ite allergen populations were not normally distributed in these studies and tric tests were used for the statistical analyses. The Wilcoxon Signed Rank ed to analyze paired data, comparing each sites' pre and post cleaning values. the pairing, variance due to differnces in the sites themselves is largely nd a relatively pure analysis of the effect of cleaning is obtained. This test detected significant reductions in all categories of allergen in the sample groups which received cleaning. No significant changes were observed in the control group. At a given site, allergen levels were significantly reduced when measured 24 hours after cleaning.

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THE INFLUENCE OF THE OCCUPANTS AND THE CONSTRUCTION PERIOD ON THE RESULTING INDOOR ENVIRONMENT

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ABSTRACT

This study, in progress in Trondheim, Norway, deals with the connection between energy economy and indoor air quality in detached houses. It includes 41 new houses, all equipped with balanced ventilation and heat-pump for energy savings.

The study includes both questionnaires and various measurements, and will be finished in 1994. Comparing the new and old housing, 90 % of the occupants are more satisfied with the indoor air quality in their new home, than their old home.

Nevertheless there have been some problems and there are reasons to emphasize the importance of responsibility in the building period and advice on operation and maintenance of the technical installations.

INTRODUCTION

Investigations of indoor air quality are usually concerned with measurements of typical indoor climate parameters such as temperatures, air velocities and different volatile components from materials and other contaminants. Several investigations have been carried out, many in schools and commercial buildings, to find connections between different problems and the buildings' physical qualities. Some studies have also been done with the intention of solving problems for sufferers from allergy and hyper-sensitive persons. Houses have been built and materials chosen in order to secure the health of the occupants. The results do not always agree about for example, use of different materials and their influence on health.

We know however that our common definition of health consists of both physical and psychical well-being and not only lack of illness. This is the main reason for planning and carrying out this project as described.

The study in progress in Trondheim, Norway, includes 41 new houses situated in the same area of the town. Rational use of energy and materials have been considered as important during the planning period and all of the houses are equipped with balanced ventilation and heat-pump for energy-savings. The heat-pump primarily heats water, the excess heat is used to raise the temperature of the ventilation air. The heated ventilation air does not meet the demand of heat to cover up transmission loss from the house. The houses are equipped with electric wall heaters controlled by a unit which makes it possible to decrease the indoor air temperature during the night and any other period

with no need for high temperature. The system does also give the users possibility to divide the housing into zones dependent on different use of the rooms. The users' understanding of, and relation to the technical installations have been paid great attention in our investigations.

All of the owners have built the foundation wall themselves, while craftsmen have been in charge of the rest of the work except the work of fitting-out the house.

The reason why the owners wanted to buy and build their houses at the site was for most of them the location in the town. Technical installations, meaning balanced ventilation and heat-pump for energy-savings have been the second main reason except for a few families whose children are sufferers from allergy and asthma.

The sosio-economic background of the occupants (education level, occupation, age and demands made on the house) were quite evenly scattered. Before commencing our investigations, our policy regarding the owner's choice of materials and ways of solving problems was clear; we did not want to influence their fitting-out decisions. Nevertheless the investigations involve a great deal of personal contact with the occupants and through conversations we pick up a lot of useful information and we are also trying to give some objective information when questions occur.

METHODS

The purpose of this study is complex and roughly divided into three parts :

- evaluate the chosen technical installations regarding energy-savings
- evaluate the resulting indoor air quality by questionnaires and measurements if problems occur
- make an overall picture regarding use of house and technical installations versus resulting indoor air quality and gather insight into the occupants' knowledge and understanding of how the technical installations work

The study includes :

- 4 questionnaires, concerning building, health of users and indoor environment
- registration of building materials used
- measurements of energy-consumption
- indoor climate measurements when problems occur

The first questionnaire deals with the old housing, use of the new housing and the technical installations. The others deal with use of technical installations, indoor air quality, and general considerations of the house.

The first questionnaire was carried out approximately 2 - 3 months after the buildings were occupied, the second 5 months later. The third and fourth questionnaires are planned to be finished this year.

