VENTILATION OF DWELLINGS AND AIR HEATING

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Elektrowärme International (FRG)
Vol 43, No A1, pp 16-20, January 1985

The paper mentions the problems encountered in highly insulated flats and houses as a result of inadequate ventilation. Based on this, the advantages of a system for ventilation with heat recovery are presented. In the second part of the paper such a ventilation system is presented combined with an air heating system.

With the increasing recognition that a controlled, central ventilation is necessary for the well-insulated and airtight house, the question is raised whether the ventilation cannot at the same time also provide the heating.

Air change requirements

In the ventilation of dwellings, the ideal aimed at in general is a ½ to 1 air change per hour, in order to maintain a good air quality in the dwelling. The used air in the dwelling, enriched with carbon dioxide, contaminated with noxious substances and filled with water vapour, must be exchanged for fresh air. Noxious substances, which have to be removed by constant ventilation, are released by building materials, stained woods treated with formaldehyde and also by textiles.

Air circuit for air heating

A single air change is adequate for a completely satisfactory ventilation, related to the dwelling. For the heating of living areas, however, such a small air change is not adequate. There should be as constant as possible air temperature in the room. A room which is not constantly heated should be able to be heated up quickly. Apart from the room air temperature the following also determine the comfort of a room: the surface temperatures of the room surrounding surfaces, the windows, the air movement in the sitting area, the air humidity - the purity of the air and the acoustics.

These components are dependent on the heat output and on the air volume of the air heating and also on the heat insulation and the density of the building elements. Experience so far shows the following:

- with a heat requirement of about 100 W/m^2, four air outlets are necessary from the air heating appliance to the living area,

- if the heat requirement is about 80 W/m^2, a size that is reached today with very many new buildings, three air outlets are required for heating, in order to have a constant air temperature in the room,

- with even higher heat insulation and thus with a heat requirement of about 60 W/m^2, two air outlets are sufficient,

- if a super heat insulation is available and thus the heat requirement is only about 40 W/m^2, a single air outlet should be sufficient.

Thus the state would probably be reached where heating could be provided with ventilation at the same time. Yet here it is not yet clear whether then the ventilation with heating still allows different room temperatures at all, or whether there is a uniform temperature in the whole dwelling.

Architects, building contractors and public health specialists require different temperatures in the individual rooms and the possibility of being able to make quick temperature changes, if the room temperature rises above the design value by solar gain or by additional heat sources such as people, lighting etc. A single air change per hour is too little to be able to react effectively.

Traditions, habits and sluggishness will however permit only a very slow change in the heating ideas. Here the architect plays a large part, who willingly expends a great deal of effort on his personal architecture, but has little interest in domestic installations.

The heating specialist has had good experiences with his predominantly water heating, so that he has no interest in and also no time for anything new.

The high heat insulation and compact method of construction, required by legislation, are not yet adequately taken into account by the architect and workman, in relation to the heating and ventilation of a flat or a house. The first reaction is that they choose smaller boilers, use better control installations and change more and more to floor heating. The housewife then has to take care of ventilation.

If in the planning stage the talk turns to ventilation, then this mostly founders in the planning expenditure and the construction costs, as well as in the too long amortisation period. The comfort that is achieved by good ventilation is simply not visible.

The architect does not yet take into account in planning the necessary ducts for ventilation and the room arrangement required for this, nor the space requirement for ventilation equipment. The installation of ventilation connections and of the air ducts in the shell construction is still unfamiliar to the architect or builder, so that the time which is favourable in terms of costs is overlooked. The air ducts have too large dimensions and, with planned heat recovery, they ought to be insulated when installed against heat loss.

Even the specific building trade which ought to install the ventilation is not yet firmly determined. According to the job description, the heating and ventilation engineer is the expert for this task. However, he mostly does not come on to the site until after the shell construction work is finished and then not much more can be done.

The sanitary fitter and the plumber are on the site earlier, but ventilation is not their area of work. The electrician is on the site for a long period and also already in the shell construction stage. The electrician would also in many cases be the right person, since the electrical connections must in any case be carried out by him, yet his job description does not permit him to fit ventilation and heating installations.

The mechanical, central ventilation of dwellings with heat recovery is a future necessity, in order to save energy and create a good interior climate.

The ventilation of dwellings is an independent system that can be combined with all heating possibilities. For air heating the central extraction of the moist areas with heat recovery is the ideal supplement.

The task of central, mechanical ventilation is, over the whole year, to supply a certain exchange of external air. For a flat this lies between ½ and 1. The air extraction should come about in the areas most affected by pollution and water vapour: from the kitchen, the utility room, the WC, the shower and the bathroom.

