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Simple and Reliable Systems for Demand Controlled Ventilation in Apartments

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SYNOPSIS

The paper is presenting experience from a several year long time of operation in a group of apartment buildings in the Stockholm area, Sweden, having an extremely low energy usage, less than 110 kWh/(m2.year), electricity supply to the building services included.

The system solution used has a very low pressure drop in the exhaust ducts. Every exhaust point is connected to an individual duct leading to a fan chamber in the attic. The pressure in that chamber is kept constant. The attendant in a flat wanting a higher flow rate starts an individual booster fan situated at the top of his own duct. Supply air is furnished by valves installed in the external walls of the flat. Balancing is made in the fan chamber only. Thus nobody can arrange a higher base flow rate for an individual flat without having access to the fan chamber.

The investment level is comparable to that of a traditional system. Duct dimensions are chosen so as to allow them to be built-in into the walls. The system, which was designed by Mr Henry Willman of HEWAB Engineering, Stockholm, is applicable for offices and the like with or without a mechanical air supply system.

1. DCV IN GENERAL

Demand Controlled Ventilation is a method to achieve the energy conservation wanted and at the same time serve those residing in the treated space with an acceptable air quality. The user's rightful requirements on air treatment systems are in short mainly the following:

a. Clean air in the occupation zone
b. Demand controlled flow rate
c. Individual climate in room where you stay permanently
d. Energy efficient operation
e. Simple and easily understandable design
f. High availability
e. Low life cycle cost for building and installations

In most cases these requirements are also in line with those set by the owner as well as the administrator and the operator, to whom low LCC requirement normally leads to low density of automatic systems.

2. BALANCING - A LIFE CYCLE PROCESS

Most systems are built in the form of stems and branches. Thus, in order to achieve a correct distribution of air, supply or exhaust, in all branches and air terminal devices (ATDs), it is necessary to balance the system. Normally the ATDs are furnished with or themselves act as pressure reducing valves. Here is one of the major problems: The user of the apartment or office room can himself (mostly the responsible are men !) "adjust" the pressure drop of the newly set position of the ATD. Thus the system is once mor out of balance, meaning that some room get too much air and some too little. The way of coping with this problem is to put all types of adhusting valves outside the apartment or office. By doing so you win twofold: No uauthorized tampering with the valves is possible, and no admittance to the apartment or office will be necessary for the purpose of balancing. A further step is to arrange the system so that each ATD is connected to the fan room by a separate duct, in which the adjustiable valve is inserted.

3. DCV IN APARTMENTS

According to IEA Annex 18, "Demand Controlled Ventilation Systems", DCV, the main environmental problem in apartments is moisture. The maximum level of relative humidity of room air, 55% to prevent dust mites, 75% to prevent mold growth in building material, can be met by using DCV. Ventilation systems for appartments can be designed so as to allow for individual flow rate control without a complicated technical equipment. A heat pump system using exhaust air and to some extent outdoor air as a source renders the system a very low energy usage for heating, ventilating and production of heated tap water. The amount of refrigerant in the system can be kept at a low level by using a package heat pump unit connected to a water circulation system with a heat exchanger in the exhaust air, see figure 1.

The physical background to the fact that the so-called "Controlled Ventilation", using high pressure drop in the air terminal devices, cannot fulfill the requirements on a reasonable noise level and energy demand in a system where ventilation flow rate is increased at certain times, is shown by simply using the Bernoulli therorem, see figure 2.

