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"Why Tight Houses?"

Translated from the original Swedish
"Varfor täta hus?"
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Why tight houses?

Dr Per Olof Nylund, of Tyrens, contends that a building envelope and ventilation system must be regarded as interacting components in a total system. Using an analogy of hydraulics, he explains why air leakage through the envelope is greater if supply and exhaust ventilation is used as opposed to exhaust air ventilation and why tight houses should be built.

Energy consumption in supply/exhaust ventilated houses is seldom what is expected. The reason being that air leakage through the building envelope has not been considered.

Thus calculation has become a sub-optimisation of the ventilation system by itself. This is quite natural since it was not known how the ventilation system affected air leakage. People were aware that there was a connection. The basic pattern is now clear even if there are many details which must be given further consideration.

The building envelope and the ventilation system are two components in a total system. Different ventilation systems mean different conditions for air leakage. The analogy of hydraulics is used in this article to provide an explanation.

"Water analogy" for a simple case

Air leakages or airflow through gaps result from a pressure drop across the gaps. Bearing in mind the low pressure differences in building technology, air can be considered incompressible. Thus the flow laws of hydraulics apply. This can be illustrated with a leaky container immersed in water.

Figure 1 shows a walk-through apartment with two pervious outer walls and pervious joist structures. Applying the water analogy, the apartment is a container with two leaky sides.

Figure 1a shows the initial state without pressure interference and Figure 1b how an apartment is subjected to interference pressure in the form of positive pressure acting on the left-hand outer wall.

Figure 1. A walk-through apartment with two pervious walls and tight joist structures. A = initial state, B = interference pressure.

Three cases will be illustrated: An apartment without a ventilation system, with an exhaust system and with a supply/exhaust system. The initial state in all cases is as indicated in Figure 1a, unaffected by interference pressure. From this initial state, interference pressure is gradually increased on the left-hand wall.

For simplicity, it is assumed that leaks in the outer walls are equal and allow a flow which is proportional to the drop in pressure, as illustrated in Figure 2.

Flow Q

Q = K x P

Pressure drop P

Figure 2. Relationship between pressure drop and flow through outer walls.

An apartment with a "Zero system"

Figure 3, in the left-hand column, illustrates what happens in an apartment without a ventilation system, the "zero system", when an interference pressure is applied to the initial state.

"ZERO SYSTEM" EXHAUST SYSTEM SUPPLY/EXHAUST SYSTEM

Figure 3. The hydraulic model

In the initial state, the model is the same as outside. There is no leakage.

A gradually increasing interference pressure, as shown in Figure 1b, corresponds to a gradual increase in water level in the other diagrams in column 1 in Figure 3. The equilibrium level of the surface in the vessel lies between the "upstream" and "downstream" levels.

The leakage is given by the expression at the bottom of column 1. This is represented graphically by the lower curve in Figure 4.

An apartment with an exhaust system

The case of an apartment with an exhaust system is illustrated in the second column of Figure 3. In the initial state the water level in the vessel is lower than outside. In the second diagram from the top, the inner water level is still lower than the outer water level. Leakage flows inwards through both sides. The sum of the leakages is equal to flow G.

The level on the left-hand side is further increased to the level shown in the third diagram from the top. The flow is still constant. Leakage from the right-hand side is now zero.

With a further increase in level to the left, the flow state and balance change - the bottom figure. Leakage now goes through the right-hand wall. The expression for mean change rate is given at the bottom of the column. The relationship is illustrated by the middle curve in Figure 4.

An apartment with a supply/exhaust system

The right-hand column illustrated the corresponding sequence for a supply/exhaust system. The supply and exhaust flows are assumed to be constant and therefore do not affect the inner water level. This will stay the same as the "zero system" described earlier. The mean change rate L is given by the expression at the bottom of the column in Figure 3.

Comments

On this basis it can be stated that:

° Zero ventilation is a linear function which depends entirely on interference pressures and leaks.