The new, fresh external air must flow into the living rooms and bedrooms in a controlled way, or must be supplied in a fixed volume to these rooms. Because of this correct prerequisite one has to understand that this only makes possible a mechanical, controlled ventilation and extraction.

The mechanical, controlled ventilation and extraction of dwellings can in addition also facilitate heat recovery (Figs 1 and 2). Thus the heat requirement for ventilation is determined. In calculating the heat requirement, the heat requirement for ventilation can then be deleted, the heat requirement of the air volume flow is calculated in the size determined and is taken as the basis for heating planning.

<u>Example</u>

Ventilation volume 240 m^3/h, required room temperature 22°C, external temperature -15°C and heat recovery 60%,

240 x (15 + 22) x 1.2 x 0.24	=	2557 W
Heat recovery 60%	=	1534 W
Ventilation heat requirement	=	1023 W

The most important points for ventilation of dwellings are:

- Economical but constant ventilation of living rooms and bedrooms.

- Economical but adequate extraction of humid areas, kitchen, WC, bath and shower.

- Air flow from the living rooms and bedrooms to the humid areas, in order to prevent a transfer of smells, water vapour etc into the living areas. (Because of the constant air extraction there is, in the humid areas, always a low pressure that cannot be perceived).

- The new, external air is to be heated by the waste heat that is released with the polluted air. For this purpose as large as possible heat exchangers are used, which do not have too great air resistance and can also be cleaned. Example: air in room 22°C, external air 0°C, supplied external air after the heat exchanger +15°C and extracted air 7°C.

- Draught-free air movement in the living area and possibility of the air flowing through the whole dwelling to the humid areas. In the internal area no airtight doors and sufficient distance of the door from the floor. Because of the constant airflow in the dwelling, the state of the air is so good that there is no longer any need for window ventilation.

- Filtering of the sucked in external air and the exhaust air in front of the heat exchanger by large filters, in order to make do with one maintenance per year.

- Filtering of the exhaust air at the extraction vents and in the cooker hood, so that the air ducts do not get dirty.

- Control possibilities for concentrating the introduced external air, during the day in the living area or at night in the bedrooms.

- Control possibility for increased extraction of the kitchen during cooking - with simultaneous reduction of quantities of exhaust air from the other humid areas.

- In the kitchen the polluted air should be extracted both over the cooker and also from the ceiling. With the arrangement of the two extraction points the quantity of exhaust air does not need to be very large - about 120 to 180 m^3/h and not 600 m^3/h.

- Minimal or no extraction noises because of acoustic considerations of the manufacturers of the appliances. Remote installation and separate air collectors with changeover of air quantities.

- Amortisation of additional expenditure for investment by reduced consumption of heating energy. The countercurrent heat exchangers have a heat recovery of up to 70%. With built-in installations the operators report of a saving of up to 25% in the heating costs.

- As low as possible power consumption for the fans. Because of this, however, the ventilation ducts have to be of large enough dimensions to have low frictional resistances. For the cooker extraction: pipe diameter 150 mm, for the extraction pipes of the other humid areas and from the kitchen ceiling 80 mm diameter or air ducts of 50 x 100 mm.

- The installations for ventilation of dwellings should be offered as complete building sets with all the building components required.

- The planning information should be simple, but comprehensive enough, so that the architect can include the ventilation installation in his plans. It became apparent up to now that the co-operation between architect and planner is not sufficient and the time spent by the planner is too great.

- The manufacturer's instructions for assembly should be so good that the master craftsman can have the installation fitted by his people, without training.

These mechanical types of ventilation can be built into any heating system.

In the case of single fireplaces, however, the air intake must in general be greater than the air removed (corresponding to the number of fireplaces).

Ventilation and air heating

The ideal combination is mechanical ventilation and extraction with air heating. Here too there are of course different design possibilities and stages of comfort (Fig 3).

Such an installation must be planned in good time, before completion of the definitive building plans, by an experienced engineering office. The architect should also have certain knowledge in the ground planning.

In the case of air heating with the small air ducts, which are installed in the floor, for the preliminary planning an air quantity of 60 m^3/h and a heat output of 400 W can be assumed per duct. The right number of air ducts must be provided to match the heat requirement.

As a rule one distributor per floor is required for the small ducts. If the house is very large, one distributor each is chosen for the living and sleeping areas. The distributors must be accessible from above or below (Fig 4).

An omnibus circuit leads from the air-heating appliance to the distributor. It should be of such dimensions that the air speed is about 3m/s.

