conferences, which have become a central events in science, architecture, engineering and product development in the this area.

In 1999 CEPHEUS (Cost Efficient Passive Houses as European Standards) projects were planed. Project consisted of testing and proving the viability of the Passive house concept at the European level. As the result 221 housing units in 14 building projects have been built in Germany, Sweden, Austria, Switzerland and France (Schnieders and Hermelink 2004).

"The project demonstrated the functional viability of the Passive House concept at all sites, the actual achievement of the space heat savings target, practical implementability of Passive Houses in a broad variety of building styles and constructions, project-level economic viability and a high degree of satisfaction of building occupants" (Schnieders and Hermelink 2004).

The implementation of Passive Houses increased sharply. About 300 dwellings were realized by the end 1999 in Germany, by the end of 2000 there were already 1000 and by 2006 between 6000 and 7000 (Feist 2006b). In framework of CEPHEUS project, the first Swedish Passive houses in Lindås outside Gothenburg were built in 2001 (Janson 2008). In early 2009 Sweden had around 400 apartments in Passive houses (Passivhuscentrum 2010).

The first passive house in Latvia was built in 2009, last year. Two floor family building *Lielkalni* is located in Ģipska, rural municipality of Roja, region of Talsi, see Figures 2.4 and 2.5 (Ērgle and Baņģieris 2009).

The increasing number of passive houses is not only because of increasing number of Passive House components on the market and decreasing prices, but also because of the increasing variety of the buildings. Single family homes, row-houses, blocks of flats, several office buildings and schools as well as a factory have been built within Passive house standard (Feist 2006b).

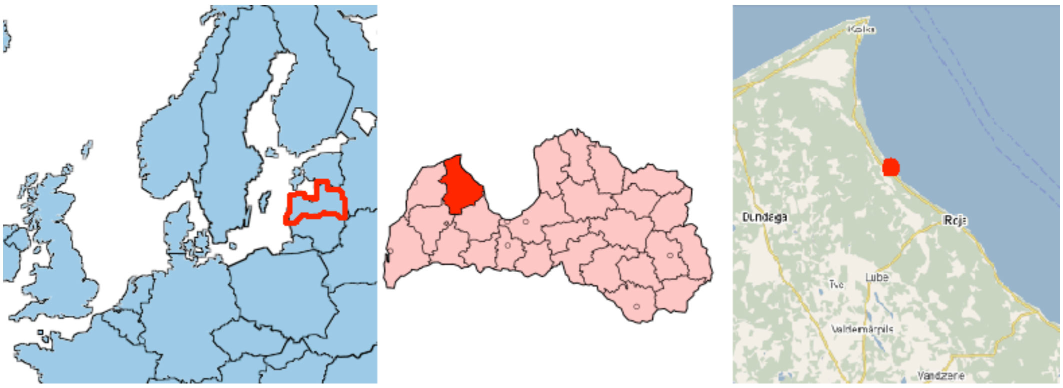

Figure 2.4: Latvia, region of Talsi, Ģipska


Figure 2.5: The first Passive house in Latvia (in late construction stage) (Ērgle and Baņģieris 2010)

2.3 Relatives of Passive house

The *low-energy building* could be considered as “parent” of Passive house, because exactly on its base the term of Passive house was developed. Audenaert et al. (2007 after Sartori and Hestnes 2007) describes low-energy building as a building built according to special design criteria aimed to minimize the need of energy.

Under the term of *low-energy building* we understand building with less energy use and higher energy efficiency than a traditional building. Thick insulation, minimized thermal bridges, air tightness, insulated glazing and heat recovery ventilation were already well known issues of *low-energy building.* Therefore we can say that the building elements of Passive house are improved elements of *low-energy building*. And it would be reasonable to call Passive house as *Ultra low energy house*.

Yde (1996) writes that *low-energy houses* were increasingly common already in 1996 in Denmark. Further steps in development of energy saving houses were *Zero Energy Houses* and *Plus-Energy Houses*. First *Zero-Energy building* actually was attempted to achieve zero-heating in the form of solar house, where solar thermal collectors and water storage were used (Hernandez and Kenny 2009). Also Hernandez and Kenny (2009) point out that definitions of *zero energy building* (zero annual energy use for the building’s operation) and *zero net energy building* (zero annual energy balance of a grid) do not include the energy inputs spent on the process of building the house and production of building material.

Whereas *Green building* is a design philosophy which requires the consideration of resources depletion and waste emissions during its whole life cycle (Wang, et al. 2004 after Woolley, et al. 1997). A green building is designed with strategies that conserve resources, reduce waste, minimize the life cycle costs, and create healthy environment for people to live and work (Wang, et al. 2004).

2.4 Benefits of Passive house

The main aim of a Passive house is energy saving. Building components are optimized to reduce the need of energy for space heating to the lowest possible level (Janson 2008). Feist (2007d) presented additional benefits from decreased energy use and improved building components of Passive house:

- No mouldy walls, no drafts and no cold feet (indirectly);
- Decreased environmental impact (emissions from a Passive house);
- Less influence of energy price increase;
- Independence of imported energy. (Could be completely independent through the use of renewable energy);

At 8th Passive House Conference in 2004 in Krems, Robert Hastings stated the following (Feist 2007d): "*Passive Houses minimize environmental impacts and maximize the joy of life.*"

2.5 Short summary - What is Passive house

After Energy Crises in 1970's and 1980's energy prices increased and energy became a matter of great importance and it became a reason for introducing low-energy building standard requirements for new buildings in some countries as early as 1980's. In May 1988, the base concept of Passive house was developed. The first Passive house – four-unit building was built in 1991 in Darmstadt Kranichstein, German. In 1999, in framework of CEPHEUS project, many Passive houses were built in Germany, Sweden, Austria, Switzerland and France. After the project demonstrated the functional viability of the Passive house concept at the European level, the implementation of Passive Houses increased sharply. The first Passive house in Latvia was built in 2009, last year.

Passive house is a type of low-energy building, which is well insulated, airtight construction with mechanical ventilation where building components are optimized to reduce the need of energy. Passive house is more demanding in regard to conception, design and execution of construction work compared with a standard building.

There is no one exact international and generally accepted definition of term "passive house" on this moment, but the most recognized definition is provided by the one of main stockholder in field of a Passive house nowadays - the German Passive House Institute.

3. Energy efficiency requirements for Passive house

3.1 Building envelope

The main principle of a Passive house is a good insulation applied continuously around all building envelope, see Figure 3.1. This principle allows reduction of heat losses to a minimum. At the same time it is of vital importance to understand that besides good insulation, including thick insulation layer with low thermal heat loss coefficient (U-value), building envelope should also include:

- Envelope without thermal bridges;
- Airtight envelope;
- Highly efficient windows and external doors.

Passive House Institute (2006a) writes that many construction methods can be used for Passive houses building - masonry construction, lightweight construction, prefabricated elements, insulating concrete formwork construction, steel construction.

To reach energy efficiency in a Passive house, proper attention should be paid for construction stage and possible mistakes should be corrected. Air tightness is checked by the air tightness test after the building has been built.

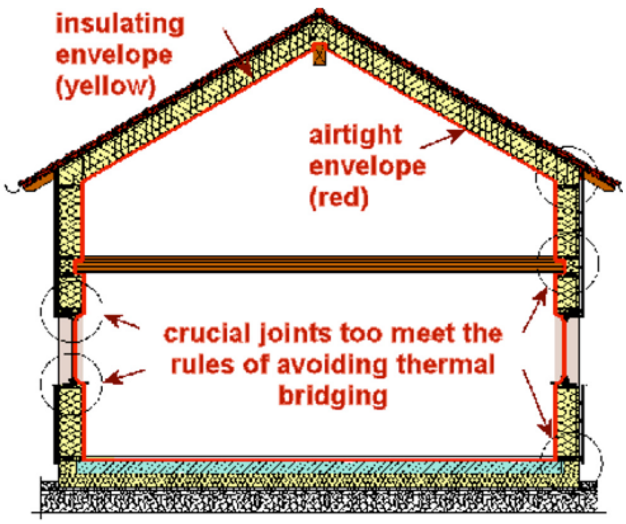

Figure 3.1: Building envelope of Passive house (Passive House Institut 2006a)

3.1.1 Insulation

The main principle of Passive house is a very good insulation. It minimizes heat losses, therefore even in cold winter Passive house should not need an active heating. There are different insulation materials (see some of them in Figure 3.2) with different properties. Usually, U-value is used as the main descriptive property of insulation.

U-value for insulation of building shell equal 0.1 W/(m²K) was permitted in CEPHEUS (2010) project, see chapter 2.2. Passive House Institute (2006a) mention the similar U-values for external walls, slabs to the ground and roof - 0.1 to 0.15 W/(m²K).

The type and thickness of the insulation varies depending on climate (outdoor temperature). In formula 1 we can see that, if outdoor temperature is decreasing, U-value also has to be decreased, in order to obtain the same amount of heat losses. Further U-value is dependent on thickness and thermal conductivity of building material layer. Good example is shown in Table 3.1. Around 700 mm thick insulation will be required for Passive house in Latvian climate (Builevics 2008).

$$Q = A * U * (T_{in} - T_{out}) \quad (1)$$

$$U = 1/R \quad (2)$$

$$1/U = R_{out} + \sum_{i=1}^{N} l_i/\lambda_i + R_{in} \quad (3)$$

Where Q - heat losses [W];
A - area of the walls [m^2];
U - heat losses coefficient (U-value) [$W/(m^2K)$];
T_{in} - indoor temperature [°C];
T_{out} - outside temperature [°C];
R - thermal resistance [$(m^2K)/W$];
R_{out} - outside convective thermal resistance [$(m^2K)/W$];
R_{in} - inside convective thermal resistance [$(m^2K)/W$];
l_i - thickness of layer [m];
λ_i - thermal conductivity of layer [W/mK];

Table 3.1: Insulation thickness and U-value of windows for different Passive house locations (Golunovs 2009)

	Mannheim	Kiruna	Helsinki	Almaty	Moscow
External wall insulation (cm)	20	60	50	50	50
Slab to the ground insulation (cm)	30	100	60	60	80
Roof insulation (cm)	15	40	40	40	40
U-value of window glazing (W/m^2K)	0,72	0,36	0,72	0,72	0,72
U-value of window frame (W/m^2K)	0,7	0,35	0,49	0,7	0,7

The interesting data is presented by Passive House Institute (2006a): "*The following table (Table 2.2) shows the thickness needed of an exterior construction, if that is solely built from the material given, to meet a typical passive house U-value of 0,13 W/(m²K).*"

Vacuum insulation can be considered as the new type of insulation and it is not widely available in the market yet. Therefore the costs are high, approximately 8 times higher compared to usual insulation (Builevics 2008). Also such fixing material as glass hobnails with strength close to metal and very low heat conductivity is innovation on the market (Builevics 2008).

The additional benefits from insulation are mentioned by Passive House Institute (2006a):

- *"During hot periods in summer, a high thermal insulation is a protection against heat;"*
- *"Insulation is efficient for energy conservation, increasing thermal comfort in existing buildings."*

Table 3.2: Building material (see Figure 2.2) thickness with U-value 0.13 W/(m²K)(Passive House Institute 2006a)

Nr	Material	Thermal conductivity	Thickness to meet U=0.13 W/(m^{2}K)
		W/mK	m
1	Concrete B50	2.1	15.8
2	Solid brick	0.8	6.02
3	Hollow brick	0.4	3.01
4	Wood	0.13	0.98
5	Porous bricks, porous concr.	0.11	0.83
6	Straw	0.055	0.41
7	Typical insulation material	0.04	0.3
8	Highly insulation material	0.025	0.188
9	Nonporous "super insulation" (normal pressure)	0.015	0.113
10	Vacuum insulation (silica)	0.008	0.06
11	Vacuum insulation (high vacuum)	0.002	0.015

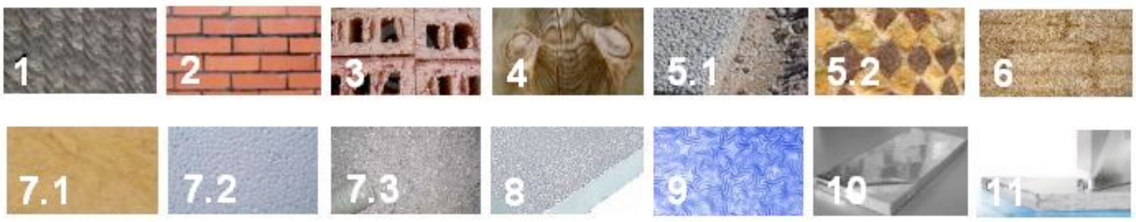

Figure 3.2: Building materials (1 - Concrete; 2 - Solid brick; 3 - Hollow brick; 4 - Wood; 5.1 - Porous concrete; 5.2 - Porous bricks; 6 - Straw; 7.1 - Mineral wool; 7.2 - Polystyrene; 7.3 - Cellulose; 8 - Highly insulation material (Heat conductivity 0.025 W/mK); 9 - Nonporous; 10,11 - Vacuum insulation)

3.1.2 Thermal bridges

Passive house has very good insulation that minimizes heat losses, but it is also important to minimize heat losses through so called thermal bridges in order to achieve better efficiency of thermal insulation, see Figure 3.3.

The larger heat transport occurs where the thermal resistance is lowest. Very often heat will "short circuit" through an element which has a much higher thermal conductivity than surrounding material. In such cases the experts call this a "thermal bridge" Passive House Institute (2006b).

Thermal bridge coefficient, Ψ, is an indicator of the extra heat losses of a thermal bridge. If is lower than 0.01 W/(mK) then building envelope is said to be "Thermal Bridge Free" (Passive House Institute 2006b).

Avoiding thermal bridges has the same importance in both stages: designing and building. In Figure 3.4 is presented good example how to avoid thermal bridges in design stage. Passive House Institute (2006b) writes that to avoid thermal bridge a porous concrete block has to be used for the first row of bricks (Figure 3.4).

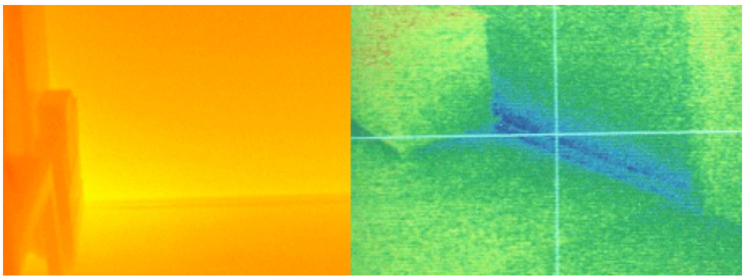

Figure 3.3: Thermal bridges in the corner of the room (color difference represents the temperature difference) (Passive House Institute 2006b)

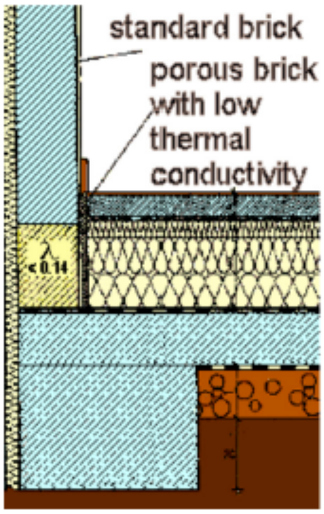

Figure 3.4: Example of avoidance of thermal bridges (Passive House Institute 2006b)

3.1.3 Air tightness

Most of the insulation materials are not airtight; therefore there is a need for airtight envelope in order to avoid moisture infiltration, exfiltration or penetration into the construction that could cause moisture damages (Figure 3.5). Hagentoft (2001) writes that in order to obtain the ventilation system's air flow through intentionally provided openings, building envelope should be airtight.

Air tightness of the building is measured at 50 Pa pressure difference between indoors and outdoors, n50. The results are presented in air change per hour, h^{-1}, in regard to the building volume.

Uncontrolled infiltrated air can not provide good air quality, therefore the mechanical ventilation system is needed. As a good example from German building code ("EnEV" Energy Saving Standard) is presented by Passive House Institute (2006c): *"Without a ventilation system the n50 – air change values have to be less than 3 h^{-1}, with ventilation systems 1.5 h^{-1}."*

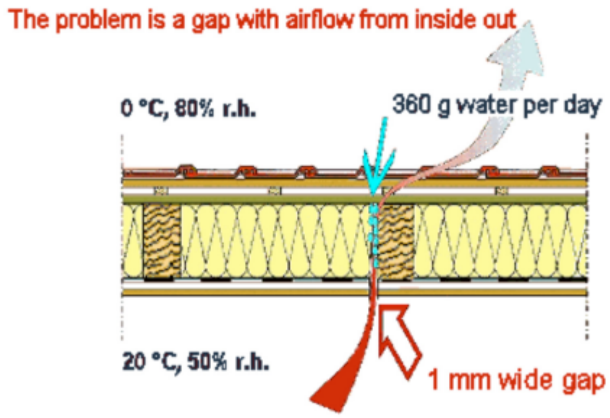

Figure 3.5: Moisture penetration (Passive House Institut 2006c)

The important note on this issue has been made by Passive House Institute (2006c) write that air tightness should not be mistaken with the function of a "vapour barrier".

After the building has been built the air tightness test should be done in order to measure air tightness, to find air leakages and, if such has been found, to seal them. During the air tightness test the exterior door are replaced with a sealed aluminium plate with a hole for a fan which either sucks or pressurizes and infrared camera indicates where air leakages is.

The typical places for air leakages are (KL Nami 2010):

- Joints between exterior and interior walls with ceilings, roof and floor;
- Joints of windows, doors and roof;
- Installations in exterior wall;
- Doors going to unheated rooms.

3.1.4 Windows, doors and shading

In typical buildings, windows have considerable heat losses; therefore in Passive house this should be minimized. In Passive house the main part of the windows is oriented to south in order to gain more solar heat. Building.lv (2009) research showed that windows oriented south gain more heat than they lose. And if windows could be closed with shutters during the night time, heat losses will be decreased to a minimum.

According to Feist (2006b after Feist 1995), additional movable airtight sealed insulating panels in front the windows, provides the possibility to reach "zero-heating energy house"

Referring to Janson (2008), well dimensioned window overhangs are important to let the winter sun enter the building while the summer sun is shaded to avoid overheating.

According to Feist (2006f), top windows should be placed southern, bottom windows - northern, as this position and direction of the windows allows to have more solar gains in winter and to avoid them in the summer in order to prevent overheating.

In Passive houses only highly efficient windows are used. The type of glazing and frames vary depending on climate, but three essentials should be considered, see Figure 3.6 (Passive House Institute 2006d):

- Triple glazing;
- "Warm Edge" – spacers;
- Super-insulated frames.

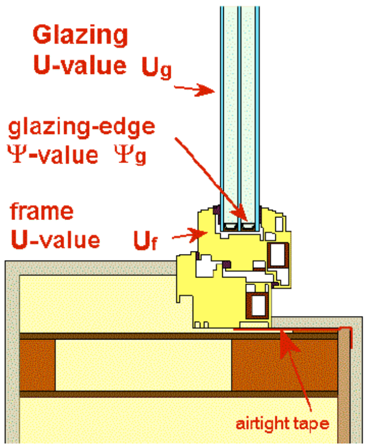

Figure 3.6: Passive house window (Passive House Institute 2006d)

U-value describes heat losses through windows and window frames. There is no other component in the building sector which quality develops so rapidly as the construction of windows (Passive House Institute 2006e). Already now, researchers in Japan developed vacuum windows with U-value 0.05 W/(m^{2}K) that is close to mineral wool property of insulation (Builevics 2008).

Windows of Passive house should be well screened with sun screens, both passive and active. Another way is to use the leafy vegetation, when in summer time trees are with leafs, they screen summer sun, but during the winter they let the sun enter (Sikander E. et al. 2009).

The same attention should be paid also for doors of Passive house. According to Janson (2008) entire doors used in apartment buildings in Värnamo, Oxtorget are 7 cm thick and have a U-value of 0.6 W/m^2K. The entry door in this case is estimated to save 200kWh per year.

3.2 Heating system

Passive houses have high insulation standard, therefore even in coldest days it is possible to adequately heat the house just preheating the fresh air entering the rooms (Feist 2006c). Passive house primary is heated by radiant solar energy (Figure 3.7), heat produced by humans, light fittings, household appliances and domestic electronic equipment (Passivhuscentrum 2010). As an additional heat source could be considered heat recovered by ventilation system (90%), DHW and sewage system (Builevics 2008).

Heating with the ventilation system is heating only with fresh air (not recirculated air) where the mass flow is limited to avoid dry air conditions and the temperature is not allowed to exceed 55°C. This type of heating will work only for buildings with very low heat requirement. This gives the opportunity to use quite smart and space saving solutions for the building services such as compact ventilation units (Figure 3.8) (Feist 2006e).

Heating by the ventilation system, so called passive heating, is one of the principles of Passive house, however as presented by Feist (2006b) the first Passive house at Darmstadt Kranichstein has radiators, but still the maximum heating loads was less than 10 W/m^2 of floor area. Feist (2006a) admits that to heat space just by heating with fresh air can work only in case if heat losses are very low.

At this moment, the more optimal technical-economic solution of the space heating system with 10W/m^2 (and lower) is replacing radiator heating system with ventilation heating system (Golunovs 2009). If the heating with ventilation system is used, the fact that heated air will be supplied only to supply air rooms should be considered.

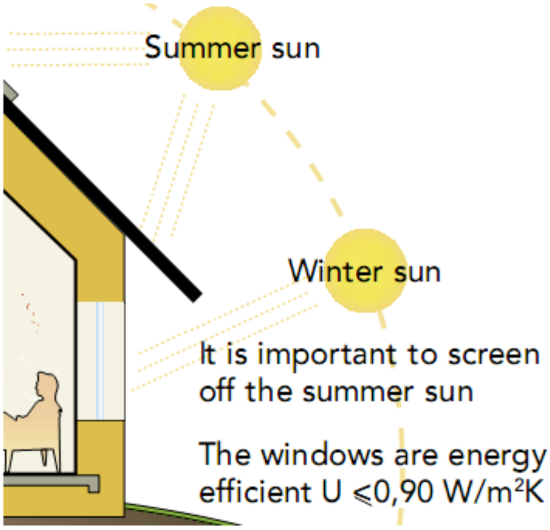

Figure 3.7: Heating by solar energy in winters (Passivhuscentrum. 2010)

Heating, ventilation, domestic hot water (DHW) and cooling (if it is necessary) can be supplied by one appliance, showed in Figure 3.8. Here heat generation can be chosen from following solutions (Feist 2006d):

- Heating with the remnant energy of the exhaust air: compact unit with heat pump;
- Heating using biomass: the pellet compact unit;
- Heating with condensing units: a compact unit using natural gas.

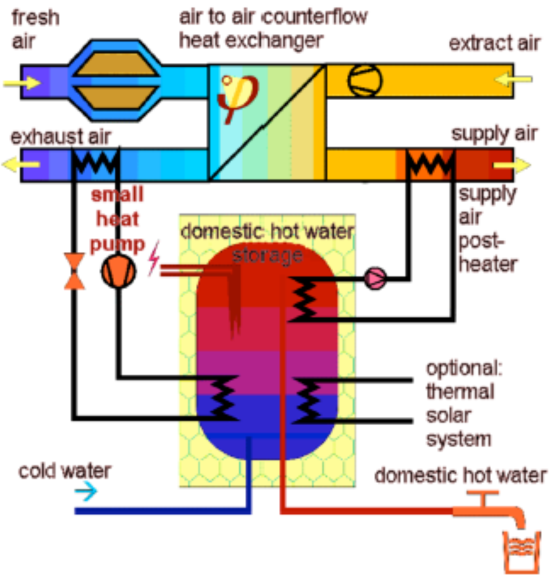

Figure 3.8: Combined appliance for heating, ventilation, DHW (Feist 2006d)

3.3 Domestic hot water (DHW)

When the heat losses through external walls are minimized, the domestic hot water represents the highest energy source in house. Solar heating for DHW is recommended in Passive houses (Passivhuscentrum 2010).

For primary heating the hot water is heated using a vacuum tube solar collector. Secondary heating could be done using natural gas or another heat generation solution. The solar thermal system provides about 66 % of DHW (Feist 2006b). DHW could be prepared by the combined appliance such as showed in Figure 3.8 (p.23).

Feist (2006b) also writes that an efficient hot water distribution network is important, where pipe network are designed to be compact and well insulated.

3.4 Air conditioning system

Passive house does not have active cooling due to very good thermal insulation, but to ensure high thermal comfort during summer, well designed shading and sufficient ventilation are important (Passive House Institute 2006a). In Figure 3.7 (p.23) is showed also passive cooling, when the summer sun is screen by shading.

3.5 Ventilation

Mechanical ventilation is an irreplaceable part of Passive house because of many reasons. It is not possible to use efficiently energy with random opening of windows as well as good indoor air quality can not be ensured in this way. The scheme of ventilation system is shown in Figure 3.9. Heat recovery in ventilation system with heat exchanger is the main energy saving action in the building (in practice it can recover up to 95% of heat from extract air).

Passive House Institute (2006f) writes that polluted air is removed constantly out of all room with significant air pollution, such as kitchen and bathrooms. Fresh air is supplied to substitute the removed air to the living room, children’s room, sleeping rooms and working rooms. In this way also cross flow ventilation principle can be achieved.

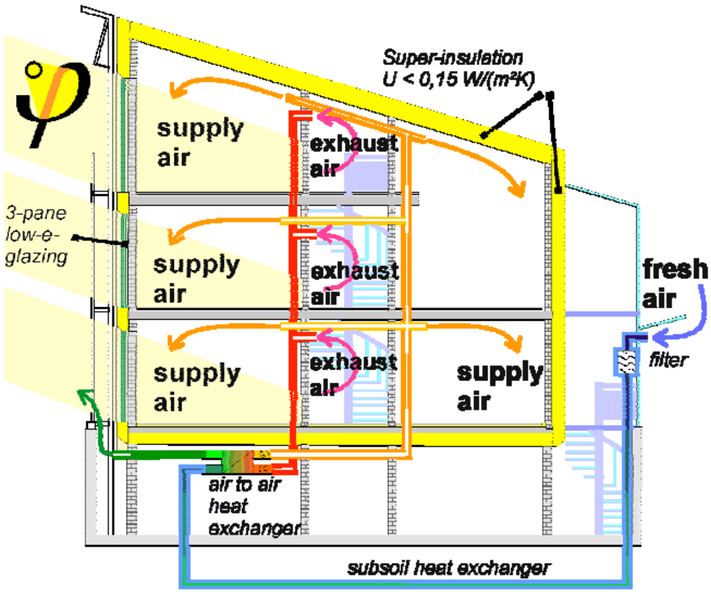

Figure 3.9: The scheme of ventilation system ("*Stale air (pink) is removed permanently from the rooms with the highest air pollution. Fresh air (orange) is supplied to the living rooms.*" (Passive House Institute 2006f)) (Feist 2008)

It is essential that the ventilation system (not only in Passive house) can provide high indoor air quality. Feist (2006e) writes that the mechanical ventilation system is the most appropriate for Passive house for the following reasons:

1. Opening windows at regular intervals is impractical and unacceptable and uncontrolled infiltration through cracks in the building envelope is inadequate. If the ventilation is inadequate, the indoor air quality will be unhealthy and there will be significant risk of condensation. Uncontrolled warm and humid air leakages can lead to moisture problems inside the construction;
2. Exhaust fan ventilation system are not suitable for Passive houses, because cold air is supplied to the rooms that lead to high heat losses. The resulting annual energy consumption for heating in this case will be at least double that of a truly Passive house;
3. Mechanical supply-exhaust ventilation are the most appropriate for Passive house (Figure 3.9):
    a. Controlled supply and exhaust air system is most suitable for an appropriate distribution of fresh air and an sufficient volumes of extract air;
    b. The principle of cross flow ventilation allows an optimal utilization of the fresh air (Figure 3.10);
    c. Supply and exhaust ventilation systems open the opportunity for heat recovery from the exhaust air to the incoming fresh air (Figure 3.11);
    d. There is the opportunity to heat the rooms by heating the supply air (heating with the ventilation system) in Passive house.

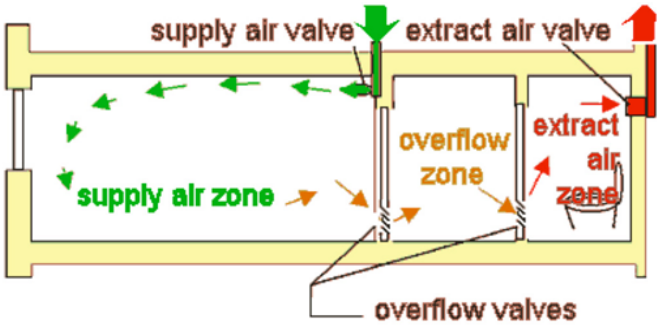

Figure 3.10: Cross flow ventilation (can ensure good indoor air quality by small air flows) (Feist 2006e)

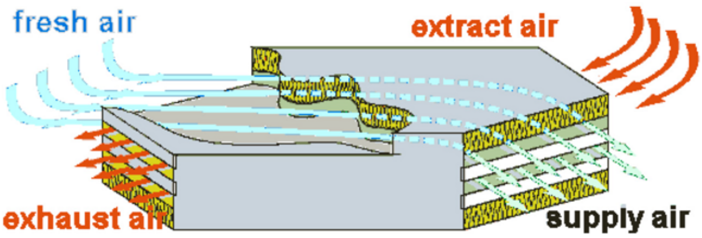

Figure 3.11: Heat exchanger, counterflow air-to-air (The warm air delivers heat to the plates. This air leaves the exchanger cooled. On the opposite side of the exchanger plates the fresh air flows in separate channels. This air will absorb the heat and it will leave the exchanger with a higher temperature)(Passive House Institute 2006f)

Feist (2006e) also points out that besides the heat recovery in ventilation system with heat exchanger is the main energy saving action in Passive house, it has also few following additional advantages:

- A distinct separation between exhaust and fresh air;
- Requires only a small amount of electricity to run (very energy efficient ventilators - EC-motors (Passive House Institute 2006f));
- Extremely quiet;
- Increase the temperature of the supply air to a value quite near to the room air temperature;
- Opens the opportunity to reduce the peak heating load and to reduce the cost for heat distribution throughout the house.

As can be observed in Figure 3.9, counter flow air-to-air heat exchanger is carefully sealed and thermally insulated (Feist 2006b). Ventilation air ducts are located as follows: “cold” air ducts are located in external part of insulation, “warm” air ducts in interior part of insulation (KL Nami 2010). Also this can be observed in Figure 3.9. With this technology of heat recovery the recovered heat is 8 to 15-times higher than the electricity needed (Passive House Institute 2006f).

Passive House Institute (2006f) writes that Earth buried ducts can be used to improve the efficiency of ventilation system. As ground has higher temperatures in wintertime and lower in summertime compared with outdoor air temperature, there is possible to preheat fresh air in an earth buried duct in winter, or to cool it in summer. Builevics (2008) point put that additional opportunity to preheat air could be ventilated roofs.

Only high quality ventilation technology with highly efficient heat recovery is suitable for Passive houses (Feist 2006e; Passive House Institute 2006f).

3.6 Lighting and equipment

Passive houses have high requirements for energy efficiency and it concerns all energy consuming units, including lighting and equipment. As now the main energy consumption for heating is reduced by the using good insulation and DHW is preheated by the solar collectors, the next largest energy consuming part could be considered - lighting and equipment.

Intelligent Energy Europe (2006 after European Commission report) presents that "*The energy demand in households accounts for 25% of the final energy needs in the EU. Electricity used for domestic appliances in households show the sharpest increase. Higher standards of living and comfort, multiple purchases of electric appliances and the growing need for air-conditioning are main reasons for this trend to prevail. Energy consumption by consumer electronics and new media as Internet is also steadily growing.*" Therefore it is important to apply energy efficient lighting and equipment in order to save energy. Another thing concerning household appliances is that they could be not considered as a part of a house that means they could be independent from designers of builders of the house. Also it means that the choice of particular household appliance and maintenance of it will be upon people living in the house.

To influence the choice of the appliance the EU has two sets of legislation (Intelligent Energy Europe 2006):

- EU labelling schemes - with a purpose to market of household appliances become highly visible to the consumer;
- Minimum Efficiency Requirements - with a purpose to encourage producers of household appliances to improve the energy consumption of their product.

A-class white goods and low-energy light sources should be used in Passive house, as for example, Intelligent Energy Europe (2006) recommends to use A/B rated appliances and energy savings lamps (in Austria) and A++ appliances and A rated lighting (in UK). Passivhuscentrum (2010) in order to minimize the use of house hold electricity, recommends to avoid leaving television sets and stereo equipment in standby mode and to avoid unplug chargers which are not in use.

3.7 Location of the building

Initially Passive house was projected for typical central European climate. As to other climates, Passive house standard has to be adopted in a particular way such as in Northern and Eastern Europe the insulation should be better and less insulation could be needed in Western Europe (Feist 2007d).

3.8 Indoor climate

There is significant reduction of energy use in Passive house, but at the same time it must not be achieved by the lowering quality of indoor air or comfort. Feist (2007c) writes that "*Comfort is determined by many very subjective feelings and it is well documented that a substantial part of comfort depends on "thermal comfort".*" The main comfort affecting parameters are (Hanssen 2009):

- Air temperature;
- Radiant temperature;
- Air velocity;
- Air humidity;
- Metabolic heat;
- Clothing insulation.

Feist (2007c) presents following factors to achieve very good thermal comfort:

- The air is not too humid;
- Air speeds remain within the acceptable limits (for speeds under 0.08 m/s, less than 6 % of people will feel a draft);
- The difference between radiant and air temperature remains small;
- The difference of the radiant temperature in different directions remains small;
- The room air temperature stratification is less than 2 °C between head and feet of a sitting person;
- The perceived temperature varies less than 0.8°C within the living area.

Feist (2007c) writes that by achieving the passive house standard requirements all comfort criteria are automatically fulfilled – improving the thermal insulation, thermal comfort is improved. Thanks to good insulation of the Passive house there is a smaller temperature difference between room air and the interior surfaces both in summer and in winter. The same applies to windows - meaning small temperature difference between window surface and room air. *"As the temperatures of the internal surfaces are almost the same as the indoor air temperature. This leads to a very comfortable indoor climate and avoids damages caused by the humidity of indoor air."* (Passive House Institute 2006a).

The amount of the relative humidity in the indoor air of a building depends on the following critical variables (Feist 2007b):

- The intensity of the internal sources of moisture (flowers, cooking, drying);
- The quantity of fresh air supplied.

The water vapour generated by the internal sources is diluted by the supply of fresh air. This dilution effect is particularly strong in the winter, when cold air outside contains very little water vapour. If during standard ventilation the air humidity appears too low for the inhabitants, there is an easy remedy: decreasing the outside air flow rates (Feist 2007b).

Good Passive house thermal protection of all external construction components leads to warm interior surfaces so no condensation occurs even if room air humidity is 60% (Feist 2007b). But these houses are still at risk as regards moisture damage. Moisture damage can appear in the construction from moist room air exfiltration (Passive House Institute 2006c). As one of the innovation the enthalpy recovery ventilators now are available which recover humidity in addition to heat (Feist 2007b).

