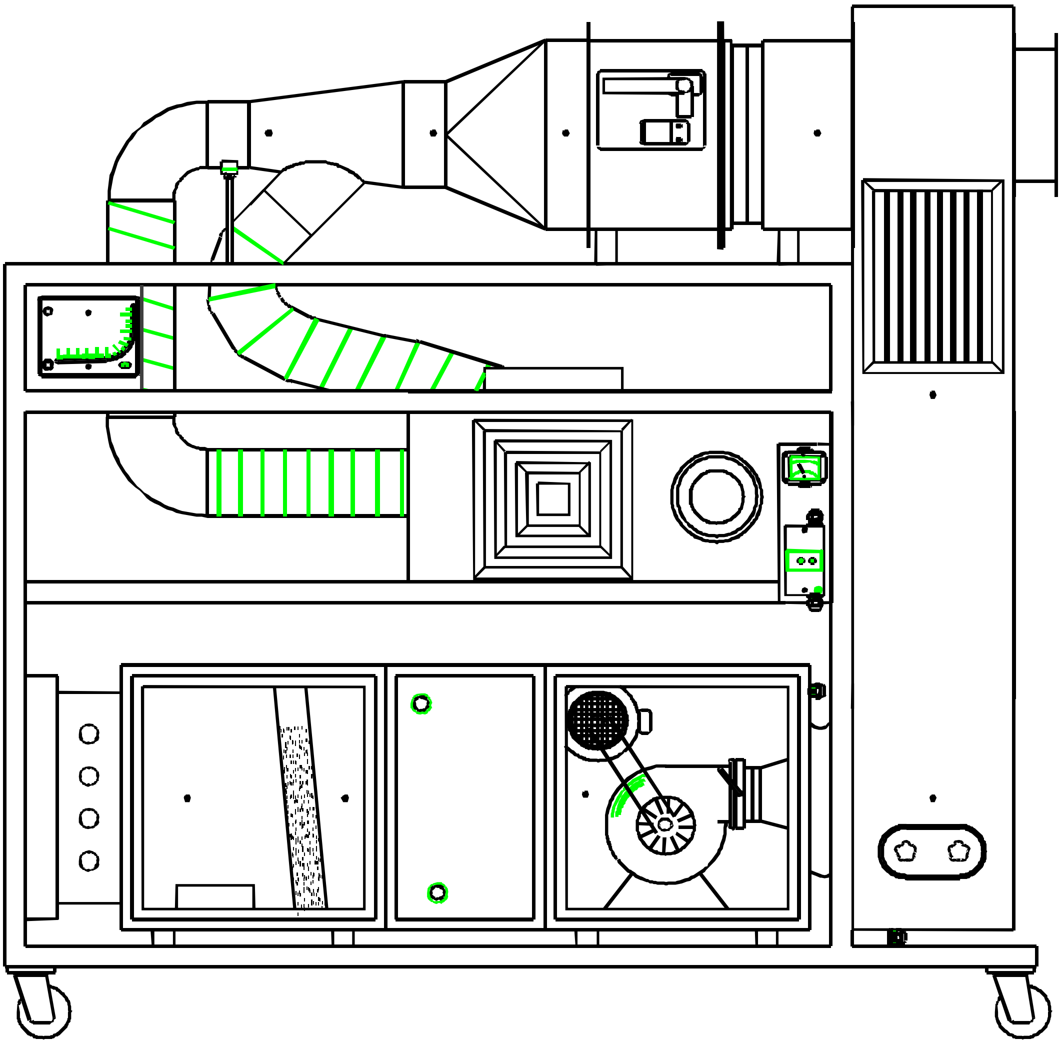
# Operating Instructions

HL 720 Trainer, Domestic Ventilation System

# HL 720 Trainer, Domestic Ventilation System



# Operating Instructions



Publication No.: 916.000 00F 720 12

10/97

# Table of contents

# HL 720 Trainer, Domestic Ventilation System

## 1 Introduction

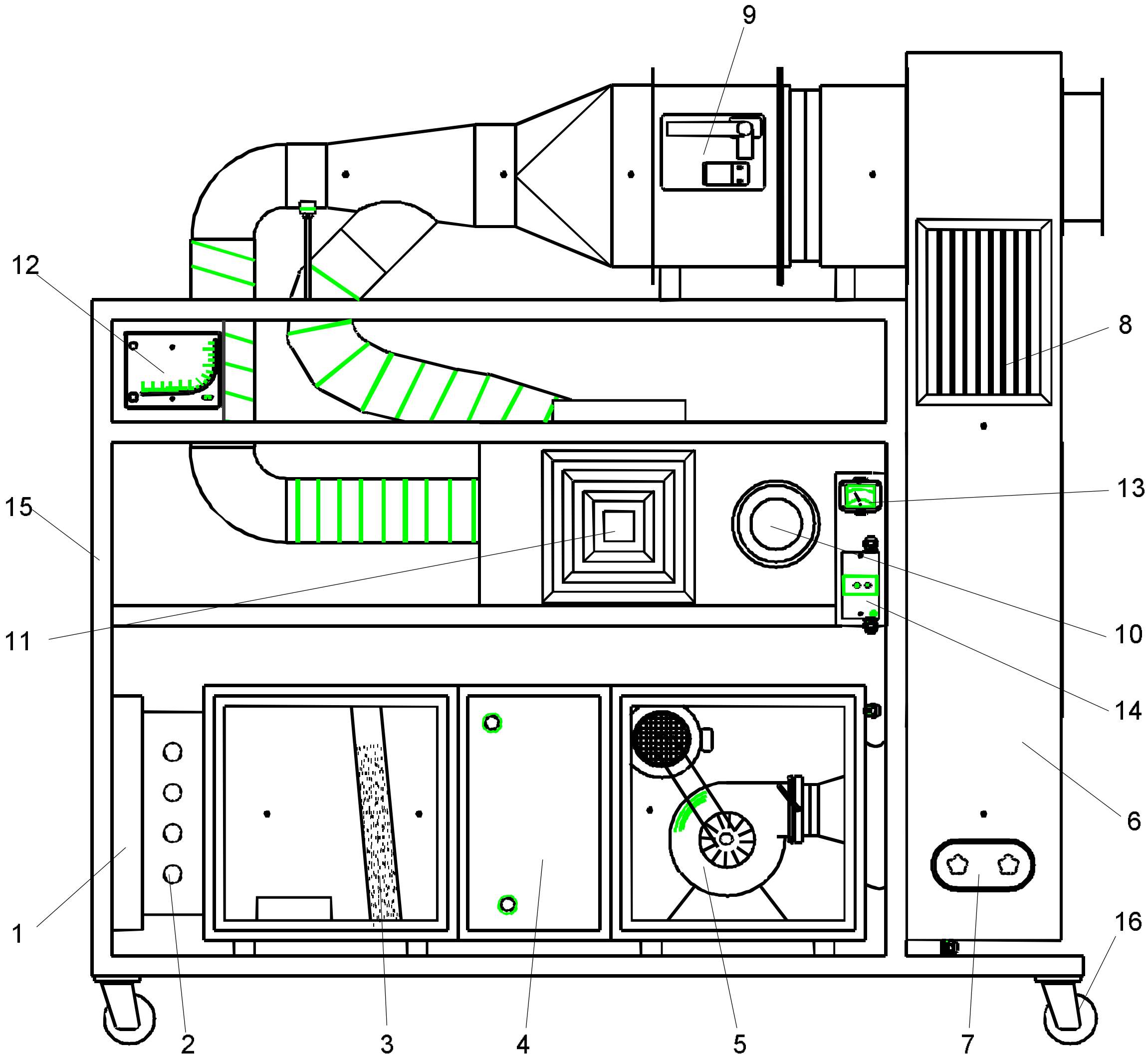
Today, many different ventilation systems are used in buildings in order to guarantee the necessary air change in individual rooms. At the same time, the air is heated (or cooled) in a heat exchanger. A ventilation system is therefore an initial stage for an air-conditioning system, in which the air can be additionally humidified or dried.

The ventilation system with the air heating and filtering functions is, according to DIN 1946, one of the simplest room air systems which are used to achieve the required air conditions. They are particularly used for creating a pleasant and healthy room climate in recreation and production rooms.

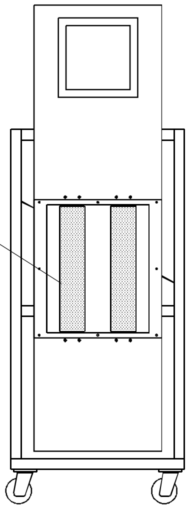
The **G.U.N.T. Trainer, Domestic Ventilation System HL 720** is made exclusively of components which are also used in the ventilation structures of buildings. Particular attention is paid here to good workmanship and a correct arrangement in the ventilation ducts. Several plexiglass panels ensure that the observer can see otherwise hidden parts. At the same time, all components maintain their original functions. The mobile air-conditioning system represents a pure air intake system.

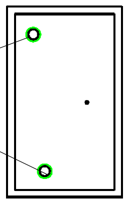
# 2 Unit Description

## 2.1 Design of the ventilation system




1. Weather protection grille
2. Slat flap
3. Filter
4. Air heater (or cooler)
5. Fan
6. Ventilation duct
7. Inspection cover
8. Ventilation grille (wall outlet)
9. Fire-protection cap
10. Plate valve
11. Ceiling air outlet (rectangular)
12. Inc lined-tube pressure gauge
13. Ammeter
14. Motor circuit breaker
15. Tubular steel frame
16. 4 rollers, 2 with brakes




The front view of the system does not show all components. In addition to the already listed parts, the ventilation duct contains additional sound-absorbing panels which can be seen through a plexiglass window on the side.

In total, the system has three inspection windows, so that it is possible to look into the filter chamber and the fan during operation.