The room air from all the living areas must be led back to the air-heating appliance. A closed room air duct, with the opening below the ceiling, is to be recommended. If the stairwell is open to the basement or cellar, in certain circumstances this can also be used as an room air duct. The room air is then sucked in from the stairwell through a sound absorber.

The room air from the individual rooms is supplied by equalising openings above the doors - as a rule with sound absorbers - to the extraction point. Each room can be controlled individually by a room thermostat. The room thermostats activate the air flaps in the distributors.

When using the combination with central extraction, the WC, shower and bathrooms are constantly rinsed by the air with dwelling temperature, 2 to 10 times depending on the size of the room. Thus these rooms are warm enough for normal requirements. For a short-term, higher room temperature, the most economic method then is to switch on an electric rapid heater with thermostat.

The most important advantages of air heating are as follows:

- Pleasant, healthy, room climate in accordance with the individual feeling of comfort in every season (so not only for heating in winter).
- Favourable temperature profile, ie as low as possible temperature differences in the area where people stay, also in high rooms.
- Dust, noise and insects remain "outside". Window ventilation is a thing of the past, for even when the window is closed, air central heating always brings fresh, filtered air.
- Rapid heating up and adapting to changing weather by means of automatic control means considerable saving of energy.
- The floor is pleasantly warmed by the mini-air-duct system laid in the composition floor. The floor temperature is a maximum of 2 K above the room temperature.
- An undisturbed glance outside is possible when the windows are pulled down deeply. The invasion of cold is prevented by the rising warm air which is supplied.

- Ceilings, walls and curtains stay clean longer because of the constant air filtering. At the most one cleaning of the curtains per year is sufficient. Because of this the additional costs of air-conditioned central heating are offset in a few years.

- Air-conditioned central heating does not require any radiators in the room, so that more space is available.

- The subsequent installation of a central air humidifier to attain the necessary relative air humidity in winter is possible at any time.

- By installation of an electrostatic air filter, cigarette smoke, finest particles of dust, aerosols, pollen, bacteria and the like can be absorbed.

- The heat requirement, very low in new buildings in any case because of good heat insulation, is further reduced with central extraction of the moist areas. Installations for heat recovery use the warm waste air for preheating the external air supplied in measured amounts.

- The air-conditioned central heating offers ideal conditions for later conversion to economic heat pump operation powered by electricity and in the near future powered by gas or by fuel oil.

As a comfort variant in air heating, combined with mechanical ventilation and extraction with heat recovery, a controllable direct ventilation of the bedrooms can be installed. From the external air duct a corresponding quantity of air can be supplied by a three-way valve direct to the bedrooms, while the remaining quantity of air is supplied to the general air intake. Then as a rule 2 x 30 m^3/h are supplied to the parents' bedroom and 30 m^3/h to each of the children's rooms. The quantity of air intake can be measured accurately by the built-in air quantity controllers in the distributor.

The experience of recent years has shown that an additional air humidifier is not necessary in the case of air heating with combined ventilation and extraction. The installation of an air heating system is carried out quickly and simply. The labour expended for a single-family house is 80 to 100 hours.

The procurement costs for an air heating system are somewhat higher than in a conventional hot water central heating system. However much more is offered for this and about 25% of heating costs are saved.

Maintenance is roughly comparable to any other form of heating. In addition to boiler inspection there is also the cleaning and exchange of filters.

The market is now slowly showing that the necessity of controlled, mechanical ventilation with heat recovery is being recognised.

The "non-plus-ultra" would be a full air heating system, combined with a mechanical ventilation and extraction with heat recovery.