Regarding materials used in Passive house, in the first Passive house in Kranichstein, German, the interior finish materials were selected to create as little indoor air pollution as possible. Feist (2006b after Rohrmann 1994) writes that the insulating materials are isolate from the interior by continuous interior plaster and/or completely airtight membranes.

Well designed shading and sufficient ventilation are also important to ensure high thermal comfort during summer (Passive House Institute 2006a). In addition the Passive houses are comfortly warm in winter, as presented by Feist (2006b after Feist (1997b)): *"Even the ice cold winter 1996/9, during which temperatures fell well below normal for several weeks causing comfort problems in many conventionally heated houses, it was always comfortable warm in the passive houses. Not only that, but heating energy consumption remained low (under 11 kWh/(m²a))."*

Builevics (2008) writes that in some cases there are comfort limitations living in Passive house. Thermal environment of low energy and Passive houses is said to be good in winter, whereas in the summer, spring or autumn low energy and Passive houses could have over temperatures (Sikander E. et al. 2009 after T Bostrom et al. (2003) and M Nordberg (2008). The greatest risk of over temperatures is probably linked to solar radiation through windows. Therefore, proper sun screening, both passive and active, should be considered. To prevent over temperatures Sikander E. et al. (2009) propose to pay attention to:

- Window size and placement;
- Sun screening (passive, active);
- More even temperature is achieved by using windows with a heavy frame;
- Airing Facilities;
- Ventilation, which uses the night cooled outside air;
- Building design and location;
- To assess the risks of the temperatures, dynamic simulations should be performed.

It is important to consider the risk of over temperature due to heat exchanger. It requires that ventilation system has a decoupling or bypass of heat exchanger function when there is no heating (Sikander E. et al. 2009).

3.9 Energy use

According to the energy conservation principle, no energy can disappear. However it can escape ("energy loss"), it can move to another place or change its form. Energy balances in this case makes sense only if the boundary (building envelope, the external surface of the insulated external building shell) is defined, see Figure 3.12. In case of heating the volume of the building is of interest. In same cases it is convenient to include passively heated or cooled parts of the building (Feist 2006f).

Feist (2006f) considers that "heating" is the substitution of energy/heat losses, therefore "heating" can be reduced to a low amount by effectively avoiding heat losses. "Heat gains" in the building are from following sources:

- Solar radiation through the window panes (so called passive solar energy);
- The energy of the electricity supply ("internal heat sources");
- Persons inside the building (energy transfers also through the envelope when the persons enter the building or nourishments are delivered).

An energy balance (the sum of the heat losses equals the sum of the heat gains) can be calculated after the heat losses and heat gains from heat sources and the passive solar energy are estimated. The minor problem of this calculation can be the determination of the solar gains which can not be utilized. However there is well validated simplified formula in European norm EN 832 (Feist 2006f).

It is important to distinguish heat load values (power in Watts) from annual consumption values (heat or energy in kWh). In a Central European climate the typical heating energy consumptions of Passive houses are some 15 kWh/(m²a) - but these are only raw figures. In Stockholm it could be up to 20 kWh/(m²a), in Roma more like 10 kWh/(m²a) (Feist 2006a). As presented by Passivhuscentrum (2010) according to the Swedish definition provided by FEBY (Forum för Energieffektiva Byggnader/ 'Forum for Energy-Efficient Buildings') the recommended value for energy use for heating in Passive house is 15 kWh. Maximum purchased energy for heating- 15kWh per square mater area.

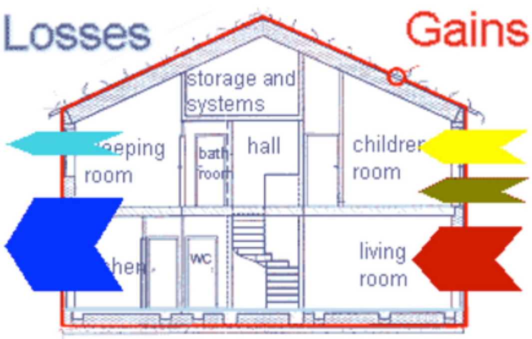

Figure 3.12: Heat losses and heat gains (Losses: transfer and ventilation losses; Gains: solar radiation, internal heat sources and persons inside the building) (Feist 2006f)

Another energy use descriptive value for Passive houses is specific primary energy demand. As it is described further, the Specific Primary Energy Demand of Passive house is max. 120 kWh/(m²a).

PHPP (The Passive House design (planning) package) is a tool for design of Passive houses and energy balance. PHPP is widely used in Europe, and as presented by Feist (2007e), PHPP includes following:

- Energy calculations (incl. R or U-values);
- Design of window specifications;
- Design of the indoor air quality ventilation system;
- Sizing of the heating load;
- Sizing of the cooling load;
- Forecasting for summer comfort;
- Sizing of the heating and DHW systems;
- Calculations of auxiliary electricity, primary energy requirements, projection of CO_2 emissions;
- Verifying calculation proofs of KfW* and EnEV** (Europe);
- Climate Data Sheet;
- Heat loads, data tables for primary energy factors, etc.
- A comprehensive handbook (PHPP use and crucial topics to be considered in Passive House design).

KfW is a German government-owned development bank
**EnEV is German energy portal (http://www.enev-online.de/)

3.10 Maintenance

An important factor in realization of the model of Passive house is the behavior of the inhabitants (Builevics 2008). As example, mechanical ventilation system (working non-stop) should be switch to a minimal mode when leaving the house and switch to a maximum when having guests at home. Windows could be opened and they have to be equipped with blinds (Builevics 2008).

Whereas Passivhuscentrum (2010) states that *"Passive house is easy to run as well as it is less demanding on inhabitants. And it is quite possible to adopt a proactive approach to energy use while living in a Passive house."*

International Energy Agency (2010a) mentions the instructions for inhabitants, that all inhabitants were instructed how to us the ventilation system. They may open windows, but they do not need to accomplish ventilation through windows. Also inhabitants should know how they can control indoor humidity. Feist (2007b) writes that remedies for dry indoor humidity levels could be achieved in following way:

- Reduction of fresh air amount;
- Adding the moisture sources in the dwellings (plants);
- Keeping the interior as dust free as possible (cleaning with a good dust filter).

The every day behaviour of inhabitants is important; avoiding television sets and stereo equipment in unnecessary standby mode, unplugging chargers that are not in use will minimize the use of household electricity. A-class white goods and low-energy light sources should be always used.

3.11 Passive house standards

The main numbers regarding Passive house in many literature sources are taken from the "Certification as "Quality Approved Passive House" Criteria for Residential-Use Passive Houses" presented by Feist (2007a). This paper could be also considered as the international standard of Passive house. It describes the criteria that should be met for the term of Passive house. Evaluation Criteria for the Certification is presented in Table 3.3.

Specific space heat demand is kilowatt hours per square meter living space yearly. In fact, specific space heat demand could vary from 10 to 20 kWh/(m²a) depending on building location and climate, as for example in northern parts this value could be higher. In Stockholm it could be up to 20 kWh/(m²a), whereas in Roma more like 10 kWh/(m²a) (Feist 2006a). Pressurization test result n50 is air change rate per hour at an artificially inducted pressure 50 Pa (n50). Entire specific primary energy demand is kilowatt hours of entire energy including domestic electricity per square meter living space yearly.

Table 3.3: Evaluation Criteria for the Certification of Passive House (Feist 2007a)

Specific Space Heat Demand	max. 15 kWh/(m²a)
Pressurization Test Result n50	max. 0.6 h^{-1}
Entire Specific Primary Energy Demand	max. 120 kWh/(m²a) incl. domestic electricity

Passivhuscentrum (2010) distinguishes Passive house standard as follows:

- <u>Basic standard.</u> Introducing heating effect at +20^{o}C indoor temperature and designed outdoor temperature: 10 W per square meter ;
- <u>Energy requirement.</u> Maximum purchased energy for heating: 15 kWh per square meter and year;
- <u>Building standard.</u> Maximum air leakage through the thermal envelope: 0.30 l/s per m^2 at +/- 50 Pa. Windows, doors U-value < 0.90 W/(m^2K). Floor, ceiling, walls U-value ~ 0.10 W/(m^2K). Noise: Minimum B class in bedrooms.

With in the project CEPHEUS (Cost Efficient Passive Houses as European Standards) around 200 housing units were built to Passive house standards in five European countries (Schnieders and Hermelink 2004). One of the goals of project was to demonstrate technical feasibility at low extra cost. Within this project the following requirements (shown in Table 3.4) were set up (CEPHEUS 2010).

Interesting is to see when the Passive house standard will become a building standard in Europe and Latvia. As presented by Passivhuscentrum (2010), in some parts of Austria the standard of Passive house is already taking place, whereas Germany is planning to achieve it by 2012. European Union tends to implement Passive house standard in 2016. As regards Latvia in this issue, Passive house standard in Latvia could be implemented within year 2016, when it will be a requirement in European Union.

Table 3.4: CEPHEUS requirements for Passive house (CEPHEUS 2010)

Passive solar gain	
Passive solar gain	Optimized south-facing glazing
	Close to 40% contribution to space heating demand
Superglazing	Low-emissivity triple glazing
	U-value ≤ 0.75 W/(m²K), solar transmission factor ≥ 50%
Superframes	Superinsulated window frames
	U-value ≤ 0.8 W/(m²K)
Superinsulation	
Building shell	Superinsulation
	U-value ca. 0.1 W/(m²K)
Building element junctions	Thermal-bridge-free construction
	Ψ (linear thermal transmittance, exterior dimensions) below 0.01 W/(m^{2}K)
Air tightness	Airtight building envelope
	Less than 0.6 air changes per hour at n50
Combining efficient heat recovery with supplementary supply air heating	
Hygienic ventilation	Directed air flow through whole building; exhaust air extracted from damp rooms
	Around 30 m³ per hour and person
Heat recovery	Counterflow air-to-air heat exchanger
	Heat transfer efficiency η ≥ 80%
Latent heat recovery from exhaust air	Compact heat pump unit
	Max. heat load 10 W/m²
Subsoil heat exchanger	Fresh air preheating
	Fresh air temperature ≥ 8°C
Electric efficiency means efficient appliances	
	Electricity slashed by 50%, without any loss of comfort or convenience
	Designed with maximum efficiency
Meeting the remaining energy demand with renewables	
	40–60% of the entire low-temperature heat demand

3.12 Examples of Passive houses

There are many Passive house examples worldwide today compared with ten years ago. Besides the increasing number of Passive houses the variety of the buildings also increases. Feist (2006b) writes that there are single family homes, row-houses, blocks of flats, several office buildings and schools as well as a factory have been built within Passive house standard. As presented by Ērgle and Baņģieris (2009) children garden building is under construction in Estonia. There is also possibility to visit Passive houses in several European countries during Passive house days when doors of Passive houses are opened for visitors during one weekend in November (Passivhuscentrum 2010).

In this chapter following examples form different countries is described:

- First Passive house, four-unit building in Darmstadt Kranichstein, Germany;
- 20 terrace houses in Lindås, 20 km south of Göteborg, Sweden;
- First Passive house in Latvia.

The Passive house in Kranichstein, Germany (Figure 3.13)(Feist 2006b)

Building envelope*:* One of the main emphases of the Passive house design and construction is heat conservation. Regarding building envelope it is good thermal insulations. Feist (2006b): writes following about Passive house in Kranichstein *"The house has an extremely good thermal insulation, which in the 16 years since occupancy, has worked outstandingly."* The descriptive values of building elements and envelope are presented below:

- Roof: 0.1 W/(m^2K);
- Exterior Walls: 0.14 W/(m^2K);
- Basement Ceiling: 0.13 W/(m^2K);
- Window: U-value 0.7 W/(m^2K); Triple pane glazing;
- Air tightness: n50value below 0,3 h^{-1}.

Figure 3.13: The Passive house, Kranichstein (Feist 2006b)

Heating & Ventilation: The second main emphases of the Passive house design and construction is heat recovery form ventilation. Passive house in Kranichstein has counterflow air-to-air heat exchanger that is located in the cellar, carefully sealed and thermally insulated and has electronically commutated DC fans. Heat recovery efficiency is approximately 80%. Also ground-coupled fresh air preheating is used. 100 m^3/h of fresh air is supplied to the living and sleeping areas. In the maximum setting, between 160 and 185 m^3/h are supplied. As it was the first Passive house radiators was still presented, but maximum heating loads during the winter were less than 10 W/m^2 of floor area (Feist 2006b).

DHW: Hot water is heated using a vacuum tube solar collector that provides about 66% of DHW. (5.3 m^2 for each household or 1.4 m^2 per person) Secondary heating is done using natural gas. Pipe network is designed to be compact, within the well insulated thermal envelope.

Energy use: Maximum heating loads during the winter were less than 10 W/m^2 of floor area.

20 terrace houses in Lindås, 20 km south of Göteborg, Sweden (Figure 3.14) (International Energy Agency 2010b)

20 terrace houses were designed to provide a pleasant indoor environment with minimum energy use. A traditional heating system has been replaced by a heat exchanger in combination with an exceptionally well insulated construction. The houses have been designed for normal Scandinavian climatic conditions.

Building envelope:

- External wall: 0.10 $W/(m^2K)$; Framed construction with 43 cm insulation;
- Roof: 0.08 $W/(m^2K)$; Masonite beams with 48 cm insulation;
- Floor: 0.11 $W/(m^2K)$; Concrete slab laid on 25 cm insulation;
- Windows: 0.85 $W/(m^2K)$; Three pane windows with two metallic coats and krypton or argon fill. Energy transmittance is 50% and light transmittance is 64-68%;
- External door: 0.80 $W/(m^2K)$;
- Air tightness: 0.3 ach at +/-50 Pa.

Figure 3.14: 20 terrace houses in Lindås (International Energy Agency 2010b)

Windows and Shading: Facade towards the south has large windows to make full use of solar heat. Balconies and roof overhang provide protection against excessive solar radiation during the summer. The roof window above the staircase gives light in the middle of the house, and is also used for effective ventilation in the summer.

Heating & Ventilation: Counterflow heat exchanger (P=70 W). It provides 80% heat recovery (η=80 – 85%). In the summer the heat exchanger can be turned off (automatic bypass) and the house ventilated by opening windows. Part of the space heating demand is covered by heat gains from the occupants, ca 1200 kWh/year and energy efficient appliances and lighting, 2900 kWh/year which partly is useful to heat the building. The remaining space heating demand is covered by electric resistance heating, 900 W, in the supply air.

DHW: Solar collectors of $5m^2$ per house provide the energy for half DHW. The 500 l storage tank is equipped with an electric immersion heater to cover the rest of the demand.

Indoor climate & Maintenance: Very low outdoor temperatures over extended periods are rare and are regarded extreme. In such cases the indoor temperature may drop by a degree or two. The houses are neither more nor less complicated to live in than ordinary houses. If it is cold outside, the occupants do not open the windows to create a through draft. If it is warm and sunny, they lower the blinds or the awnings outside the southerly windows.

Energy use: The total delivered energy demand varies between 45 and 97 kWh/m^2a for different households. Savings compared to houses built according to the national building code and practice is 50 – 75%.

- Heating of space and ventilation air (electricity: 14.3 kWh/m^2);
- Domestic hot water (electricity): 15.2 kWh/m^2;
- Fans and pumps: 6.7 kWh/m^2;
- Lighting and appliances: 31.8 kWh/m^2;
- Delivered energy demand: 68.0 kWh/m^2;
- Domestic hot water (solar energy): 8.9 kWh/m^2;
- Total monitored energy demand: 76.9 kWh/m^2;

First Passive house in Latvia (Figure 3.15**)** (Rubīna et al. 2009)

First Passive house in Latvia is two floor family building *Lielkalni* that is located in Ģipska, rural municipality of Roja, region of Talsi (Ērgle and Baņģieris 2009). Passive house technical solutions were adapted to Latvian climate conditions. Latvian climate is colder in comparison with central Europe climate. Theoretical and practical advices were based on Darmstadt Passive house experience (Building.lv 2009).

Building envelope:

- Roof: 0.068 W/(m^2K);
- Exterior Walls: 0.065 W/(m^2K);
- Basement Ceiling: 0.049W/(m^2K);
- Window: 0.8 W/(m^2K);
- Doors: 0.9 W/(m^2K);
- Air tightness: 0.53 ach at +/-50 Pa.

Heating & Ventilation: Heating with heat pump. Heat pump provides heat to ventilation air and some small power floor heating areas. Heating is provided by ventilation system and floor heating. Ventilation system has heat exchanger.

DHW: In addition to heat pump - 250 l boiler.

Energy use: Space heating: 12 - 18 kWh/m²a.

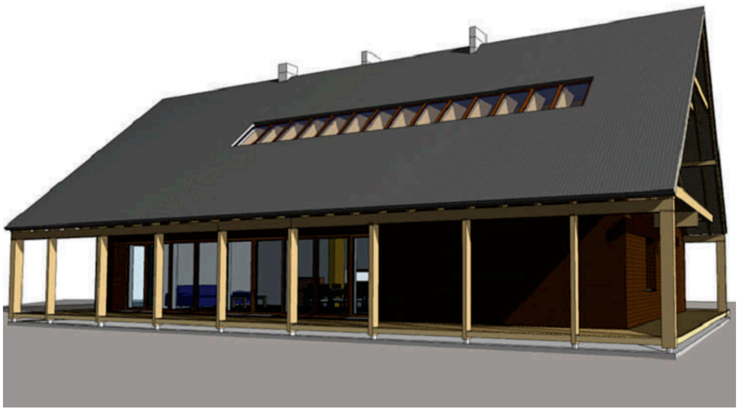

Figure 3.15: First Passive house in Latvia (Rubīna et al. 2009)

Nowadays, number of Passive houses is rapidly growing across Austria, Germany and Switzerland. In January 2004, in Germany alone more than 4000 dwelling units have been built in a Passive house standard (Janson 2008).

3.13 Short summary - Energy efficiency requirements for Passive house

Passive houses have high requirements for energy efficiency and all building components there are optimized to reduce the need of energy. A good insulation is applied continuously around all building envelope, besides that building envelope should include also:

- Envelope without thermal bridges;
- Airtight envelope;
- Highly efficient windows and external doors.

A good insulation minimizes heat losses so low that house can use passive heating and cooling. To heat the house is possible just a preheating of fresh air entering the rooms. The primary heating of DHW is provided by vacuum tube solar collectors (about 66% of DHW). Secondary heating could be done using another heat generation solution.

Passive cooling is provided by insulation that minimizes heat gains, well designed shading and sufficient ventilation air flow rates. Passive houses have high quality mechanical supply-exhaust cross flow ventilation system with highly efficient heat recovery (counterflow air-to-air heat exchanger, heat recover up to 95%) and very energy efficient ventilators. A-class white goods and low-energy light sources should be used in Passive house.

The significant energy reduction in Passive house should not be achieved by the lowering indoor air quality or comfort. In winter thermal environment of a Passive houses is good whereas more attention should be paid to summer, spring and autumn time, because the over temperatures could be possible. Energy use in a Passive house is set by an Evaluation Criteria for the Certification of Passive House and it requires following:

- Specific Space Heat Demand - max. 15 kWh/(m^2a);
- Pressurization Test Result n50 - max. 0.6 h^{-1};
- Entire Specific Primary Energy Demand - max. 120 kWh/(m^2a) incl. domestic el.

An important factor in realization of the model of Passive house is the behaviour of the inhabitants. Careful design and accurate workmanship are the prerequisites to energy efficiency success in a Passive house. Fixing the problem after the house is built can be difficult and costly.

Around 700 mm thick insulation will be required for Passive house in Latvian climate. Passive house standard in Latvia could be implemented within year 2016, when Passive house standard is going to be a requirement in European Union.

4. Technical-economic aspects

Janson (2008) writes: "*The Passive House concept is not an energy performance standard, but a concept to achieve high indoor thermal comfort conditions at low building costs.*" Due to this fact and fact that in general all projects and building services should have economic justification, some analysis to asses the viability of one or another appliance in the building should be done.

The available literature on the topic of Passive house economics is mainly case studies where the data presented is for exact case. It would not be appropriate to assume any average number, as well as data can vary from project to project depending on many factors. Therefore this chapter is based on 5 following case studies:

Case 1: Study investigates 11 Passive house projects with more than 100 dwelling units (Germany, Sweden, Austria, Switzerland and France). The aim is to test and provide the viability of the Passive house concept at the European level (Schnieders and Hermelink 2004).

Case 2: Study investigates four Passive house demonstration projects (south-west of Sweden): three new constructions and one renovation project. The aim is to practically participate and to find guiding principles and tools needed for Passive house planning and make the system solutions usable for planning in more general terms (Janson 2008).

Case 3: Paper describes an example analysis of a single family house (Germany). The aim is to analyze profitability to build a Passive house (Feist 2007d).

Case 4: Study investigates four building types in Belgium: Passive house, low-energy house with mechanical ventilation, a common price house with natural ventilation, and a normative house according to the actual energy performance regulation. The aim is to analyze the life cycle costs and payback period of a retrofitted one familiar house in Belgium (Versele et al. 2009).

Case 5: Study investigates three building types in Belgium: the standard house, the low-energy house and Passive house. The aim is to perform an economic analysis in order to determine the economic viability of all three building types (A. Audenaert et al. 2007).

Low energy buildings are house that use less energy than a traditional houses, specific heat demand in such kind of building are 30 kWh/m^2a to 20 kWh/m^2a.

4.1 Costs of PH

"*The improved construction quality of the building envelope and the highly efficient ventilation systems in Passive Houses require extra investment.*" (Schnieders and Hermelink 2004). As presented by Audenaert et al. (2007) and Janson (2008), the specific extra costs of a Passive house are:

- Costs for heating;
- Costs for ventilation (by-pass function);
- Costs for isolation;
- Costs for windows and entry doors;
- Costs for air tightness (measurements of air tightness);
- Costs for very energy efficient (energy class A++) white goods;
- Costs for ground works;
- Costs for differentiation in net floor surface;
- Miscellaneous costs.

As can be seen in Figure 4.1 below insulation (64%) and ventilation (27%) represents the biggest extra costs for Passive house. In this case, in Case 5, Passive house has the total extra cost of approx. 44,000 EUR. In this study it was also calculated that the extra cost of Passive house is 16% in comparison with the standard house (Audenaert et al. 2007).

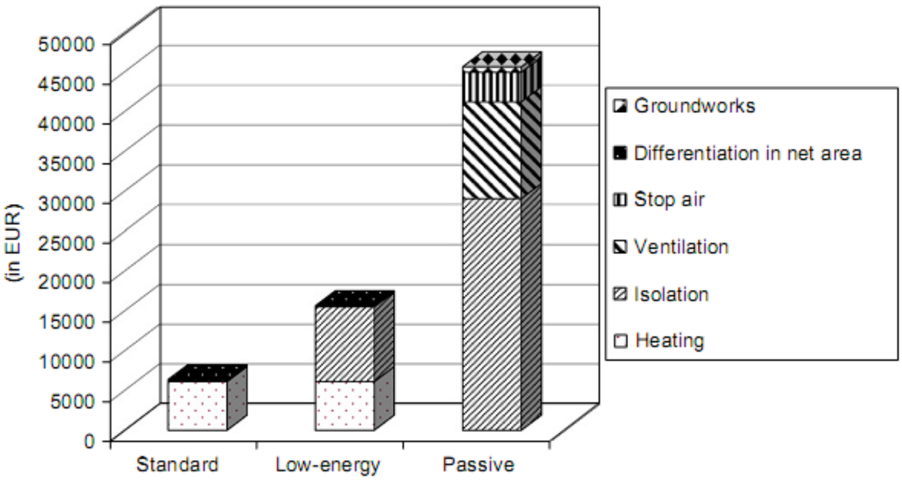

Figure 4.1: Analysis of the specific additional costs of three building types, Case 5 (Audenaert et al. 2007)

In Case 1, in total, the extra costs (construction and engineering system investment) is between 0% and 17% of the pure construction costs. On average, the specific extra investment cost is 91 EUR/m^2 or 8% of total building cost (Schnieders and Hermelink 2004). In Case 3 the additional costs for Passive house is 15,000 EUR, which is about an 8% increase in construction costs compared to the German average Feist 2007d. As to a retrofit project, Case 4, the additional investment costs for Passive house retrofit scenario is 27.0% compared with the normative scenario (Versele et al. 2009).

The total costs of a Passive house in Case 5 is 283,401 EUR and 1349.5 EUR/m^2, while in Case 2 the cost of Passive house is 17,898 – 14,500 SEK/m^2 depending on project. That is approximately 1789.8 – 1450.0 EUR/m^2. The total costs of Passive house were not given in all papers, therefore the total costs of Passive house were calculated from the given values. Results are presented in Table 4.1. In addition, in Table 4.1 are presented data about 1st Passive house in Latvia (a) (Ērgle and Baņģieris 2009) and standard house in Latvia (b) (Latvijas statistika 2010).

Table 4.1: The total costs of Passive house in 5 cases studies (a- 1st PH in Latvia, b- standard house in Latvia)

Case	Year	Floor space	Additional costs			Total costs		Heating demand
		m^2	EUR	EUR/m^2	%	EUR	EUR/m^2	kWh/m^2
1	2004	-	-	91	0-17 (8)	-	1137.5*	7-37
2	2008	-	-	-	-	-	1789.8 - 1450.0	12.6-15.2
3	2007	149	15000	101*	8	187500*	1258.4*	14
4	2009	134	5664*	341*	27	214718	1602	15
5	2007	210	39090*	186*	16	283401	1349.5*	15
a	2009	178	-	-	10—20	-	-	12 - 18
b	2006	100-300	-	-	-	-	1235-1255	~230

* calculated values

Since working group on economical Passive houses started to work, the extra costs for Passive houses have been reduced from over 50,000 EUR to between 6,000 and 15,000 EUR per unit. Moreover, Feist (2006b) writes that *"progress is not just based on quantity, because of the increasing number of Passive House components on the market, implementation prices are also shrinking."*

Schnieders and Hermelink (2004) have the same promising view. They write the following: "*The additional investment costs of the Passive House standard may be expected to decrease significantly in the future. Thermal insulation is already relatively inexpensive, whilst suitable windows and high efficiency ventilation systems make up for most of the additional costs. If Passive House windows with triple glazing were mass produced, they might cost about 10% more than conventional windows with double glazing. Compact building services, on the other hand, need not be much more expensive than a common refrigerator. By analyzing the development of investment costs it is expected that within a few years building Passive Houses will be economical even at present energy prices."*

4.2 Annual costs of PH

The additional costs of a Passive house invested in energy efficiency of the building are supposed to be paid back by the annual energy savings provided by this obtained energy efficiency. As to annual costs, they can vary in a quite wide range depending on affecting factors, such factors are energy costs, inflation, governmental support etc. (described in one of the following chapters). One is clear, the principle of annual costs line during the life time of the building.

The appropriate way to see the annual costs of a Passive house is to see them in comparison with the annual costs of the Low energy house as it is presented in Figure 4.2 by Feist (2007d), Case 3. In figure we can see forty year total costs development including fixed and operational costs with the predicted ownership costs over a 30 year period. Only after 30 years when the fixed costs are paid, family can enjoy the benefit of small energy bill due to profit from reduced energy costs.

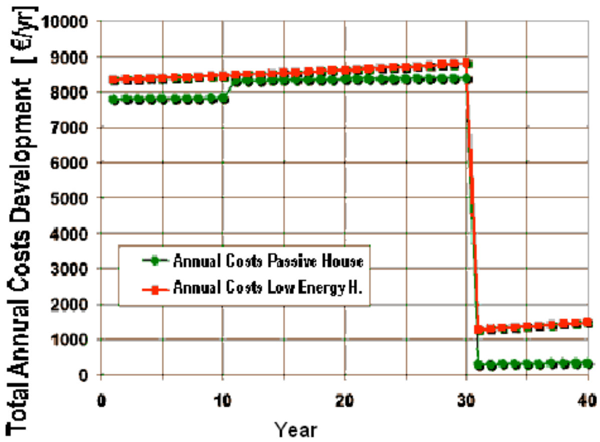

Figure 4.2: Total annual costs of Passive house and Low energy house (Feist 2007d)

In Case 5 (A. Audenaert et al. 2007) are presented annual cost analysis for Passive house, Low-energy house and standard house. The emphasis here is on strong impact of an annual growing rate of the energy costs. Therefore no average annual cost figures or numbers are presented. After 20 years Passive and Low-energy house have a positive impact on the annual family budget, because of the paid mortgage and the remaining energy saving. An analysis performed with energy sources different from natural gas, which is the classical energy source in Belgium for house heating, could give new results (Audenaert et al. 2007).

As to energy savings, the cost of the heat saved in Passive houses determined in Case 1 in average is 6.2 Cent/kWh, while the present reference costs of final energy is 5.1 Cent/kWh in the CEPHEUS projects (Schnieders and Hermelink 2004).

4.3 Pay back time

As Passive house requires extra investment, any additional investments of the building will prolong the pay back time as long as this investments won't save any energy or money. Also Audenaert et al. (2007) admits that the additional cost can be partially returned by the saving in energy consumption.

There are many different opinions about the pay back time of Passive house. Some of them would state that Passive houses would never pay back, while others would promise even a profit with a single family Passive house (Feist 2007d). Also Feist (2007d) states that at the present economic conditions in Germany and Austria Passive house can be paid back if it is properly planned and built.

Pays back

Schnieders and Hermelink (2004) write that "*A good measure for economic appraisal (*assessment*) is provided by determining the costs of the energy conserved.*" Also Feist 2006b) admits that because of the energy conservation the Passive house "pays itself back" if an average future price for heating oil or natural gas are € 6 cent/kWh. Today these fuels often cost even more.

Very promising point of view has Passivhuscentrum (2010), where is stated that Passive house with the minor additional expenses thanks to improved insulation and heat-exchanger based ventilation are recovered within a few years through a reduction in energy costs.

Does not pay back

Schnieders and Hermelink (2004) admit that in most of the CEPHEUS sub-projects it was not possible to reduce the overall costs of building services.

Depends

Versele et al. (2009) writes that the payback time depends on the energy price evolution and Passive house is justified economically when energy prices increase with 8 to 10% every year over the next 40 years. Also Audenaert et al. (2007) specify that pay back time it is very dependent on the growth of the energy prices.

4.4 Technical-economic analysis of insulation

In Figure 4.1, was showed insulation represents 64% of additional investment costs of Passive house. Therefore the proper analysis of insulation is needed in order to find out the most reasonable choice from technical and economical point of view.

Feist (2006c) presented (see Table 4.2) the typical heat losses for different external walls and annual costs caused by heat loss of external walls with area of 100 m². Typical central Europe temperatures are used: winter temperature -12 °C outside and 21 °C inside.

It is a wide spread believe, that super insulation, like it is used in Passive houses, does not pay back, while Table 4.3 shows the opposite. In the first row, the values for a typical external wall of an old building are given. Some 536 EUR have to be paid every year just to compensate the heat losses through 100 m² of this wall. With an additional insulation used in Passive houses the heat losses is reduced. The annual costs of the energy loss now are lower than 54 EUR/a. That means: 482 EUR/a cost reduction for heating according to Feist (2006c).

Table 4.2: The typical heat losses for different external walls and annual costs caused by heat loss of external walls with area of 100 m (Feist 2006c)

U-value	Heat loss	Annual heat loss	Annual costs of heat loss of external walls
W/m^2K	W	$kWh/(m^2a)$	EUR/a
1.00	3300	78	429
0.80	2640	62	343
0.60	1980	47	257
0.40	1320	31	172
0.20	660	16	86
0.15	495	12	64
0.10	330	8	43

Table 4.3: Annual costs of heat loss of external walls depending on U-value of the wall (Feist 2006c)

U-value	Heat loss	Annual heat loss	Annual costs of heat loss of external walls
W/m^2K	W	$kWh/(m^2a)$	EUR/a
1.25	4125	98	536
0.125	412	10	45

4.5 Main factors affecting economic aspects

From the chapters above, the obvious fact was that total costs, annual costs, pay back time as well as technical-economic analysis of Passive house strongly depend on the following factors:

- Energy costs;
- Energy source;
- Inflation;
- Bank loan;
- Governmental support;
- Other.

Energy price

Audenaert et al. (2007) state that the impact of the Passive house is strongly dependent on the evolution of the energy prices. As is described in Case 5, in the case the energy prices increase with 5%, the impact on the family budget is negative over a 20 year time, in the case with 10% - the Passive house becomes just rentable and in the case of an annual growth of 15% - the Passive house becomes very profitable (Audenaert et al. 2007). Audenaert et al. (2007) also admit that a low-energy house is the safest choice at this moment, because the energy prices in the future is unpredictable. Also the payback period varies according to the energy price evolution. The same opinion have Versele et al. (2009).

Energy source

The influence of energy source on a Passive house economics are presented by Audenaert et al. (2007). In Case 5 for energy cost calculations the natural gas was considered as energy source. As it is a relatively cheap energy source in Belgium, the replacement of it with some more expensive energy source would cause more favorable results for Passive house.

Inflation

Inflation is also one of the influencing factors on Passive house economics. In this case it is not direct, inflation influences such things as energy price and interest rate. Feist (2007d) states that "*Energy price increase equal inflation rate of 1,6% per annum (nominally).*" As well as the market interest rate is strongly influenced by the inflation rate (Feist 2007d).

Bank loan

When the house is financed by a mortgage from a bank, in this case, the interest rate and repayment of capital (disbursement) have to be paid regularly during fixed period of time. All three issues: the interest rate, repayment of capital (disbursement) and time to repay the capital could influence total costs, annual costs, pay back time and technical-economic analyze of a Passive house.

Governmental support

In some countries, as for example in Germany, Austria and Belgium, government stimulates energy efficiency in buildings by the lower interest rates and subsidies. The KfW bank in Germany promotes the building of Passive houses with a low-interest loan of 50,000 EUR (Feist 2006b). At the same time Feist (2006b) admits that "Even without *the promotion, the implementation of Passive Houses has increased sharply in the last few years.*" In Belgium it is possible to receive subsidies to build energy-saving houses at different governmental levels such as national, provincial and municipal Audenaert et al. 2007. As to a Passive house Audenaert et al. (2007) write that "*When energy-saving buildings are to be promoted at a large scale, governments should aid with larger subsidies to make passive houses more attractive to individuals planning projects in the residential sector*."

Different opinion on governmental support has Schnieders and Hermelink (2004):

"It is generally not a good idea to subsidize the additional investment cost of energy saving measures because the incentive for reducing the cost of the respective components would be lost. What appears to be more helpful is the support of additional planning efforts or quality assurance. Fixed subsidies for reaching a certain efficiency level might be helpful, too. Further- more, politics could financially support demonstration and dissemination: guided tours, test living in realized buildings, production and distribution of information material."

Other

Feist (2007d) w*rites* that at present economic conditions in Germany and Austria Passive house is paid back if it are properly planned and built.

All above mentioned factors can greatly influence the economics and technical-economic analysis of a Passive house, fore that reason it become a complicated process. Returning back to case studies, many of them are carried out under the different conditions.

