PERFORMANCES OF A NEW GENERATION HIGH EFFICIENCY HEAT RECOVERY UNITS FOR DOMESTIC VENTILATION

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ABSTRACT

In 1998 the Dutch ventilation industry launched a new generation of domestic ventilation systems with high efficiency heat recovery on the market applying counter flow heat exchangers and DC fans. It is expected that these ventilation systems will play an important role in realising the goals of the Dutch national energy policy for reducing energy use in the built environment. Another important aspect is the contribution to a healthy indoor environment in dwellings with an extreme high energy efficiency, specially in relation to increasing air tightness and thermal insulation. First measurement results in practice show that these systems provide a good indoor environment regarding indoor air quality, thermal comfort and noise. Energy losses for ventilation can be reduced by 8 to 10 GJ/year.

INTRODUCTION

The role of ventilation, and as a result IAQ and energy use for ventilation losses, is getting more and more important in extreme energy efficient homes. In 1999 and 2000 a programme will be carried out to investigate indoor air and ventilation quality in new built energy efficient homes (i.e. complying with the latest Dutch Energy Performance Standard) with different types of ventilation systems. One of the goals of this programme is to study the impact of strengthening the national requirements on energy efficiency on the indoor environment regarding IAQ, ventilation and thermal comfort. In this programme several parties will co-operate like Novem, several regional health care organisations, the Dutch ventilation industry and Gasunie. The Dutch ventilation industry, united in "Stichting HR-Ventilatie (Foundation for High Efficiency Ventilation) is responsible for researching the performances on IAQ, ventilation and energy use of the counter flow heat exchangers in practice. Therefor in 1999 in six low energy houses a measurement and evaluation program was carried out. A second project in six low energy apartments is executed in 2000. This paper will focus on the first results of this research programme in practice. In the same framework a large scale occupants survey was carried out amongst 700 households with balanced ventilation and natural ventilation systems.

Figure 1. Impression of the project

METHODS

This measurement and evaluation programme contains:

- Performances of the counter flow heat recovery units including system noise, air flows of supply and exhaust devices.
- Ventilation rates measured with passive tracer gas technique (PFT).
- Measuring indoor air quality in terms of TVOC, CO_2, CO, NO_2, Radon, relative humidity and temperature.
- Thermal comfort.
- Air tightness of the building envelope.
- Occupants survey on using ventilation provisions.

Energy efficiency measurements were carried out during February and March 1999. Ventilation rates were measured during one heating season by means of PFT technique.

Simultaneously in these dwellings indoor air quality parameters were measured. CO_2, CO, TVOC, temperature and relative humidity were measured during one week by using a Bruel & Kjaer 1302 gas monitor and 1303 sampler and doser unit. NO_2 was measured by using Palmes diffusion samplers. Radon is measured by Radon impact foil cups provided by the KVI of the university of Groningen. During the measurements occupants recorded the use of ventilation provisions, window airing, inner doors and heating system.

Thermal comfort was evaluated by measuring air temperature, radiant temperature, air velocity and relative humidity by using a B&K 1213 comfort analyser.

Noise levels were measured by using a B&K 2213 Modular Precision Sound level Meter.

RESULTS

Energy performances of counter flow heat recovery units

In 2000 several counter flow heat recovery units are available on the Dutch market. The energy performance can be measured by the Dutch standard NEN 5138: Heat Recovery in Residential Buildings - Determination method. This method is more or less similar to the European standard EN 308 but is in its boundary conditions more suitable for measuring domestic ventilation units. In NEN 5138 a standardised method is given for measuring the energy efficiency and the Performance Factor of domestic heat recovery units. The Performance Factor is defined as the yearly (useful) saved energy divided by the needed electrical input for fans. In table 1 the measured energy performances under laboratory conditions are given.