OA Trans 2761
EPC/September 1985

- 4 Figures

FIGURES

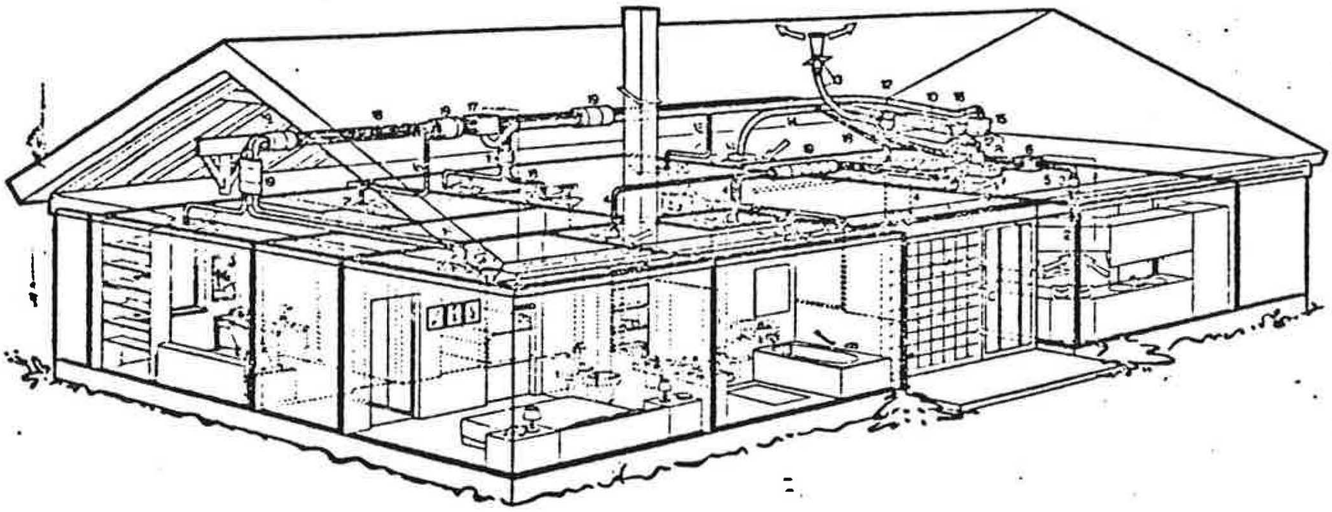

FIG 1 SYSTEM FOR CONTROLLED VENTILATION OF DWELLINGS WITH HEAT RECOVERY

1 Exhaust air connections with filters in the humid areas
2 Kitchen exhaust air hood with lighting and damper
3 Ceiling outlet with flame protection cap
4 Flexible exhaust air ducts (80 mm ɸ)
5 Flexible kitchen exhaust air duct (150 mm ɸ)
6 Exhaust air collector with damper control
7 Exhaust air 35 W fan
8 Three-way valve for summer operation
9 By-pass duct and T connection piece
10 Cross flow heat exchanger (degree of efficiency 65%)
11 Condensate outlet
12 Drum air filter
13 Exhaust air duct and roof outlet
14 External air connection and external air duct 150 mm ɸ, flexible
15 Air intake fan 35 W
16 Air intake duct for the external air heated by the exhaust air (150 mm ɸ)
17 Air intake distributor with damper control
18 Air intake ducts, 80 mm ɸ, flexible
19 Sound insulation of the supply and extract air ducts
20 Air intake nozzles
21 On-off switch for every fan and switch for summer operation and time-switch

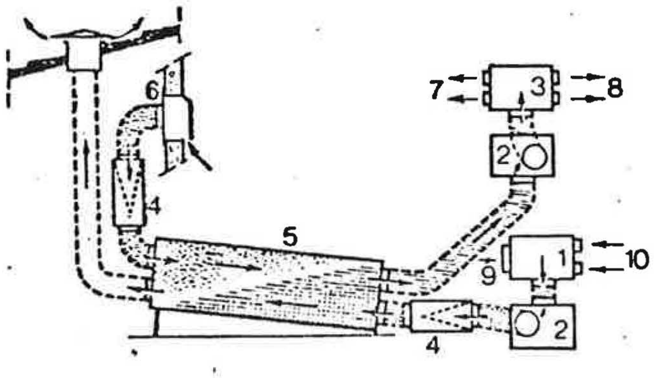

FIG 2 DIAGRAM OF HEAT RECOVERY IN THE AIR SYSTEM

1 Distributor of the exhaust air
2 Fan box
3 Distributor of the air intake
4 Drum filter
5 Heat exchanger
6 External air intake grille
7 Living room
8 Bedrooms
9 Kitchen
10 WC and bath

FIG 4 DISTRIBUTORS AND AUR DUCTS BEFORE THE FLOOR SCREED IS LAID

(This is a photograph not suitable for reproduction)