RESULTS

General

The occupants have been asked general questions about temperature and indoor air quality in their old and new homes. The questions have been asked separately for the two housing-types.

Table 1 shows in which way the occupants' opinions of temperature- and air quality-conditions have changed after moving into the new house.

Table 1. Opinions of temperature and indoor air quality in old and new housing.

	Better	As before	Worse
Temperature	48 %	38 %	14 %
Air quality	90 %	7 %	3 %

It is obvious that balanced ventilation leads to better indoor air quality. Measurements of exhaust air flow indicates a minimum forced air exchange of approximately 0.6 h^{-1} in all houses. Ventilation air is supplied in rooms for long staying as living-rooms and sleeping-room. Exhaust air is taken from bathrooms, kitchen and washroom.

As mentioned in the introduction, we have paid great attention to the user's relation to the technical installations. Among other questions the occupants were asked if they were totally satisfied with the installations. This kind of information is subjective and must only be used to make clear the user's relation to the installations and if he is able to use them. The information should not be used as a way of comparing the different users.

At the time when the first questionnaire was carried out, 25 % said they were very satisfied, 53 were medium satisfied, and 22 % were not satisfied. The second questionnaire gave as predicted (and hoped) other values. The corresponding values are 45 % very satisfied, 45 % medium satisfied, and 10 % not satisfied. Comments from the users to these questions show that their trust in the producer and the products is of great importance.

The occupants have been asked to give general comments on the house and it's qualities. Most of the occupants emphasize the good air quality and the ventilation system's capacity to remove odour and contaminated air from the housing.

Another general comment, even if it is not positive, is the presence of dust in the housing. Complaints about dust usually occur after some talking, and are seldom mentioned in the questionnaires. This may be due to the fact that it is not considered as important as the other parameters, for instance the good indoor air quality. Measurements have been done in two houses to find the levels and types of particles/fibres in the air.

Fibres were found, but in low levels, considering type of building (0.01 - 0.03 fibres/cm^3)

Analysis of fibres from the ventilation ducts shows man-made mineral fibres (MMMF) which obviously originate from insulation used in the construction.

Another observation made by the occupants is the smell of smoke from the neighbours' chimneys when they are lightning a fire in the stove. This is an indication of the fact that the air intake is placed in an unfavourable way in relation to the surroundings.

Indoor air quality

The occupants have been asked if someone in the house has been nuisanced by any particular indoor environment parameters during the last three months. The results are given in table 2.

It appears from the answers that the most prevelant problems are low air humidity and noise. The nuisance of low air humidity is often based of dry skin and lips, sometimes soar throat. Problems caused by low air humidity are obviously attached to the air-conditions. Man's conception of the relative humidity is influenced by the temperature, rate of particles and fibres in the air and the velocity of the air. We often find that the complaint of low relative humidity is a substitute for too high values of the other parameters. It is too early to know if this is the problem in the houses being investigated. The questionnaire however, was carried out in the winter season, and thus the expected relative humidity indoors is low. No measurements of relative humidity have been carried out yet, but rough calculations based on the minimum air change and an estimate of humidity production from persons in the house give a predicted relative humidity of 25 %; outdoor temperature 0°C, indoor temperature 22°C.

Table 2. Percentage distribution on different nuisances (29 out of 41 dwellings).

	Often *	Rarely **	Never
Draught	14	3	83
High temperature	24	21	55
Low temperature	10	28	62
Stuffy	3	14	83
Low air humidity	38	14	48
Bad odour	0	14	86
Static electricity	7	7	86
Passive tobacco smoke	3	10	86
Noise	38	17	45
Others	0	3	97

* More than once a week
** Less than once a week

Noise is a technical problem. We know how to avoid noise in ventilation systems caused by components and ducts. This kind of problem should be prevented through both good planning and correct building.

Two of the families with children who suffer from allergy and asthma emphasize the fact that their children are much better and use less medicine in the new house. Both of the families moved from blocks of flats from different sites in the town.