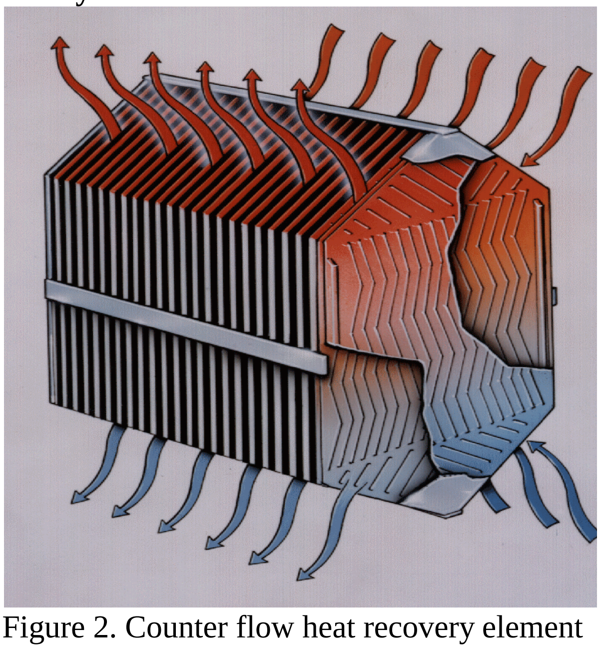

Figure 2. Counter flow heat recovery element

Table 1. Energy performance (laboratory conditions – NEN 5138)

Manufacturer/type	Energy efficiency (%)	Electrical input (W)	Performance Factor (-)
Brink Renovent HR	96	46	9.8
Itho Ecofan HRU	97	40	10.4
J.E. Stork Air WHR 90	96	48	8.6

In the six demonstration houses counter flow heat recovery units of manufacturer Brink were applied. The energy performances in practice were determined by real time measuring the in and outgoing temperatures of the air flows. For correcting temperature efficiency to energy efficiency the in and outgoing mass flows were also measured. In figure 3 the measured energy efficiency in practice is given. The average measured energy efficiency is 85%. This is less then the measured energy efficiency under laboratory conditions. The difference is caused by the instability of the measurements, especially the fluctuations of the in and outgoing air flows and the accuracy of temperature measurements.
In figure 4 the gas savings are given, calculated from the measured energy efficiency and mechanical air flows. The gas savings vary from 210 to 290 m^3 nat. gas/year. The average electricity consumption for fans was 200 kWh/year.

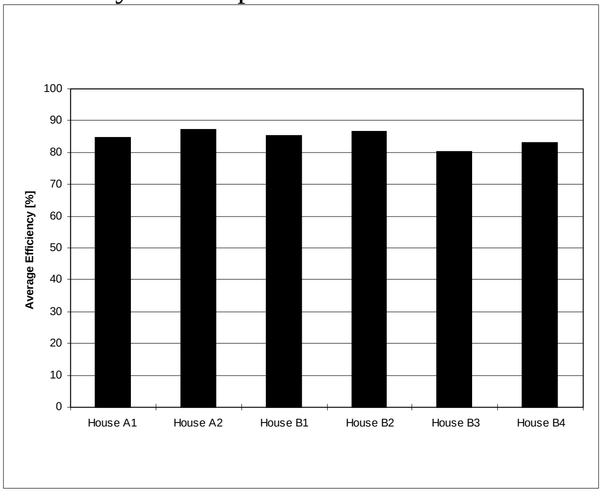

Figure 3. Measured heat recovery energy efficiency in practice.

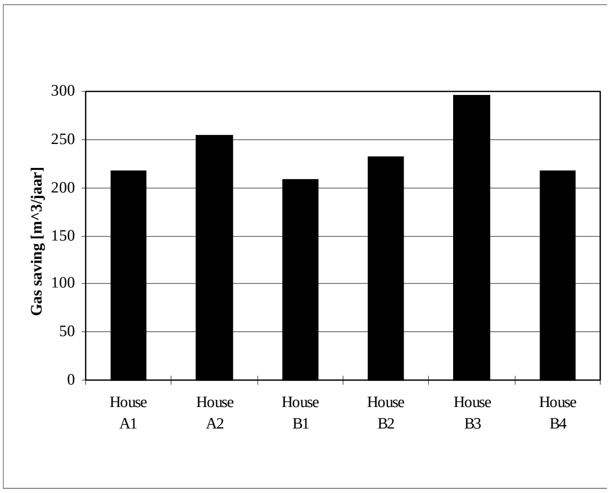

Figure 4. Measured gas saving/year

Ventilation performances and air flows

The total ventilation as well as the separate ventilation components were measured as follows:

- Total average air change rates during 8 weeks by passive tracer gas method (PFT)
- Air tightness of building envelope by Dutch standard NEN 2686: Air Leakage of Buildings - Method of Measurements.
- Monitoring use of fans by datalogging.
- Inventory of use of other ventilation provisions by questionnaires.