Case 5: All the analyses are performed at constant energy costs. No discount rate is taken into account. This is a partial compensation for not considering inflation. In the analyses with growing energy costs, these are discounted by the return of government bonds with duration of 20 years. Their interest rate is taken at the actual rate of 4.49%. The calculations are done making use of nominal growing rates and interest rates, eliminating the influence of inflation.

Case 3: Is assumed that the house is financed by a mortgage. The interest rate in Germany is 4.7 % and with a repayment of capital of 1.6 %. If a Passive house is built, the German Federal States Bank "Building Ecologically" credit for the "Passivhaus" can be considered. This loan has a 100% disbursement and only 2.10 % interest.

4.6 Short summary - Technical-economic aspects

The Passive house concept could be described also as a concept to achieve high indoor thermal comfort conditions at low annual building costs due to low energy demand compared with standard building. The study of technical-economic aspects of Passive house in this chapter is based on 5 different case studies.

The improved construction quality of the building envelope and the highly efficient ventilation systems in Passive houses require extra investment. The extra investment costs (construction and engineering system investment) are between 0% and 17% compared with a regular building. Additional investment costs of the Passive house may be expected to decrease significantly in the future. The additional costs of a Passive house invested in energy efficiency of the building suppose to be paid back by the annual energy savings provided by this obtained energy efficiency from investments. There are many different opinions about the pay back time of Passive house, but one is clear that pay back time of Passive house is very dependent on the growth of the energy prices. Technical-economic analysis should be made in order to prove one or another choice of building service. The following factors could strongly influence economics of Passive house:

- Energy costs;
- Energy source;
- Inflation;
- Bank loan;
- Governmental support;
- Other - proper planning and building.

5. Practical part

In the practical part of this work, ventilation system for Passive house for winter time is designed. The heat losses of the building are calculated and added to ventilation system in order to obtain heating with ventilation, as one of the Passive house prerequisites. Principles of Passive house are applied for one specific building as an alternative of standard applications. Building is not designed as Passive house initially. Additional part of practical work is the technical-economic calculations. Comparison of annual costs of two scenarios (Passive house and standard building) is carried out.

Requirements set for Passive house ventilation system are showed in Table 5.1. Drawings of ventilation system are drawn in AutoCAD program and are showed in Appendix1. All calculations of ventilation system are done in Excel and are presented in Appendix 2.

Table 5.1: Requirements set for Passive house ventilation system

Requirements	In calculations	In drawings
Mechanical ventilation system	√	√
- Air flow rate and air exchange rate	√	√
- Duct dimensions	√	√
- Components	√	√
- Pressure drop	√	√
- Sound level	√	√
Cross flow principle	-	√
Heat recovery	√	√
Preheating of supply air	√/-	-
- Heat losses	√	-
- Possibility to heat with ventilation	√	-
Subsoil heat exchanger	-	√

5.1 Description of buildings

The location of both buildings is in town Tukums, region of Tukums, Latvia. Building is 2-floor single family house with a basement and garage with total living area of $145m^2$. In following Table 5.2 main descriptive data are showed.

In order to adapt Passive house principles for standard building, the shape of the building, floor area, location of the windows and building orientation will remain the same. The following changes are assumed for Passive house compared with standard one:

- Insulation thickness;
- Air tight envelope;
- Energy efficient windows and doors;
- Active heating to passive;
- Natural ventilation to mechanical.

Building is assumed to fulfil following criteria for Passive house:

- Specific space heat demand - max.15 kWh/(m^2a);
- Pressurization test result n50 - max.0.6 h^{-1};
- Entire specific primary energy demand - max.120 kWh/(m^2a) incl. domestic electricity;
- Heat load - max.10 W/m^2.

Table 5.2: Descriptive data for two buildings

	Passive house	Standard building
Insulation W/(m^2K)	0.07	0.2 – 0.25*
Windows W/(m^2K)	0.8	1.8* (Double glazing)
Doors W/(m^2K)	0.9	2.5
Air tightness	Air tight envelop	≤ 3 h^{-1}
Heating	Passive, ventilation system	Active, wood boiler
Ventilation	Mechanical	Natural

*LBN 002-01 Heat transfer coefficient, normative value (Likumi.lv 2010)

5.2 Mechanical ventilation system

In mechanical ventilation system design first determination of supply and exhaust air amount is done. Then location of the ducts and air handling unit (AHU) is determined. Air ducts are sized to meet 1 Pa pressure drop per m. Ventilation system components are chosen from available catalogues and total pressure drop are calculated according to method presented by Ķigurs (1976). Sound level is calculated as described in Swegon (2008).

5.2.1 Air flow rate and air exchange rate

Air flow rate is based on Latvian Building Code LBN 007-09 „Higiēnas prasības būvēm" that states that fresh air supply has to be at least 0,35 l/s to 1 m^2 of floor or 4 l/s for one person to ensure comfort in living rooms. To take out exhaled air, surplus heat and air pollutants from the room at least 1 air change per 2 hours or 14 m^3 per person is needed (The Cabinet of Ministers of the Republic of Latvia 2010). Imbalance of 5% is applied. Air exchange rate is calculated as follows (Thullner 2010):

$$n=R/V \tag{4}$$

Where: n - air exchange rate, h^{-1};
R - air flow rate, m^3/h;
V - volume of building, m^3.

The results of air flow rates and air exchange rate are presented in Appendix 2.

5.2.2 Duct dimensions

Ducts are hot dip galvanized steel sheet and are sized to meet 1 Pa pressure drop per 1 m. Graph for duct sizing is taken from catalogue Air Duct Systems (Lindab 2004-2007) and is presented in Appendix 3. When cold duct (air from outside) is indoors then it is insulated. In this case no warm ducts going out of insulated envelope, therefore no warm ducts are insulated.

5.2.3 Ventilation system components

All ventilation system components are chosen from easy available catalogues. Supply and exhaust diffusers are chosen from Swegon catalogue (Swegon 2008). Bends, T-pieces, dampers, reducers, roof hoods, silencers and filter are chosen from catalogue Air Duct Systems (Lindab 2004-2007).

Air handling unit (AHU) is chosen after the pressure drop is calculated. Flexible heat recovery unit ILTO R80 with high efficiency and with EC fan motors is chosen. The extract air from the cooker hood can be connected to ILTO R80 (does not pass through the heat exchanger). Supply air EC fan motor working at 180 m^3/h and 86Pa will have 73% efficiency. Extract air EC fan motor at 190m^3/h and 70Pa - 65%. Description of AHU and all ventilation system components are presented in Appendix 3.

5.2.4 Pressure drop

Pressure drop in branches is calculated as described in catalogue Air Duct Systems (Lindab 2004-2007), Pressure drop calculation (presented in Appendix 3). System is divided in sections, scheme of the sections division and sections numbers are showed in Appendix 1. Total pressure drop are calculated according to method presented by Ķigurs (1976). According with this method, pressure drop in parallel branches cannot exceed 10% difference. Results are presented in Appendix 2.

5.2.5 Sound level

Sound level is calculated as described in Swegon (2008). Sound level generated by fans of AHU is taken from AHU description (Appendix 3). Graph for sound attenuation in ducts are presented in Lindab (2004-2007), see copies in Appendix 3. Sounds generated by dumpers and air diffuser can be read from Pressure drop - Sound level graphs (Appendix 3). Sound distribution in branches is based on principle described in Swegon (2008). Sound attenuated in branches, bends and reductions are not taken into account. Calculations are presented in Appendix 2.

5.3 Cross flow principle

Cross flow principle consists of three ventilation zones - supply, exhaust and overflow zone. All of them are applied for designed ventilation system. In Figure 5.1 below the division of ventilations zones can bee seen.

5.4 Heat recovery

Heat recovery is performed by rotary heat exchanger that is mounted in chosen AHU ILTO R80. As presented in ILTO R80 description (Appendix 3) temperature efficiency is always approximately 80%. Bypass of heat exchanger for summer time (cooling facilities) is not considered.

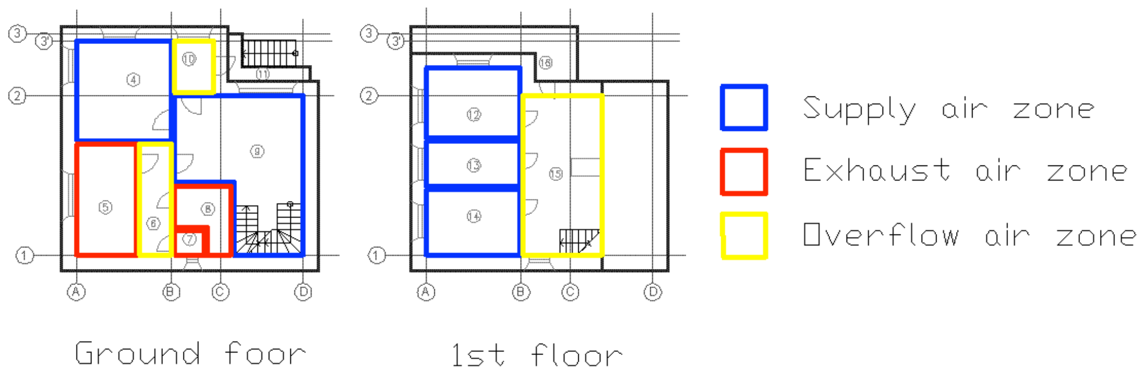

Figure 5.1: Three ventilation zones - supply, exhaust and overflow zone (drawings from Appendix 1)

5.5 Preheating of supply air

In Passive house ventilation have function of heating the supply air. In order to know how much heat will be needed, heat losses of the building should be calculated. Heat losses occur from transmission, ventilation and air leakage. Heat gains are obtained from solar radiation, internal heat sources and persons inside the building. In practical part heat losses from air leakage are not taken in to account (Passive house is assumed to be air tight). Also negligible air leakage is prevented by 5% imbalance in ventilation system. Heat loss calculation through envelope are based on Akmens and Krēsliņš (1995), it includes: heat losses from transmission and surplus (heat gains) from solar radiation. Heat gains from internal heat sources and persons inside the building are assumed (based on Norwegian standard NS 3031).

5.5.1 Heat losses calculation

Heat losses are calculated for peak load. For calculation of heat losses the following formula is taken (Akmens and Krēsliņš 1995):

$$Q = A * U * (T_{in} - T_{out}) * (1 + \Sigma\eta) \qquad (5)$$

Where Q - heat losses [W];
A - area of the walls [m²];
U - heat losses coefficient [W/(m²K)];
T_{in} - indoor temperature [°C];
T_{out} - outside temperature [°C];
$\Sigma\eta$ - the sum of additional heat losses coefficients (heat gains) from solar radiation included) [%].

Heat losses are calculated for each room, except unheated rooms (basement, balcony). Table 5.3 is taken to calculate the heat losses in Excel. Room numbers and name are presented in Appendix 1.

Table 5.3: Heat losses calculation

		Outer envelope										Additional heat losses							
Room Nr.	Name	Symbol	Orientation	Length [m]	Width [m]	Are [m²]	Uo [W/m²C°]	θi [°C] (room temp.)	θe [°C] (outside temp.)	tΔθ [°C] (θi-θe)	Q' [W]	Depending upon orientation [%]	Depending upon wind strength [%]	Depending upon room orientation(in corner) [%]	The other [%]	Coefficient of additional heat losses	Q W	Heat losses in room [W]	Notes
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

The abbreviations of outer envelope symbols are as follows:

- EW - external wall;
- W - window;
- D - door;
- F - floor;
- C - ceiling.

The abbreviations for orientation of outer envelope for celestial parts are following:

- S - south;
- W - west;
- N - north;
- E - east.

Length, width and area of outer envelope parts are measured or calculated according to drawings of the building (Appendix 1). Heat losses coefficient for standard building is taken as normative value from Latvian Construction Regulation LBN 002-01 "Ēku norobežojošo konstrukciju siltumtehnika" (Likumi.lv 2010a), where U-values in $W/m^2C°$ are as follows:

- Roof (ceiling in heat losses calculation) - 0.2 $W/m^2C°$;
- Walls - 0.25 $W/m^2C°$;
- Windows, doors - 1.8 $W/m^2C°$.

U-values for Passive house case are based on the first Passive house example in Latvia (Rubīna et al. 2009). U-values for Passive house case are rounded and they are following:

- Walls, roof, floor - 0.07$W/m^2C°$;
- Windows/doors - 0.8/0.9 $W/m^2C°$.

Room temperatures for both cases are taken from Latvian Building Code LBN 007-09 „Higiēnas prasības būvēm", II. Higiēnas prasības ēku apkurei un ventilācijai (The Cabinet of Ministers of the Republic of Latvia 2010). In premises, where people are regularly staying, heating and insulation in the cold period of the year provide temperature not lower than 18 °C (The Cabinet of Ministers of the Republic of Latvia 2010). In WC and bathroom temperature is taken 25 °C. Outside temperature for both cases are taken from Latvian Building Code LBN 003-01 "Būvklimatoloģija", Visaukstāko piecu dienu vidējā gaisa temperatūra (°C) un tās varbūtības (Likumi.lv. 2010b). In LBN 003-01 "Būvklimatoloģija", there is not climate data for Tukums town, therefore the climate data for closest city Riga is taken, -20.7 °C.

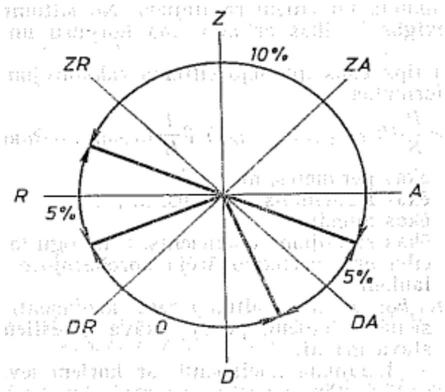

Figure 5.2: Additional heat losses depending upon orientation (D - south, R - west, Z - north, A - east) Akmens and Krēsliņš (1995)

Table 5.3: Assumed heat gains

Gains	[W/m^2]
Lighting	2.9
Equipment	2.4
Persons	1.5

Additional heat losses could be gained mainly from infiltration through outer envelope, sun radiation and wind power. Also heat could be lost through opened doors. In this case additional heat losses are calculated as coefficient, percentage form main heat losses. The additional heat losses that are included in calculation are:

- Depending upon orientation [%] - north, east have highest additional heat losses - 10 %, west - 5% and south has 0 % of additional heat losses (Figure 5.2);
- Depending upon wind strength [%] - as Passive house is supposed to be air tight, additional heat losses depending upon wind strength are taken as 0 %;
- Depending upon room orientation [%] - if room has 2 or more external walls it is suspected to be corner room and 5% additional heat losses are applied;

The results of heat losses calculations are presented in Appendix 2. Heat gains from solar radiation are included in heat losses calculation afterwards. Heat gains from internal heat sources and persons inside of the building are assumed as showed in Table 5.3.

5.5.2 Possibility to heat with ventilation

The indicator for possibility to heat with ventilation system firstly is supply air temperature. The temperature is not allowed to exceed 55 °C. As the second value maximum heating load is set to be maximum 10 W/m^2 in order to meet Passive house requirement. Heat losses calculation results are showed in Appendix 2.

5.6 Subsoil heat exchanger

Additional preheating of supply air in winters or lowering intake air temperature in summers can be done with use of earth buried ducts. Also called subsoil heat exchanger, it can be performed in two ways - with air ducts buried in the ground or with water, when PE ducts (filled with water and frost protection liquid) are buried in ground. In the second way additional water-to-air heat exchanger is needed. For short description of both ways see Krause (2007).

In case of our building subsoil heat exchanger with air is chosen. Heat that could be gained in winters is not calculated, but subsoil heat exchanger is schematically drawn, see Appendix 1.

5.7 Annual costs for heating for PH and standard house

Annual costs for heating are calculated for Passive house and standard house (SH). Passive house heating is provided by ventilation system (preheating the supply air). Heat is supplied from combined appliance (for heating, ventilation, domestic hot water). Standard house heating is provided by conventional radiator system and heat is supplied from a boiler.

Most likely, PH will run on electricity due to its low energy need and SH on wood boiler that is most common solution in towns of Latvia, where gas pipe lines are not available. In calculations it is not considered that PH combined appliance for heating, ventilation, domestic hot water is partly supplied by solar collectors. To see the annual heating cost variation depending on energy source, three cases of different energy source combinations are compared:

1. PH and SH energy source is electricity;
2. PH - electricity and SH - wood;
3. PH - wood and SH – electricity.

In all cases, the following data are taken to calculate annual costs:

- Heating period: 203 days with average outside temperature +0.0 C^{o} (Likumi.lv 2010b);
- Energy price for Latvia: electricity 0.071 LVL/kWh, wood 0.025 LVL/kWh (0.102 and 0.036 EUR/kWh respectively) (Ļebedeva 2008);
- Average energy need for heating, in kWh, is calculated for bout PH and SH as described in chapter Heat losses calculation;
- Total heated living area in both of the houses is 145m^2.

The results are shown in Table 5.4. Passive house has 2 - 19% of standard house annual costs for heating depending on energy source used. This ratio can vary if energy source or system solutions will be changed. In calculations, system losses are not taken into account, but also that factor could influence the ratio between PH and SH annual heating costs.

Table 5.4: Annual costs of heating for PH and SH

Case		Average outside temp.	Heating period		Average energy need for heating		Electricity price	Annual costs of heating	Ratio PH/SH
		^{o}C	Days	Hours	kWh	kWh/m2	EUR/kWh	EUR	%
1	PH	0	203	4872	906	6.25	0.102	92	7
	SH	0	203	4872	13471	92.9	0.102	1368	
2	PH	0	203	4872	906	6.25	0.102	92	19
	SH	0	203	4872	13471	92.9	0.036	482	
3	PH	0	203	4872	906	6.25	0.036	32	2
	SH	0	203	4872	13471	92.9	0.102	1368	

6. Discussion & Conclusion

Before the practical part was carried out, in theoretical part of this thesis Passive house was been studied in order to see the particularity of its energy efficiency requirements and technical-economic aspects. In practical part ventilation system for Passive house for winter-time is designed and annual heating costs for Passive house and standard Latvian house are calculated.

The location of building is town Tukums, region of Tukums, Latvia. Building is 2-floor single-family house with total living area of 145m^2. Building is not designed as Passive house initially. Fulfilment of requirements set for ventilation system is shown in Table 6.5.

Mechanical supply-exhaust ventilation system is designed. Air flow rate is based on Latvian Construction Regulation LBN 007-09 and air exchange rate is calculated taking building volume in to account. As well as imbalance of 5% is applied. Ducts are sized to meet 1 Pa pressure drop per 1 m. Cold ducts are insulated when they are inside of building envelope. Ventilation system components are chosen from available catalogues. AHU is flexible heat recovery unit ILTO R80 with high efficiency and EC fan motors. Pressure drop and sound level is also calculated. Cross flow principle are applied for Passive house ventilation system. Heat recovery is performed by rotary heat exchanger that is mounted in chosen AHU, where temperature efficiency is approximately 80%.

Table 6.5: Fulfilment of ventilation system set requirements

Requirements	In calculations	In drawings	Fulfilled
Mechanical ventilation	√	√	√
-Air change rate	√	√	√
-Duct dimensions	√	√	√
-Components	√	√	√
-Pressure drop	√	√	√
-Sound level	√	√	√
Cross flow principle	-	√	√
Heat recovery	√	√	√
Preheating of supply air	√	-	√/-
-Heat losses	√	-	√
-Possibility to heat with ventilation	√	-	√
Subsoil heat exchanger	-	√	√/-

To preheat supply air, firstly heat losses are calculated. Calculated maximum heat load of the building is 10.5 W/m^2 that is slightly higher than required number of 10 W/m^2. Reason of higher heat load could be building design - initially building is not designed as Passive house. Passive house requires specific and proper design to be done in initial stages of the building. As well minimal heat load increase can be caused by heat losses calculation method where solar heat gains are added as coefficient. Passive house is aimed to be build more properly and precisely compared with standard building; the same applies for design and calculations. Supply air temperature at the peak heat load is 30 °C and it is acceptable.

During the practical part, many relevant questions regarding Passive house ventilation system appeared. These questions could be studied further as future work. Heating by ventilation in wintertime and by-pass function in summer time, makes ventilation system of Passive house more complicated and important in design.

Results of annual cost calculation for heating showed that Passive house in this case has 2 - 19% of standard house annual costs for heating and it depends no energy source used. Also this ratio can vary due to different system solutions.

Conclusions regarding Passive houses in Latvia are following:

- Building of Passive house in Latvia is just started, the first Passive house was built in 2009;
- To design and build a Passive house, Passive house standard has to be adapted for Latvian climate;
- At this moment, there are few references available about technical-economic aspect of Passive house implementation in Latvia;
- Useful would be a feedback from the 1st Passive house in Latvia, in order to precede in future implementation of this kind of buildings.

The overall conclusions of this work, on the introduction of Passive house in Latvia, are that Passive house is specific type of the building that requires proper planning, design and construction; from economic point of view Passive house justification is influenced by many factors, mainly by energy price; Passive house usually do not have active heating system, instead ventilation system is equipped with function of preheating supply air. Ventilation system of Passive house is more complicated and important in design compared with standard building.

7. Further work

On bases of this work the following future work could be done:

- More could be studied regarding Passive house ventilation system, both in winter and summer time. Calculation methods and guidelines could be prepared.
- Combined appliance for heating, ventilation, DHW could be studied more closely and calculation methods could be drawn out.
- The first Passive house in Latvia could be practically explored regarding indoor environment, maintenance, expectations, comfort, and real pay pack time.
- Technical-economic aspects could be studied in detail and practical calculations could be done. Also Passive house advantage and barriers in the building market could be explored.

Abbreviations & Glossary

Air diffuser	Ventilation unit distributing air into a room
A/B, A++	Energy class for energy saving appliances
n50	Air changes per hour at 50 Pa pressure difference between indoors and outdoors
Ach	Air changes per hour
Active cooling	Cooling by use of mechanical system
Active heating	Heating by use of mechanical system
AHU	Air handling unit
AutoCAD	Computer aided design software application for 2D or 3D design
By-pass	Function of bypassing the heat exchange under specified conditions - temperature or pressure
B50	Concrete type with average strength of 655 kgs/cm^2
CADvent	An object-oriented AutoCAD© application with a complete toolbox for drafting, dimensioning, calculation, quantification and presentation of complete HVAC installations
Cent/kWh	Euro cent per kilo-Watt-hour
CEPHEUS	Cost Efficient Passive Houses as European Standards
Counter flow	Fluids flow in the opposite direction
Cross flow ventilation	Design principle, that includes three zones- supply, overflow and exhaust air flow zone; recommended to ensure good indoor air quality by small air flows
DC	Direct Current fan motors
DHW	Domestic hot water
DIN 1946	German National Standard, for ventilation and air conditioning; technical health requirements (Deutsches Institut Fur Normung E.V.)
EC-motor	Electronically commutated motor, high efficiency compared to other motor types
EnEV	German energy portal (http://www.enev-online.de/)

EU	European Union
EUR, €	Official currency of European Union, Euro
Exhaust air	Air leaving the building through an outtake
Extract air	Air leaving a room and entering the buildings ventilation system
Heat conductivity	Transfer of thermal energy, measured in W/mK
h^{-1}	Air change rate in one hour
ILTO R80	Flexible heat recovery unit
ISO 7730	International standard for Ergonomics of the thermal environment
KfW	German government-owned development bank
LBN	Latvian Construction Regulation
LVL	Official currency of Latvia, Latvian lats
MagiCAD	3D software for Building Services design
P	Power in Watts
Passive cooling	Cooling without use of mechanical system
Passive heating	Heating without use of mechanical system
PH	Passive house
PHPP	Passive House design (planning) package
PHI	Passive House Institute
SEK	Official currency of Sweden, Swedish Krona
SH	Standard house
Supply air	Air entering a room by an air diffuser
Thermal bridge	A piece of metal, such as pipe or wall tie (or any other conducting substance), that passes through a wall and carries heat through it." (Maclean and Scott 1995).
U-value	Thermal heat loss coefficient, measured in W/m^2K
"Vapour barrier"	High-quality vapour control layer, mostly used in 'warm' side of insulation, to prevent condensation, when associated with suitable ventilation from the cold side (Maclean and Scott 1995)

W/m^2K ($W/m^2C°$)	Watt per m^2 at a standard temperature difference of 1 degree Kelvin (Celsius), unit of value and measurement for heat losses through building components
η	Heat transfer efficiency, measured in %
Ψ	Thermal bridge coefficient

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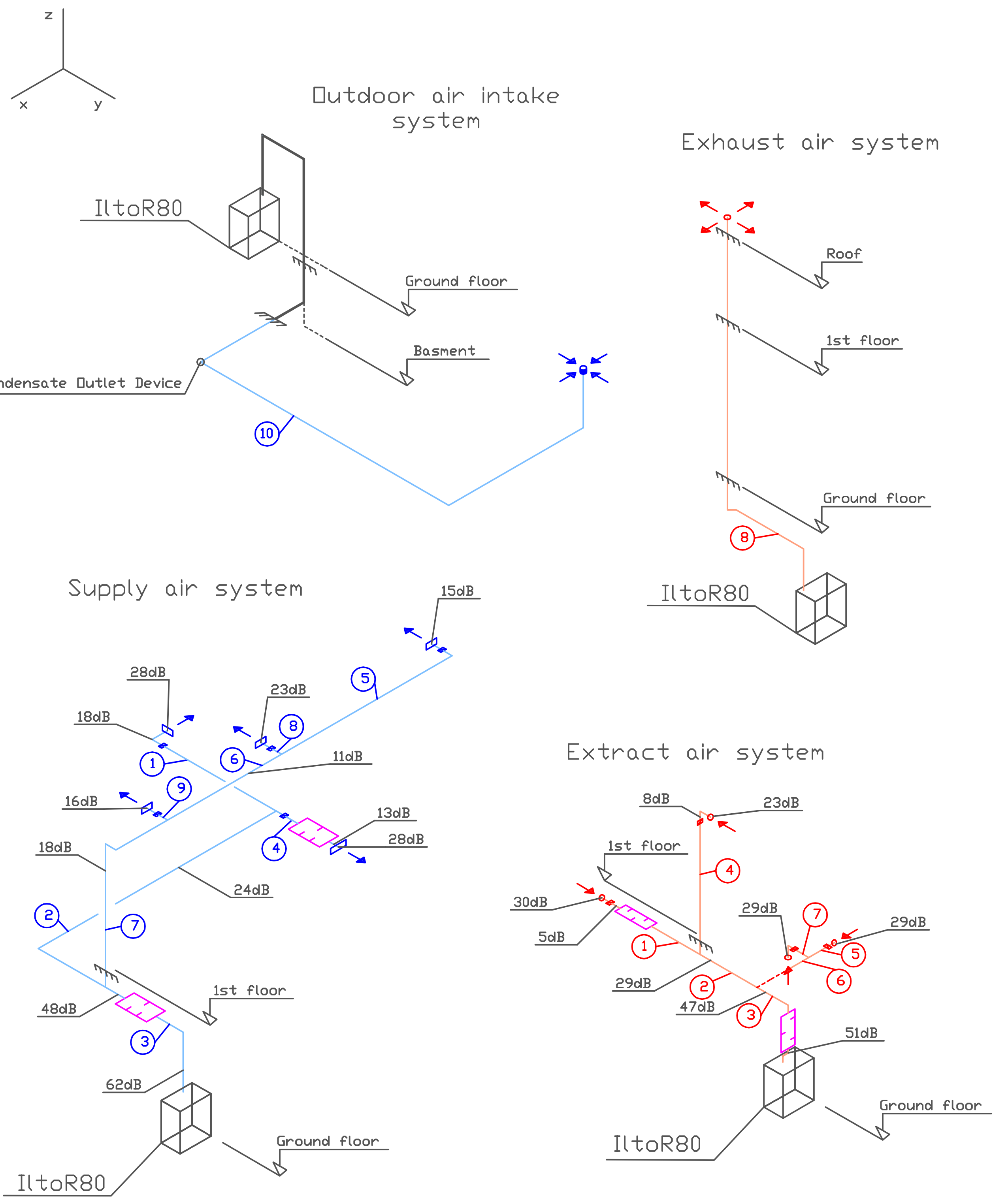
Appendix 1



Lund University
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Thesis work "Passive house for Latvia"

Practical part
Ventilation system

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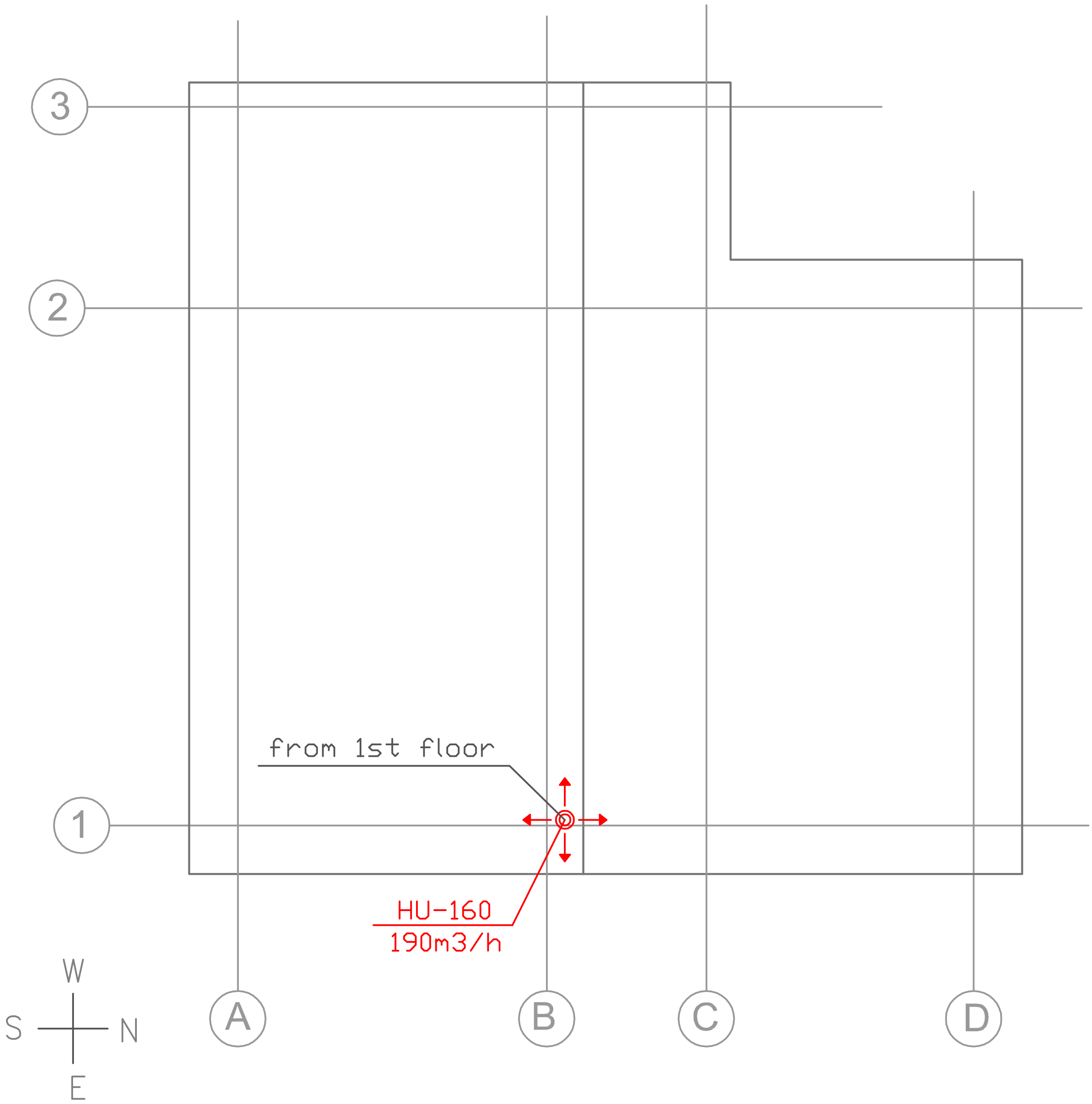
Student	A.Antonova		

Axonometry, sound level and section division

Exchange student
860614P722



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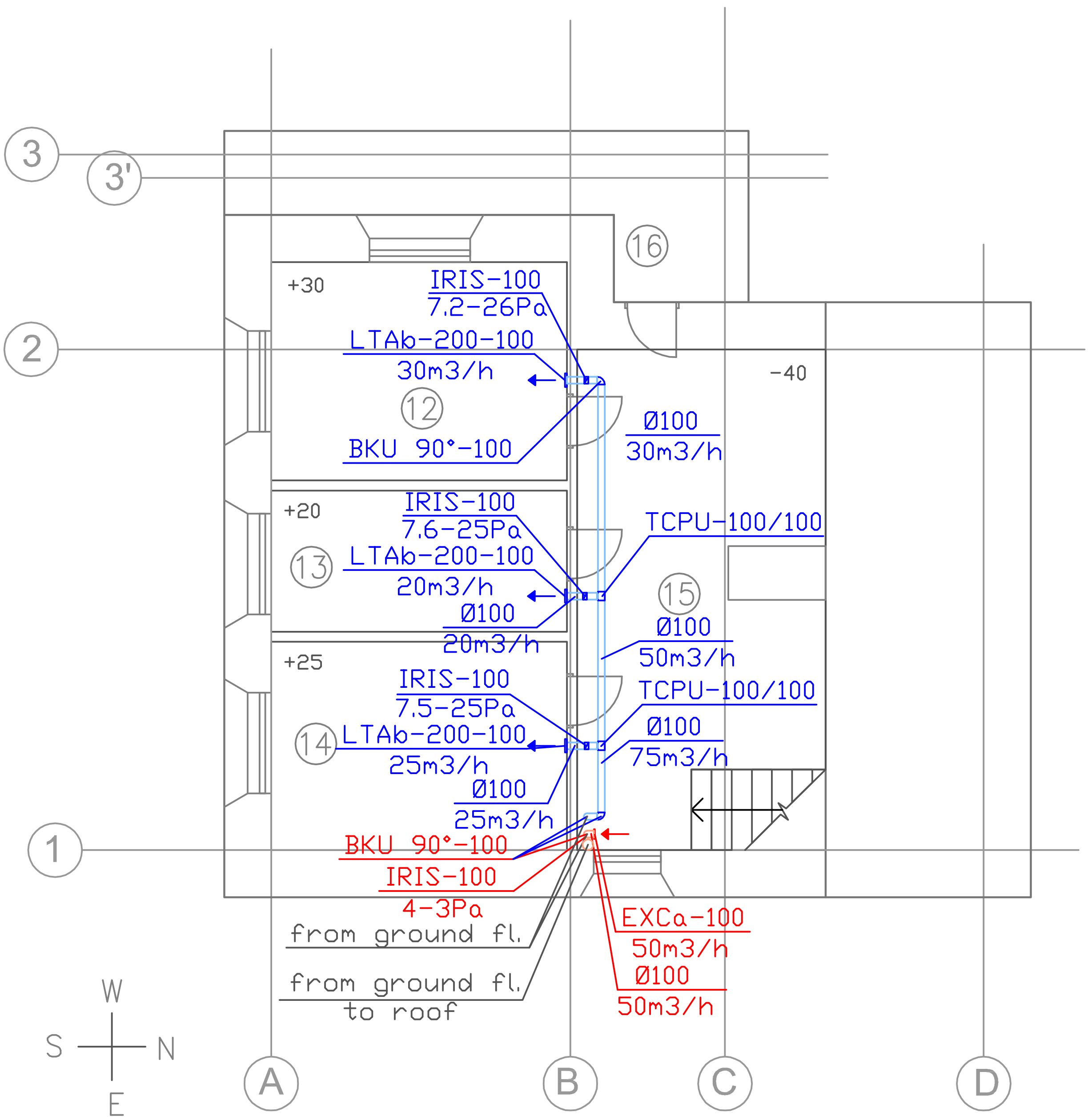
Student	**A.Antonova**						