Several inspection covers are distributed over the entire system to allow observation of the internal workings of most components. When the system is switched off, these covers can be removed very easily so that, for example, the triggering mechanism of the fire-protection flap can be seen.

The heat exchanger has two 3/4" connections with male threads. This allows the sucked-in air to be heated by hot water.



## 2.2 Set-up

The system should be set up so that it is easily accessible from all sides, because only in this way is it possible to see all system components and their functions inside the system. The system requires the following connections in order to be operated:

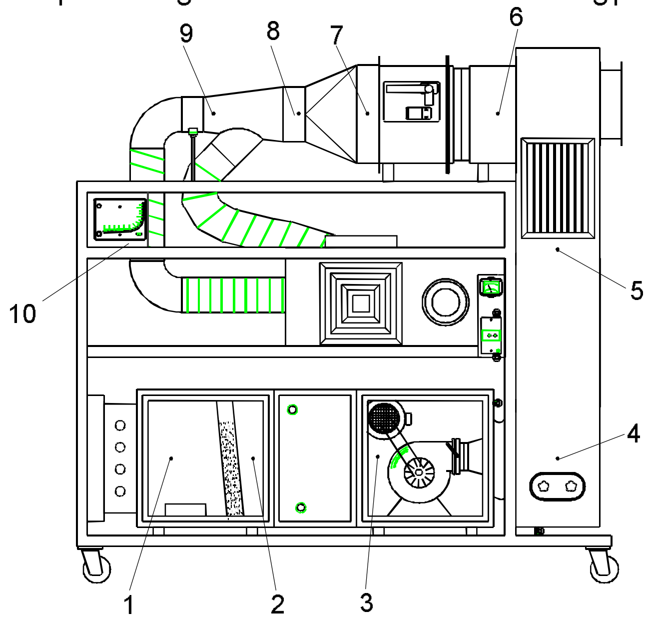
- power supply 380V / 50Hz / 16A,
- water connection for hose with $Ø_{Inner}$ = 13mm, hot or cold water.

Also, the air intakes and outlets should not be covered, so as to prevent the occurrence of irregular flow and pressure conditions.

## 2.3 Arrangement of the pressure measuring glands

A total of 10 pressure measuring glands are fitted in the air-conditioning system. The arrangement of the measuring points allows the pressure movement to be recorded in the entire system. The differential pressure at the individual components must also be measured.

The pressure glands are installed at the following points.




1. Output, slat flaps
2. Output, air filter
3. Output, heat exchanger
4. Output, fan
5. Output, sound-absorbing panel
6. Input, fire-protection flap
7. Output, fire-protection flap
8. Input, branch
9. Output, branch

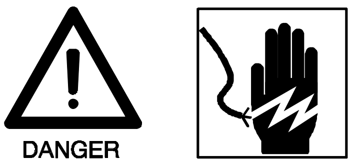
An additional measuring gland (10), located directly under the pressure gauge allows pressure measurements compared with the atmosphere.

## 3 Safety

This Chapter lists possible consequences of incorrect operation of the mobile air-conditioning system.

### 3.1 Work safety

When handling the ventilation system, attention must be paid to the following things with regard to work safety:



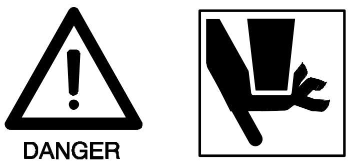

- **DANGER! Caution when reaching into electrical systems.**

There is a risk of electric shock.

It is essential to pull out mains plugs first.

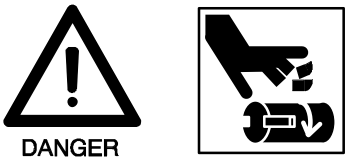
Only specialist electricians may carry out the work.

- **DANGER! Do not put fingers through the weather protection grille from the front into the slat flaps.**
  There is a risk of crushing when the flaps are activated.

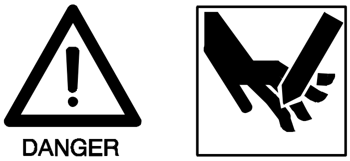



- **DANGER! Do not reach with your hands into the fire-protection flap through the open connection gland.**

The hand will be trapped if the flap closes suddenly.




- **DANGER! Do not switch on the fan when the duct is opened.**
  The results can be cuts and crushing if someone's hand is in the rotating impeller.




- **DANGER! The metal parts have sharp edges.**
  Cutting injuries can occur.



## 3.2 Operation

Incorrect operation of the ventilation system's components can cause them to stop functioning.


- **IMPORTANT: Never turn the slat flaps and quantity controller past the stop.**

This destroys the operating mechanism (toothed wheels, rods, etc.).

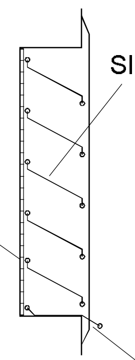

- **IMPORTANT: Do not adjust the tripping current of the motor circuit-breaker.**

Damage caused by overheating can result if the current at the motor is too high.