Total air change rates were measured in habitable and service rooms (figure 5) as well as for the whole building (figure 6). These total air change rates include mechanical air flows (MVHR-unit), infiltration of air through the building envelope and window airing. The air leakages of the dwellings are measured by pressurisation tests (blower doors). The air tightness is expressed as the airflow through the building envelope at a pressure difference over the envelope of 10 Pa ($q_{v;10}$). The $q_{v;10}$ values of most dwellings were between 60 and 80 dm^3/s. This corresponds with n50 value of 1.6 to 2.2. The measured $q_{v;10}$ values are given in figure 7

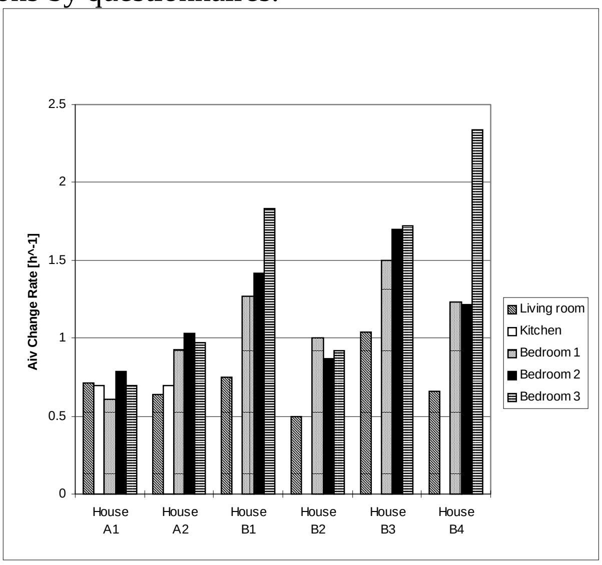

Figure 5. Measured air change rates in rooms

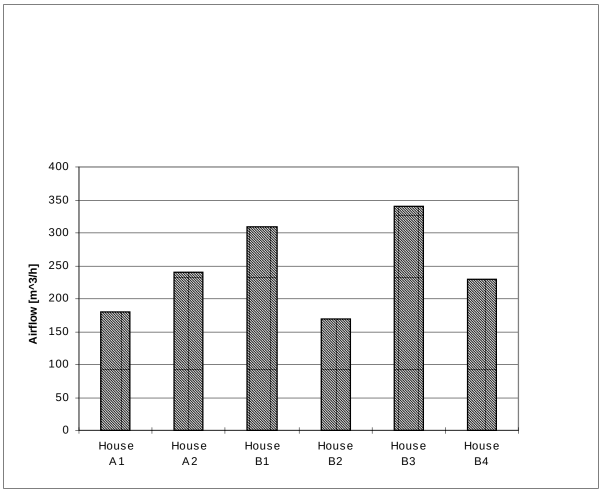

Figure 6. Total air flow rates in dwellings

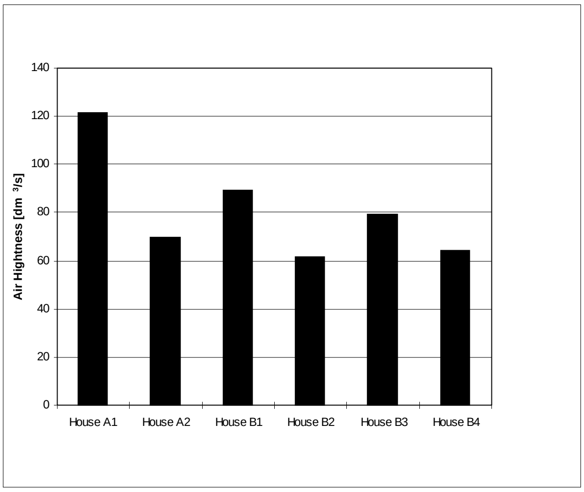

Figure 7. Measured air leakage at 10 Pa

Indoor air quality

In figures 8 to 11 the measured concentrations CO_2, CO, TVOC (related to CH_4), as well as the relative humidity are given. These concentrations were measured real time during one week. In figure 12 and 13 measured concentrations of NO_2 and Radon are given.