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Thesis work "Passive house for Latvia"

Practical part
Ventilation system

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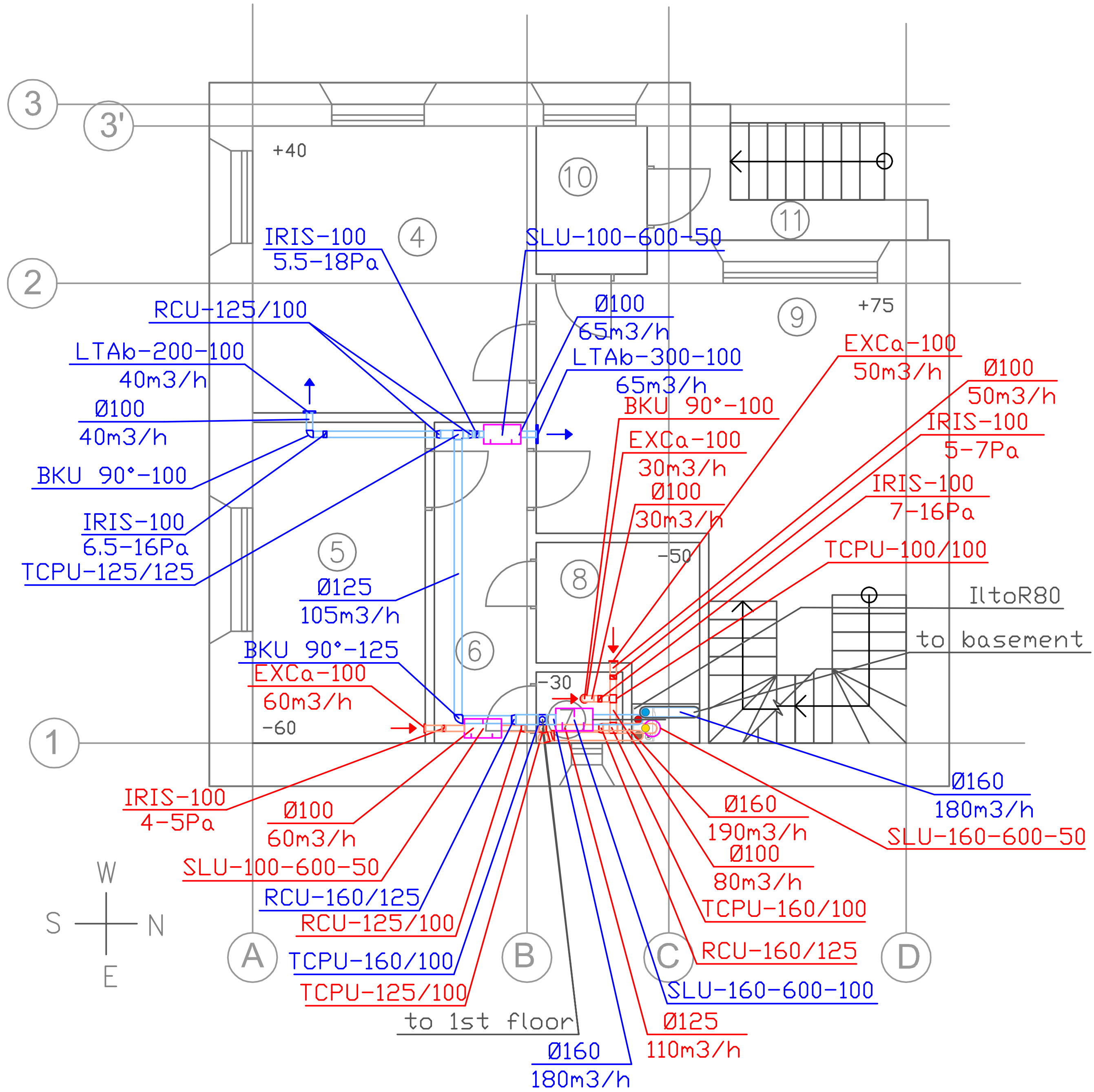
		Signature	Date
Student	A.Antonova		

1st floor

Exchange student
860614P722



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				Thesis work "Passive house for Latvia"
				Practical part **Ventilation system**
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Student	**A.Antonova**			

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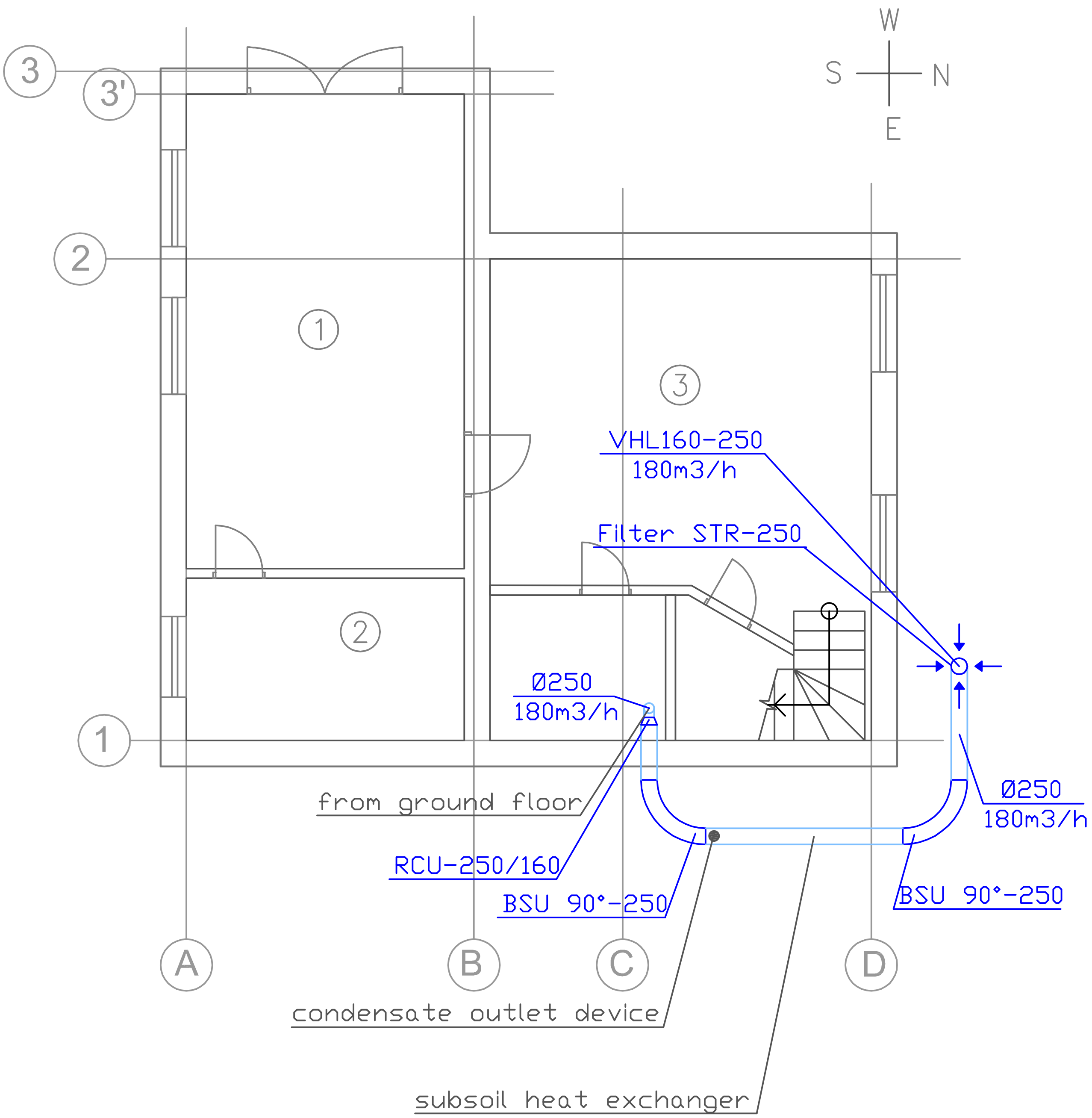
Exchange student
860614P722



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				Thesis work "Passive house for Latvia"
		Signature	Date	**Practical part** **Ventilation system** — Scale: 1:100; Page Nr.: 2; Pages: 6
Student	A.Antonova			Basement — Exchange student 860614P722

Content

Nr.	Name
1	General data
2	Basement
3	Groung floor
4	1st floor
5	Roof
6	Axenometry, sound level and branch division

Explication

Room Nr.	Name	Area [m2]
1	Garage	31.5
2	Basement room 1	10.8
3	Basement room 2	37.3
4	Room 1	20.7
5	Kitchen	14.6
6	Corridor	7.8
7	WC	1.6
8	Bathroom	6.6
9	Living-room 1	27.5
10	Anteroom	4.3
11	Balcony 1	5.7
12	Room 2	14.3
13	Room 3	9.2
14	Room 4	13.6
15	Living-room 2	25.2
16	Balcony 2	11.4
	Total	242.1
	Total heated	145.4
	Heat load	1525 W

Nomenclature

Supply duct

Exhaust duct

Damper

Supply grille

Exhaust register

Reducer

T-piece

Silencer

EXCa-100 - Diffuser

50m3/h - Air amount

IRIS-100 - Reducer

5-7Pa

- Pressure drop Pa
- Setting position

		Signature	Date	
Student	A.Antonova			

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Thesis work "Passive house for Latvia"

Practical part Ventilation system	Scale	Page Nr.	Pages
	1:100	1	6

General data

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860614P722

Appendix 2

Supply air temperature

Given:

Q=	1523	W	10.5	W/m2
V=	0.05	m3/s	190	m3/h
ρ=	1.2	kg/m3		
Cp=	1000	J/(kgK)		
ηt=	0.7	%		
Tin=	291.15	K	18	℃
Toutd=	252.45	K	-20.7	℃

$$\eta_t = \frac{t_{sup} - t_{out}}{t_{extr} - t_{out}} \quad (-) \qquad \text{(Johansson, D., 2005, p. 247)}$$

t_{sup} = *temperature of supply air after heat exchanger, °C*

t_{out} = *outdoor temperature, °C*

t_{extr} = *extract air temperature, °C*

tsup=	6	℃

$$T_{supply\ air} = \frac{Q}{V \cdot \rho \cdot c_p} + T_{indoor} - (1-\eta) \cdot (T_{indoor} - T_{outdoor}) \qquad \text{(Janson, U., 2008, p.161)}$$

Q = Peak load for space heating, W

V = Ventilation rate m^3/s

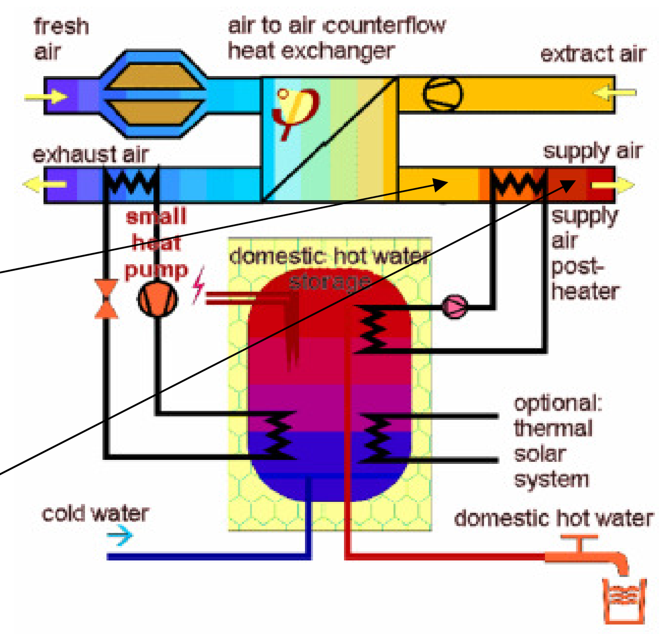
ρ = Density of air at 20°C = 1.2 kg/m^3

c_p = Thermal capacity of air = 1000 J/(kg K)

η = Temperature efficiency of heat exchanger, %

T = Temperatures, K *(K=°C+273.15)*

Tsup=	304	K
	30	℃



Reference for formulas: Krause 2007.
Reference for picture: Feist 2006d.

Heat loss calculation

Nr.	Room Nr.	Name	Outer envelope: Symbol	Orientation	Lenght [m]	Width [m]	Are [m2]	Uo W/m2C°	θi [C°] (room temp.)	θe [C°] (outside temp.)	tΔθ C° (θi-θe)	Q' W	Additional heat losses: Depending upon orientation [%]	Depending upon wind strength [%]	Depending upon room orientation (in corner) [%]	The other [%]	Coefficient of additional heat losses	Q W	Heat losses in room [W]	Notes
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1	Garage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	Basement room 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	3	Basement room 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	4	Room 1	EW	D	3.4	5.45	18.53	0.07	18	-20.7	38.7	50.20	0	0	5	0	5	53	374	
5			W	D	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	0	0	5	0	5	73		
6			EW	R	3.4	5.25	17.85	0.07	18	-20.7	38.7	48.36	5	0	5	0	10	53		
7			W	R	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	5	0	5	0	10	77		
8			F	-	-	-	28.5	0.07	18	-20.7	38.7	77.21	0	0	5	0	5	81		
9			C	A	-	-	12.4	0.07	18	-20.7	38.7	33.59	5	0	5	0	10	37		
10	5	Kitchen	EW	D	3.4	5.95	20.23	0.07	18	-20.7	38.7	54.80	0	0	5	0	5	58	252	
11			W	D	1.5	2	3	0.8	18	-20.7	38.7	92.88	0	0	5	0	5	98		
12			EW	A	3.4	3.6	12.24	0.07	18	-20.7	38.7	33.16	5	0	5	0	10	36		
13			F	-	-	-	21.4	0.07	18	-20.7	38.7	57.97	0	0	5	0	5	61		
14	6	Corridor 1	EW	A	3.4	1.6	5.44	0.07	18	-20.7	38.7	14.74	5	0	0	0	5	15	42	
15			F	-	-	-	9.7	0.07	18	-20.7	38.7	26.28	0	0	0	0	0	26		
16	7	WC	EW	A	3.4	1.5	5.1	0.07	25	-20.7	45.7	16.31	5	0	0	0	5	17	36	
17			W	A	0.5	0.5	0.25	0.8	25	-20.7	45.7	9.14	5	0	0	0	5	10		
18			F	-	-	-	2.85	0.07	25	-20.7	45.7	9.12	0	0	0	0	0	9		
19	8	Bathroom	EW	A	3.4	1.25	4.25	0.07	25	-20.7	45.7	13.60	5	0	0	0	5	14	41	
20			F	-	-	-	8.2	0.07	25	-20.7	45.7	26.23	0	0	0	0	0	26		
21	9	Living-room	EW	A	3.4	4.2	14.28	0.07	18	-20.7	38.7	38.68	5	0	5	0	10	43	444	
22			W	A	1.5	2.5	3.75	0.8	18	-20.7	38.7	116.10	5	0	5	0	10	128		

23			EW	Z	3.4	8.85	30.09	0.07	18	-20.7	38.7	81.51	10	0	5	0	15	94		
24			EW	R	3.4	4.4	14.96	0.07	18	-20.7	38.7	40.53	5	0	5	0	10	45		
25			F	-	-	-	47.6	0.07	18	-20.7	38.7	128.95	0	0	5	0	5	135		
26	10	Anteroom	EW	R	3.4	2.55	8.67	0.07	18	-20.7	38.7	23.49	5	0	5	0	10	26	210	
27			W	R	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	5	0	5	0	10	77		
28			EW	Z	3.4	2.55	8.67	0.07	18	-20.7	38.7	23.49	10	0	5	0	15	27		
29			D	Z	2	1	2	0.9	18	-20.7	38.7	69.66	10	0	5	0	15	80		
30	11	Balcony 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
31	12	Room 2	EW	D	2.9	4.05	11.75	0.07	18	-20.7	38.7	31.82	0	0	5	0	5	33	326	
32			W	D	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	0	0	5	0	5	73		
33			EW	R	-	-	21.5	0.07	18	-20.7	38.7	58.24	5	0	5	0	10	64		
34			W	R	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	5	0	5	0	10	77		
35			EW	Z	4.8	1.3	6.24	0.07	18	-20.7	38.7	16.90	10	0	5	0	15	19		
36			C	D	5.15	4.05	20.86	0.07	18	-20.7	38.7	56.50	0	0	5	0	5	59		
37	13	Room 3	EW	D	2.9	2.2	6.38	0.07	18	-20.7	38.7	17.28	0	0	0	0	0	17	118	
38			W	D	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	0	0	0	0	0	70		
39			C	D	5.15	2.2	11.33	0.07	18	-20.7	38.7	30.69	0	0	0	0	0	31		
40	14	Room 4	EW	D	2.9	3.9	11.31	0.07	18	-20.7	38.7	30.64	0	0	5	0	5	32	224	
41			W	D	1.5	1.5	2.25	0.8	18	-20.7	38.7	69.66	0	0	5	0	5	73		
42			EW	A	-	-	18.7	0.07	18	-20.7	38.7	50.66	5	0	5	0	10	56		
43			C	D	5.15	3.9	20.09	0.07	18	-20.7	38.7	54.41	10	0	5	0	15	63		
44	15	Corridor 1	EW	R	-	-	16.1	0.07	18	-20.7	38.7	43.61	5	0	5	0	10	48	447	
45			D	R	2	0.8	1.6	0.9	18	-20.7	38.7	55.73	5	0	5	0	10	61		
46			EW	A	-	-	19	0.07	18	-20.7	38.7	51.47	5	0	5	0	10	57		
47			W	A	1.5	1	1.5	0.8	18	-20.7	38.7	46.44	5	0	5	0	10	51		
48			W	Z	1.45	0.8	1.16	0.8	18	-20.7	38.7	35.91	10	0	5	0	15	41		
49			C	Z	6.85	8.85	60.62	0.07	18	-20.7	38.7	164.23	10	0	5	0	15	189		
50	16	Balcony 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Temperatures:	
Rooms	18
WC, bathroom	25
U-value:	
Walls	0.07
Window	0.8
Door	0.9

- EW- external wall;
- W- window;
- D- door;
- F- floor;
- C- ceiling.

	Total:	**2512**	W
	Total heated area:	145.4	m2
	Heat losses/m2:	**17.28**	W
Gains/m2 from:	Lighting	2.9	W
	Equipment	2.4	W
	Persons	1.5	W
	(Heat losses+Gains)/m2:	**10.48**	W
	Heat losses+Gains:	1523	W

Sound attenuation- exhaust air ducts system

Section	Component	Value	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB(A)	Total dB(A)
-	Corr. for filter A	-	-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1	-	-
-	Duct attenuation	dB/m	0.1	0.1	0.12	0.18	0.3	0.3	0.3	0.3	-	-
-	Requirement	**dB (A)**	-	-	-	-	-	-	-	-	30	-
AHU	EC fan motor	dB	74	62	50	44	35	27	20	9	-	
AHU	EC fan motor	**dB (A)**	**47.8**	**45.9**	**41.4**	**40.8**	**35**	**28.2**	**21**	**7.9**	-	**51**
3	Duct, l =1.5m	dB	0.15	0.15	0.18	0.27	0.45	0.45	0.45	0.45	-	
	After Duct	dB	73.85	61.85	49.82	43.73	34.55	26.55	19.55	8.55	-	
		dB (A)	**47.65**	**45.75**	**41.22**	**40.53**	**34.55**	**27.75**	**20.55**	**7.45**	**51**	
3	Silencer SLU 50, Ø160-600	dB	3	4	8	21	37	40	22	14	-	
	After Silencer SLU 50	dB	70.85	57.85	41.82	22.73	-2.45	-13.45	-2.45	-5.45	-	
		dB (A)	**44.65**	**41.75**	**33.22**	**19.53**	**-2.45**	**-12.25**	**-1.45**	**-6.55**	**47**	
3	Branch	*	*	*	*	*	*	*	*	*		
3		**dB (A)**	**44.65**	**41.75**	**33.22**	**19.53**	**-2.45**	**-12.25**	**-1.45**	**-6.55**		**47**
2	Duct, l =1.1m	dB	0.11	0.11	0.132	0.198	0.33	0.33	0.33	0.33	-	
	After Duct (72% of 3)	dB	50.90	41.54	29.98	16.17	-2.09	-10.01	-2.09	-4.25	-	
2	T-piece, TCPU	*	*	*	*	*	*	*	*	*		
2		**dB (A)**	**24.70**	**25.44**	**21.38**	**12.97**	**-2.09**	**-8.81**	**-1.09**	**-5.35**		**29**
1	Duct, l =1.9m	dB	0.19	0.19	0.228	0.342	0.57	0.57	0.57	0.57	-	
	After Duct (61% of 2)	dB	30.86	25.15	18.06	9.52	-1.85	-6.68	-1.85	-3.16	-	
		dB (A)	**4.66**	**9.05**	**9.46**	**6.32**	**-1.85**	**-5.48**	**-0.85**	**-4.26**	**14**	
	Silencer SLU 50, Ø100-600	dB	3	8	13	25	40	50	40	21	-	
	After Silencer SLU	dB	27.86	17.15	5.06	-15.48	-41.85	-56.68	-41.85	-24.16	-	
		dB (A)	**1.66**	**1.05**	**-3.54**	**-18.68**	**-41.85**	**-55.48**	**-40.85**	**-25.26**	**5**	
1	Regulating damper, IRIS	dB (A)	-	-	-	-	-	-	-	-	10	
1	Register, EXCa	dB (A)	-	-	-	-	-	-	-	-	15	
1												**30**

Sound attenuation- exhaust air ducts system

Section	Component	Value	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB(A)	Total dB(A)
-	Corr. for filter A	-	-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1	-	-
-	Duct attenuation	dB/m	0.1	0.1	0.12	0.18	0.3	0.3	0.3	0.3	-	-
-	Requirement	**dB (A)**	-	-	-	-	-	-	-	-	30	-
4	Duct, l =2.5m	dB	0.12	0.12	0.144	0.216	0.36	0.36	0.36	0.36	-	
	After Duct (39% of 2)	dB	19.73	16.08	11.55	6.09	-1.18	-4.27	-1.18	-2.02	-	
		dB (A)	**-6.47**	**-0.02**	**2.95**	**2.89**	**-1.18**	**-3.07**	**-0.18**	**-3.12**	**9**	
4	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	3	
4	Grille, LTAb	dB (A)	-	-	-	-	-	-	-	-	15	
												27
6	Duct, l =0.5m	dB	0.05	0.05	0.06	0.09	0.15	0.15	0.15	0.15	-	
	After Duct (28% of 3)	dB	19.79	16.15	11.65	6.27	-0.84	-3.92	-0.84	-1.68	-	
6	Branch	*	*	*	*	*	*	*	*	*		
7		**dB (A)**	**-6.41**	**0.05**	**3.05**	**3.07**	**-0.84**	**-2.72**	**0.16**	**-2.78**		**9**
5	Duct, l =0.6m	dB	0.06	0.06	0.072	0.108	0.18	0.18	0.18	0.18	-	
	After Duct (50% of 6)	dB	9.83	8.01	5.75	3.03	-0.60	-2.14	-0.60	-1.02	-	
		dB (A)	**-16.37**	**-8.09**	**-2.85**	**-0.17**	**-0.60**	**-0.94**	**0.40**	**-2.12**	**7**	
5	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	7	**14**
5	Register, EXCa	dB (A)	-	-	-	-	-	-	-	-	15	**29**
5												**29**
7	Duct, l =0.4m	dB	0.04	0.04	0.048	0.072	0.12	0.12	0.12	0.12	-	
	After Duct (50% of 6)	dB	9.85	8.03	5.78	3.07	-0.54	-2.08	-0.54	-0.96	-	
		dB (A)	**-16.35**	**-8.07**	**-2.82**	**-0.13**	**-0.54**	**-0.88**	**0.46**	**-2.06**	**7**	
7	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	14	
7	Register, EXCa	dB (A)	-	-	-	-	-	-	-	-	8	
7												**29**

Sound attenuation- supply air ducts system

Section	Component	Value	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB(A)	Total dB(A)
-	Corr. for filter A	-	-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1	-	
-	Duct attenuation	dB/m	0.1	0.1	0.12	0.18	0.3	0.3	0.3	0.3	-	
-	Requirement	**dB (A)**	-	-	-	-	-	-	-	-	30	
AHU	EC fan motor	dB	75	69	61	60	55	51	46	35		-
AHU	EC fan motor	**dB (A)**	**48.8**	**52.9**	**52.4**	**56.8**	**55**	**52.2**	**47**	**33.9**		**62**
3	Duct, l =2.7m	dB	0.27	0.27	0.32	0.49	0.81	0.81	0.81	0.81	-	
	After Duct	dB	74.73	68.73	60.68	59.51	54.19	50.19	45.19	34.19	-	
		dB (A)	**48.53**	**52.63**	**52.08**	**56.31**	**54.19**	**51.39**	**46.19**	**33.09**	**61**	
3	Silencer SLU 100, Ø160-600	dB	5.00	8.00	15.00	23.00	31.00	40.00	22.00	16.00	-	
	After Silencer SLU 100	dB	69.73	60.73	45.68	36.51	23.19	10.19	23.19	18.19	-	
		dB (A)	**43.53**	**44.63**	**37.08**	**33.31**	**23.19**	**11.39**	**24.19**	**17.09**	**48**	
3	Branch	*	*	*	*	*	*	*	*	*		
3		**dB (A)**	**43.53**	**44.63**	**37.076**	**33.314**	**23.19**	**11.39**	**24.19**	**17.09**		**48**
2	Duct, l =6m	dB	0.60	0.60	0.72	1.08	1.80	1.80	1.80	1.80	-	
	After Duct (58% of 3)	dB	39.84	34.62	25.77	20.10	11.65	4.11	11.65	8.75	-	
2	T-piece, TCPU	*	*	*	*	*	*	*	*	*		
2		**dB (A)**	**13.64**	**18.52**	**17.17**	**16.90**	**11.65**	**5.31**	**12.65**	**7.65**		**24**
1	Duct, l =2.4m	dB	0.24	0.24	0.29	0.43	0.72	0.72	0.72	0.72	-	
	After Duct (50% of 2)	dB	19.68	17.07	12.60	9.62	5.11	1.34	5.11	3.66	-	
		dB (A)	**-6.52**	**0.97**	**4.00**	**6.42**	**5.11**	**2.54**	**6.11**	**2.56**	**13**	
1	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	5	
1	Grille, LTAb	dB (A)	-	-	-	-	-	-	-	-	10	
1												**28**
4	Duct, l =1.2m	dB	0.12	0.12	0.14	0.22	0.36	0.36	0.36	0.36	-	
	After Duct (50% of 2)	dB	19.80	17.19	12.74	9.83	5.47	1.70	5.47	4.02	-	
		dB (A)	**-6.40**	**1.09**	**4.14**	**6.63**	**5.47**	**2.90**	**6.47**	**2.92**	**13**	
	Silencer SLU 100, Ø100-600	dB	3.00	8.00	13.00	25.00	40.00	50.00	40.00	21.00		
	After Silencer SLU	dB	16.80	9.19	-0.26	-15.17	-34.53	-48.30	-34.53	-16.98		
		dB (A)	**-9.40**	**-6.91**	**-8.86**	**-18.37**	**-34.53**	**-47.10**	**-33.53**	**-18.08**	**-3**	
4	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	16	
4	Grille, LTAb	dB (A)	-	-	-	-	-	-	-	-	15	
												28

Sound attenuation- supply air ducts system

Section	Component	Value	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB(A)	Total dB(A)
-	Corr. for filter A	-	-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1	-	
-	Duct attenuation	dB/m	0.1	0.1	0.12	0.18	0.3	0.3	0.3	0.3	-	
-	Requirement	**dB (A)**	-	-	-	-	-	-	-	-	30	
7	Duct, l =3m	dB	0.30	0.30	0.36	0.54	0.90	0.90	0.90	0.90	-	
	After Duct (42% of 3)	dB	28.99	25.21	18.82	14.80	8.84	3.38	8.84	6.74	-	
7	Branch	*	*	*	*	*	*	*	*	*		
7		**dB (A)**	**2.79**	**9.11**	**10.22**	**11.60**	**8.84**	**4.58**	**9.84**	**5.64**		**18**
9	Duct, l =0.4m	dB	0.04	0.04	0.05	0.07	0.12	0.12	0.12	0.12	-	
	After Duct (50% of 7)	dB	14.45	12.56	9.36	7.33	4.30	1.57	4.30	3.25	-	
		dB (A)	**-11.75**	**-3.54**	**0.76**	**4.13**	**4.30**	**2.77**	**5.30**	**2.15**	**11**	
9	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	5	
9	Grille, LTAb	dB (A)	-	-	-	-	-	-	-	-	0	
9												**16**
6	Duct, l =2.1m	dB	0.21	0.21	0.25	0.38	0.63	0.63	0.63	0.63	-	
	After Duct (50% of 7)	dB	14.28	12.39	9.16	7.02	3.79	1.06	3.79	2.74	-	
6	Branch	*	*	*	*	*	*	*	*	*		
6		**dB (A)**	**-11.92**	**-3.71**	**0.56**	**3.82**	**3.79**	**2.26**	**4.79**	**1.64**		**11**
8	Duct, l =0.4m	dB	0.04	0.04	0.05	0.07	0.12	0.12	0.12	0.12	-	
	After Duct (50% of 6)	dB	7.10	6.16	4.53	3.44	1.77	0.41	1.77	1.25	-	
		dB (A)	**-19.10**	**-9.94**	**-4.07**	**0.24**	**1.77**	**1.61**	**2.77**	**0.15**	**9**	
8	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	14	
8	Grille, LTAb	dB (A)	-	-	-	-	-	-	-	-	0	
8												**23**
5	Duct, l =3.4m	dB	0.34	0.34	0.41	0.61	1.02	1.02	1.02	1.02	-	
	After Duct (50% of 6)	dB	6.80	5.86	4.17	2.90	0.87	-0.49	0.87	0.35	-	
		dB (A)	**-19.40**	**-10.24**	**-4.43**	**-0.30**	**0.87**	**0.71**	**1.87**	**-0.75**	**8**	
5	Regulating damper , IRIS	dB (A)	-	-	-	-	-	-	-	-	7	
5	Grille, LTAb	dB (A)	-	-	-	-	-	-	-	-	0	
5												**15**

Pressure drop- exhaust air ducts

Section Nr/ Component	Model	Air flow rate	Section length	Velocity	Diameter	Specific pressure drop Δpt	Pressure drop	Pressure drop in section	Pressure drop in branch	Note: Pressure drop of sections	Pressure difference between 2 parallel branches	Note: Pressure difference between sections
[-]	[-]	[m3/h]	[m]	[m/s]	[mm]	[Pa/m]	[Pa]	[Pa]	[Pa]	[-]	[%]	[-]
1	Duct	60	1.9	2.3	100	0.8	**1.52**	29.76	29.76	1	-	-
Exhaust register	EXCa	60	-	-	100	-	**22**					
Regulating damper	IRIS	60	-	-	100	-	**5**					
Silencer	SLU 50	60	0.6	-	100-210	0.9	**0.54**					
Reducer	RCU	60	-	-	125-100	-	**0.7**					
2	Duct	110	0.9	2.7	125	0.8	**0.72**	6.52	36.28	1,2	-	-
T-piece	TCPU	110	-	2.3-2.5-1.9	-	-	**5.5**					
Reducer	RCU	110	-	-	160-125	-	**0.3**					
3	Duct	190	2	2.8	160	0.5	**1**	13.58	49.86	1,2,3	-	-
T-piece	TCPU	190	-	2.5-2.5-3	-	-	**8.1**					
Silencer	SLU 50	190	0.6	-	160-270	0.8	**0.48**					
Bend- short	BKU 90°	190	-	-	160	-	**4**					
4	Duct	50	2.5	1.9	100	0.6	**1.5**	31.3	31.3	4	5	1 - 4
Exhaust register	EXCa	50	-	-	100	-	**25**					
Regulating damper	IRIS	50	-	-	100	-	**3**					
Bend- short	BKU 90°	50	-	-	100	-	**1.8**					
5	Duct	50	0.6	1.9	100	0.6	**0.36**	31.36	31.36	5	-	-
Exhaust register	EXCa	50	-	-	100	-	**24**					
Regulating damper	IRIS	50	-	-	100	-	**7**					
6	Duct	80	0.5	3	100	1.5	**0.75**	0.45	31.81	5,6	-12	1,2 - 5,6
T-piece	TCPU	80	-	1.9-3-1	-	-	**-0.3**					

Section Nr/ Component	Model	Air flow rate	Section length	Velocity	Diameter	Specific pressure drop Δpt	Pressure drop	Pressure drop in section	Pressure drop in branch	Note: Pressure drop of sections	Pressure difference between 2 parallel branches	Note: Pressure difference between sections
[-]	[-]	[m3/h]	[m]	[m/s]	[mm]	[Pa/m]	[Pa]	[Pa]	[Pa]	[-]	[%]	[-]
7	Duct	30	0.7	1	100	0.25	**0.175**	31.175	31.175	7	-1	
Exhaust register	EXCa	30	-	-	100	-	**15**					
Bend- short	BKU 90°	30	-	-	100	-	**0**					
Regulating damper	IRIS	30	-	-	100	-	**16**					
8	Duct	190	8	2.8	160	0.6	**4.8**	20.1	20.1	8	-	-
Bend- short	BKU 90°	190	-	-	160	-	**4**					
Bend	BU 15°	190	-	-	160	-	**0.3**					
Bend- short	BKU 90°	190	-	-	160	-	**4**					
Roof hood	HU	190			160		**7**					