° Exhaust ventilation has a stable action, ie it maintains the intended air change rate until interference (interference times leaks, in actual fact) reaches a certain threshold value.

° Supply/exhaust seldom provides the intended air change rate. The slightest interference gives rise to immediate adventitious ventilation through leakage.

Mean change rate L

Supply/exhaust system
Exhaust system
Zero system

Perviousness (K) x interference pressure (P)

Figure 4. Mean change rate L as a function of perviousness x intereference pressure.

The reasons for tight houses

Despite the simplified presentation, it is obvious that calculations of air changes and ventilation losses must consider the interaction between the perviousness of a building envelope and the way a ventilation system operates.

The reason why the expected energy consumption in supply/exhaust ventilated houses does not live up to expectations can be explained in that calculations have assumed air leakage to be the same whatever the type of ventilation system. This is why altogether too optimistic results are assumed for energy consumption in supply/exhaust ventilated houses.

If air leakage and a 50% efficient heat exchanger is assumed, heat losses in a supply/exhaust ventilated house will be the same as an exhaust ventilated house on the basis of the simple cases illustrated here. The logic is valid if the product of the interference pressure and the perviousness is sufficient for the "gap" between the upper and the middle curves in Figure 4 to be fully developed. The idea is to have the gap as small as possible.

In other words - **tight houses!**

(Translated for the Air Infiltration Centre by Transcript Translators, Bracknell, England.)

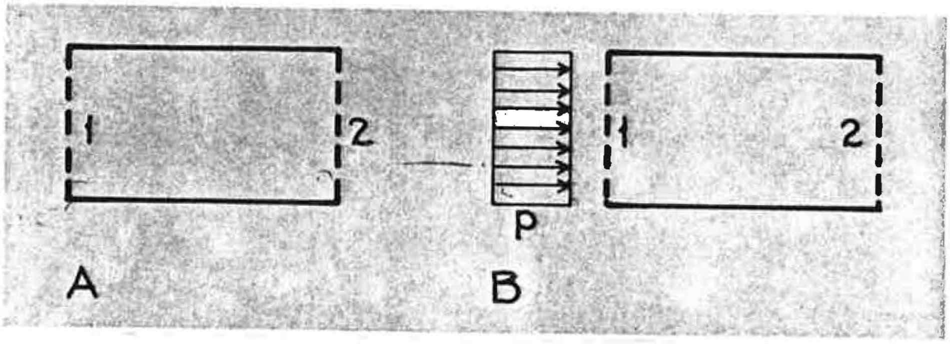


Figure 1. A walk-through apartment with two pervious walls and tight joist structures. A = initial state, B = interference pressure.

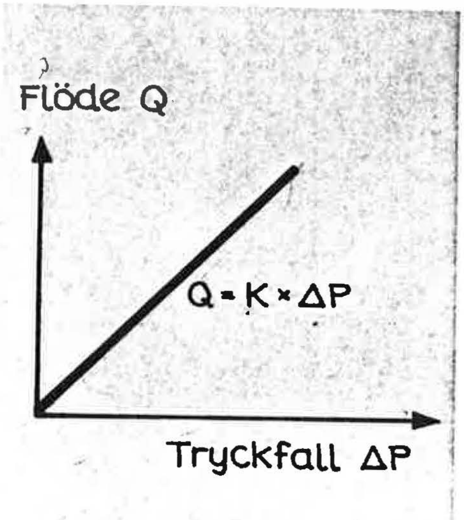


Figure 2. Relationship between pressure drop and flow through outer walls.