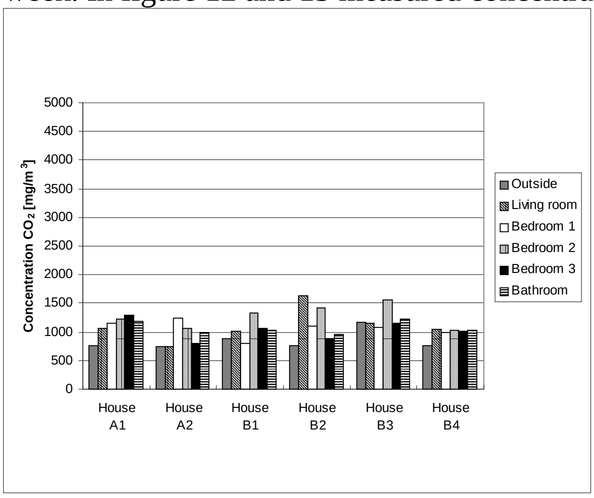

Figure 8. Measured CO_2 concentration

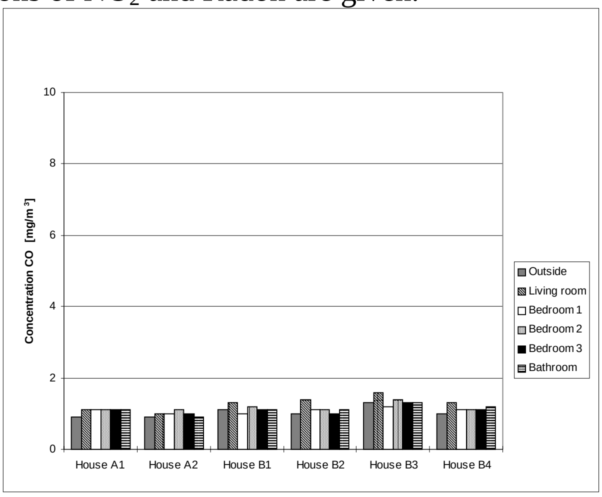

Figure 9. Measured CO concentration

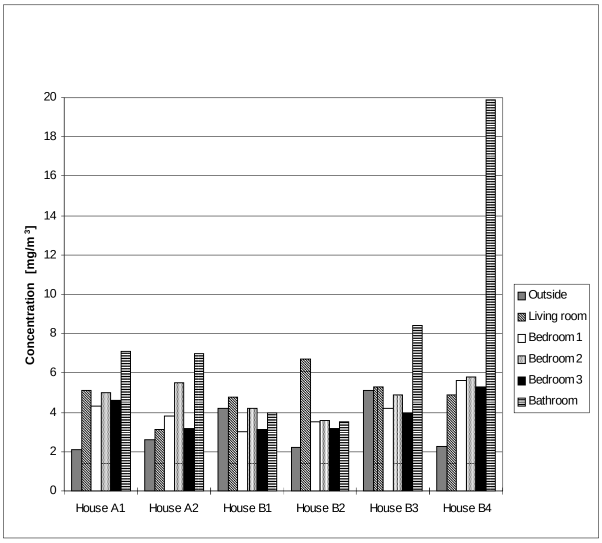

Figure10. Measured TVOC concentration

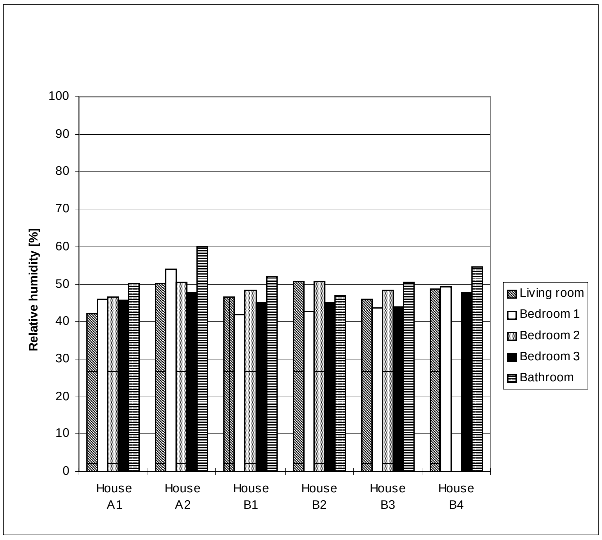

Figure 11. Measured relative humidity

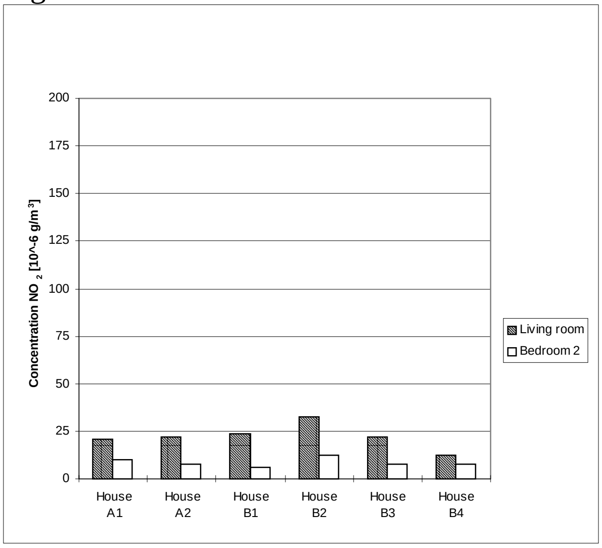

Figure 12. Measured NO_2 concentration

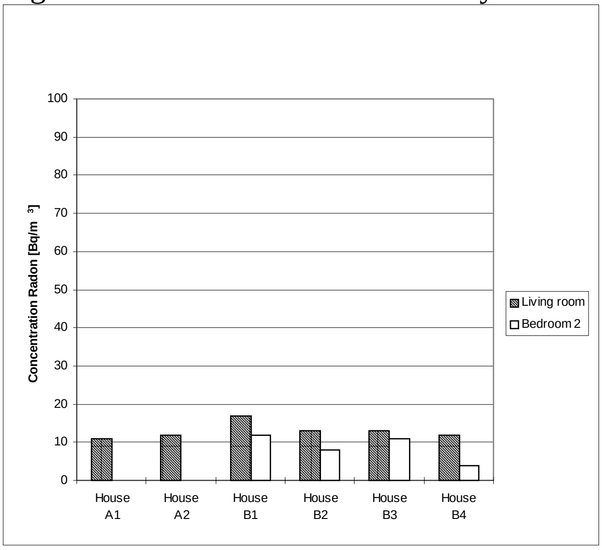

Figure 13. Measured Radon concentration

Thermal comfort and noise

Thermal comfort and noise (i.e. the absence of noise) are two of the most important parameters for occupants to assess the quality and appreciation of ventilation systems. Thermal comfort is measured in the middle of the living room at 0.1 m and 1.1 m. Local thermal comfort is evaluated on draught. Figure 14 shows the PD values calculated from measured air velocity, air temperature and turbulence.

System noise was measured in the middle of the living room and in one of the bedrooms. The fans were switched to the middle position, corresponding with the nominal air flows according to the Dutch building regulations. Figure 15 shows measured A-weighted noise levels.

