THE EFFECT OF END UNITS ON SUPPLY AIR QUALITY

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ABSTRACT

The aim of the present research was to define the effects of end units on supply air quality, to find out whether there is need for further investigation, and to gain more knowledge for the development of sensory testing. A sensory panel assessed the odour intensity of new units and a used end unit. The amount of dust collected on the surface of the used unit was measured.

Sensory testing is a difficult method to use and it needs developing. Because of the small number of end units tested, it is questionable to draw very definite conclusions. The results showed that the majority of the new end units assessed with this method seemed to have some effect on the odour intensity of the test room but the used end unit did not have, although it was visibly dirty. Methods should be developed which would enable researchers to determine the reasons for odour emissions.

KEY WORDS: HVAC system, Dust, Odour, Perceived air quality

INTRODUCTION

In many mechanically ventilated buildings the quality of supply air is often worse than the quality of outdoor air. Many studies show that the components of a HVAC system are significant polluters of indoor air. Previous research has investigated the effects of filters, humidifiers, rotating heat exchangers and air ducts on supply air quality. Used filters are among the worst sources of indoor air pollution.

The quality of indoor air is evaluated using sensory evaluation because chemical analyses do not provide satisfactory results. Unnecessary odours are considered an annoyance comparable to background noise and therefore many possible sources of odour are investigated carefully today. However, not only used components pollute supply air but new, unused components, such as supply air ducts having a large surface area of oily sheet metal, are also sources of odour emissions [1]. Björkroth proves that processing oil residuals are the cause for odour emissions in supply air ducts and that there exists a linear correlation between the total mass of oil residuals in ducts and the intensity of odour [2]. Pasanen investigated that supply air ducts in a building contain a considerable amount of dust, the average surface density in ducts of a HVAC system less than a year old being 5.1 g/m^2 and the yearly accumulation rate being approximately 1 g/m^2 per year [3].

No previous research has been carried out on the effect of end units on the quality of supply air, although undoubtedly end units also collect dust both from the supply air ducts and from the space they are in. One of the goals of the present study was to investigate the effect of unused end units on supply air quality. The unused end units were either transported directly from the manufacturer or had been stored for a number of years. A trained sensory panel was used to assess the odour intensity of the units. The effect of a used end unit recovered from the field on supply air quality was also assessed using sensory evaluation and dust analysis. Sensory testing is not however very fair on end units because other components of the HVAC system generate much more odour. Assessing the odour intensity of an end unit in a test room overemphasises its odour intensity compared to, for example, the odour intensity of filters or rotating heat exchangers. Our aim was to find out whether further investigation is needed to explain why end units pollute indoor air.

Another goal was to gain experience and knowledge for the development of sensory evaluation. Several factors have an effect on sensory evaluation and have to be taken into account when preparing test procedures, and valuable knowledge was gained from the present research.

The sensory panel assesses odour intensity on a scale from 0 to 20. The following descriptions of the odour values are rough outlines for the person who is unfamiliar with the reference scale. The value 0 means no odour is detected, value 3 corresponds to good indoor air quality, which in practice is almost odourless, and value 7 corresponds to stuffy indoor air, meaning there is noticeable odour in the air. Value 10 corresponds to passable or tolerable air quality and many persons consider an odour intensity of 13 very disagreeable.

METHODS

Tested end units

The end units selected for the tests included

Three ventilated cooling beams, which are combined cooling and supply air devices. Two of the ventilated cooling beams were old models, the third beam was a new model. The bottom, end and side plates of the beam and ceiling bracket are made of galvanised steel, epoxy-painted white. The supply air plenum, intermediate supports and brackets are of galvanised steel, the heat exchanger pipes of copper and finned coils of aluminium.

- cooling beam A was a new unused model transported directly from the manufacturer
- cooling beam B was an old unused model stored for about 5 years
- cooling beam C was a ventilated cooling beam, which had been used in an office for 5 years (old model)

A low velocity unit, which consists of a casing, detachable front panel and inner structure, and a fixed flow equalisation device, made of epoxy-painted galvanised steel, with white as the standard colour.

- the low velocity unit was unused and transported directly from the manufacturer

A cone diffuser, which is a supply air diffuser for ceiling installation. The diffusers of size D 160 are manufactured from hard rolled steel, with white as the standard colour.