Total pressure drop: 70 Pa

Pressure drop- supply air ducts

Section Nr/ Component	Model	Air flow rate	Section length	Velocity	Diameter	Specific pressure drop Δpt	Pressure drop	Pressure drop in section	Pressure drop in branch	Note: Pressure drop of sections	Pressure difference between 2 parallel branches	Note: Pressure difference between sections
[-]	[-]	[m3/h]	[m]	[m/s]	[mm]	[Pa/m]	[Pa]	[Pa]	[Pa]	[-]	[%]	[-]
1	Duct	40	2.4	1.5	100	0.6	**1.44**	25.24	25.24	1	-	-
Grille	LTAb	40	-	-	200-100	-	**6**					
Bend	BKU 90°	40	-	1.5		-	**1.5**					
Regulating damper	IRIS	40	-	-	100	-	**16**					
Reducer	RCUF	40	-	-	125-100	-	**0.3**					
2	Duct	105	6	2.5	125	0.7	**4.2**	12.3	37.54	1,2	-	-
T-piece	TCPU	105	-	-	125	-	**4.5**					
Bend	BKU 90°	105	-	2.5	125	-	**3**					
Reducer	RCUF	105	-	-	160-125		**0.6**					
3	Duct	180	2.7	2.6	160	0.55	**1.485**	9.105	46.645	1,2,3	-	-
T-piece	TCPU	180	-	-	160-100	-	**3.2**					
Silencer	SLU 100	180	0.6	-	160-365	0.7	0.42					
Bend	BKU 90°	180	-	2.6	160	-	**4**					
4	Duct	65	1.4	2.5	100	1	**1.4**	27.8	27.8	4	10	1 - 4
Grille	LTAb	65	-	-	300-100	-	**7**					
Regulating damper	IRIS	65	-	-	100	-	**18**					
Silencer	SLU 50	65	0.6	-	100-210	1	0.6					
Reducer	RCUF	65	-	-	125-100	-	**0.8**					
5	Duct	30	3.9	1	100	0.25	**0.975**	26.975	26.975	5	-	-
Grille	LTAb	30	-	-	200-100	-	**3,5**					
Regulating damper	IRIS	30	-	-	100	-	**26**					
Bend	BKU 90°	30	-	-	100	-	**0**					

Section Nr/ Component	Model	Air flow rate	Section length	Velocity	Diameter	Specific pressure drop Δpt	Pressure drop	Pressure drop in section	Pressure drop in branch	Note: Pressure drop of sections	Pressure difference between 2 parallel branches	Note: Pressure difference between sections
[-]	[-]	[m3/h]	[m]	[m/s]	[mm]	[Pa/m]	[Pa]	[Pa]	[Pa]	[-]	[%]	[-]
6	Duct	50	2.2	1.9	100	0.2	**0.44**	0.44	27.415	5,6	-	-
T-piece	TCPU	50	-	1.9-1	100	-	**0**					
7	Duct	75	3.4	2.5	100	1	**3.4**	10.4	37.815	5,6,7	1	1,2 - 5,6,7
T-piece	TCPU	75	-	2.9-1.9	100	-	**0**					
Bend	BKU 90°	75	-	2.5	100	-	**3.5**					
Bend	BKU 90°	75	-	2.5	100	-	**3.5**					
8	Duct	20	0.4	0.5	100	0.11	**0.044**	26.544	26.544	8	-2	5 - 8
Grille	LTAb	20	-	-	200-100	-	**1.5**					
Regulating damper	IRIS	20	-	-	100	-	**25**					
9	Duct	25	0.4	0.5	100	0.11	**0.044**	27.244	27.244	9	-1	5,6 - 9
Grille	LTAb	25		-	200-100	-	**2.2**					
Regulating damper	IRIS	25	-	-	100	-	**25**					
10	Duct	180	5.8	2.5	160	0.55	**3.19**	39.12	39.12	10	-	-
Bend- short	BKU 90°	180	-	-	160	-	**3.8**					
Bend- short	BKU 90°	180	-	-	160	-	**3.8**					
Bend- short	BKU 90°	180	-	-	160	-	**3.8**					
Reducer	RCUF	180	-	-	250-160	-	**0.8**					
Duct	duct	180	8	0.3	250	0.06	**0.48**					
Bend- short	BSU 90°	180	-	-	250	-	**0.25**					
Bend- short	BSU 90°	180	-	-	250	-	**0.25**					
Bend- short	BSU 90°	180	-	-	250	-	**0.25**					
Filter	STR	180	-	-	250	-	**12**					
Roof hood	VHL	180	-	0.9	250	-	**10.5**					

Total pressure drop: 86 Pa

Air flow rate and air exchange rate

Room Nr.	Name	Area [m2]	Living area [m2]	Air [l/s]	Air [m3/h]	Supply air [m3/h]	Extract air [m3/h]
1	Garage	31.5	-	-	-	-	-
2	Basement room 1	10.8	-	-	-	-	-
3	Basement room 2	37.3	-	-	-	-	-
4	Room 1	20.7	21	7	26	40	-
5	Kitchen	14.6	15	5	18	-	60
6	Corridor 1	7.8	8	3	10		
7	WC	1.6	2	1	2	-	30
8	Bathroom	6.6	7	2	8	-	50
9	Living-room	27.5	28	10	35	65	-
10	Anteroom	4.3	4	2	5		
11	Balcony 1	5.7	-	-	-	-	-
12	Room 2	14.3	14	5	18	30	-
13	Room 3	9.2	9	3	12	20	-
14	Room 4	13.6	14	5	17	25	-
15	Corridor 2	25.2	25	9	32		50
16	Balcony 2	11.4	-	-	-	-	-
	Total	242.1	145	51	183	180	190
			Due to Imbalanc(5%):				189

Volume:	349	m3
Air change rate:	0.544	h-1
Imbalanc:	5	%

Supply air zone
Exhaust air zone
Overflow zone

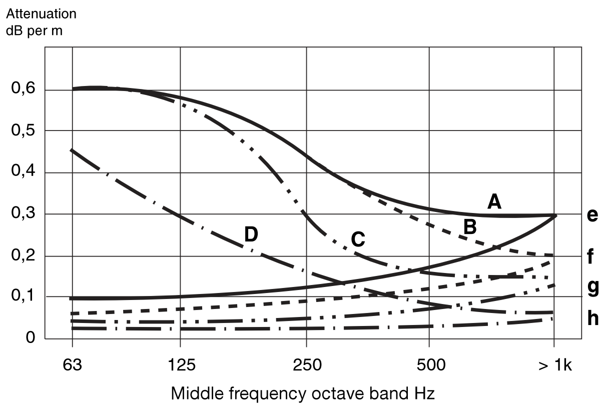
Requirements
Supply:
> 0,35 l/s/m2*
4 l/s for 1 inhabitant*
Exhaust:
1 ach per 2 hours*
14 m3 per person*

* www.mk.gov.lv. 2010

Appendix 3

Sound

Attenuation in straight sheet etal ducts (1 mm sheet metal thickness)

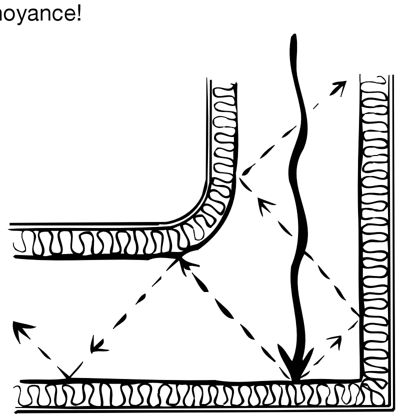


Duct dimensions			
Rectangular sheet metal ducts			
□ 75–200	200–400	400–800	800–1000
A ———	B - - - - - -	C — · · —	D — · — ·
Circular sheet metal ducts			
Ø75–200	200–400	400–800	800–1600
e ———	f - - - - - -	g — · · —	h — · — ·

Absorption is more effective

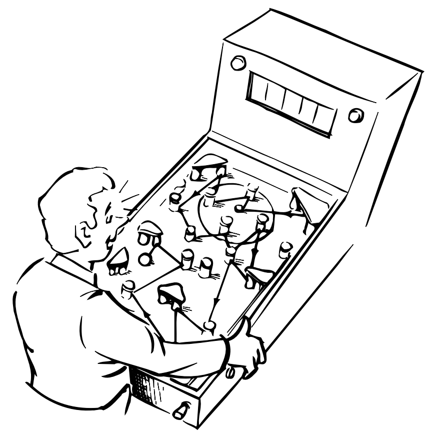
The damping becomes more effective if we put absorbent material into the duct system. The way that sound is damped was described above, part of the sound energy is absorbed by the absorption material which is hit by the sound.

If the sound waves bounce enough times against porous surfaces, the remaining sound energy, the kinetic energy which makes your eardrums vibrate, will be so low that it does not cause annoyance!

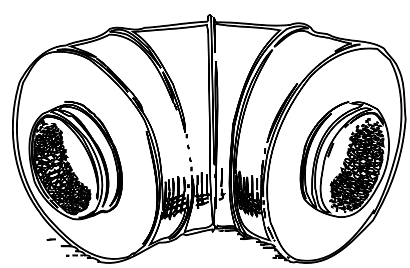


Where should you put the absorption material in the ducts?

The answer is obvious - where the material comes into contact with the greatest number of sound waves. Noise which travels along a long, unlined, straight duct will be directed by reflection against the duct walls. Absorption material here is of less use than if it is put in a bend, a suction or pressure plenum chamber or in a straight duct just after a fan, or anywhere where we have "turbulent sound flow". The more times sound bounces against the soft sides, the more useful the material becomes.



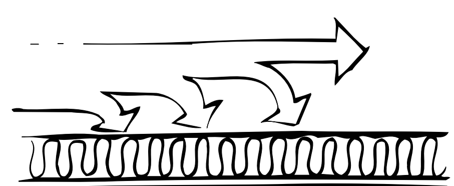
Why the curved silencer BSLU is so effective!



Straight silencers concentrate the absorption material

There is a complement to the description of sound waves above. When the sound waves travel along a porous surface, they will be deflected towards the duct walls. This deflection is called, "diffraction".

This, and the way that sound propagation is disturbed by turbulence, gives that straight silencers can have high attenuation.

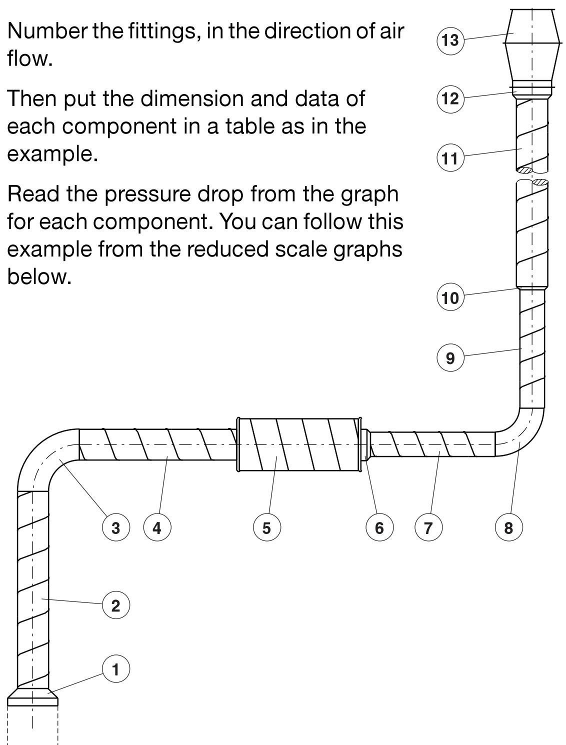


Pressure

Pressure drop calculation

Fan pressure capacity required
Let us do a pressure drop calculation for a simple duct system!

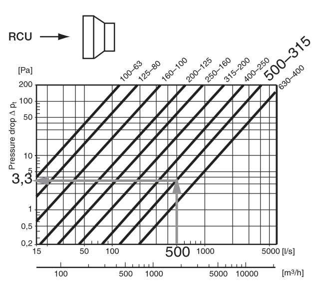
- Number the fittings, in the direction of air flow.
- Then put the dimension and data of each component in a table as in the example.
- Read the pressure drop from the graph for each component. You can follow this example from the reduced scale graphs below.



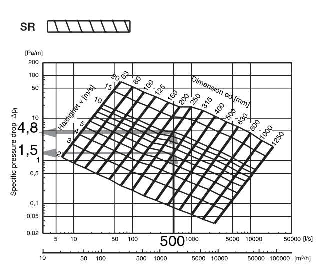
No	Flow l/s	Component Denom.	Dimension Ø mm	Length m	Pressure drop Pa/m	Pressure drop Pa
1	500	RCU	500-315	-	-	3,3
2	"	SR	315	2	1,5	3,0
3	"	BSU 90°	315	-	-	5,5
4	"	SR	315	1,6	1,5	2,4
5	"	SLBU 100	315/1200	1,2	-	42,0
6	"	RCFU	315-250	-	-	5,0
7	"	SR	250	1,5	4,8	7,2
8	"	BSU	250	-	-	14,0
9	"	SR	250	1,2	4,8	5,8
10	"	RCU	315-250	-	-	6,0
11	"	SR	315	3,5	1,5	5,3
12	"	RCFU	400-315	-	-	2,0
13	"	HF	400	-	-	22,0
		Total pressure drop (sum of rows 1 – 13) = 123,4				

Add up the pressure drops on the far right of the table. Then select a suitable fan which gives the required flow q = 500 l/s and a total pressure rise of p_t = 125 Pa.

1



2 4 7 9 11



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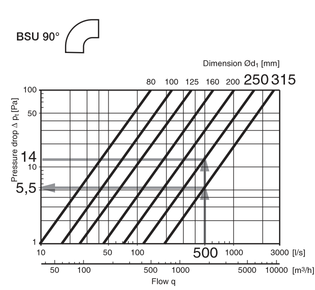

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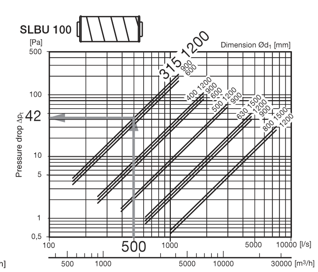

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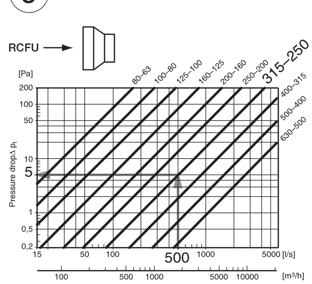

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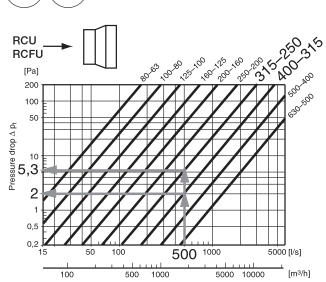

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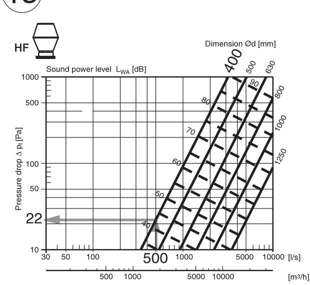


ILTO™ R80

Flexible heat recovery unit with high efficiency

- Heat recovery unit with rotary heat exchanger for detached houses, holiday cottages and flats. Suitable also for renovation.
- The airflow is 30-75 l/s for homes up to approx. 170 m^2.
- The temperature efficiency is always approx. 80%.
- Fans with energy-efficient EC motors.
- Low sound level.
- Can be installed in a laundry room, storage space or the like. Can also be located as a wall cabinet above a cooker in the kitchen.
- The extract air from the cooker hood can be connected to the bottom or the top, does not pass through the heat exchanger.
- Control via separate control panel or cooker hood.

HOME VENTILATION

Swegon

Technical Description

General

The ILTO R80 is a complete ventilation unit for homes and similar premises. The unit has supply air and extract air fans, supply air and extract air filters and the RECOnomic rotary heat exchanger which has high heat recovery performance.

The unit is designed to be mounted on a wall and a wall bracket is included. Its dimensions are such that it can be installed as a wall cabinet directly above a cooker and cooker hood in a kitchen.

Casing

The casing is made of double skin sheet steel with an intervening layer of mineral wool insulation. The external surfaces of the ventilation unit have a powder painted and baked finish in a white colour, corresponding to NCS S 0602-G.

As an accessory for the front inspection door, a cover plate is available in stainless steel or in a white painted finish.

The front inspection door can be easily removed for inspection and service.

Fans

The unit has direct-driven fans and is available with energy-efficient EC motors or traditional AC motors.

The electrical and control cables have quick-fit connections and the fans can be unfastened if required and withdrawn from the unit.

Filters

The unit is equipped with a wide-mesh class G3 filter for the extract air and a class F7 fine filter for the supply air. As an accessory, the class F7 fine filter is also available for the extract air.

Used filters can be completely incinerated.

Heat Exchanger

The heat exchanger is a RECOnomic rotary heat exchanger, patented by Swegon. The heat exchanger consists of a rotating wheel with a multitude of small passages made of aluminium. The heat is stored on the hot extract air side in the passages, and, as the rotor rotates, is emitted to the cold air on the supply air side. Since the same surfaces come into contact with both the extract air and the supply air, there is some risk for odour transfer, but in a home this is normally no problem.

The temperature efficiency is approx. 80%. Freezing normally never occurs in a rotary heat exchanger; hence its high temperature efficiency is maintained regardless of the outdoor temperature.

The heat exchanger is equipped with a motor of its own which drives the rotor.

The electrical and control cables have quick-fit connections and the exchanger package can be unfastened if required and withdrawn from the unit.

Reheating

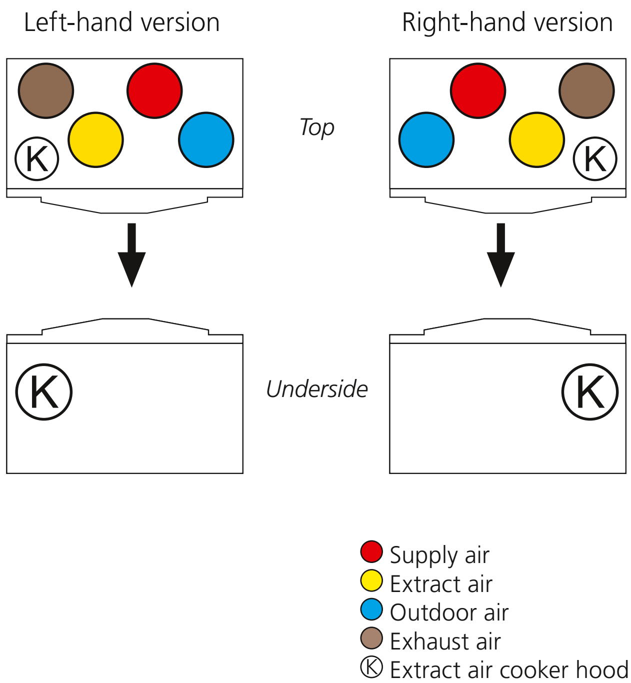
The 500 W electric air heater for reheating the supply air downstream of the heat exchanger is included as standard. The air heater is switched in if the supply air temperature drops below the preset level.

Variants

Right or left-hand design

In order to facilitate the installation ILTO R80 is available in right or left-hand version. The variants are horizontally reversed compared with one another.

This enables you to select the variant which provides the simplest duct runs. This is valuable since all extra bends and branches in the duct system give rise to a pressure drop, which causes a harder load on the fans.



EC or AC motors

The ILTO R80 can be selected with energy efficient EC fan motors or traditional AC fan motors.

The EC motors

EC = Electronically commutated

The EC-motors are energised with alternating current and built-in electronic components commutate, reverse, to direct current, which makes the motors rotate. The speed can be steplessly regulated.

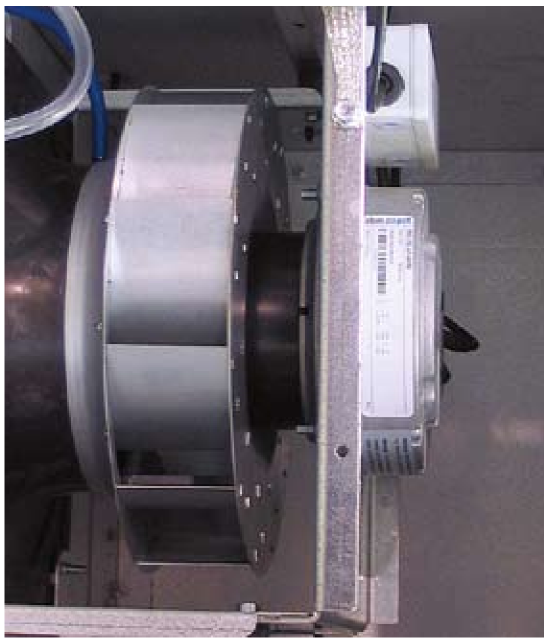
The technique involves low losses of power input and the high efficiency is largely maintained, even when the motor is decelerated.

AC motors

(AC = Alternate Current)

Alternate current creates alternating magnetic fields inside the motor, which makes its rotor rotate. The speed is regulated in fixed steps via a separate transformer.

The technique involves some of the absorbed power being lost, which is especially noticeable when the motor is controlled to decelerate.



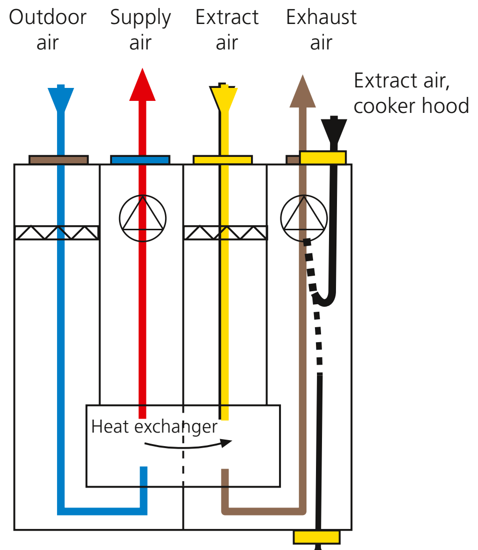
The EC motors offer high efficiency and provision for stepless speed control.

Several alternatives for the cooker hood

The ILTO R80 has extra duct connections for extract air from the cooker hood both on the bottom and the top of the unit.

Optional connection can be used and the one not used can be blanked off. The extract air from the cooker hood flows directly out via the extract air fan of the unit and never passes the heat exchanger.

The extra duct connections make the ILTO R80 a very flexible ventilation unit with several installation possibilities and no extra power roof ventilator for the cooker hood is needed.

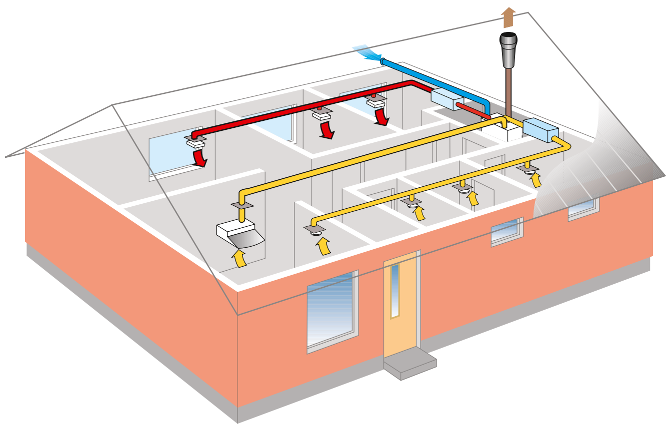


Basic flow diagram for the ILTO R80

1. The ILMO Premium cooker hood connected via a duct to the ventilation unit

The extract air from the ILMO Premium cooker hood is connected via duct to the extra duct connection on top of the unit.

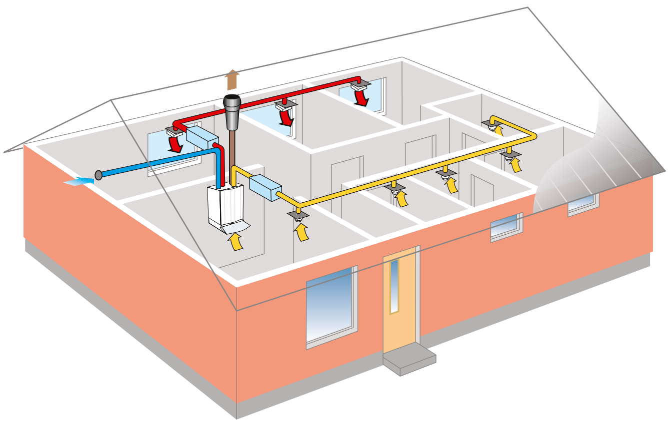
As an option, the ILTO R80 can be controlled from a separate control panel (accessory) or from the control panel of the cooker hood.



2. The ILMO Premium cooker hood connected directly to the ventilation unit

The ILMO Premium cooker hood is connected directly to the unit via the extra duct connection on the underside of the unit. The dimensions of the unit allow location as a wall cabinet in the kitchen.

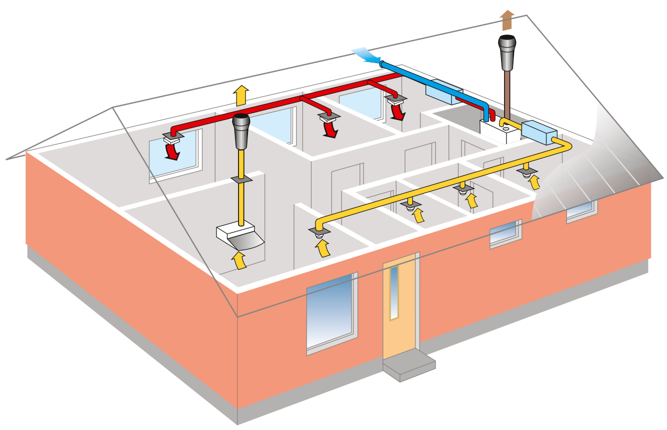
The ILTO R80 is controlled from the control panel of the cooker hood. In addition, a separate control panel (accessory) can also be used in access to additional functions.



3. Separate cooker hood

The extract air from the cooker hood is connected to a separate power roof ventilator.

The ILTO R80 is controlled from a separate control panel (accessory). The power roof ventilator is appropriately controlled from the control panel of the cooker hood.



 20090117 www.swegon.com

Control System

General

The R80 ventilation unit can either be controlled from the ILMO Premium cooker hood or from a separate Premium control panel, or a combination of both.

The simplest way to control the ventilation unit is from the cooker hood, but an extra Premium control panel is required for altering the factory settings. The operating times can be programmed from this control panel and all the settings can be read and changed in a display.

Control from the ILMO Premium cooker hood

Optional functions:

The cooker hood has a control panel with three pushbuttons. In addition to switching the cooker hood lighting on and off, two control functions can be set as follows:

- **Fan speed.** The unit fans can be controlled in three speeds: low flow/normal flow/boost.

  The speed of the supply air fan can be lower than the speed of the extract air fan.
- **Damper, cooker hood.** When preparing food or the like, the user can select the period during which the damper is open: 30, 60 or 120 min.

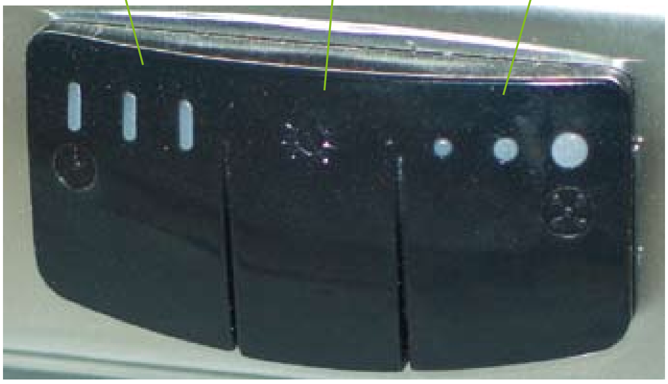
Automatic functions

- **Heat exchanger.** Started or stopped in response to a signal from the temperature sensor.
- **Reheating.** The electric air heater starts when the supply air temperature drops below 17°C.
- **Negative pressure compensation.** Negative pressure arises in the home when separate cooker hood or central vacuum cleaner is used, since the extract airflow becomes greater than the supply airflow. The function compensates for this by automatically increasing the supply airflow.
- **Overheating protection.** For motors and the electrical air heater.
- **Anti-freeze protection.** Prevents freezing in the heat exchanger.

Demand control

In addition, the following accessories can be used for demand control:

- **Timer.** 24 hour/weekly timer where you can set the desired times for the unit to operate in the normal flow mode. The unit runs in the economical low flow mode at other times.
- **Boost timer.** Manual pushbutton for installation at an optional location. Suitable for location next to a sauna, bathroom, laundry room, etc.
- **Fireplace switch.** Manual pushbutton for installation at an optional location. When activated, the extract air fan of the ventilation unit is stopped at the desired time. This generates positive pressure in the home and thus "forces" the chimney flue to extract the combustion gas, preventing it from smoking into the room when a fire is lit in the fireplace.



A stainless cooker hood – black control panel.
A white cooker hood – white control panel.

- **Occupancy detector.** Detects movement in the home and increases the fan speed. Suitable for economical operation of premises used irregularly, such as a holiday cottage, an overnight flat, etc.
- **Humidity sensor.** Detects when the humidity increases and increases the fan speed. Suitable for location in a sauna, bathroom, laundry room, etc.
- **Carbon dioxide sensor.** Detects when the carbon dioxide content increases and increases the fan speed. Suitable where number of occupants vary.

See also the product Control equipment datasheet.

Controlled from the Premium control panel

The Premium control panel (accessory) can be installed recessed in or surface mounted on the unit cubicle. A 20 m long cable with modular connectors is included.

An extra control panel can be connected, if you want to control the unit from more than one place.

The control panel has a display screen, four multi-functional buttons and an LED, which indicates the operational status.

Optional functions:

- **In-operation.** The unit can be stopped and started.
- **Fan speed.** The unit fans can be set and controlled to operate at five different speeds.

  The speed of the supply air fan can be lower than the speed of the extract air fan and if EC motors are installed in the unit, the speeds can be adjusted in the control panel.
- **Timer.** 24 hour/weekly timer where you can set the desired times for the unit to operate at normal flow (Home). The unit operates in the economically low flow mode at other times (Away).
- **Temperature.** Desired start temperature for the electric air heater for reheating is set between 13-20°C. The reheating can also be shut off.
- **Negative pressure compensation.** Negative pressure arises in the home when separate cooker hood or central vacuum cleaner is used, since the extract air flow becomes greater than the supply airflow. The function compensates for this by automatically increasing the supply airflow.
- **Summer night cooling.** The function is switched in at night under certain temperature conditions. The heat exchanger of the unit stops, the electric air heater is switched off and the fans run at a higher speed. This utilises the cooler air at night to cool down the home.
- **Fireplace switch function.** Temporarily stops the extract air fan. This generates positive pressure in the home and thus “forces” the chimney flue to extract the combustion gas, preventing it from smoking into the room when a fire is lit in the fireplace.
- **In-operation indications.** The operation status is continually shown in the display, both in clear text and with an LED in various colours.
- **Service.** The required time interval for obtaining a service reminder is set to 3-12 months.

The Premium control panel is operated in a way that is similar to that of mobile telephones with pushbuttons and a system of menus.

Automatic functions

- **Alarms.** An alarm is initiated when it is time for replacing the filters, when servicing is needed and in the event of a disruption in operation.
- **Heat exchanger.** Started or stopped in response to a signal from the temperature sensor.
- **Overheating protection.** For motors and the electric air heater.
- **Anti-freeze protection** Prevents freezing in the heat exchanger.

Demand Control

The Premium control panel has provision for control functions for demand control with the following accessories:

- **Filter guard.** Measures the pressure difference across the filter and initiates an alarm when the filters are fouled.
- **Occupancy detector.** Detects movement in the home and increases the fan speed to boosting. Suitable for economical operation of premises used irregularly, such as a holiday cottage, an overnight flat, etc.
- **Humidity sensor.** Detects when the humidity increases and starts boosting the air flow from the ventilation unit. Suitable for location in a sauna, bathroom, laundry room, etc.
- **Carbon dioxide sensor.** Detects when the carbon dioxide content increases and increases the fan speed. Suitable where the number of occupants vary.
- **Extra fireplace switch.** The function is integrated in the Premium control panel as described above and is displayed under Selectable Functions. However, an extra switch can also be installed close to a fireplace heating stove.

See also the product Control equipment datasheet.

Accessories

ILMO Premium cooker hood

- A specially adapted cooker hood for the ILTO R80 ventilation unit. Can be connected via duct or directly to the unit.
- An integrated control panel for the ILTO R80 ventilation unit.
- Neutral and pure design.
- Low sound level.
- A large hood offers high cooking odour arresting capacity.
- Large grease filter made of metal.
- Easy to clean. The grease filter can be washed in a dish washing machine.
- 125 mm dia. extract air connection, with rubber gasket. The connection is dimensionally matched for direct mounting underneath the R80.
- 11 Watt fluorescent tube.
- Electrical connection via mains plug with cord, 230 V 10 A.

Alternative

- White or in stainless steel

The ILMO Premium cooker hood is specially adapted to the R80 ventilation unit.

Air Handling Unit Accessories

Cover plate

The cover plate for the front door in white or stainless steel is an option when the ILTO R80 is installed as a wall cabinet in the kitchen. It provides a smooth surface that is easy to keep clean.

The cover plate is hooked on to the front door and is simple to both fit in place and remove.

Moisture barrier for duct

Provides a moisture-proof duct penetration point. Available in set of 5 for size 100, 125 and 160 mm dia. ducts.

Replacement filters

Filter set consisting of one class G3 filter and one class F7 fine filter.

Extra extract air filter

1 class F7 fine filter.

Filter class G3 is standard for the extract air, but may be insufficient if the extract air contains many dust particles. The class F7 fine filter then prevents clogging in the passages of the heat exchanger.

Cover plate, to be hooked on the front door to obtain a flat surface.

A moisture barrier for individual ducts.

Replacement filters

Accessories

System Products

The ventilation unit is a part of a system for the economical and comfortable ventilation of a home.

Swegon offers a complete program for home ventilation. In that all the components are supplied by one subcontractor, you are assured that all the units will operate together in harmony in one system and that correctly sized products can be selected. It is therefore e.g. possible to control the ventilation units from the cooker hood.

Cooker hoods

The ILMO Premium cooker hood is specially adapted for connection to the ILTO R80 ventilation unit.

If you do not want to connect the cooker hood to the ventilation unit, you may want to select the ILMO or the INTELLE cooker hood with power roof ventilator.

See the product datasheet: Cooker Hoods.