Energy savings

Although the measurements of energy-consumption are not yet completed, preliminary results are already available. There were great expectations regarding energy-savings, and some of the owners find the consumption too high. The reason for this is often a comparison between the new and old housing. Most of the families moved from blocks of flats and thus should expect a higher energy-consumption in their new house than they are used to. Moreover, the producer of the technical installations stipulated the energy-consumption to be of the order of 17.000 - 18.000 kWh per year. Calculations based on measurements give predicted consumption approximately 35 % higher. These measurements have been carried out during the first 8 months after moving in. Experience shows however that the energy-consumption decreases after some time in a new housing.

The measurements are still in progress, and will be finished this october. Hopefully they will give a true reflection of the consumption. If the preliminary calculations turn out to be correct, the questionnaires and information based on conversations with the occupants will indicate whether it is the occupants habits or the technical installations causing the higher consumption.

DISCUSSION

Although some of the results presented in this paper are preliminary results and most investigations are in progress, we have learned some important things from the work already done.

The investigation shows that the advice on operation and maintenance of the technical installations is of the utmost importance to ensure correct use and satisfied users. During a building period, all participants must be aware their field of responsibility to ensure quality as specified of both the owner and the contractors. In this case, the MMMF found in the ventilation ducts is a good example. The owners did not know they were responsible for keeping the ducts shut and cleaning them before starting the ventilation system.

Missing, or indistinct distribution of responsibility is often the reason for later IAQ-problems.

The user's opinion of good indoor air quality is subjective, dependent of who you are asking and in what way they react to change in different parameters. When moving into a new housing the old housing and it's qualities will in some degree influence on the opinion of the IAQ.

Regarding well-being, comfort and health, it is of great importance to ensure that the user and the one giving advice on different fields understand each other. The owner must be given advice in a way that also makes him understand the consequences of different choices.

The houses investigated in Trondheim are built in a typical Norwegian way. The materials used are standard for housing, and do not seem to cause problems for the occupants.

Our conclusion so far is that an ordinary style of building and use of materials will normally give acceptable resulting air quality for most of the users. When special requirements are to be taken into account, further planning has to be done and the necessary measures taken.

We must, however, always be sure that all steps in the construction- and building-period are done in a correct way.

We want to emphasize three conditions :

- organization during all phases of building
- correct handling and use of building-materials
- different fields of responsibility must be clear during construction and building

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COLLABORATION THROUGH PARTNERING: THE TEAM APPROACH TO ENSURING INDOOR AIR QUALITY

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ABSTRACT

Building commissioning has been recognized as an effective method to ensure that heating, ventilation and air conditioning systems - systems designed to provide indoor air quality - are performing properly. The involvement of operating and maintenance personnel in this process has been highly recommended. Partnering, a new approach to the prevention of construction disputes through interdisciplinary team-building, is explored as a possible vehicle to involve, prior to construction, those responsible for building operations and maintenance.

INTRODUCTION

There is no doubt that the parameters associated with indoor air quality do not lie within the domain of one professional only, but are provided by a variety of disciplines concerned with building design, construction and operation. It is also fairly obvious that of the three phases mentioned, operation during occupancy represents by far the longest period in the building life cycle. All too often, those having the ultimate responsibility for maintenance and operation of the building (and hence the eventual recipients of complaints concerning air quality and occupational health and safety), are not party to decisions made by investors and designers affecting building systems - decisions normally made during the design process. Rarely is the choice of building systems modified during construction.

Operating and maintenance are generally a high percentage of the annual ownership costs, especially if land and construction expenditures are amortized over long periods of time. In order to control these costs, it is necessary to ensure that building systems are operating at their best efficiency.

COMMISSIONING

Building commissioning ensures the approval of technical installations. It allows for the correction of problems which, if undetected, can lead to premature equipment failure, high operating and maintenance costs and occupancy dissatisfaction with indoor air quality. The involvement of O & M staff in this process could serve as a vital link between building construction and preventive maintenance needed to ensure the successful operation of the building. Commissioning obviously occurs however, when the building has been completed and is ready to be occupied and used. The role of those responsible for the long term functioning of the building is thereby limited to being properly trained in order that they may operate and maintain systems chosen by others whose interests may not