- the cone diffuser was unused and transported directly from the manufacturer

Two balancing plenums, an old model and a new model. A supply air device is connected to the supply or exhaust air duct with the aid of a balancing plenum, which is equipped with sound attenuation and a flow rate measurement and adjustment device. The balancing plenum is made of hot galvanised steel and the sound attenuation material of the new model is made of polyester fibre and is washable. The attenuation material of the old model is made of mineral wool.

- balancing plenum A was a new unused model transported directly from the manufacturer
- balancing plenum B was an old unused model stored for an unknown number of years

Sensory tests

Before sensory evaluation, the unused end units were preconditioned for three days in a spare room at an airflow rate of 20 l/s so that the components would be comparable to in-use situations. For the sensory measurements, the end units were placed in a test room of 19,2 m³. The floor, walls and ceiling of the test room were covered with aluminium foil. The temperature of the test room was controlled and kept at 22 ± 1°C. No humidification was used during the tests so that the humidity of the test room was approximately the same as the surrounding spaces, that is 20 – 30 % RH. The test room had mechanical air supply with a nominal airflow of 20 l/s. No mechanical exhaust was arranged.

The measurements were carried out according to the protocol developed in the AIRLESS project [4] using a trained sensory panel of 14-17 members. The members of the panel were trained to assess odour intensity using a reference scale with values from 0 to 20. On each evaluation day, before the sensory tests, the panel members were calibrated. The sensory panel assessed the odour intensity of the air of the test room from the space adjacent to the test room so that they could not see what they were assessing. The subjects were not told whether the component to be assessed was in the test room or not. The air of the test room was supplied for sensory evaluation via an exposure cone through the wall of the test room. The odour intensity of the supply air to the test room was also monitored to ensure that the supply air was clean enough for sensory evaluation because the supply air flowed through the end unit, which was being tested, and then into the test room.

The sensory panel assessed the odour intensity of the air of the test room before an end unit was placed in it and always half an hour after the end unit was placed on the floor of the test room. The balancing plenums were tested, contrary to the other end units, outside the test room where clean air flowed through the component, and the odour intensity was assessed from points just before and after the component.

Dust analysis

The surface density of dust on the used end unit was quantified using the filter sampling method and an optical method. In the filter method a small filter is connected to a vacuum pump and a soft nozzle connected to the filter sucks the dust off a 100 cm^2 area. The filter and its case are weighed before and after the collection of dust. In the optical method the surface density of dust is quantified with a dust detector. Gelatine foils sample particles from the surface of the end unit and the foils are evaluated by laser light extinction. The amount of particles collected is expressed as the area percentage covered by particles [5].

RESULTS

The results show that most of the end units had some effect on the odour intensity of the test room. Figure 1 demonstrates the odour intensity of each end unit on a scale from 0 to 20 evaluated after the assessment of the odour intensity of the empty room, or, in the case of balancing plenums, after the assessment of supply air. Cooling beam A and balancing plenum B had a more significant effect on the odour intensity of the test room at $p<0,01$ than any of the other end units. The low velocity unit, cooling beam B, and balancing plenum A had a much slighter effect on the odour intensity at $p<0,05$. The cone diffuser and cooling beam C did not have a significant effect on the odour intensity of the test room ($p>0,05$).