# 4 Theoretical principles

This chapter describes the structure and function of the most important components of a ventilation system.

## 4.2 Weather-protection grille




The weather and bird-protection grilles are fitted in the suction intake opening of the outside air duct. A special arrangement of the slats prevents rain and snow entering, as well as birds and other small animals. A projection in the bottom end (drip edge) prevents escaping water running down the installation wall. A large-mesh grille also serves as a type of prefilter which keeps leaves and other parts of plants out of the intake duct.

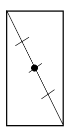
## 4.3 Slat flaps

The slat flaps close when the system is at a standstill, thereby allowing no cold air to flow in (heating cost savings).

In the case of systems with circulating air, the use of several slat flaps adjusts the mixing ratio between the circulating air and fresh air.

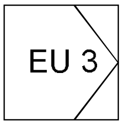
The flaps consist of several metal strips which rotate on bearings. There is a toothed wheel at the end of each axis. The toothed wheels all engage in each other so that when an axis is turned, every second plate is inclined in the same direction.

Graphic symbol for slat flaps DIN 1946:



## 4.3 Air filter

Graphic symbol for air filter DIN 1946:

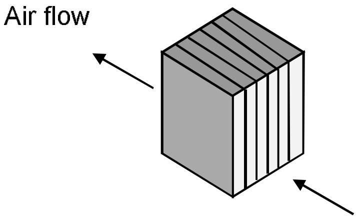



Air filters in air-conditioning and ventilation systems are units or apparatus which filter and separate particles or gaseous impurities from the air. Materials of different particle sizes occur in the air, with the diameters of these particles measuring between 0.001 and 500 micrometers.

Gaseous impurities are bound by chemical or physical absorption processes.

A class EU 3 mat filter is installed in the mobile air-conditioning system. This filter has a medium filtration efficiency with synthetic dust of 80-90%. In addition to the mat filters, there are also pocket-type and roll-type strip filters which have the same filter medium. The latter are mostly used with large suction cross- sections.

Pocket filter:



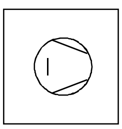

The higher the number after the letters EU, the greater the filtration efficiency. This means that $Ifilter class filter class EU 9 has the best filtration efficiency.

These filters operate on the inertia effect. This means that due to their inertia, the dust particles impact against the surface of the filter fabric and remain stuck to it. Other air filters such as electric air filters and gas adsorption or active carbon filters operate on different principles.



## 4.5 Fan

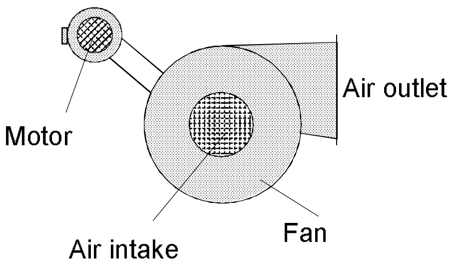
Graphic symbol for fan DIN 1946:



Fans are flow machines and serve to conduct air and gases up to a pressure of 30,000 Pa (corresponds to 0.3 bar). A distinction is made between radial and axial fans, and also cross-flow fans. Axial fans are those in which the air flows towards the axis through the impeller, whereas in the case of radial fans (of the type used in the practice system), the air flows through the housing perpendicular to the axis of the impeller.

Radial fans are normally driven via a belt. However, direct drive via a motor shaft or via an additional coupling are also possible.

Radial fan with belt drive:




## 4.6 Heat exchanger

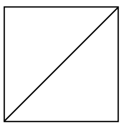
Heat exchangers, which are also referred to as air heaters (and coolers) in ventilation construction are used for heat transfer between air and water. The flow of heat always takes place from the body with the higher temperature to the body with the lower temperature.

In the case of air heaters, hot or warm water and steam are mainly used as the thermal energy carrier. However, gases, organic liquids and electrical energy are also employed to heat air.

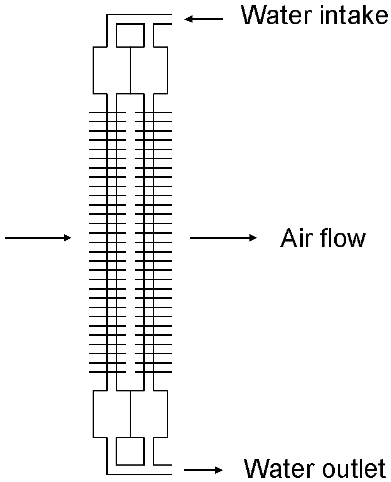
The air heater consists of water chambers, pipes with slats and connections to the heating system. While hot or warm water flows through the pipes, air flows around them on the outside, causing them to absorb thermal energy while at the same time cooling the flowing warm water. The slats serve here to increase the size of the surface and improve the efficiency.

The same heat exchangers can be used for cooling. In this case, they are flowed through by cold water.