Tryckfall = Pressure drop
Flöde = flow

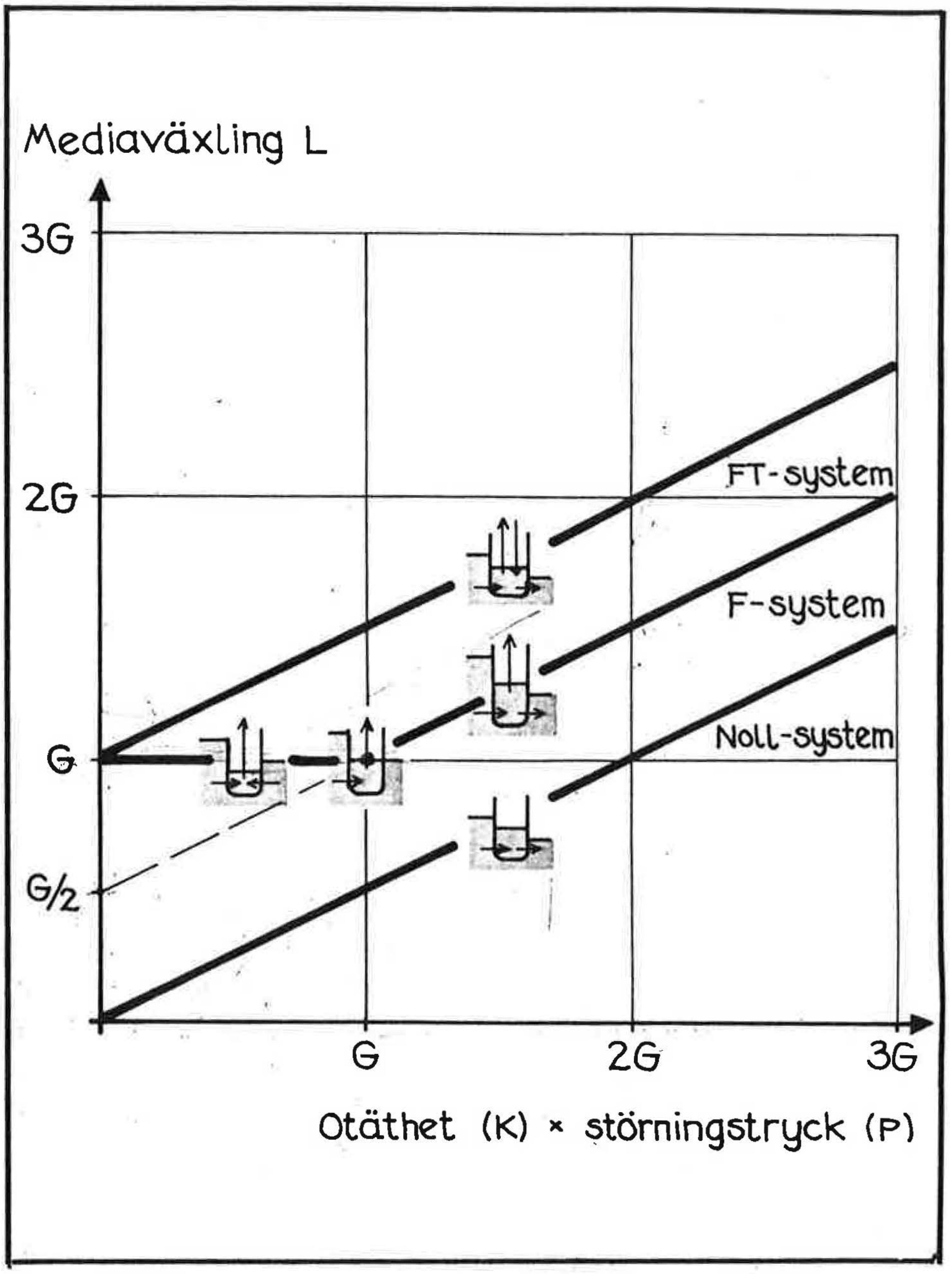
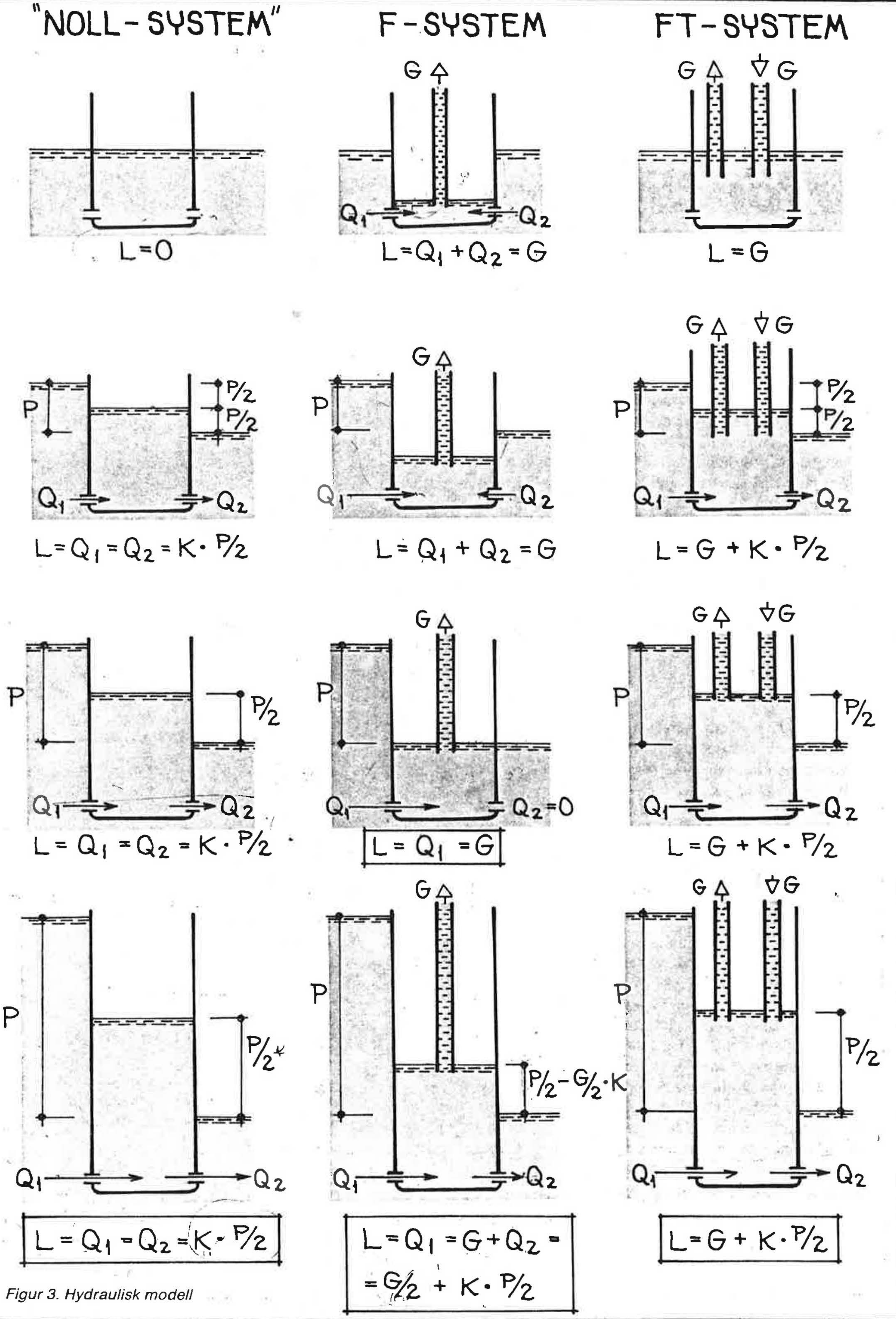


Figure 4. Mean change rate L as a function of perviousness x interference pressure.

FT-system = Supply/exhaust system
F-system = Exhaust system
Noll-system = no system.
Mediaväxling L = Mean change rate L



Figur 3. Hydraulisk modell