Supply air diffusers and extract air valves

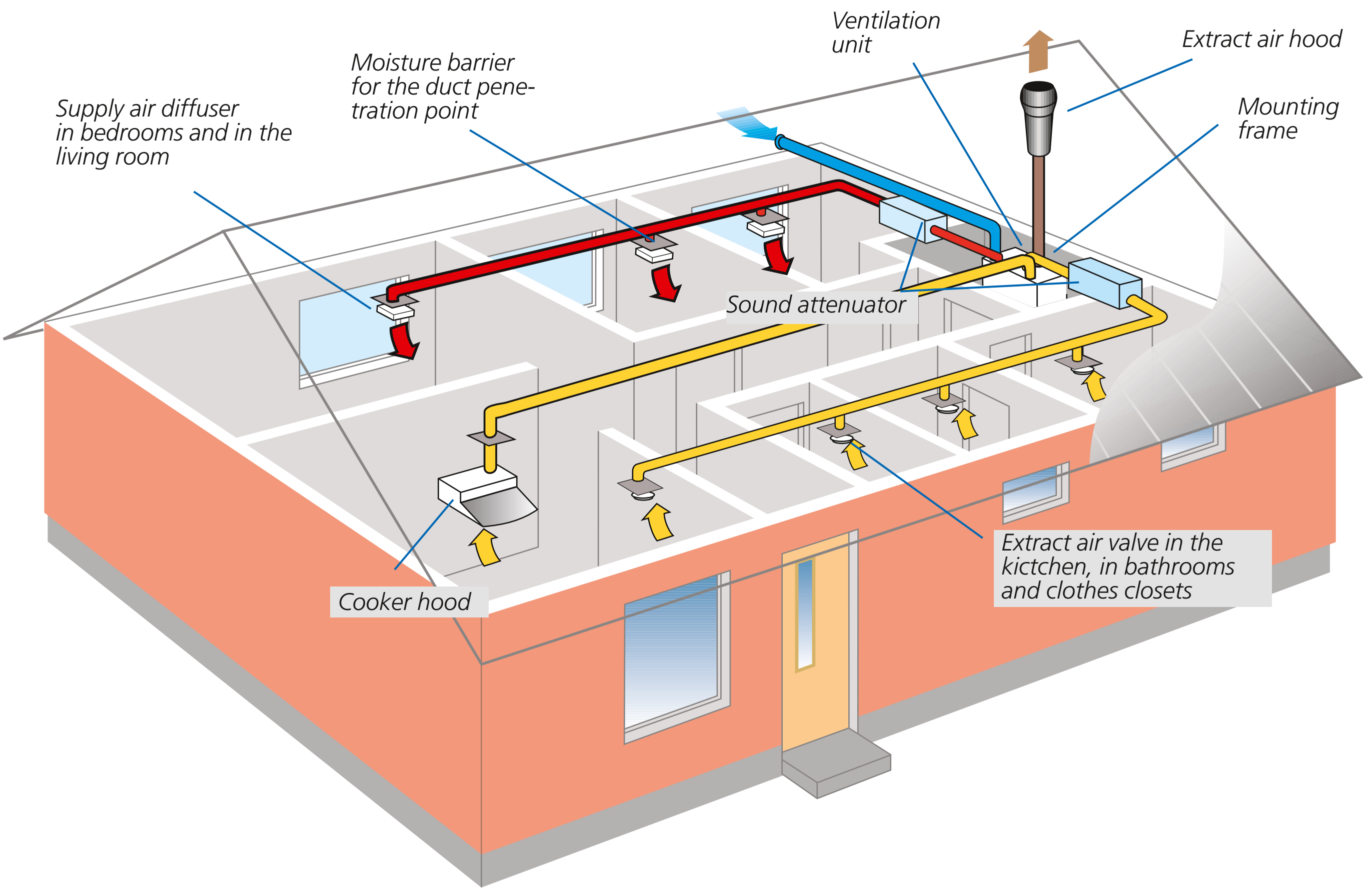
See the product datasheet: Air Diffusers.

Sound attenuator

See the product datasheet: Sound attenuators.

Roof products

Power roof ventilators, roof hoods, etc.
See the product datasheet: Roof Products.



Installation

The ILTO R80 has extra duct connections for extract air from the cooker hood both on the bottom and the top of the unit. The extract air from the cooker hood flows directly out via the extract air fan of the unit and never passes the heat exchanger.

The connection(s) not used should be blanked off with a cover or an end section for spiral ducts (not included in the supply).

Three installation alternatives

The extra duct connections make the ILTO R80 a very flexible ventilation unit with three installation options.

1. The ILMO Premium cooker hood connected via a duct to the ventilation unit

The ILTO R80 can be located at an optional place, suitably in a laundry room, a storage room, etc. The space should be warmer than +10°C. The unit should be secured to a wall with the wall mounting kit supplied.

The extract air from the ILMO Premium cooker hood is connected via a duct to the extra duct connection on top of the unit.

The ILTO R80 can be controlled from the control panel of the cooker hood and, if required, also from a separate control panel (accessory).

2. The ILMO Premium cooker hood directly against the ventilation unit

The renovation alternative for replacing old spice rack units. The ILTO R80 should be secured to a wall with the wall mounting kit supplied, as a wall cabinet above the cooker.

The ILMO Premium cooker hood is connected directly to the ventilation unit via an extra duct connection on the underside of the unit. The ILMO Premium cooker hood is available in both a right-hand and left-hand version, to suit the ILTO R80 in both the right-hand or left-hand version.

The ILTO R80 can be controlled from the control panel of the cooker hood and, if required, also from a separate control panel (accessory).

3. Separate cooker hood

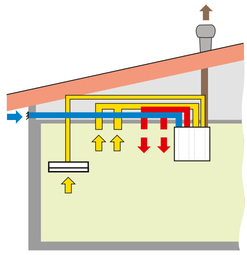
The ILTO R80 can be located at an optional place, suitably in a laundry room, a storage room, etc. The space should be warmer than +10°C. The unit should be mounted against a wall with the wall mounting kit supplied.

The extract air from the cooker hood is connected to a separate power roof ventilator.

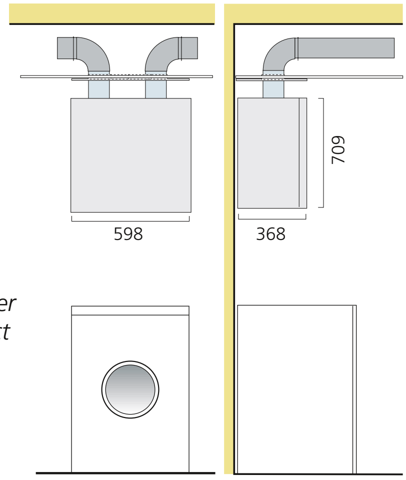
The ILTO R80 is controlled from a separate control panel (accessory). The power roof ventilator is appropriately controlled from the control panel of the cooker hood.

All alternatives

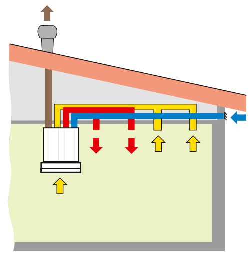
The wall structure should be able to support the weight of a 70 kg ventilation unit.



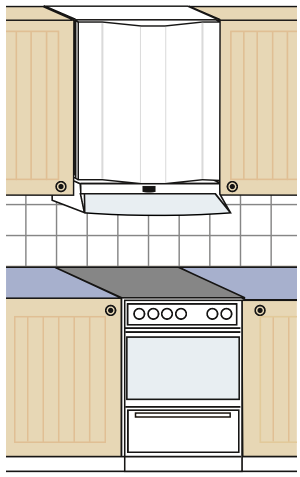
The ILMO Premium cooker hood, connected via duct to the ventilation unit.



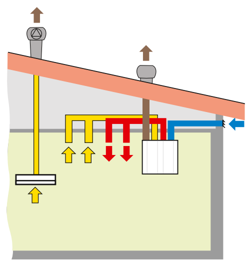
The ILTO R80 against a wall in a laundry room.



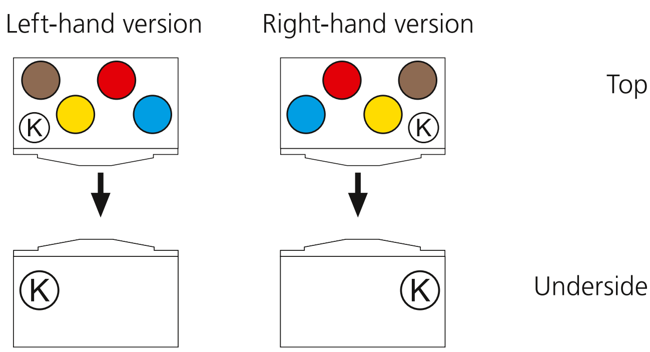
The ILMO Premium cooker hood connected directly to the ventilation unit.



The ILTO R80 as a wall cabinet.



Separate cooker hood.



- Supply air
- Extract air
- Outdoor air
- Exhaust air
- Ⓚ Extract air cooker hood

Right-hand or left-hand version and connection both on the top and bottom for connecting a cooker hood offers great installation flexibility.

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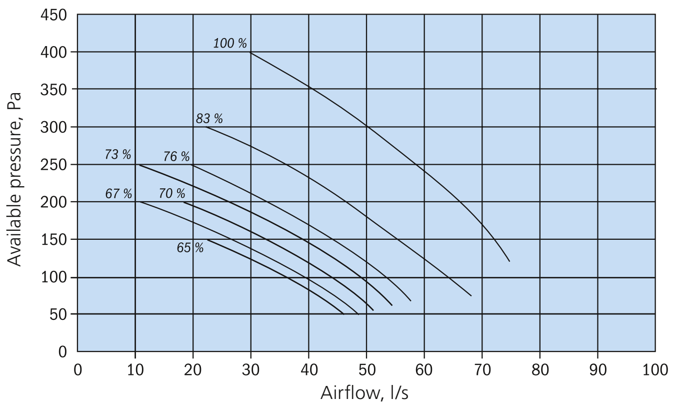
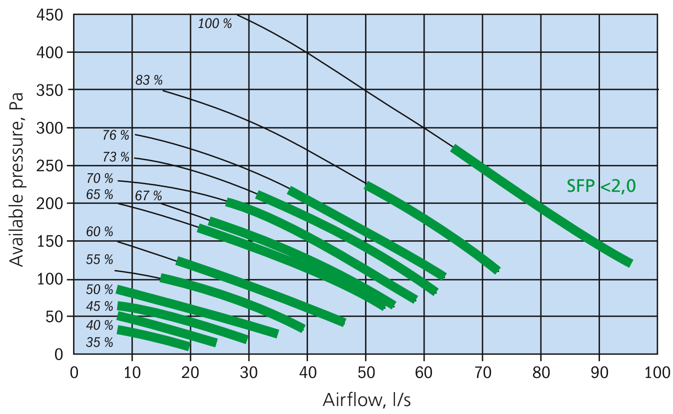
Sizing, ILTO R80, EC fan motors

Supply air, ILTO R80, EC fan motors

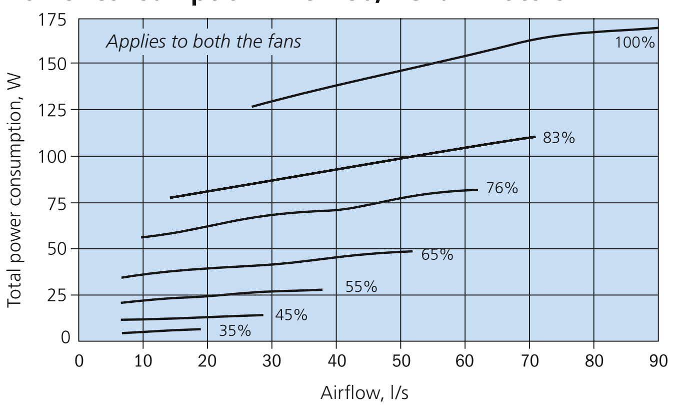


Extract air, ILTO R80, EC fan motors



Green line = SFP 2.0 or lower.

Power consumption ILTO R80, EC fan motors



Extract air via cooker hood, ILTO R80, EC fan motors

Regulation %	65	73	85	100
Airflow, l/s	28	32	39	43

Sound emitted to the supply air duct, ILTO R80, EC fan motors

Regulation %	Airflow l/s	Sound power level broken down into octave bands, L_{wokt}, dB								Totally weighted sound power level, L_{WA}, dB(A)
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
35	18	62	47	42	41	36	28	17	-	42
45	26	63	55	48	47	43	37	28	12	49
55	36	63	60	53	51	48	43	37	22	54
65	46	75	65	58	56	51	48	41	30	58
73	54	75	69	61	60	55	51	46	35	62
83	68	76	73	65	63	58	55	49	39	65
100	75	81	77	69	67	61	59	53	45	69

Sound emitted to the extract air duct, ILTO R80, EC fan motors

Regulation %	Airflow, l/s	Sound power level broken down into octave bands, L_{wokt}, dB								Totally weighted sound power level, L_{WA}, dB(A)
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
35	20	61	53	38	34	27	26	20	9	41
45	30	64	55	39	40	29	26	20	9	44
55	40	67	56	45	39	31	26	20	7	45
65	54	74	62	50	44	35	27	20	9	51
73	63	74	62	53	46	37	28	22	10	52
83	73	74	64	56	50	40	31	24	12	54
100	84	74	65	59	52	42	32	26	12	55

Sound emitted to the surroundings, ILTO R80, mounted against cooker hood, EC fan motors

Regulation %	Airflow l/s	Sound pressure level at 10 m² sound absorption, $L_p(10)$, dB(A) *
35	20	26
45	30	31
55	40	32
65	54	33
73	63	35
85	74	37
100	84	40

**) Equivalent to a normally sound attenuated room*

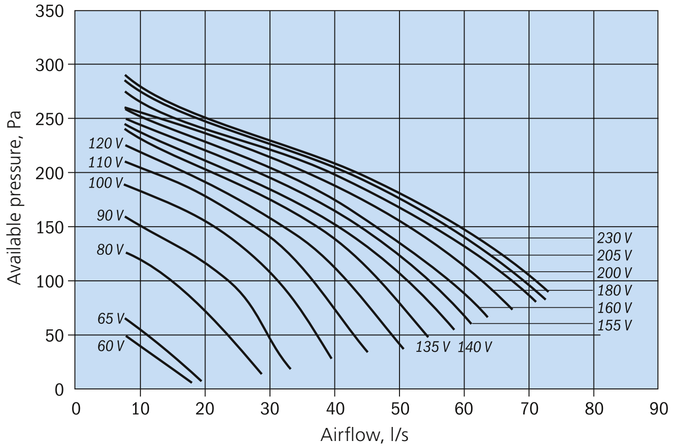
Sound emitted to the surroundings, ILTO R80, wall mounted, EC fan motors

Regulation %	Airflow l/s	Sound pressure level at 10 m² sound absorption, $L_p(10)$, dB(A) *
35	20	29
45	30	32
55	40	33
65	54	36
73	63	38
85	74	39
100	84	43

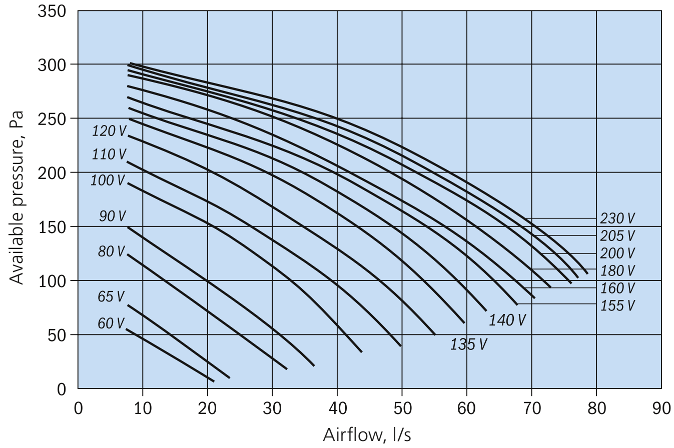
**) Equivalent to a normally sound attenuated room*

Sizing, ILTO R80, AC fan motors

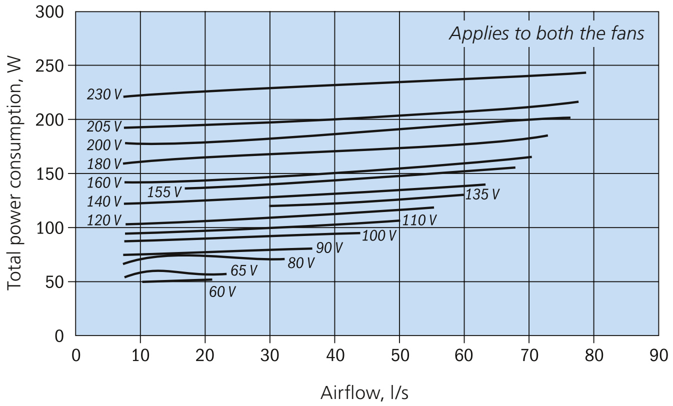
Supply air, ILTO R80, AC fan motors



Extract air, ILTO R80, AC fan motors



Power consumption, ILTO R80, AC fan motors



Extract air via cooker hood, ILTO R80, AC fan motors

Voltage V	120	140	160	180	205	230
Airflow, l/s	28	32	34	39	43	43

Sound emitted to the supply air duct, ILTO R80, AC fan motors

Voltage V	Airflow l/s	Totally weighted sound power level, L_{WA}, dB(A)
60	21	45
100	43	57
140	63	65
180	73	69
205	77	70
230	79	71

Sound emitted to the surroundings, ILTO R80 mounted against cooker hood, AC fan motors

Voltage V	Airflow l/s	Sound pressure level at 10 m² sound absorption, L_p(10), dB(A) *
60	21	29
100	43	32
140	63	38
180	73	41
205	77	42
230	79	43

Sound emitted to the extract air duct, ILTO R80, AC fan motors

Voltage V	Airflow, l/s	Totally weighted sound power level, L_{WA}, dB(A)
60	21	34
100	43	46
140	63	52
180	73	56
205	77	58
230	79	59

Sound emitted to the surroundings, ILTO R80 wall-mounted, AC fan motors

Voltage V	Airflow l/s	Sound pressure level at 10 m² sound absorption, L_p(10), dB(A) *
60	21	29
100	43	33
140	63	39
180	73	42
205	77	43
230	79	44

**) Equivalent to a normally sound attenuated room*

Electrical connections

The unit has cord with a mains plug for connection to a 230 V 10 A supply.

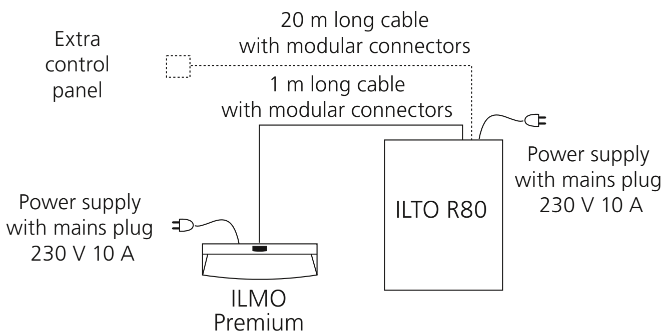
Max. total power consumption (incl. electric air heater):
R80, EC fan motors: 750 W, 3.3 A.
R80, AC fan motors: 850 W, 3.7 A.

Control via the ILMO Premium cooker hood
A 1 metre long cable with modular connectors is included. Used when the unit is placed directly on the cooker hood.

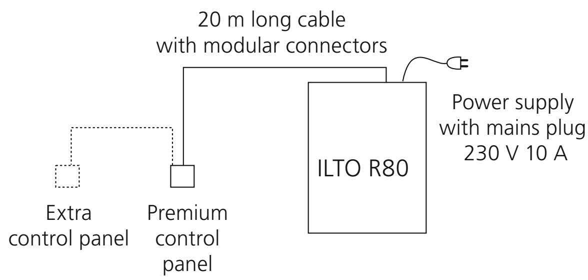
An extra control panel (accessory) can be connected if the unit and the cooker hood are installed at different locations, or if you wish to be able to make changes in the factory settings of the unit. A 20 m long cable with modular connectors is included.

Control via Premium control panel *(accessory)*
The control panel can be located at an optional place. A 20 m long cable with modular connectors is included. In addition, an extra control panel (accessory) can be connected if it is desirable to control the ventilation unit from more than one place.

Control via ILMO Premium cooker hood

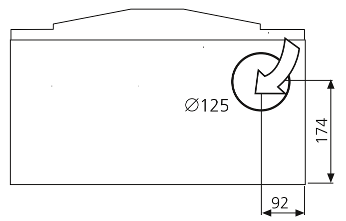


Control via Premium control panel

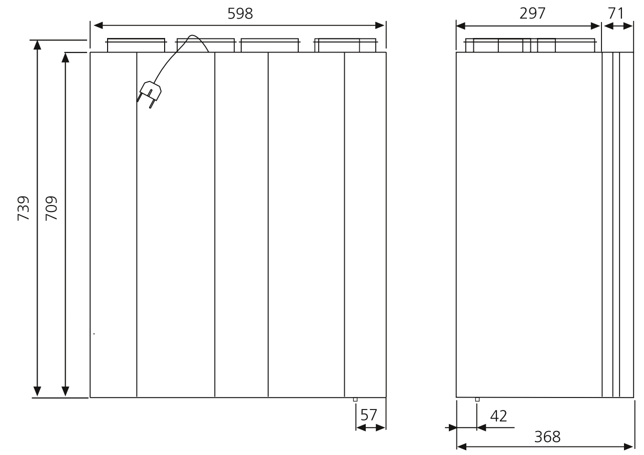


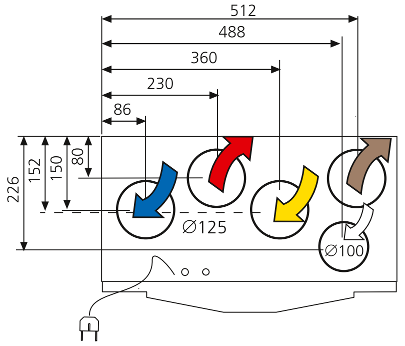
Dimensions

ILTO R80



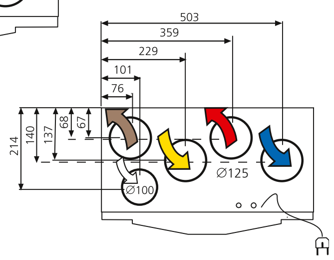
Underside





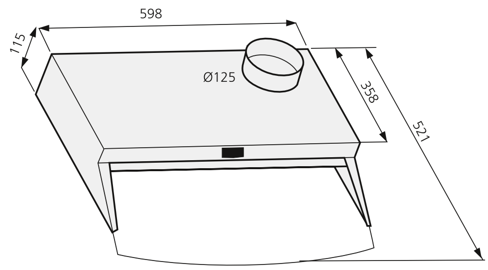
Top

Left-hand variant



Outdoor air | Supply air | Extract air | Exhaust air | Extract air cooker hood

ILMO Premium cooker hood



Right-hand version is shown. The duct connection is on the left-hand side on a left-hand unit.

Weight
70 kg

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Ordering Key

Ventilation unit

ILTO R80 Premium ventilation unit, EC fan motors

R, right-hand	1028RRD
L, left-hand	1028RLD

ILTO R80 Premium ventilation unit, AC fan motors

R, right-hand	1028RRA
L, left-hand	1028RLA

Controls

For controlling the ventilation unit, a Premium control panel or control via an ILMO Premium cooker hood is required. An extra control panel can be connected, if the Premium control panel is selected, if it is desirable to control the unit from more than one place.
If control is selected via the ILTO Premium cooker hood, an extra control panel can be connected, to enable the user to make changes in the factory settings.

ILTO Premium control panel	102POK

Moreover, demand control can be carried out via a humidifier sensor, etc.

See the product datasheet: Control Equipment.

Accessories

ILMO PRE cover plate, for front door of the ILTO R80

White	1216PREVH
Stainless stel	1216PRERH

Moisture barrier for duct, set of 5

Ø 100 mm	102LT10
Ø 125 mm	102LT12
Ø 160 mm	102LT16

Replacement filters, set 1 class G3 filter + 1 class F7 filter	10280SS
Extract air filter, class F7 fine filter (supersedes the standard G3 extract air filter)	10280SFP

ILMO Premium cooker hood

ILMO Premium SV cooker hood, white

R, right-hand	1216PRER
L, left-hand	1216PREL

ILMO Premium SR cooker hood, stainless steel

R, right-hand	1216RPRER
L, left-hand	1216RPREL

System products

Other cooker hoods	*See the product datasheet: Cooker Hoods.*
Air diffusers	*See the product datasheet: Air Diffusers.*
Sound attenuators	*See the product datasheet: Sound attenuators.*
Roof hoods and power roof ventilators	*See the product datasheet: Roof Products.*

Duct filter

STR

Description

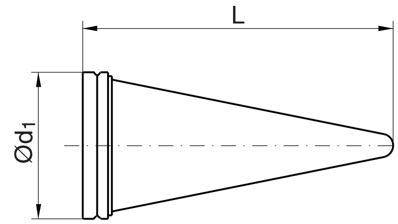
The duct filter fits in all fittings with a Safe-groove. To install the filter in a T-piece means a simple mounting and replacing.

The special tapered shape gives 4–5 times larger filter area than the equivalent duct cross section area, giving lower pressure drop and longer exchange intervals than the equivalent flat filter.
Standard filter class is G4, but class F5 is optionally available. The diagram shows the pressure drop across a clean filter, including T-piece. The filter can be used to twice this pressure drop. It is a good idea to dimension the system for the average value.
$\Delta p_{t\ dim} = 1{,}5 \cdot \Delta p_{t\ clean}$

Max temperature = 120 °C
Highest recommended air speed in the duct.

Filter class	v_{max} (m/s)
G4	10
F5	4,5

Dimensions



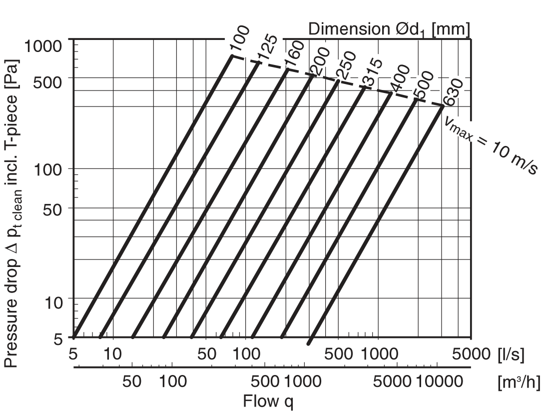
Ød1 nom	L mm	Tolerance mm	Area m²	m kg
100	220	±20	0,04	0,04
125	260	±20	0,05	0,08
160	340	±20	0,09	0,12
200	420	±25	0,14	0,16
250	540	±30	0,22	0,23
315	670	±30	0,34	0,36
400	860	±35	0,55	0,59
500	1100	±50	0,89	0,72
630	1350	±50	1,37	0,91

Ordering example

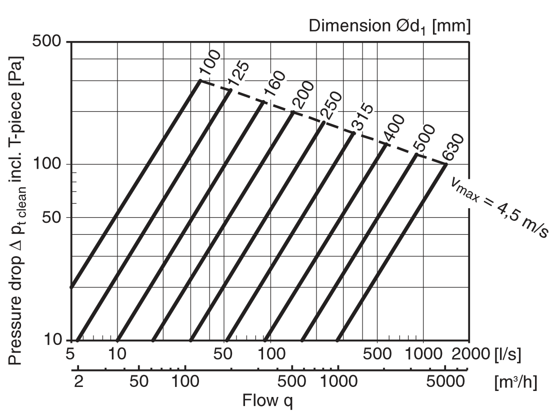
STR 200 G4

Product — STR
Dimension Ød1 — 200
Filter class — G4

Filter class G4

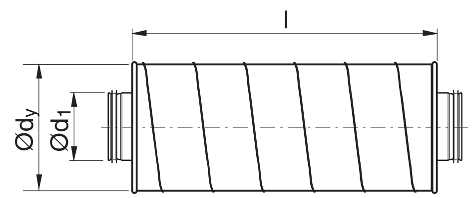


Filter class F5



Circular straight silencer SLU 100

Dimensions



Description

Insulation thickness 100 mm.

Good attenuation in 125 and 250 Hz bands.

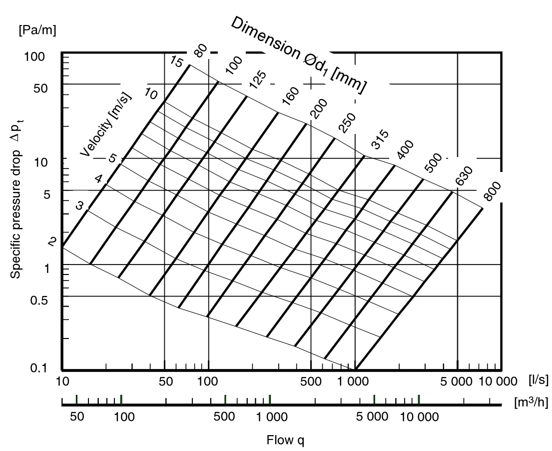
For general information about the silencer´s design, please refer to page 132.

Ordering example

SLU 200 600 100

Product	SLU
Dimension $Ød_1$	200
Length l	600
Insulation thickness	100

Technical data



$Ød_1$ nom	l mm	Attenuation in dB for centre frequency Hz 63	125	250	500	1k	2k	4k	8k	$Ød_y$ mm	m kg
80	300	1	6	15	21	26	33	31	17	295	4,70
80	600	7	13	26	32	50	50	45	25	295	7,90
80	900	8	14	29	38	58	57	55	39	295	10,2
80	1200	8	17	33	40	60	59	59	45	295	13,3
100	300	4	6	13	18	26	29	22	13	310	5,00
100	600	6	10	19	28	38	47	33	18	310	8,20
100	900	8	14	26	37	54	52	45	25	310	12,6
100	1200	7	15	30	38	58	55	50	30	310	15,3
125	300	3	6	10	14	20	27	20	12	325	5,70
125	600	6	10	19	28	39	42	28	17	325	8,60
125	900	3	11	26	36	52	47	41	24	325	13,4
125	1200	6	10	29	37	54	53	47	27	325	16,7
160	300	4	4	8	13	17	23	15	10	365	6,30
160	600	5	8	15	23	31	40	22	16	365	10,7
160	900	3	9	21	32	47	52	29	19	365	14,9
160	1200	4	10	29	34	49	53	30	18	365	19,8
200	300	3	3	6	9	14	19	13	10	410	8,40
200	600	2	6	15	18	27	29	19	15	410	13,0
200	900	2	7	21	26	40	39	24	18	410	17,4
200	1200	3	9	27	34	48	45	27	17	410	22,2
250	600	1	5	13	16	23	25	15	13	465	15,4
250	900	1	5	18	25	35	31	17	16	465	20,5
250	1200	3	7	21	29	41	39	20	18	465	26,2
315	600	2	4	8	11	16	15	11	11	510	16,7
315	900	3	5	12	15	24	21	14	13	510	22,8
315	1200	3	7	16	21	32	26	17	15	510	29,8
400*	600	1	3	6	9	13	13	9	8	615	23,0
400*	900	1	4	10	14	21	18	12	11	615	33,6
400*	1200	2	7	13	19	27	24	15	13	615	42,9
500*	900	2	5	8	12	15	14	12	10	735	38,9
500*	1200	3	6	12	18	21	17	14	12	735	50,4
630*	900	1	5	8	11	11	12	9	7	880	49,4
630*	1200	3	5	11	16	15	15	11	9	880	61,4
800*	1200	3	5	8	11	10	11	9	6	1030	84,8
800*	1500	3	5	10	14	13	13	11	8	1030	104

* Supplied with two loose couplings

Circular straight silencer SLU 50

Description

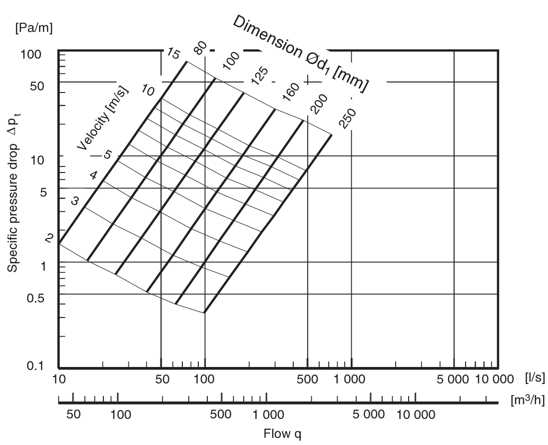
Insulation thickness 50 mm.

For general information about the silencer´s design, please refer to page 132.

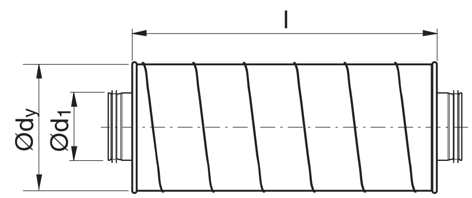
Ordering example

	SLU	125	600	50
Product	SLU			
Dimension $Ød_1$		125		
Length l			600	
Insulation thickness				50

Technical data



Dimensions



$Ød_1$ nom	l mm	Attenuation in dB for centre frequency Hz 63	125	250	500	1k	2k	4k	8k	$Ød_y$ mm	m kg
80	300	2	4	8	16	27	34	35	19	190	2,21
80	600	3	9	16	28	46	53	46	25	190	3,73
80	900	4	5	20	36	56	57	58	41	190	5,49
80	1200	5	6	23	40	62	61	62	45	190	6,90
100	300	3	4	8	14	23	27	25	14	210	2,64
100	600	3	8	13	25	40	50	40	21	210	4,80
100	900	3	5	18	33	53	55	48	28	210	6,25
100	1200	3	6	22	39	60	61	53	33	210	7,89
125	300	3	2	7	14	21	26	20	12	235	3,05
125	600	2	7	12	23	39	47	32	18	235	5,18
125	900	0	3	16	29	53	52	39	24	235	7,38
125	1200	0	3	18	37	60	59	52	28	235	9,05
160	300	3	2	5	12	17	24	17	11	270	3,45
160	600	3	4	8	21	37	40	22	14	270	6,30
160	900	0	4	12	27	46	51	29	20	270	8,88
160	1200	0	3	14	34	51	53	33	18	270	11,1
200	300	3	1	4	10	16	20	14	11	310	4,43
200	600	2	4	8	20	31	32	20	15	310	7,54
200	900	0	4	10	25	32	40	24	18	310	10,7
200	1200	0	4	13	32	51	48	28	17	310	13,3
250	600	1	2	6	15	27	25	15	14	365	9,30
250	900	0	2	8	22	37	34	18	16	365	12,8
250	1200	0	2	10	27	42	39	20	18	365	16,5
315	600	3	3	7	12	17	14	11	10	465	12,7
315	900	1	3	9	17	25	20	14	13	465	17,7
315	1200	2	3	12	24	37	23	17	15	465	23,0
400*	600	2	2	4	6	8	5	5	6	508	20,0
400*	900	2	3	5	10	12	8	6	8	508	26,0
400*	1200	3	3	7	13	16	10	7	9	508	29,0

* Supplied with two loose couplings

Roof hood HU

Description

For air exit above roof.

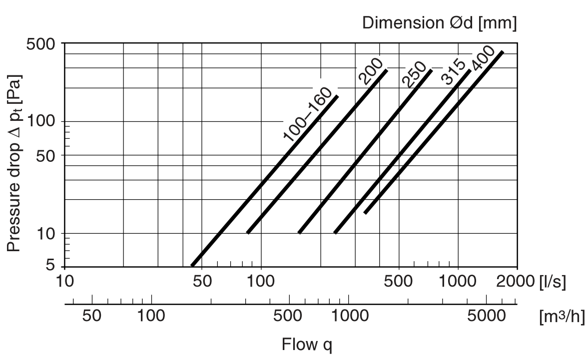
Provided with a female connection which fits outside a ventilation duct.