Graphic symbol for heat exchanger in accordance with

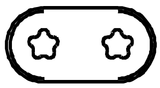


Structure, lamella heat exchanger



## 4.7 Inspection cover

oval inspection cover:



Inspection covers are installed in longer shafts, in the same way as in larger vessels. These inspection covers are referred to as manhole or handhole covers, depending on their size. During inspections, they allow the duct to be observed or walked through from the inside. The inspection covers consist of two metal parts which are inserted into a prefabricated cut-out section in the duct. One half of the cover is located inside the duct, the other outside. Between the metal plates, which are connected with screws, there are springs which press the plates apart during use. Tightening the screws presses together the springs and firmly presses the cover against the duct wall.

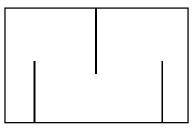


## 4.8 Sound-absorbing panels

When natural sound-absorption is not sufficient, artificial measures must be taken. In most cases, sound-absorbing panels are added which operate on the basis of the absorption principle. They generally consist of a sheet steel housing. On the inside are the absorption walls (panels) made of porous materials, particularly glass wool or mineral wool. These reduce the sound energy by way of absorption. The sound level reduction brought about by the sound absorbers is referred to as insertion absorption.

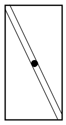
All sound absorbers must be installed as close as possible to the source of the sound, i.e. behind the fan. When selecting the panels, particular attention must be paid to their thickness with respect to their flow resistance. Thick panels have greater air resistance than thinner sound absorbers, particularly at the intake and outlet.

Graphic symbol for sound absorber in accordance with DIN 1946:

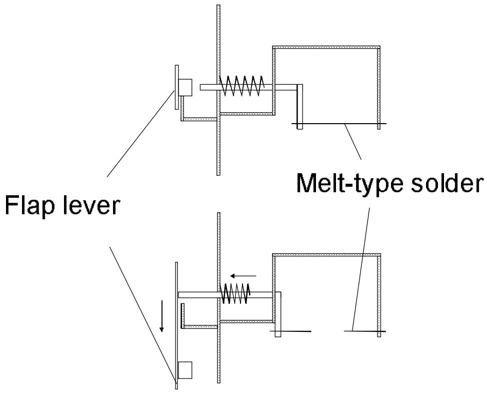


## 4.9 Fire-protection flap

Graphic symbol for fire-protection flaps in accordance with DIN 1946:



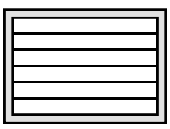
Triggering device:




Special attention must be paid to preventative fire-protection when installing air systems, because fire and smoke can be carried to other rooms through ventilation ducts in the event of a fire. This particularly applies to recreation rooms in the interior of a building, where emergency exit routes must be passable in the event of a fire.

Fire protection flaps are intended to prevent the transfer of fire and smoke through ventilation ducts if they get past firebreaks. In the event of a fire, they automatically close the ducts, with triggering normally being performed by a fusion solder at 72°C. The flaps are also made with magnetic triggering fixtures for external closure and electrical limit switches for a central flap position display.

## 4.10 Ventilation grilles



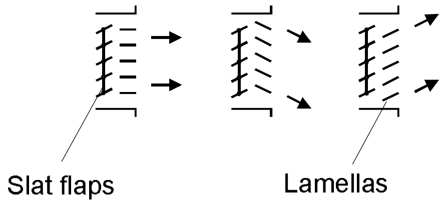
Ventilation grilles are mainly installed in wall and duct outlets in order to achieve even air distribution in the room.

Air grilles are available in many different designs. There are models with rigid and movable slats on the air outlet. Quantity regulation can be performed with an upstream slat flap.

In all cases, ventilation grilles must be arranged and set so that conditions in the room are comfortable. This means that the air velocity in the flow direction should be such that people in the ventilated room do not feel any drafts.

## 4.11 Ceiling air outlets

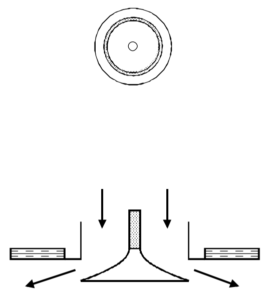
Adjustment possibilities:




The most frequent method of bringing in incoming air is via ceiling outlets rather than wall outlets. Here too, many different types of outlets are available.

Two exemplary ceiling air outlets are fitted in the mobile ventilation system. Both outlets are designed so that they can be installed in a recess in a suspended ceiling.

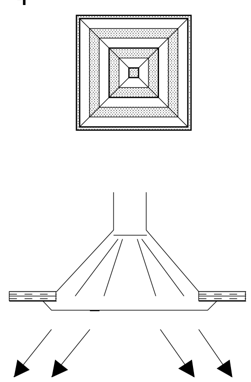
Disk valve:



In this case, the air flows at a sharp angle to the ceiling, rather than vertically downwards, so that people in the room do not experience any excessive air velocities.