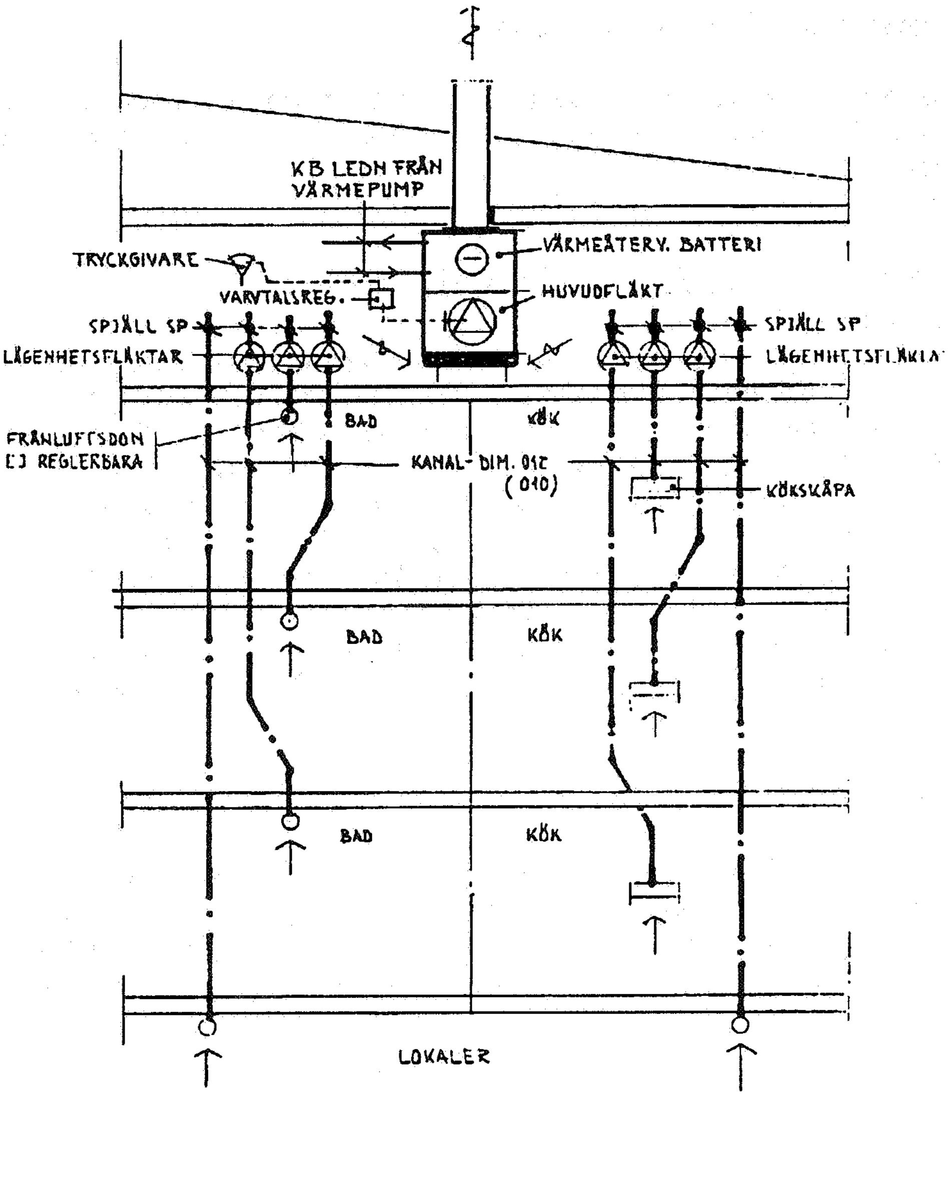

Figure 1. System layout for a domestic building

The pressure drop(δp) per unit length of a duct is approximately proportional to the square of the velocity(v) of the flow:

$$\delta p = \frac{\rho * v^2}{2} * k \quad Pa/m \qquad (1)$$

Here ρ= air density, about1,2 kg/m3
k = "constant", depending of the smotheness of the duct surface

The flow rate(q)is a function of the velocity(v) and the cross area (A) of the duct:

$$q = v * A \quad m3/s \qquad (2)$$

For a duct of circular cross area and diameter (d) we find:

$$A = \frac{\pi * d^2}{4} \quad m2 \qquad (3)$$

The "constant" (k) in eqv(1) can be set to (for given velocity range and surface smotheness):

$$k = \frac{0,02}{d} \qquad (4)$$

The fan power P) is calculated from:

$$P = q * \delta p \quad Watt \qquad (5)$$

The pressure drop, under circumstances given, will become a function of the second power of the flow rate and of the fifth power of the diameter: r

$$\delta p = \frac{\rho * v^2}{2} * \frac{\lambda}{d} = \frac{\rho * \lambda}{2d} * \frac{16q^2}{\pi^2 * d^2 * d^2} = K * \frac{q^2}{d^5} \qquad (6)$$