Ordering example

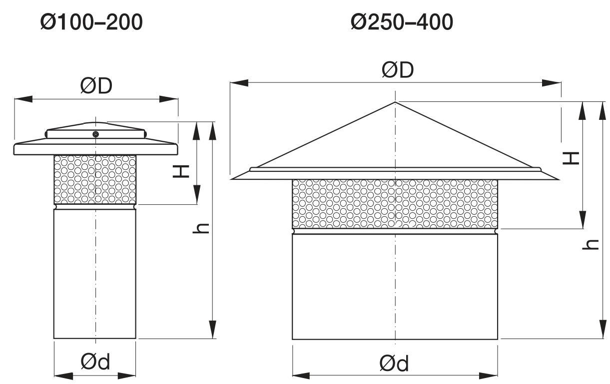
	HU	160
Product	HU	
Dimension Ød		160

Technical data

Extract air



Dimensions



Ød nom	ØD mm	H mm	h mm	m kg	Roof through connection TGR Size 50 mm	Roof through connection TGR Size 100 mm
100	200	99	264	0,51	3	3
125	225	102	267	0,65	3	4
160	260	105	270	0,81	3	4
200	315	114	273	1,09	3	4
250	400	156	291	1,45	4	5
315	500	185	303	1,99	5	6
400	600	226	344	2,70	5	6

Roof hood VHL

Description

VHL roof hood with ribs is specially developed to achieve an architecturally correct way of terminating outdoor air intakes and extract air ejectors on the roof. The ribbed hood is supplied as standard in galvanised form, but are also available painted.

VHL can be installed with duct dimensions corresponding to Ød or ØD.

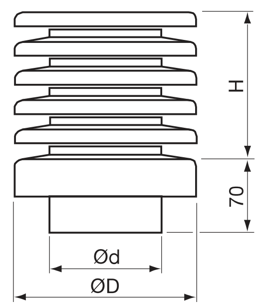
When connecting to the roof through connection TGR, the special transition piece TGR-VHL must be used (see page 272).

Ordering example

	VHL	125	200
Product	VHL		
Dimension Ød		125	
Dimension ØD			200

Standard colours, see page 257.

Dimensions



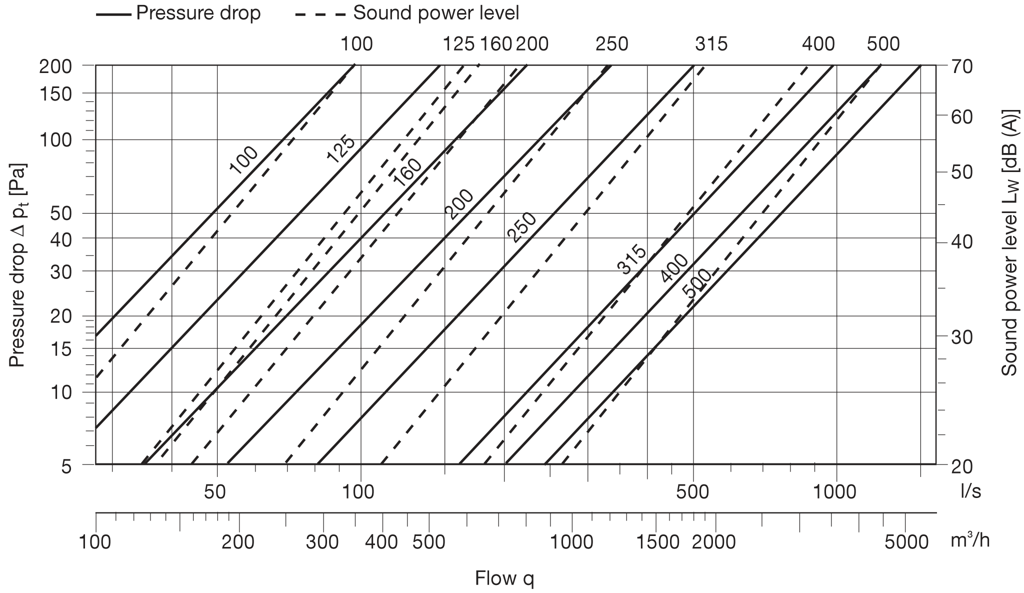
Ød nom	ØD mm	H mm	Free area m^2	m kg	Roof through connection TGR Size 50 mm	Roof through connection TGR Size 100 mm
100	160	110	0,019	1,00	3	3
125	200	145	0,033	1,50	3	4
160	250	180	0,055	2,00	3	4
200	315	250	0,100	2,90	3	4
250	315	250	0,125	3,20	4	5
315	400	290	0,182	6,40	5	6
400	500	370	0,306	10,1	5	6
500	630	410	0,441	15,9	6	7

Roof hood

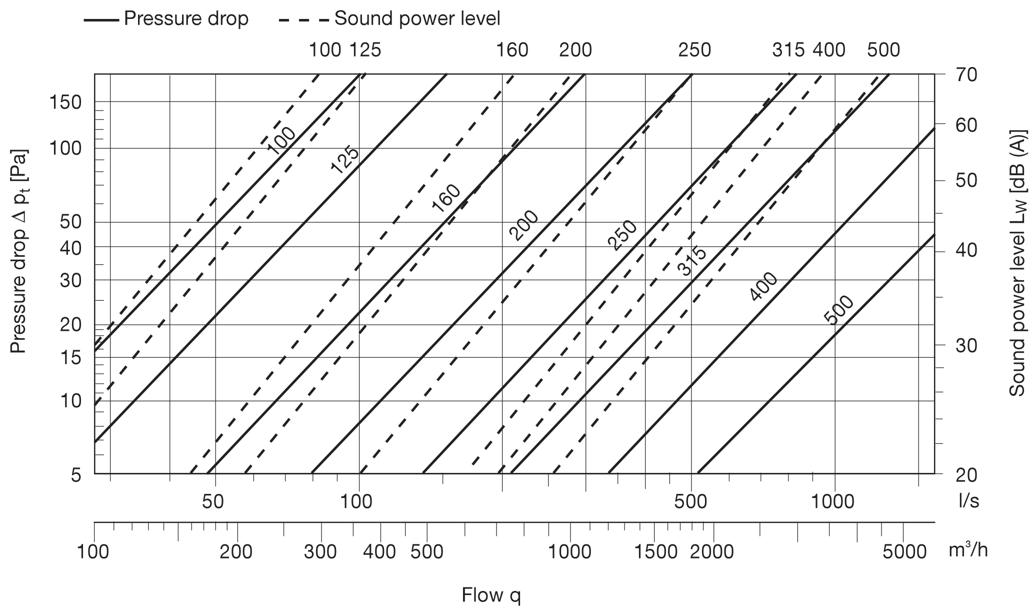
VHL

Technical data

Outdoor air



Extract air



Damper with flow meter

IRIS

Description

The IRIS damper with flow meter offers measurement of the air flow. Stable function, even in the case of air flow disturbances.

- Low noise level
- Works independent of flow direction
- Can be opened 100%, making the ducts easy to clean
- Tightness class C
- Retains the set position without locking. However, dimension 80 must be locked with locking screws.

Install the IRIS damper at a suitable distance from sources of disturbance. See technical data at page 190. The IRIS damper must not be loaded with the weight of adjoining ducts. This applies particularly in the case of vertical installation.

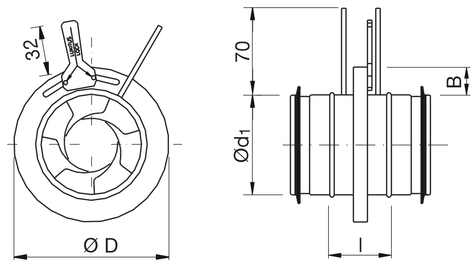
The control panels form a measuring flange that facilitates measurement of the airflow.

The pressure drop recorded over the device's measuring nozzles gives the air flow, either with the aid of the measurement graph or calculating using the k-factor.

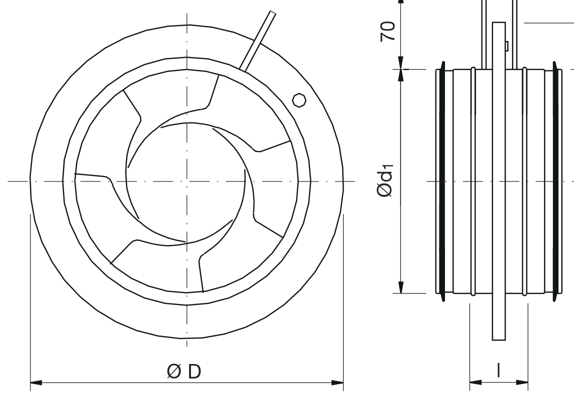
Measurement graphs and k-factors can be found on the device and at www.lindab.com. The air flow is adjusted using the adjustment nut (handle at size 80).

Dimensions

Ø80



Ø100–800

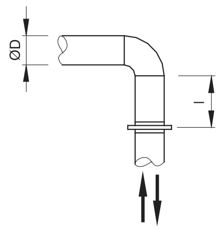
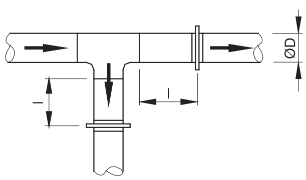
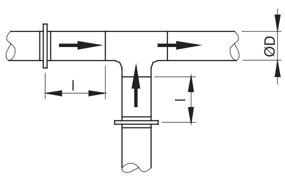
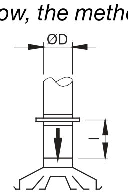


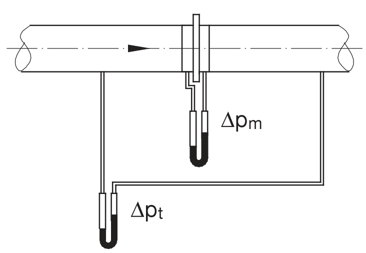
Ød_1 nom	ØD mm	B mm	l mm	m kg
80	125	22	50	0,5
100	165	32	60	0,6
125	188	32	60	0,9
160	230	35	60	1,2
200	285	42	60	1,7
250	335	42	60	2,3
315	410	47	70	3,7
400	525	62	70	6,7
500	655	77	70	9,8
630	815	92	70	15,8
800	1015	107	70	25,0

1 2 3 4 5 6 7 8 9 10 11

Damper with flow meter IRIS

Technical data

l_1 = straight duct	Method error ± 7%
	l ≥ 1 D
	l ≥ 4 D
	l ≥ 2 D
With an ideal flow, the method error is 5%. 	l ≥ 2 D



Designations

q	air flow	l/s
L_{p10A}	sound pressure level at equivalent sound absorption area of 10 m² (Room damping 4 dB)	dB(A)
L_W	sound output level	dB
K_{oct}	correction	dB
Δp_t	total pressure drop	Pa
v	mean air flow velocity	m/s

Sound correction K_{oct} [dB]

$Ød_1$ nom	Octave band, mean frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
80	10	16	12	9	5	-1	-6	-23
100	25	21	16	9	4	-6	-12	-25
125	17	17	13	7	1	-4	-6	-17
160	19	18	14	6	-1	-6	-13	-25
200	20	17	12	5	-2	-5	-14	-26
250	16	12	8	3	1	-4	-17	-32
315	24	12	5	0	1	-2	-13	-27
400	15	9	6	2	-1	-4	-9	-13
500	14	7	4	1	-1	-4	-8	-11
630	15	7	3	2	-1	-5	-9	-11
800	9	5	3	3	-1	-6	-10	-13
Tol. ±	6	3	2	2	2	2	2	3

The sound output levels in the duct for each octave band are obtained by adding the corrections K_{oct} from the adjoining table to the sound pressure level L_{p10A}, dB(A), which is found in the dimensioning diagrams, in accordance with the formula:

$L_{Woct} = L_{p10A} + K_{oct}$

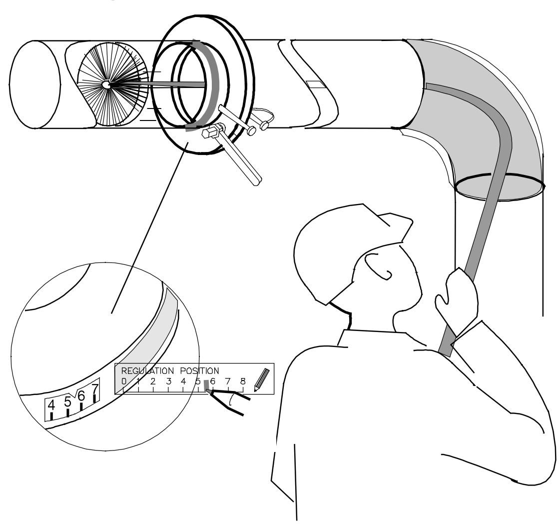
The correction K_{oct} is an average value in IRIS's working range.

Please note that the sound pressure levels reported in graphs take into consideration a room damping of 4 dB in the room that the damper is serving.

When calculating the sound output level as described above, however, the damper's sound output to the duct is obtained. This means that, in the sound calculation, the room damping shall be deducted when entering the room.

The dB(A) value in the graphs is only there to check the approximate sound pressure level.

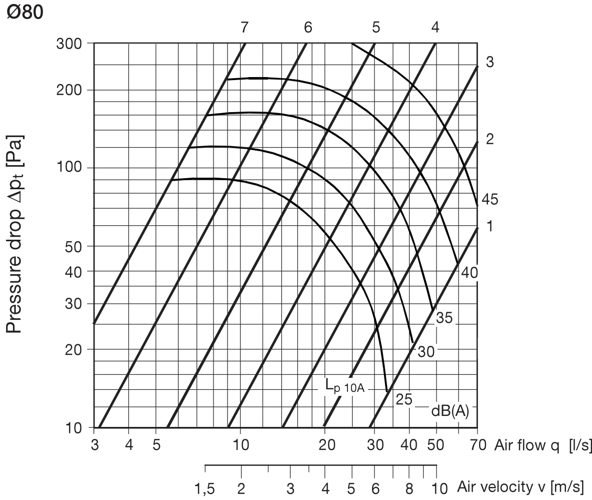
Cleaning



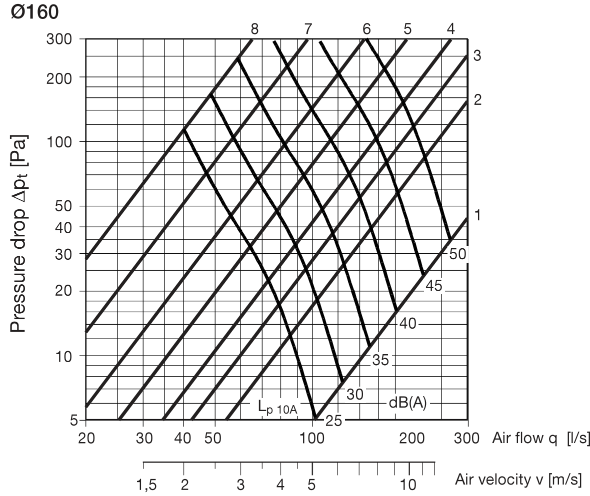
Damper with flow meter IRIS

Pressure drop graph with sound data for dimensioning

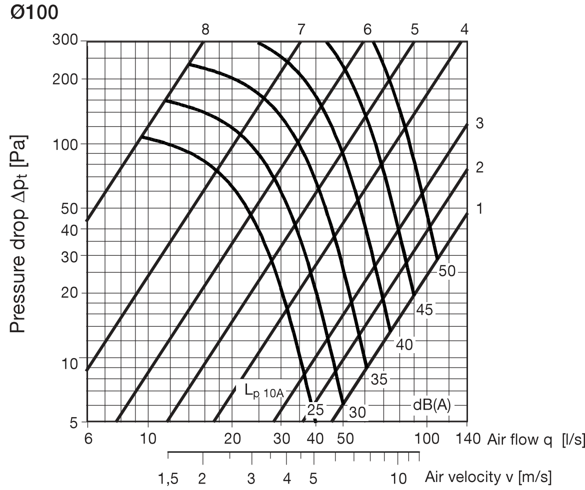
Ø80



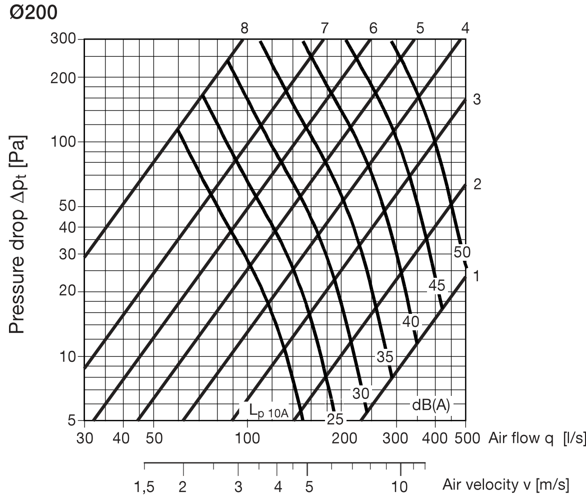
Ø160



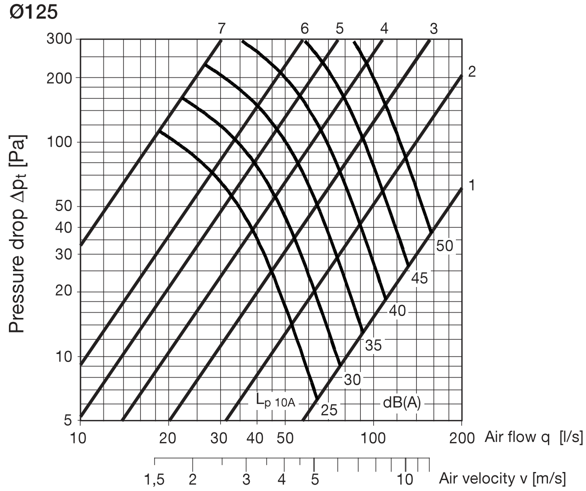
Ø100



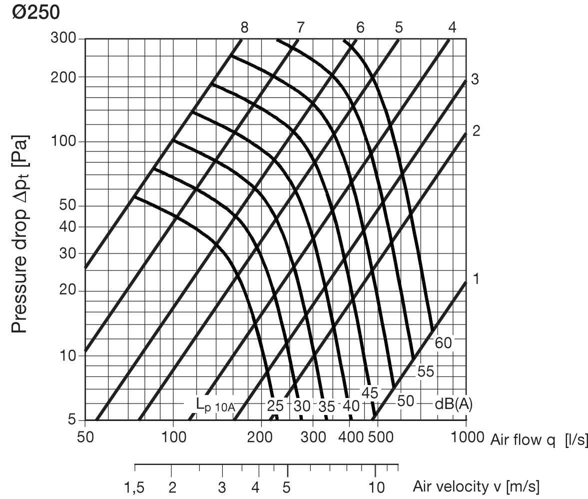
Ø200



Ø125



Ø250



Reducer RCFU

Description

Pressed, concentric reducer with female coupling, with a 45° angle to meet demands for short installation length with low pressure drop and low internal noise generation. Ød fits outside another fitting.

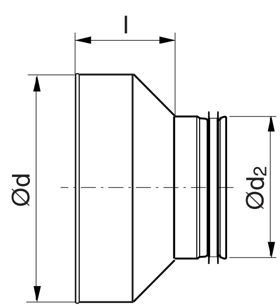
Pressure drop, see graphs on pages 65–66.

Ordering example

RCFU 200 100

- Product — RCFU
- Dimension Ød — 200
- Dimension $Ød_2$ — 100

Dimensions



Dimensions

Ød nom	$Ød_2$ nom	l mm	m kg
80	**63**	**57**	**0,11**
100	**63**	**66**	**0,14**
100*[1]	**80**	**61**	**0,16**
125*[1]	**80**	**73**	**0,16**
125*[1]	**100**	**64**	**0,14**
150	100	78	0,16
150[1]	125	66	0,17
160*	**80**	**92**	**0,24**
160*[1]	**100**	**83**	**0,16**
160*[1]	**125**	**71**	**0,20**
160*	150	57	0,25
180	100	98	0,24
180	125	85	0,31
180	150	68	0,24
180	160	66	0,27
200*[1]	**100**	**84**	**0,23**
200*[1]	**125**	**90**	**0,27**
200*	150	75	0,34
200*[1]	**160**	**73**	**0,26**
200*	180	63	0,32
224	150	92	0,45
224	160	87	0,49
224	180	76	0,46
224	200	66	0,45
250*	**125**	**133**	**0,57**
250*	150	122	0,56
250*[1]	**160**	**117**	**0,40**
250*	180	107	0,55
250*[1]	**200**	**103**	**0,42**
250*	224	89	0,53
300	200	119	0,68
300	250	94	0,66
315*	**160**	**153**	**0,82**
315*	**200**	**134**	**0,77**
315*[1]	**250**	**108**	**0,65**
355	250	136	1,04
355	315	97	0,89
400*	**200**	**196**	**1,31**
400*	**250**	**174**	**1,37**
400*	**315**	**133**	**1,20**
500**	**250**	**208**	**2,12**
500**	**315**	**185**	**2,09**
500**	**400**	**150**	**1,95**
630**	**315**	**240**	**2,76**
630**	**400**	**198**	**2,72**
630**	**500**	**148**	**2,69**

* With turned-over edge
** Hand made
1 With stream-lined transition

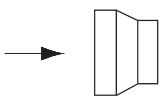
Lindab

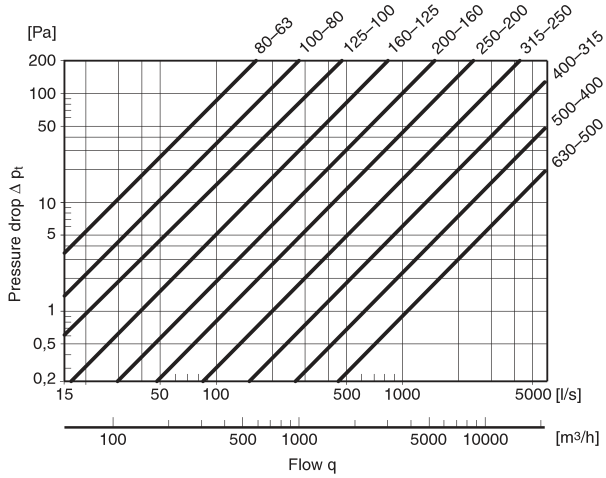
Reducers

RCU, RCFU

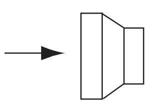
Technical data

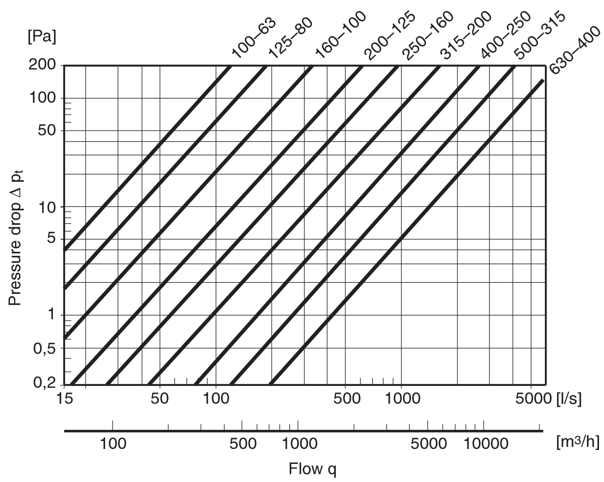
RCU, RCFU
1 step reduction



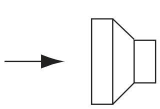


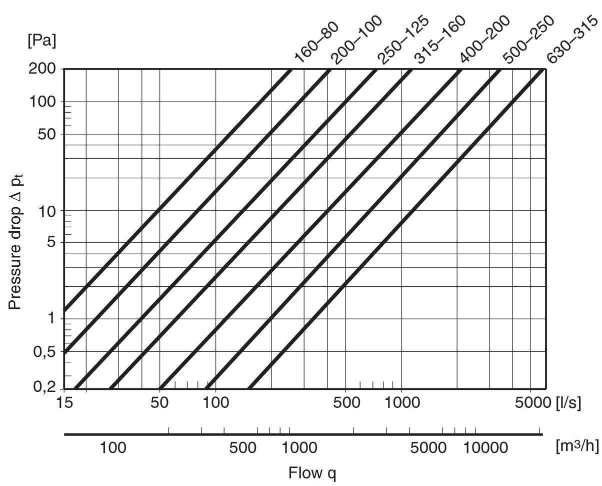
RCU, RCFU
2 steps reduction





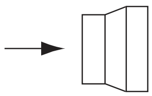
RCU, RCFU
3 steps reduction

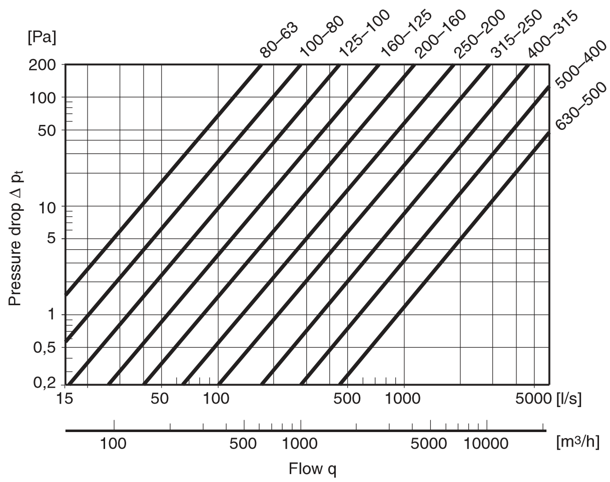




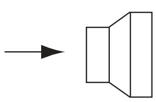
Technical data

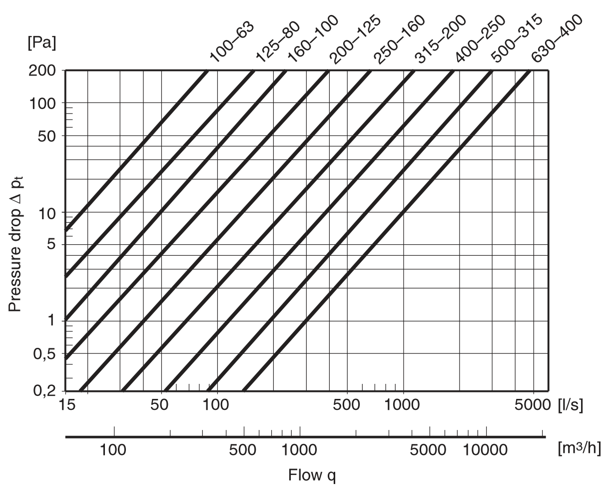
RCU, RCFU
1 step reduction



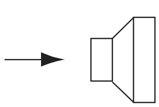


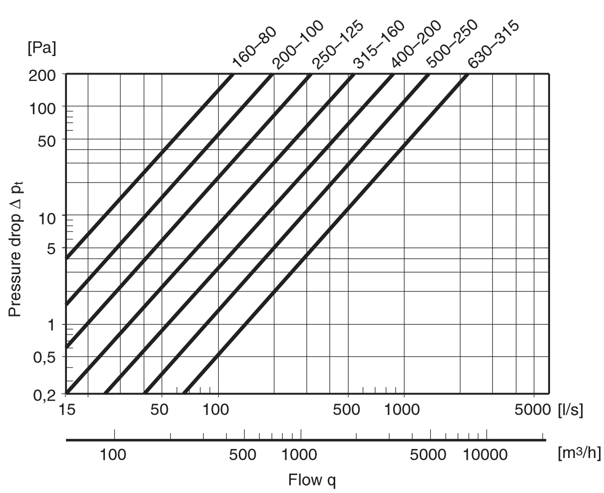
RCU, RCFU
2 steps reduction





RCU, RCFU
3 steps reduction





T-piece

TCPU

Description

T-piece built with PSU saddle or a fully pressed top section.

Pressure drop, see graphs on pages 82–83.

Ordering example

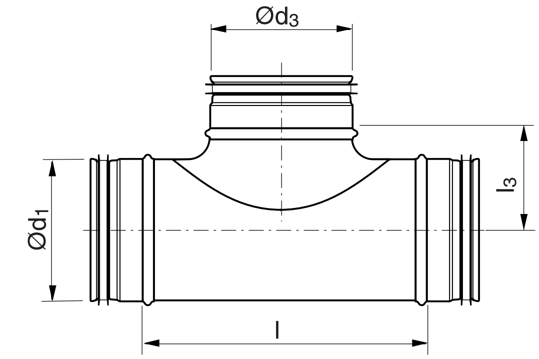
TCPU 250 160

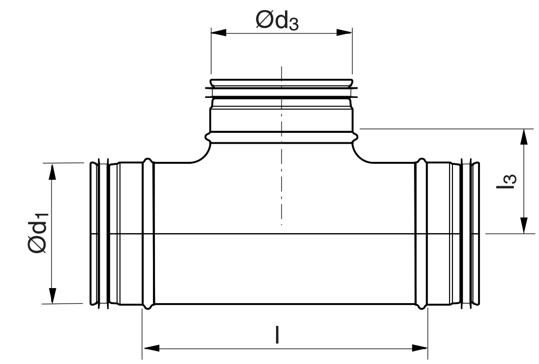
Product — TCPU

Dimension $Ød_1$ — 250

Dimension $Ød_3$ — 160

Dimensions





$Ød_1$ nom	$Ød_3$ nom	l mm	l_3 mm	m kg
63	63	125	42	0,26
80	63	125	50	0,31
80	80	140	52	0,36
100	63	125	60	0,35
100	80	103	65	0,23
100	100	130	65	0,32
112	63	125	66	0,41
112	80	140	68	0,47
112	100	175	71	0,55
112	112*	175	56	0,57
125	63	125	73	0,44
125	80	97	75	0,34
125	100	130	78	0,37
125	112	175	78	0,61
125	125	165	83	0,44
140	80	140	82	0,56
140	100	175	85	0,65
140	112	175	85	0,67
140	125*	215	70	0,76
140	140	230	90	0,78
150	80	140	87	0,58
150	100	175	90	0,69
150	125	215	95	0,76
150	140	230	95	0,82

T-piece

TCPU

Ød_1 nom	Ød_3 nom	l mm	l_3 mm	m kg
150	150	260	95	0,94
160	80	140	92	0,59
160	100	130	95	0,46
160	125	166	100	0,53
160	140	230	100	0,87
160	150	260	100	0,99
160	160	209	105	0,63
180	80	140	102	0,92
180	100	175	105	0,80
180	125	215	110	0,91
180	140	230	110	0,96
180	150	260	110	1,08
180	160	260	115	1,06
180	180	285	115	1,44
200	80	140	112	0,77
200	100	175	115	0,88
200	125	215	115	1,02
200	140	230	120	1,07
200	150	260	120	1,19
200	160	209	125	0,67
200	180	285	125	1,35
200	200	249	125	1,21
224	80	140	124	0,85
224	100	175	127	1,01
224	125	215	132	1,14
224	140	230	132	1,20
224	150	260	132	1,29
224	160	260	137	1,28
224	180	285	137	1,46
224	200	346	137	1,69
250	80	156	137	1,13
250	100	175	140	1,22
250	125	220	145	1,48
250	140	230	145	1,48
250	150	255	145	1,55
250	160	256	150	1,58
250	180	306	150	1,79
250	200	306	150	1,78
250	224	350	150	2,09
250	250	296	150	1,65
280	80	156	155	1,25
280	100	175	155	1,37
280	125	220	160	1,56
280	140	230	160	1,63
280	150	255	160	1,72
280	160	256	165	1,75
280	180	306	165	1,97
280	200	306	165	2,01
280	224	350	165	2,27
280	250*	350	140	2,44
280	280*	390	140	2,67

Ød_1 nom	Ød_3 nom	l mm	l_3 mm	m kg
300	80	156	162	1,36
300	100	175	165	1,47
300	125	220	170	1,68
300	140	230	170	1,74
300	150	255	170	1,86
300	160	256	175	1,87
300	180	306	175	2,12
300	200	306	175	2,15
300	224	350	175	2,41
300	250	350	175	2,50
300	280*	390	150	2,53
300	300	430	175	3,55
315	80	156	170	1,43
315	100	175	173	1,50
315	125	220	178	1,76
315	140	230	178	1,82
315	150	355	178	2,38
315	160	256	182	1,96
315	180	306	182	2,21
315	200	306	182	2,14
315	224	350	182	2,51
315	250	350	182	2,59
315	280	390	182	3,00
315	300	430	182	3,21
315	315	363	182	2,20
355	100	175	193	1,73
355	125	220	198	1,96
355	140	230	198	2,03
355	150	255	198	2,46
355	160	256	203	2,45
355	180	306	203	2,81
355	200	306	203	2,82
355	224	350	203	3,13
355	250	350	203	3,18
355	280*	390	178	3,63
355	300	430	203	3,87
355	315	455	203	4,06
355	355*	470	203	5,14
400	100	175	215	2,27
400	125	225	220	2,81
400	160	266	225	3,02
400	200	300	225	3,37
400	224	350	225	3,74
400	250	350	225	3,79
400	280*	390	200	4,23
400	300	430	225	4,47
400	315	415	225	4,42
400	355*	470	225	5,04
400	400	510	225	6,20
450	100	175	240	2,76
450	125	225	245	3,15

Lindab

T-piece TCPU

Ød_1 nom	Ød_3 nom	l mm	l_3 mm	m kg
450	160	266	250	3,38
450	200	300	250	3,75
450	224	350	250	4,16
450	250	350	250	4,23
450	280*	390	225	4,64
450	300	430	250	4,89
450	315	415	250	4,82
450	355	470	250	5,16
450	400	510	250	5,81
450	450*	550	225	6,99
500	**100**	**175**	**265**	**3,06**
500	**125**	**225**	**270**	**3,35**
500	**160**	**266**	**275**	**3,77**
500	**200**	**300**	**275**	**4,14**
500	**250**	**350**	**275**	**4,68**
500	300	430	275	5,36
500	**315**	**415**	**275**	**5,30**
500	355	470	275	5,70
500	**400**	**510**	**275**	**6,34**
500	450*	550	250	6,56
500*	**500**	**552**	**290**	**8,27**
560	100	175	295	3,59
560	125	225	300	3,92
560	160	266	305	4,41
560	200	300	305	4,78
560	250	350	305	5,38
560	300	430	280	5,86
560	315	415	305	6,06
560	355	470	305	6,57
560	400	510	305	7,08
560	450*	550	280	7,38
560	500*	552	280	7,57
560	560*	610	280	9,69
600	100	175	315	3,83
600	125	225	320	4,19
600	160	266	325	4,73
600	200	300	325	5,10
600	250	350	325	5,73
600	300*	430	300	6,36
600	315	415	325	6,46
600	355*	470	300	6,98
600	400	510	325	7,43
600	450*	550	300	7,84
600	500*	552	300	7,91
600	560*	610	300	8,76
600	600*	650	300	10,8
630	**100**	**175**	**330**	**4,03**
630	**125**	**225**	**335**	**4,41**
630	**160**	**266**	**340**	**4,99**
630	**200**	**300**	**340**	**5,35**
630	**250**	**350**	**340**	**6,00**
630	300*	450	315	7,23
630	**315**	**415**	**340**	**6,77**
630	355*	470	315	7,18
630	**400**	**510**	**340**	**7,69**
630	450*	555	315	8,24
630*	**500**	**552**	**340**	**8,44**
630	560*	610	315	9,11
630	600*	650	315	9,58
630*	**630**	**680**	**340**	**11,3**

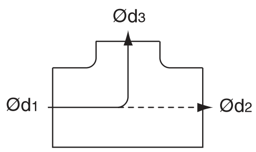
* Built with PSU saddle, without radius

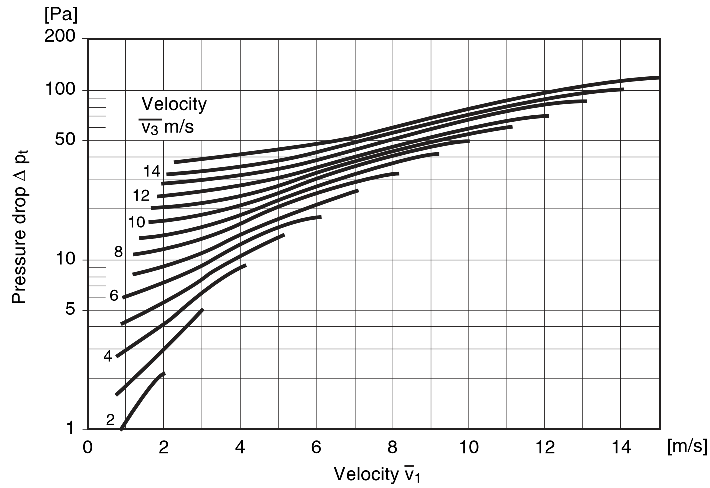
T-piece and saddle TCPU, PSU

Technical data

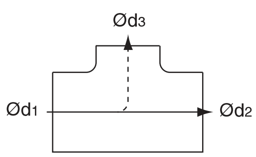
Supply air

Diverging flow

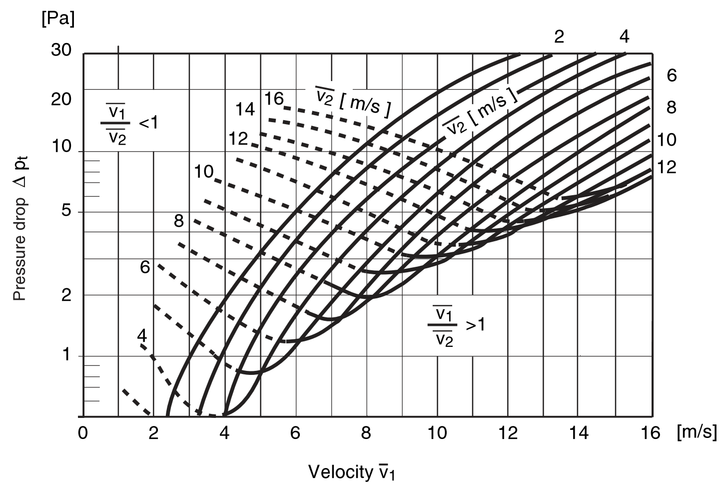




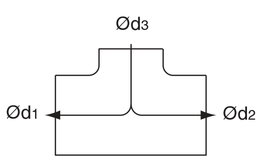
Diverging flow

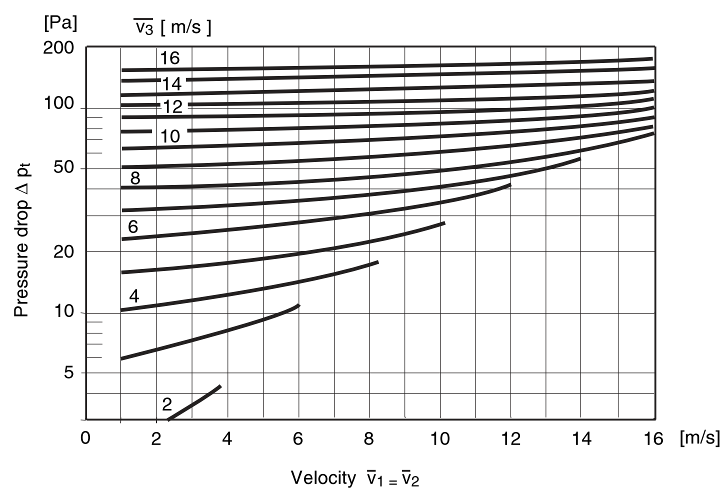


The diagram is also applicable to reduction in Ød2.