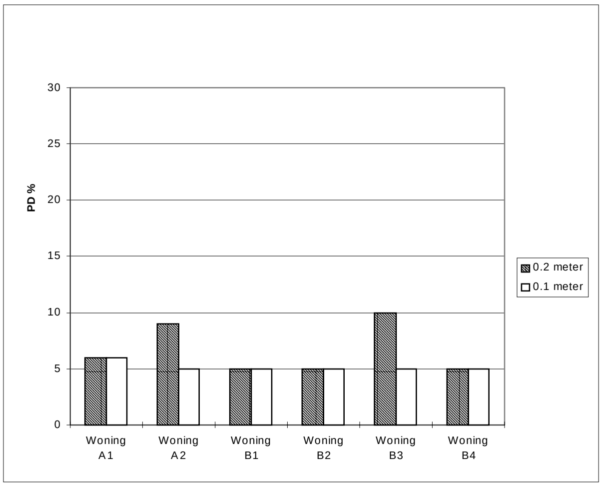

Figure 14. Measured PD values in living room

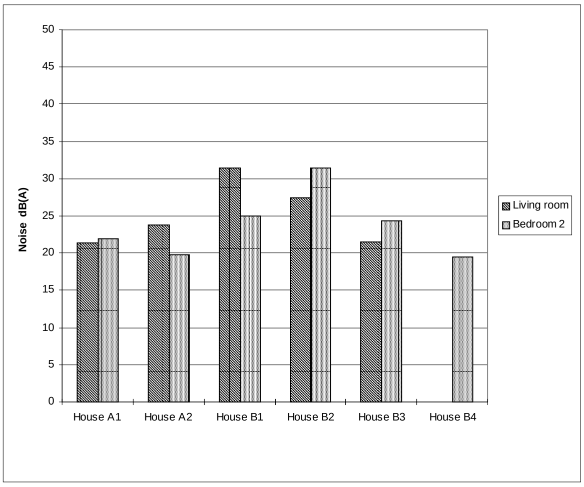

Figure 15. Measured noise levels

DISCUSSION

Energy

The measured average energy efficiency in practice is about 10% lower then the measured efficiency under laboratory conditions. This is mainly caused by the instability of the measurements and the disturbance of in and outgoing mass flows through the ventilation units. Mass flows can be disturbed by opening windows and doors or faulting of grilles and filters. Also the accuracy of measuring temperatures has influence on the results. The problem with the disturbance and instability of air flows is solved now by all manufacturers by applying self regulating DC fans which are capable of maintaining pre-programmed air flows.

Ventilation

If figure 3 is compared with figure 4 it occurs that there is no relation between the air tightness of the dwellings and total air flows. The use of ventilation provisions like fans, windows etc. (i.e. occupants behaviour) is dominant in the total air change rates. The total ventilation air flows vary between 45 and 50 dm^3/s. For bedrooms the average air flow is more then 7 dm^3/s (the minimal nominal air flow for rooms according to the Dutch building regulations). More over, a large deviation in ventilation rates of the bedrooms occurs. Living rooms show much less deviation in ventilation rates then bedrooms. This difference shows the influence of airing bedrooms. From the questionnaires it became also clear that in some of the dwellings the airing provisions were much more used (houses B1, B2, B3 and B4). Occupants of house B3 use only the highest position of the fans. This explains the larger air change rates compared to the other houses. Houses A1, A2 and B4 are using most of the time the middle position of the fans; houses B1 and B2 frequently use the lowest position. However house B1 applies frequently additional natural ventilation in bedrooms by using windows for airing.

Indoor air quality

Average CO_2 levels did not exceed the hygienic guideline level of 1800 mg/m^3. However, during night time in a number of houses this level was frequently exceeded in bedrooms. This is mainly caused by the fact that occupants use the low position of the fans, without using additional ventilation provisions. Using the middle position of the fans or opening windows lead to a much lower CO_2 concentration in bedrooms. CO and NO_2 concentrations appear to be far below the guideline values. This is due to the fact that there are no or limited sources within the houses. All houses have gas stoves for cooking. In houses B3 and B4 occasionally higher CO levels were measured, caused by tobacco smoke. In most of the bathrooms TVOC concentration show high peaks in the morning, caused by use of cosmetics and cleaning. The ventilation systems were able to lower these peaks to normal concentrations within an hour.

Thermal comfort and noise

Counter flow heat recovery units are developed to realise a healthy and comfortable indoor environment combined with extreme low energy use for ventilation losses.
The overall conclusion is that counter flow heat recovery units can provide an indoor environment that meets the guidelines concerning indoor air quality, thermal comfort and noise levels. Thermal comfort is realised under all weather conditions without the necessity of applying reheaters; the (thermal) efficiency of approximately 95% is enough to secure a supply temperature of just a few degrees under room conditions. Noise levels caused by the ventilation system vary from 20 to 30 dB(A). These levels do not exceed the guideline values for system noise.

Use of the ventilation system

Questionnaires as well as monitoring switching times of fans show that occupants do not have an optimal use of the ventilation provisions. It was not clear if this is caused by lack of information, indifference or that occupants are well-conscious of not using the ventilation provisions. Despite this observation it is remarkable that performances on both energy, indoor air quality and thermal comfort were very good. Although occupants behaviour is dominant in the total air change rates the minimum ventilation performance of the systems is sufficient to provide a healthy indoor environment in an air tight dwelling.

ACKNOWLEDGEMENTS

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