For q=3q we get $\delta p_1 = \delta p * \frac{3q)^2}{q^2} = 9 * \delta p$ (7)

If the original pressure drop is 300 Pa, the new pressure drop will become 9*300 = 2700 Pa

Figure 2:The rules of flow as applied to a duct system and a ventilator

4. DCV IN OFFICES, SCHOOLS AND DAY NURSERIES

The solution described above is also applicable for office buildings and other buildings of the same character, for instance schools and day nurseries, with or without a mechanical supply system and for all types of external energy supply.

The supply unit does not need connection to a heating system, as the unit is furnished with a high efficiency heat exchanger, see figure 3. The characteristics of such a system can be studied in figure 4.

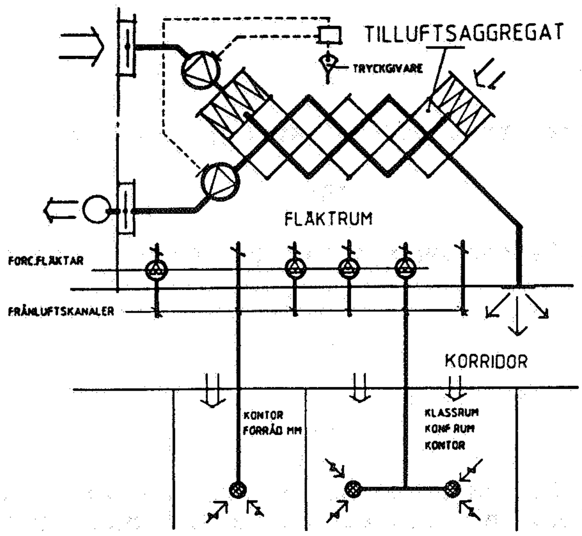

Figure 3. System layout for a DCV system in an office building

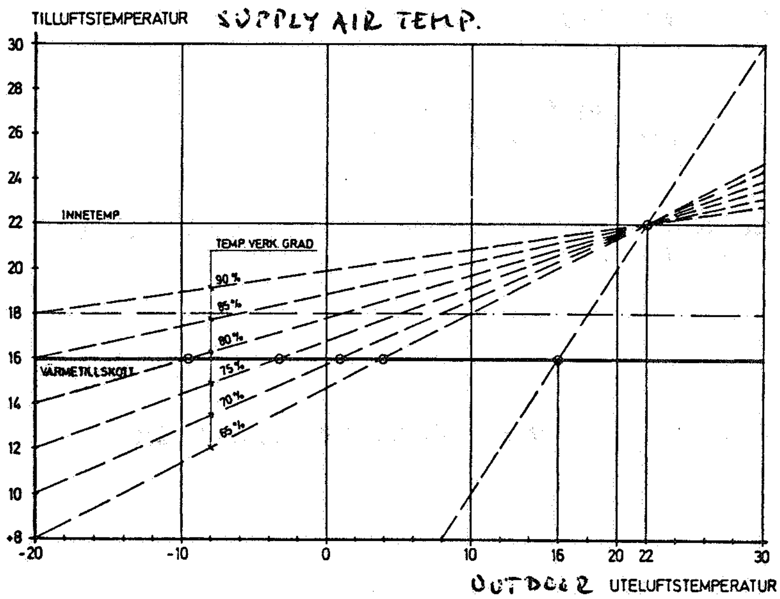

Figure 4. The influance of efficiency of a heat exchanger

The attendant in a room wanting a higher flow rate starts an individual booster fan situated at the top of his own duct. Supply air is furnished either by valves in the external walls or by a supply air unit operated in parallell with the exhaust unit,

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