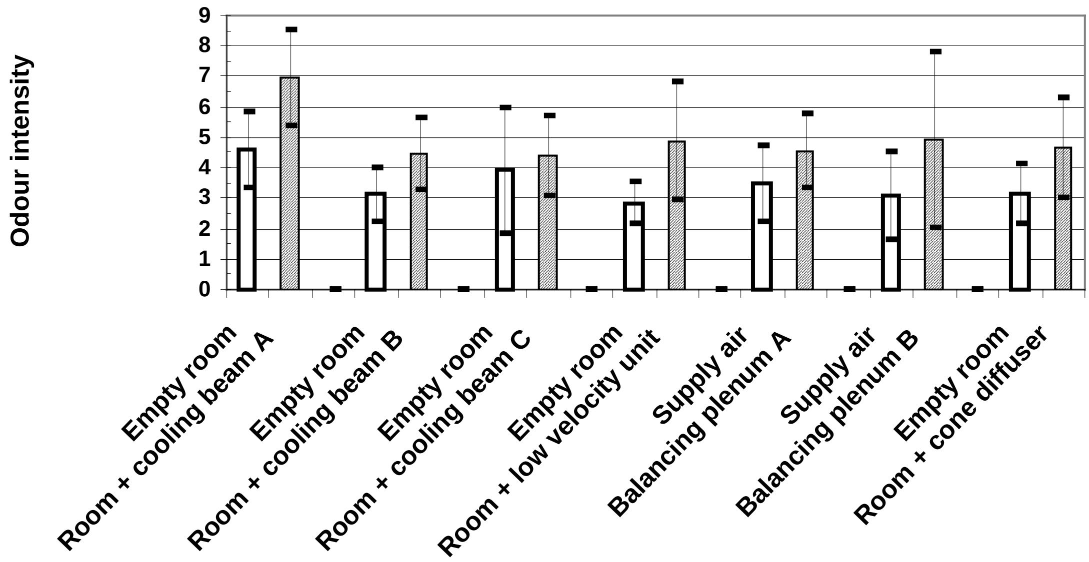

Figure 1. Odour intensity of end units

Surprisingly, cooling beam A transported directly from the manufacturer generated more odour than cooling beam B, which had been stored for 5 years, and considerably more than cooling beam C. Residual oil can not be the reason for the odour emissions of the cooling beams because they have been thoroughly cleaned before painting. Coils, sealants and rubber parts may generate odour when new, but the true reasons for the odour emissions of end units remain still unexplained.

The results reveal that mineral wool as an attenuation material in balancing plenums generates more odour than polyester fibre. The reason for the large deviation of the odour intensity of balancing plenum B is due to the intensity value of one member of the panel differing enormously from the rest of the panel. The value could have been dropped out of the results but omitting all the intensity values of the same member would have generated worse results in other cases.

Some of the sensory assessments had to be repeated in order to obtain more reliable results because it became evident that an end unit, which had been assessed in the morning, had a significant effect on the odour level of the test room. The sensory assessments carried out in the afternoons were not reliable because the test room had adsorbed odour onto its inner surfaces thus causing a high background odour level.

Dust analysis

Cooling beam C looked very dirty. Black dust had accumulated on the cooling beam just after the slots on the bottom of the beam through which the air is directed before it enters the room. The cooling beam draws induction air from the space above the beam, and the dust on the beam originates therefore from the space it is in, not the HVAC system. The amount of accumulated dust determined with the filter method was 3,7 – 4,5 g/m² and measured from the blackest areas of the beam. The results obtained with the optical method were 42,8 – 49,7 % as judged by percentage of area covered by particles. The side plates of the beam were much cleaner, they had accumulated only 0,6 – 1,15 g/m² of dust measured with the filter method, and 9,9 – 11,7 % measured with the optical method.

DISCUSSION

Although only a small number of end units were tested, the results seem to indicate that several unused end units have some effect on supply air quality. The major reasons for this are yet unknown and, therefore, further investigation will be necessary. It seemed to be of no significance whether the end unit had been stored for some years or whether it was tested directly from the manufacturer. According to previous research, if an odour level of 7 is reached, the tested component has often contained some residual oil, which has generated the odour. This is not, however, a probable reason for the odour emissions of end units because their surface has been painted and therefore they have been thoroughly cleaned from all residual oil.

Because the odour intensity of the test room was strongly affected by the odour emissions of a tested component, it is wise not to assess another end unit in the test room on the same day. The test room must be aired well in order that the odour emissions generated by the previous component, which have adsorbed onto the inner surfaces of the test room, disappear completely before the following component is tested. This ensures that only the emissions caused by the component are assessed.

The results seem to suggest that whatever causes odour emissions in unused end units, its effect diminishes during use, as cooling beam C, which had been used for five years, has very little effect on the odour intensity of the test room. However, no generalisations can be made as only one used end unit has been assessed. This does imply, though, that an unused component should be preconditioned for 30 days instead of only 3 days, as was done in this research, in order that the results would be fairer.

Some of the mean votes of the panel have a large deviation. This is presumably due to the fact that the vast majority of the panel members were trained only a week or two before the measurements and on each occasion the panel consisted of several first-timers. No subject used the reference scale consistently wrong, only occasional votes differed greatly from the votes of the rest of the panel. It must be remembered that the size of the sensory panel was sufficient (14 –17 members) for reliable results to be produced at each testing session.

The research on the effects of end units on supply air quality is still continuing and further results will be obtained. The additional results of the tests may be presented on the poster in the Healthy Buildings Conference.

Future research should first seek an answer to the question what causes odour emissions and then develop a measure to determine the odour source of the component. It would be useful if odour intensity values could be ranked so that the results of sensory evaluation of different studies could be compared better with each other, and the results would be more meaningful to the layperson. It will be important for future research to determine how high an odour intensity of a component is unacceptable, what effect an individual component has as a part of an entire HVAC system and when product development should be recommended.

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