Diverging flow



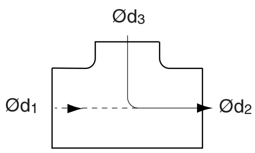


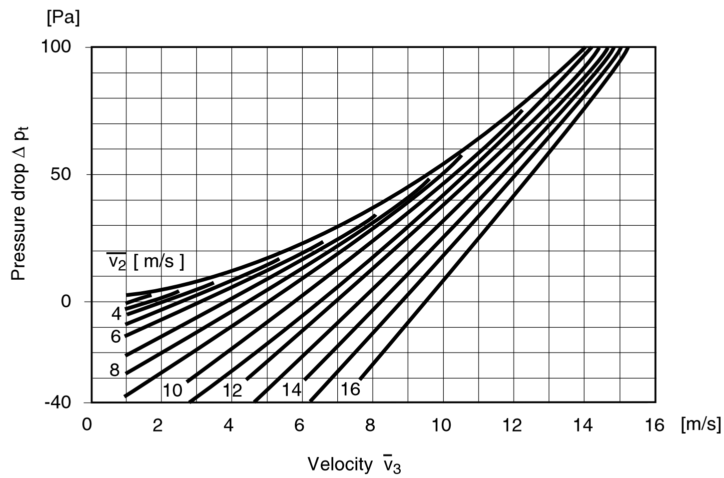
T-piece and saddle TCPU, PSU

Technical data

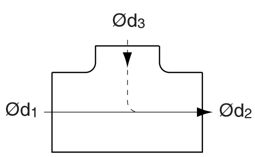
Exhaust air

Converging flow

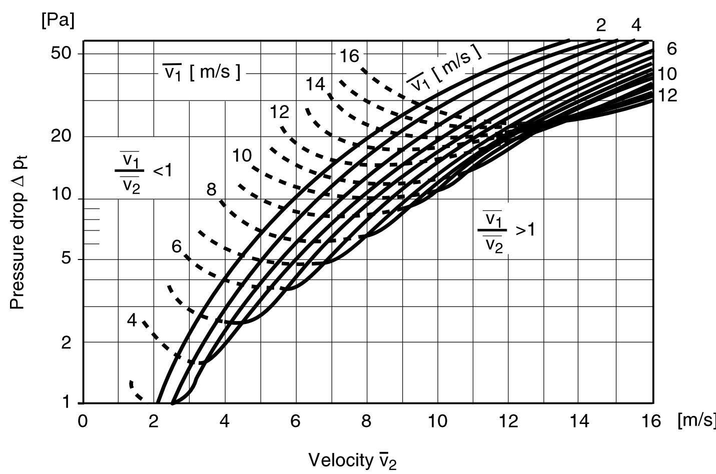




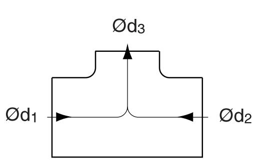
Converging flow

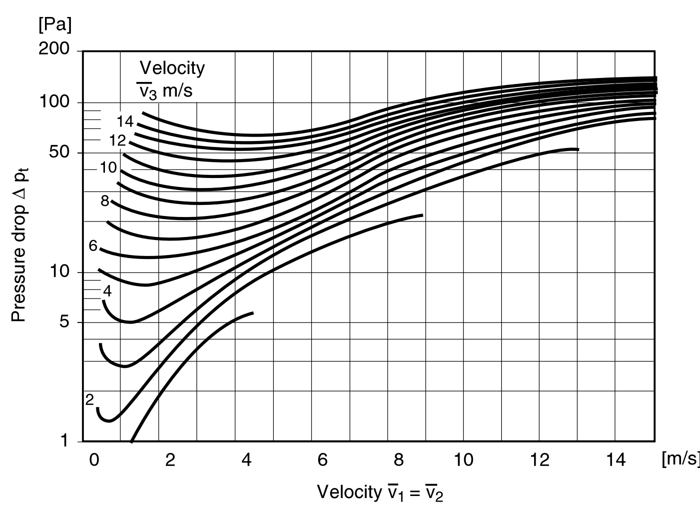


The diagram is also applicable to reduction in $Ød_1$.



Converging flow





Bend – long

BSU 90°

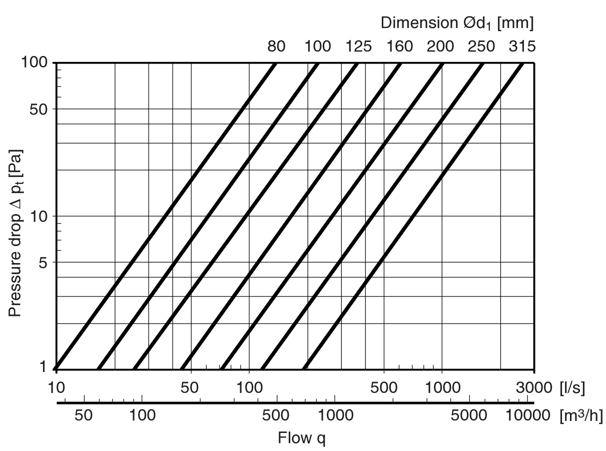
Description

Pressed and seam welded bend.

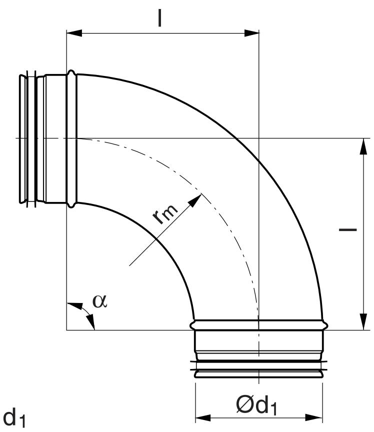
Ordering example

	BSU	160	90
Product	BSU		
Dimension $Ød_1$		160	
Angle α			90

Technical data



Dimensions



$r_m \approx 1{,}5 \cdot d_1$

$Ød_1$ nom	l mm	m kg
80	**120**	**0,35**
100	**150**	**0,50**
125	**190**	**0,79**
150	225	0,95
160	**240**	**1,14**
180	270	1,50
200	**300**	**1,80**
224	340	2,40
250	**375**	**3,20**
300	450	6,20
315	**450**	**6,72**

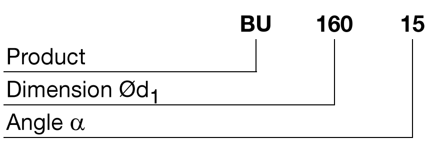
Bend

BU 15°

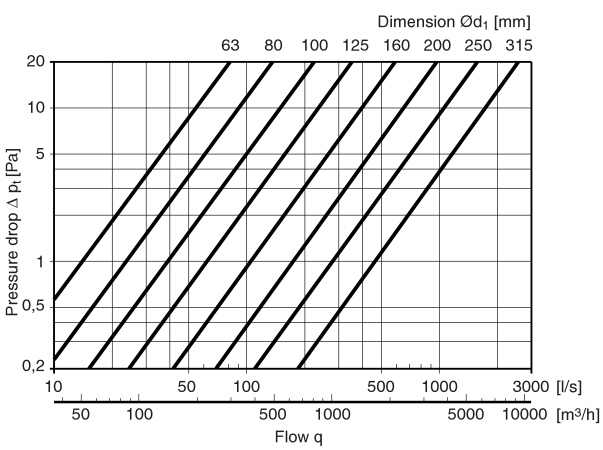
Description

Pressed and seam welded bend.

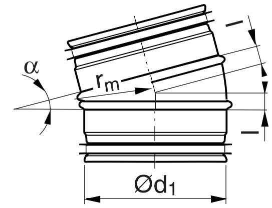
Ordering example



Technical data



Dimensions



$r_m \approx 1 \cdot d_1$

Ød1 nom	l mm	m kg
63	**14**	**0,09**
80	**13**	**0,11**
100	**13**	**0,15**
112*	25	0,29
125	**16**	**0,24**
140*	18	0,29
150*	20	0,31
160	**21**	**0,33**
180*	24	0,37
200	**26**	**0,47**
224*	30	0,56
250*	**33**	**0,65**
280*	37	0,79
300*	39	0,83
315*	**41**	**0,91**

* Segmented and lockseamed

Bend – short

BKU 90°

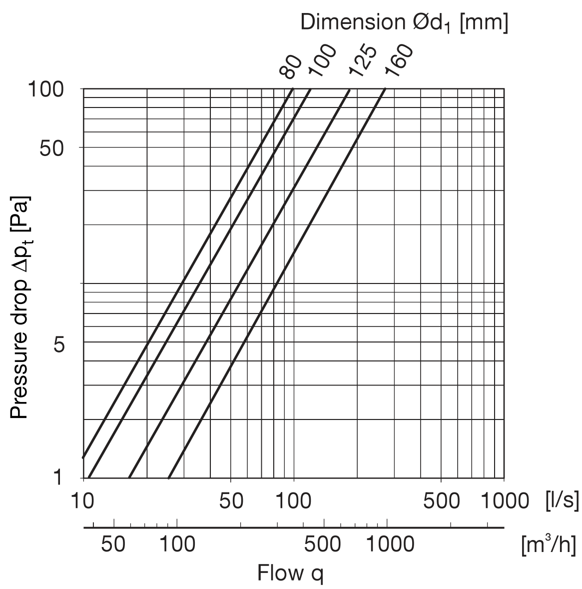
Description

Pressed and seam welded bend with short installation length.

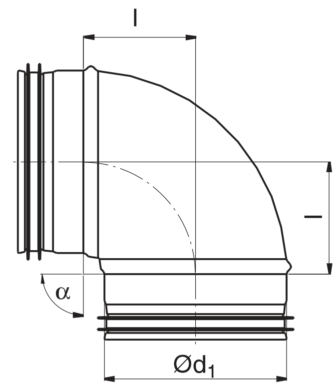
Ordering example

	BKU	100	90
Product	BKU		
Dimension $Ød_1$		100	
Angle α			90

Technical data



Dimensions



$Ød_1$ nom	l mm	m kg
80	80	0,14
100	62	0,22
125	79	0,31
160*	94	0,64

* With a seam in the middle

EXCa

Exhaust register

EXCa

Quick facts

- Easy installation
- Large throttle range
- High attenuation
- Lockable adjustment
- Included in the MagiCAD and CadVent databases

Quick guide

AIR FLOW-SOUND LEVEL			
EXCa	l/s		
Size	25 dB(A)	30 dB(A)	35 dB(A)
100	9	17	30
125	18	35	45
160	20	61	75
200	24	38	78

Data for 100 Pa total pressure drop.s

Swegon

Technical description

Design

This exhaust register consists of three parts: the mounting frame, the outer and inner cones. The mounting frame has a sleeve connection to the connecting duct and a bayonet fixing to the cone. The fixing frame is available with or without a rubber ring sealing to the duct. The aerodynamically shaped outer cone has a sealing strip on the connection to the mounting frame. The inner cone, which is suspended on a threaded bar in the outer cone, is adjustable and can be locked in position.

Materials and surface treatment

The cones are made of sheet steel. The mounting frame is made of galvanized sheet steel. The cones are painted with our pure white standard paint, RAL 9010. The unit is also available in other standard colours: Dusty grey 7037, white aluminium RAL 9006, jet black RAL 9005, grey aluminium RAL 9007 and signal white RAL 9003 (NCS 0500).

Accessories

Mounting frame EXCT 2b
Mounting frame with rubber sealed nipple connector.

Mounting frame EXCT 3b
Conical mounting frame for connection to nipple. The mounting frame has a larger inner diameter than the connecting duct. The register is turned in the bayonet socket in the mounting frame. See figure 1.

Installation

The hole is cut according to the dimension of the connecting duct. The mounting frame is fixed in the connecting duct. The register is turned in the bayonet socket in the mounting frame. See Figure 1.

Commissioning

The inner cone is rotated clockwise to increase the pressure drop and anticlockwise to decrease it. The position of the cone is locked by the locknut on the rear of the register. The k-factor is stated on the product label. It is also found in the relevant k-factor guide which can be found on our website.

The exhaust register is commissioned with air pressure measurement or air flow measurement. If air pressure is measured, a "measuring hook" isused, and when air flow is measured, any air flow measurer can be used. See Figures 2 and 3.

Maintenance

The register can be cleaned when necessary using lukewarm water and detergent or cleaned using a vacuum cleaner and brush attachment.

Environment

The Declaration of Construction Materials is available at www.swegon.com.

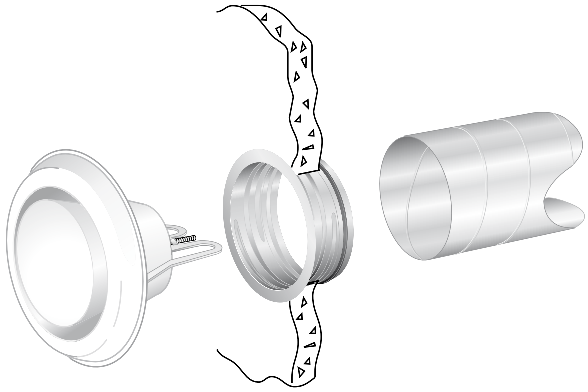


Figure 1. Installation.

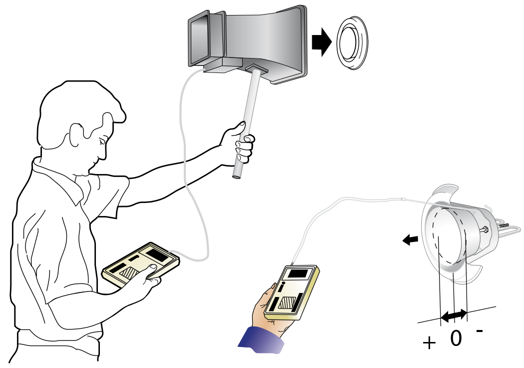


Figure 3. Commissioning.

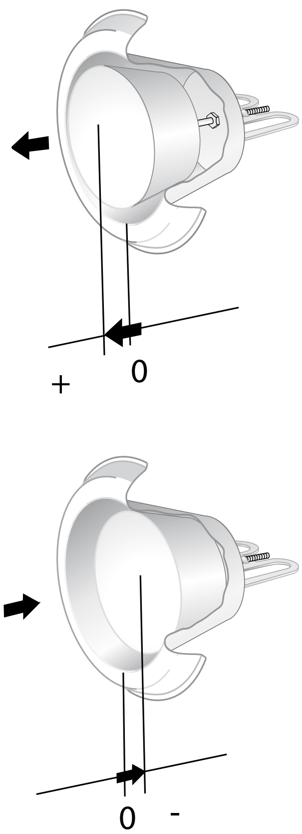


Figure 2. Commissioning.

Sizing

- Sound level dB(A) applies to rooms of 10 m² equivavelent absorption area.
- Data is for EXC + EXCT 2b.
- The octave band correction value K_{OK} is given for the zero position of the cone according to Figure 2.
- Attenuation ΔL is given for the zero position of the cone for sizes 100-160 and for size 200 at the +10 mm. cone position.

Sound data - EXC with inner cone at 0 mm

Sound effect level L_w(dB)
Table K_{OK}

Size	Mid-frequency (octave band) Hz							
EXCa	63	125	250	500	1000	2000	4000	8000
100	-1	-4	-6	-5	-1	-1	-9	-12
125	1	-2	-1	-2	-3	0	-10	-11
160	-1	0	-2	-1	0	-5	-7	-11
200	-1	-1	-6	-6	-2	-6	-10	-15
Tol.±	2	3	2	2	2	2	2	3

Sound attenuation ΔL (dB)
Table ΔL

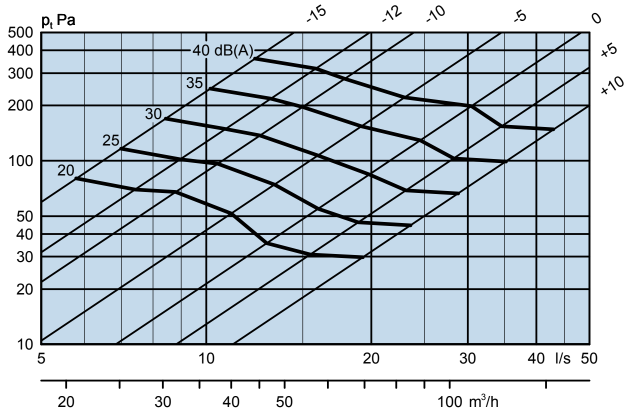
Size	Mid-frequency (octave band) Hz							
EXCa	63	125	250	500	1000	2000	4000	8000
100	23	18	14	12	12	14	5	6
125	21	17	12	11	12	11	7	6
160	19	14	12	11	11	14	5	7
200	15	13	11	11	13	12	7	7
Tol.±	6	3	2	2	2	2	2	3

Engineering graphs - EXC - Exhaust air

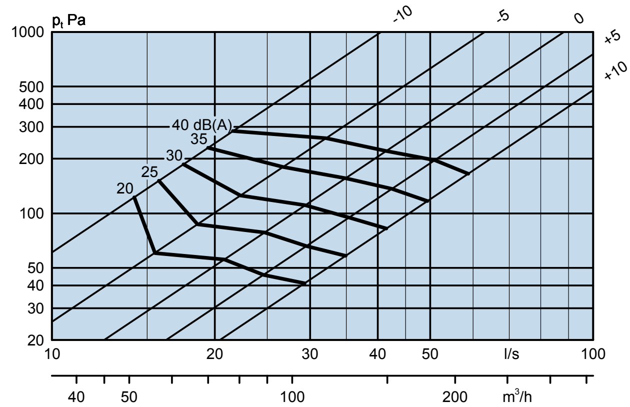
Air flow - Pressure drop - Sound level

- The graphs are not to be used for commissioning.
- The graphs show different positions for the inner cone relative to the outer cone in mm.
- The dB(A) values are for rooms with normal acoustic absorption of 4 dB.
- The dB(C) value is normally 6-9 dB higher than the dB(A) value.
- For more accurate calculations, see the calculation template in the chapter on Acoustics in the Technical Information section of this catalogue.

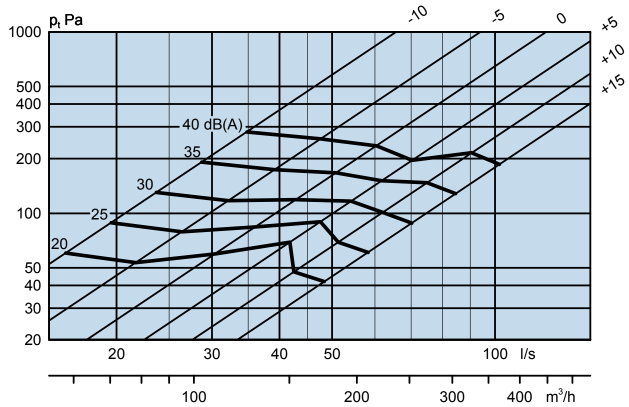
EXCa 100



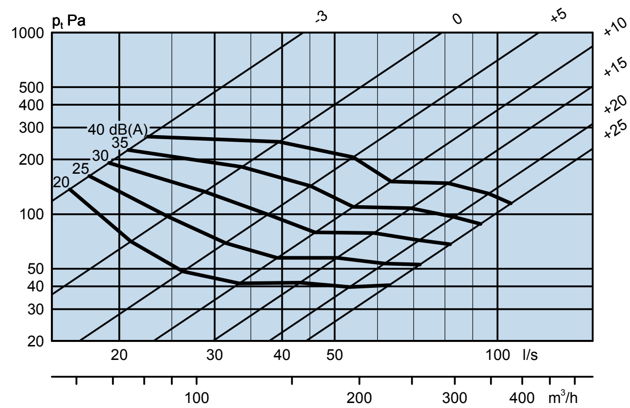
EXCa 125



EXCa 160



EXCa 200



Dimensions and weight

EXCa

Size EXCa	A	B	ØD	Weight ,g
100	70	16	142	265
125	85	16	173	350
160	85	16	205	475
200	108	16	252	700

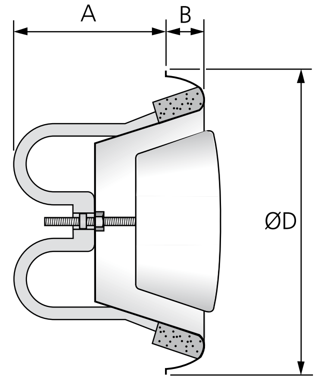


Figure 4. Exhaust register EXC.

Mounting frame EXCT 2

Size EXCT 2	ØD	H	Weight g
100	99	50	100
125	124	50	125
160	159	50	190
200	199	50	240

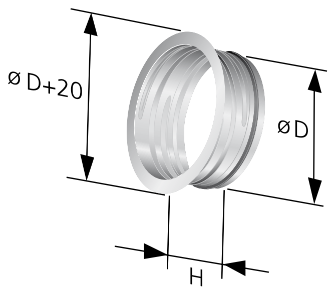


Figure 5. Mounting frame EXCT 2.

Mounting frame EXCT 3

Size EXCT 3	ØD	H	Weight, g
100	101	55	100
125	126	55	125
160	161	55	190
200	201	55	240

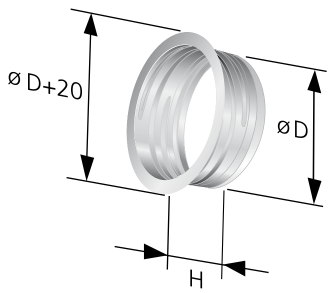


Figure 6. Mounting frame EXCT 3. Conical mounting frame for connecting directly to a duct section with nipple connector, for example an elbow.

Order key

Product

Exhaust register including mounting frame	EXCa	-aaa	-b
Size: 100, 125, 160, 200			
Alternatives:			
1. Mounting frame with rubber sealing	EXCT 2a		
2. Mounting frame for direct connection to nipple	EXCT 3a		

Specification example

ER XX
Swegon's exhaust register of the type EXCa, with the following functions:

- Settings can be locked
- Cleanable
- Powder coated in white
- Complete with mounting frame

Size:	EXCa	100-2	xx items
		125-2	xx items
		160-2	xx items
		200-2	xx items

LTAb

Light screening transfer grille for wall or door mounting

General

The LTA is a rectangular grille for installation in walls or doors. It is used as a supply or transfer air diffuser between rooms where light transmission is not desirable.

Quick facts

- Stops light transmission
- Two black painted diffusers in series are sufficient for darkroom walls
- Telescopic flanged frame supplied in two widths
- Available in alternative colours

Quick guide

AIR FLOW-PRESSURE DROP			
LTAb	l/s		
Size	10 Pa	15 Pa	20 Pa
200-100	14	19	21
400-100	30	35	42
600-100	46	55	65
400-150	52	62	72
600-150	70	83	100
800-150	110	130	150
400-200	70	83	100
600-200	110	130	150
800-200	142	180	200

The data applies to one grille mounted in a wall opening.

Technical description

Design

The grille is manufactured in two different versions.

LTA 1 consists of the angled profile blades mounted in an outer frame. The frame is supplied with countersunk screw holes.

LTA 2 consists of the blades alone.

Materials and surface treatment

The grille is manufactured entirely in extruded aluminium profiles which is anodised. The unit is also available in other standard colours: Dusty grey 7037, white aluminium RAL 9006, jet black RAL 9005, grey aluminium RAL 9007 and signal white RAL 9003 (NCS 0500).

Accessories

Flanged frame:

LTAT 1b: telescopic flanged frame. This is used as wall channel.

Planning

This grille is used primarily as a transfer air device in walls where the transmission of light is undesirable. By mounting two black painted grilles in series, there is no risk of transmitted light into a dark room.

LTA 1 is used on one side of the wall or as part of a pair mounted on both sides of the same wall.

LTA 2 is designed to be flush mounted in walls or doors. See Figure 1.

Installation

Type 1 is fixed in position in a wall or door through the countersunk screw holes.

Type 2 is recessed into a door or panel and then clamped in place using beading, profiles etc. supplied by others. See Figure 1.

Maintenance

The grille can be cleaned when necessary using lukewarm water and detergent.

Environment

The Declaration of construction materials is available at www.swegon.se.

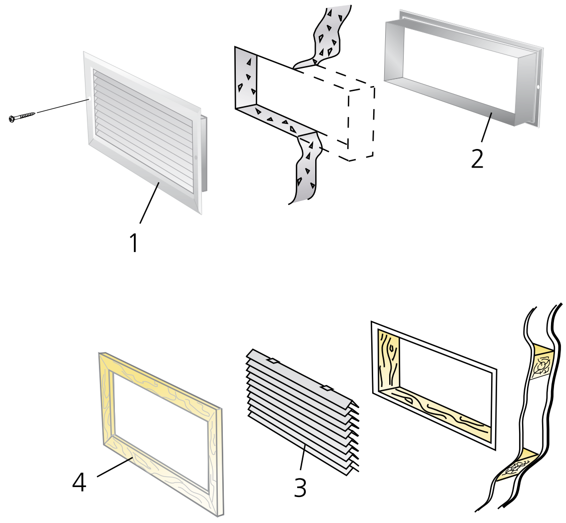


Figure 1. Planning. Installation.

1. LTA 1
2. LTAT 1b-50
3. LTA 2
4. Wooden frame, not included.

Sizing

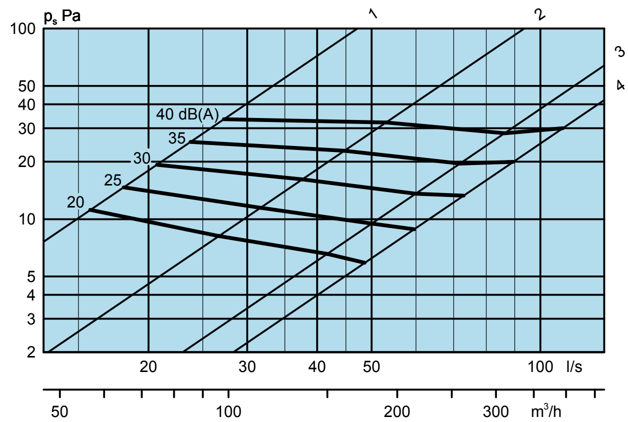
- Sound level dB(A) applies to rooms of 10 m^2 equivalent absorption area.

Engineering graphs - LTA - Transfer air

Air flow - Pressure drop - Sound level

- The graphs illustrate data for a grille mounted in a wall opening.
- The graphs must not be used for commissioning.
- The dB(A) values are for rooms with normal acoustic absorption of 4 dB.
- The dB(C) value is normally 6-9 dB higher than the dB(A) value. For more accurate calculations, see the calculation template in the chapter on Acoustics in the Technical Information section of this catalogue.

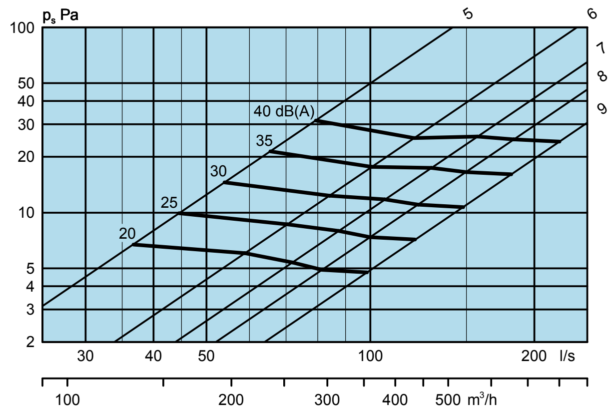
LTAb



Size designation

1. 200-100
2. 400-100
3. 400-150
4. 400-200

LTAb



Size designation

5. 600-100
6. 600-150
7. 600-200
8. 800-150
9. 800-200

LTAb

Dimensions and weight

LTAb 1 + LTAb 1b-50

Size LTAb	A	B	C	D	E	F	Weight, kg
200-100	200	100	183	83	190	90	0.4
300-100	300	100	283	83	290	90	0.5
400-100	400	100	383	83	390	90	0.6
500-100	500	100	483	83	490	90	0.7
600-100	600	100	583	83	590	90	0.8
800-100	800	100	783	83	790	90	1.2
300-150	300	150	283	133	290	140	0.7
400-150	400	150	383	133	390	140	0.8
500-150	500	150	483	133	490	140	1.0
600-150	600	150	583	133	590	140	1.2
800-150	800	150	783	133	790	140	1.6
300-200	300	200	283	183	290	190	0.9
400-200	400	200	383	183	390	190	1.1
500-200	500	200	483	183	490	190	1.3
600-200	600	200	583	183	590	190	1.5
800-200	800	200	783	183	790	190	1.9

Cutting holes according to the nominal dimensions.
Example:
Holes for LTA-1 400-200 = A x B = 400 x 200.

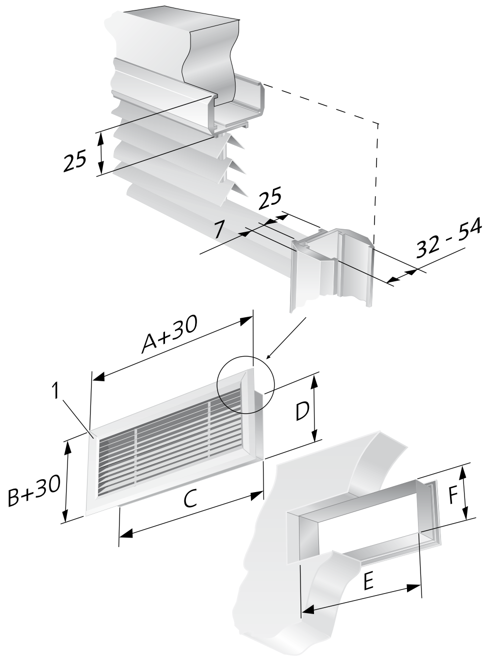


Figure 2. LTA.

1. LTA 1
2. LTAT 1b-50

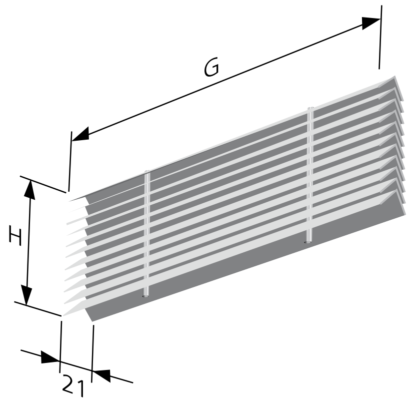


Figure 3. LTA 2.

G = Nom. width
H = Nom. height

Example:
LTAb 1-200-100 G = 200 mm, H = 100 mm.

Order key

Product

Light screening transfer grille for wall or door mounting	LTAb	-a	-bbb-ccc
LTAb: 1, 2			
Size: (see dimension table)			

Accessories

Flanged frame: LTAT 1b-50

Specification example

TG XX

Swegon's rectangular light screening transfer grille of the type LTAb, having the following functions:

- Fixed light restricting blades
- Manufactured in anodised aluminium
- Painted black

Accessories:		
Flanged frame:	LTAT 1b-50	xx items
Size:	LTAb a - bbb - ccc	xx items

Circular duct SR

1
2
3
4
5
6
7
8
9
10
11

Technical data