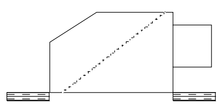
The disk valve can be placed directly on a ventilation pipe (folded spiral or flexible aluminum pipe) and allows, by way of its disk which can be unscrewed, limited adjustment of the air quantity and outlet angle.

square air outlet:



The square ceiling air outlet has fixed slats so that there is no adjustment possibility in this case. Connection is via a connection box which allows transfer to a ventilation pipe.

Connection box:



## 4.12 Pressure conditions

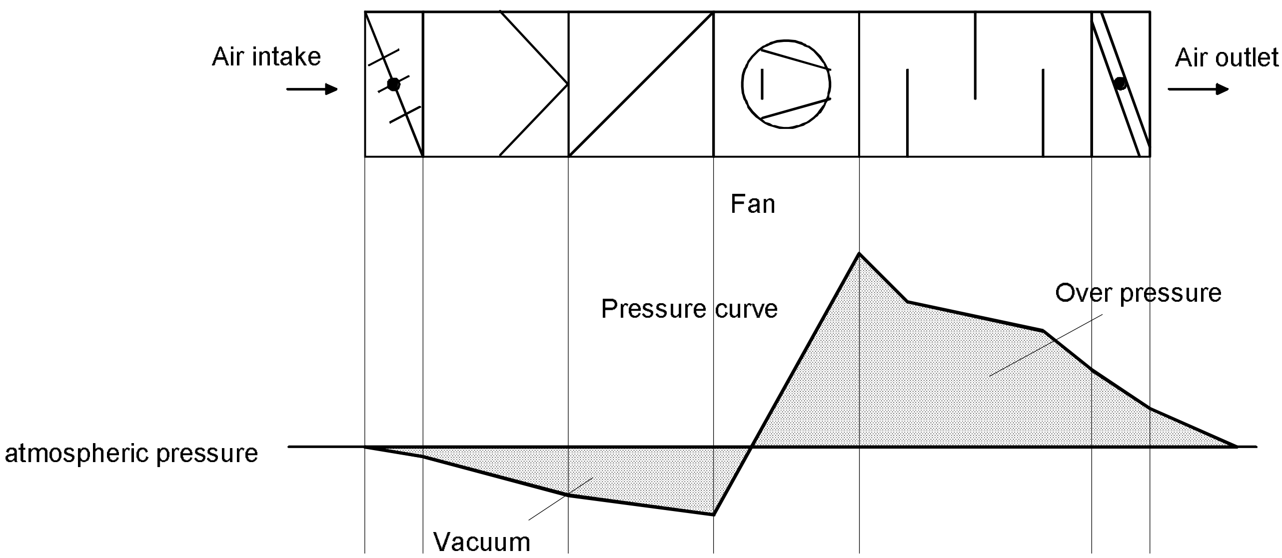
Many different pressures arise in a ventilation system.

The pressure, total pressure $p_T$ is made of the static pressure $p_{st}$ and the dynamic pressure $p_{dyn}$.

$$p_T = p_{st} + p_{dyn}$$

The dynamic pressure depends on the velocity of the flowing air. As the volumetric flow is almost constant within the system, the dynamic pressure therefore depends directly on the cross-section of the ducts. With a small cross-section, a greater dynamic pressure can be measured than is the case with a large cross-section.

In the suction intake duct, there is a pressure (vacuum) which is lower than the atmospheric pressure. The fan conveys not only the air, but also raises the pressure in the system above the atmospheric pressure. This overpressure is reduced to the atmospheric pressure by the flow resistances of the individual ventilation components.



# 5 Tests

This section explains and evaluates the current measurement and measurement of the pressures in the system.

## 5.1 Current measurement

The current (I) consumed by the motor can be measured with a built-in ammeter. The measurement is performed in one phase, so that the recorded apparent power (S) of the motor can be calculated as follows:

$$S = U \cdot I$$

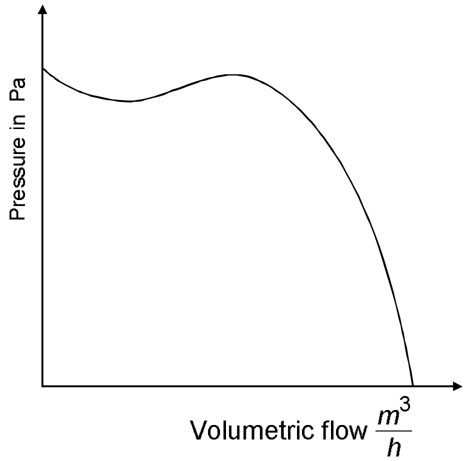
The rated current of the motor is 2.1A. The rated current is based on a connection voltage (U) of 400V.

During operation, currents of different levels occur, depending on the size of the openings in the air outlets (quantity control, position of the slats, disk valve, open connection glands). Here, measured values arise which are in the range between 1.2A and 2.4A. The reason for the currents of different levels lies in the output which the fan demands from the motor. This output (P) is made up of the product of the pressure (p), volumetric flow ($\dot{V}$) and efficiency ($\eta$),which contains all losses:

$$P = p \cdot \dot{V} \cdot \eta$$

If we examine the formula for the output in conjunction with the fan's characteristic, this explains the different levels of power consumption.