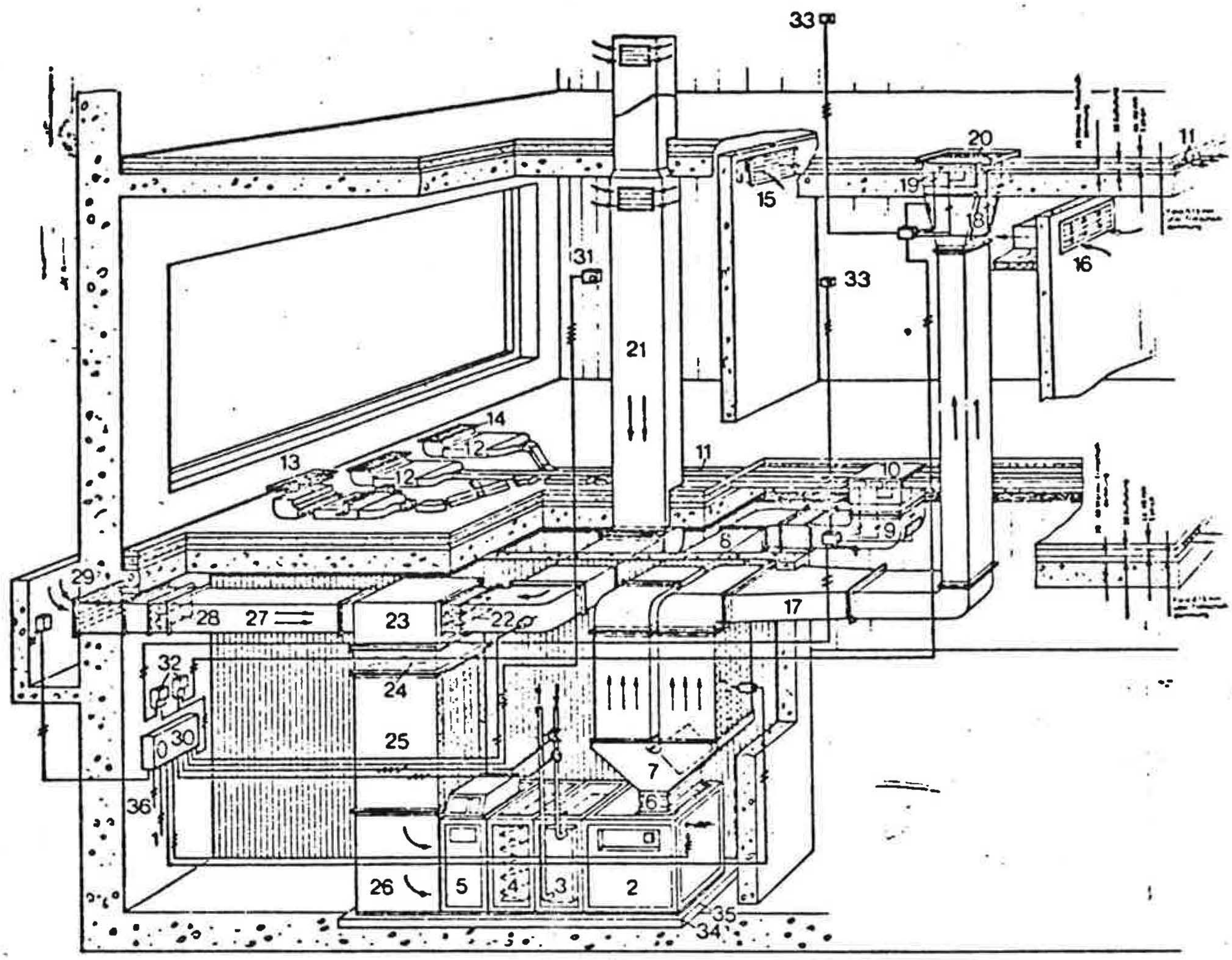

FIG 3 AIR-CONDITIONED CENTRAL HEATING WITH AIR DUCTS 50 x 100 mm

1 Heat generator
2 Air-conditioning ventilation unit with instrument board and infinitely variable speed fan
3 Heat exchanger
4 Fine dust filter
5 Electric air filter
6 Flexible flange
7 Air intake distributor with guide vanes
8 Air intake duct for ground floor
9 Connecting bend with inspection opening
10 Distributor for ground floor with air dampers
11 Air ducts embedded in the floor
12 Air intake outlets with sound absorbers
13 Raised grille for carpeted floors
14 Embedded grille for tiled floors
15 Telephone sound absorber with two grilles for room air
16 Background sound absorber with a grille for room air with suspended ceiling
17 Air intake ducts for the upper floor
18 Transition piece with inspection opening
19 Distributor for upper floor with air dampers
20 Floor framework with inspection opening
21 Enclosed room air duct
22 Lower damper room air
23 Mixing box room / external air
24 Flexible flange
25 Room air sound absorber
26 Room air connection
27 External air duct
28 External airtight damper
29 External air grille
30 Control
31 Control selector
32 220/24 volts transformer for air dampers
33 Room thermostat with summer/winter changeover
34 Foundation 50-60 mm high
35 Foam rubber pad 6 mm
36 To the flow sensor of the heat generator