Characteristic of a fan with forward-curved blades:



## 5.2 Pressure conditions

So that the inclined-tube pressure gauge displays the correct pressures, a certain amount of basic knowledge of the pressure curve within a ventilation system is necessary.

The measuring hose which is marked with a red line must always be connected to the measuring port with the lower pressure. Measurement of the pressure is only possible if the self-locking cover is on a plug-in nipple. To measure the pressure against the atmosphere, one hose coupling must be connected to the plug-in nipple located directly under the pressure gauge.



The pressure can be recorded at the following measuring points in the system.

1. Output, slat flaps
2. Output, air filter
3. Output, heat exchanger
4. Output, fan
5. Output, sound-absorbing plate
6. Input, fire-protection flap
7. Output, fire-protection flap
8. Input, branch
9. Output, branch

-The following overpressures and vacuums occur against the atmosphere when the slat flaps and the fire-protection flaps are open:

$p_{1u}$ = 100 Pa

$p_{2u}$ = 120 Pa

$p_{3u}$ = 150 Pa

$p_4$ = 300 Pa

$p_5$ = 320 Pa

$p_6$ = 320 Pa

$p_7$ = 310 Pa

$p_8$ = 280 Pa

$p_9$ = 150 Pa

(Index: = overpressure, u = vacuum)

As reading-off of the pressure gauge is less accurate in the upper measuring range than in the lower measuring range, it is best to measure the differential pressure via the individual components. This produces the following measurement results:

$p_{2,1}$ = 8 Pa

$p_{3,2}$ = 34 Pa

$p_{4,3}$ = 460 Pa

$p_{4,5}$ = 6 Pa

$p_{5,6}$ = 10 Pa

$p_{6,7}$ = 4 Pa

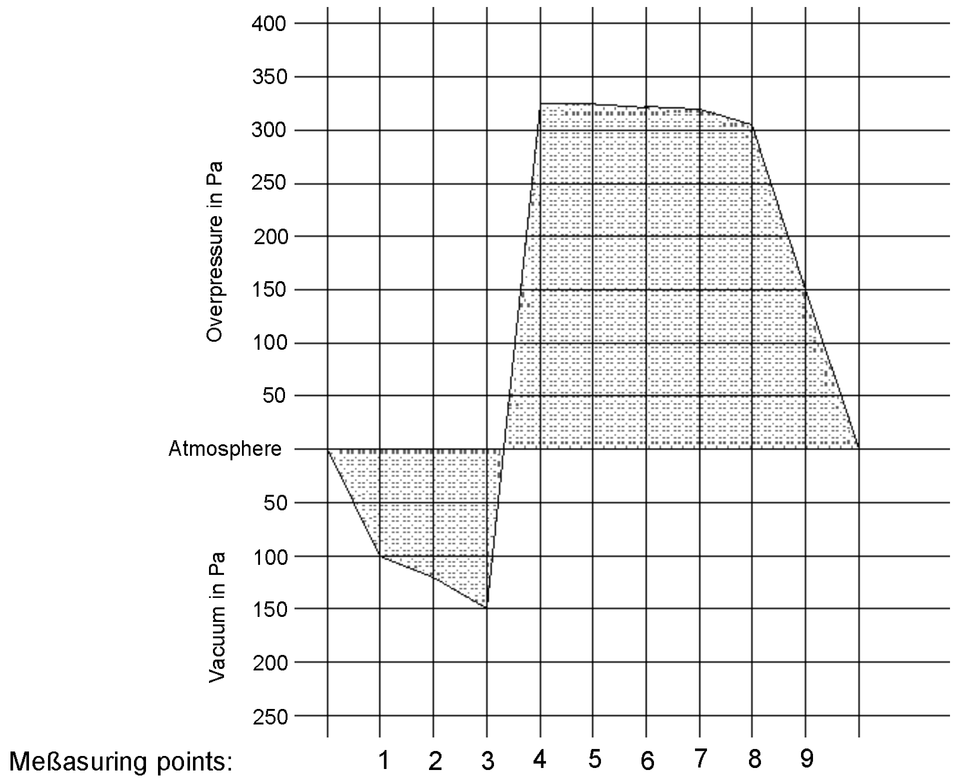
$p_{7,8}$ = 48 Pa

$p_{8,9}$ = 110 Pa

(The fist number in the index always gives the measuring point with the lower pressure level).

A comparison of these two measurements shows slight differences which arise due to reading inaccuracies.

If the measured pressures are entered in a diagram, the following pattern of the static pressure within the ventilation system is obtained.




## 5.3 Determining the volumetric flow

The air volumetric flow cannot be measured directly in the system. The throughput volume is determined on the basis of two auxiliary equations.

The first equation is defined by the conversion of pressure into velocity. The differential pressure between the measuring points 7 and 8 which occurs when the ventilation grille's quantity controller is closed is used for this purpose. The differential pressure is 48 Pa. Assuming loss-free flow (no friction, eddys, etc.), a velocity increase can be calculated from this differential pressure.

The following equation is used for this purpose:

$$c = \sqrt{2 \cdot \Delta p \cdot v}$$

The specific volume of the air (v) can be taken from tables and is approximately $0.8\,\frac{m^3}{kg}$.

If the stated values are inserted into the formula, we obtain the following result:

$$c = \sqrt{2 \cdot 48\ Pa \cdot 0.8\ \frac{m^3}{kg}} = 8.76\ \frac{m}{s}$$

This gives the first auxiliary equation:

$$c_8 = c_7 + 8.76\ \frac{m}{s} \qquad (1)$$

The second auxiliary equation is obtained by converting the continuity equation.

$$\frac{c_8}{c_7} = \frac{A_7}{A_8} \quad => \quad c_8 = \frac{A_7}{A_8} \cdot c_7$$

The two flow cross-sections can be determined from the channel dimensions.

$$A_7 = 357 \cdot 357\ mm^2 = 127450\ mm^2$$

$$A_8 = \frac{\Pi}{4} \cdot (200\ mm)^2 = 31240\ mm^2$$

This gives the second auxiliary equation:

$$c_8 = 4{,}08 \cdot c_7 \qquad (2)$$

If the two equations (1 and 2) are equated, we obtain the following absolute velocity at measuring point 7:

$$c_7 + 8{,}76\,\frac{m}{s} = 4{,}08 \cdot c_7$$

$$c_7 = 2{,}85\,\frac{m}{s}$$

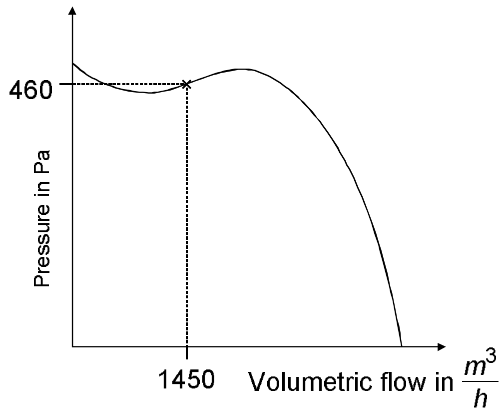
With the flow velocity and the cross-section at measuring point 7, the volumetric flow there can be calculated in simple terms as follows:

$$\dot{V} = A \cdot c$$

$$\dot{V} = 2{,}85\,\frac{m}{s} \cdot 0{,}1275\,m^2 \cdot 3600\,\frac{s}{h}$$

$$\dot{V} = 1305\,\frac{m^3}{h}$$

Characteristic of a fan:




On the characteristic of the fan used, we obtain for the operating point (460 Pa pressure difference between the suction and pressure glands) a volumetric flow of approximately 1450 $\frac{m^3}{h}$. This value is slightly above the calculated volumetric flow. The reasons for this lie in the not one hundred percent closing quantity controller of the ventilation grille, so that a certain amount of the air volumetric flowair volumetric flow already leaves the system there.

# 6 Appendix

## 6.1 Technical data of the ventilation system

Tubular steel frame: powder-coated, color black

Main dimensions of the ventilation system:

| | | |
|---|---|---|
| Width | 2100 | mm |
| Depth | 880 | mm |
| Height | 2050 | mm |
| Weight | 180 | kg |

Supply: 400 V/ 50 Hz, 10A

Pressure measurement: 1 inclined-tube pressure gauge 0-750 Pa

Current measurement: 1 Ammeter 0-6A

Components:
1 Supply air unit KG 40
max. current 2500 $m^3/h$
max. heating capacity 7.6 kW
1 Weather-protection grille
1 Inspection cover 200/100
2 Sound-absorbing panels
1 Ventilation grille 325/225 with quantity controller
1 Ventilation duct 300/630
1 Connection flange 250/250
1 Fire-protection flap 357/357
1 Contraction, angular / round 357/DN200
1 Branch DN200/DN125
2 Pipe elbows 90° DN125
3 Sleeves
1 Disk valve DN125
1 Connection box
1 Ceiling air outlet 250/250
1 Motor circuit-breaker
Folded spiral tube DN125
Flexible aluminium tube DN125

## 6.2 Literature references

Volger / Laasch,
Haustechnik,
B. G. Teubner Stuttgart,
8., Revised edition,
Stuttgart 1989

Wiemann / Eberle / Soherr,
Heizungs- und Raumlufttechnik,
B. G. Teubner Stuttgart,
2nd revised and enlarged edition,
Stuttgart 1992

Klaus Daniels,
Gebäudetechnik,
R. Oldenbourg Verlag,
Munich 1992

Recknagel • Sprenger • Schramek,
Taschenbuch für Heizung- + Klimatechnik,
R. Oldenbourg Verlag,
67th edition, Munich, Vienna 1994

## 6.3 Index

**W**