"CLEAN VENTILATION" – A FINNISH PROJECT TOWARDS CLEANER VENTILATION SYSTEMS

Esko Kukkonen[3] ,Olli Seppänen[3], Pertti Pasanen[1], Sirpa Kolari[2]

[1]University of Kuopio
[2]VTT Technical Research Centre of Finland
[3]Helsinki University of Technology, P.O.Box 4100, FIN-02015 HUT,Finland, esko.kukkonen@hut.fi

ABSTRACT

The aim of this document is to outline and summarize the principles to be followed when the aim is to produce and to install a clean air handling system. A large Finnish research and development project CLEAN VENTILATION has focused on to find the main reasons and phases where the odours and other harmful pollution from the ventilation system originate. In the project better technical solutions have been developed to produce cleaner components with less harmful emissions. The work in the project has resulted to many new products and improvements of manufacturing, designing and installation processes of ventilation systems.

The Clean ventilation project has produced also practical guidelines for the design of cleaner ventilation systems and developed and published as well as guidelines for the manufacturing and installation of cleaner ducts and other components for ventilation systems. New methods to measure and prove the cleanliness of ventilation systems has been developed and taken into use. New improved technology for the cleaning of the components and systems has also been developed and introduced.

An essential result has been the production of the background information for the Cleanliness Classification of Air-Handling Components as a part of the Finnish Classification of Indoor Air Quality. General requirements for the cleanliness of air-handling equipment and detailed requirements for ventilation ducts, duct sections, air and fire dampers and filters has been developed. Based on these principles a system for labelling the air handling components has been established in Finland in 2001.

INDEX TERMS

Clean ventilation technology, Improved HVAC practices and technologies, Measurement of cleanliness, Labelling, Commissioning

INTRODUCTION

The adequate air-change in the form of ventilation is an essential factor in creation of good indoor air quality. Unfortunately, the ventilation systems do not always work in a planned and wished way and they may even prove to be sometimes sources of pollutants to the incoming air. These harmful emissions, often odours, sometimes particles and chemicals, may be the reason why practical experiences have shown that the prevalence of the SBS symptoms or building related symptoms are often higher in air conditioned buildings that in buildings with natural ventilation.

The origin of the harmful emissions has been studied in the Clean Ventilation - project (PTIV - project) and it is found, that the emissions may originate from many different type of components in the ventilation system. Most significant sources in the measurements have been found to be filters, humidifiers, heating and cooling coils and also components in the ductwork; specially used duct liners, neoprene gaskets, duct connectors and duct sealants. Even sheet metal ducts fabricated with lubricating oils had shown to have considerable, especially sensory, emissions. Many times the new components are not cleaned after the manufacturing and the surfaces can be coated with oils or chemicals, which can pollute the air.

This Clean Ventilation project, which has been lasted four years and will be finished during this year, has not only focused on the development of less polluting components, but also on the development of practical tools to design and installation of clean non-polluting ventilation systems. Comprehensive guidelines for the designing and construction of cleaner ventilation systems have been published. Most results are also published in international conferences.

New methods for cleaner cutting and installation practices of ventilation ducts have been developed and practically tested. In addition, a numerous piloting construction projects have been carried out in connection with the project. The main research institutes participating in the PTIV-project have been the HVAC- laboratory of Helsinki University of Technology (HUT), The Department of Environmental Sciences of the University of Kuopio and the VTT Technical Research Centre of Finland -Building physics and indoor climate.

Also new solutions to the problems of the cleaning the ventilation systems during the operation period have been studied and new applications of the cleaning methods have been developed. New more reliable, but still cost effective methods to test and verify the cleanliness of the ventilation ducts and other components or the whole ventilation system have also been introduced.

THE CLEANLINESS CLASSIFICATION OF THE VENTILATION COMPONENTS

The new version of the new revised version of Finnish IAQ Classification guidelines [1] gives two different requirement levels P1 and P2 for the cleanliness of the ventilation system and its components. Requirements and guidelines to achieve these requirements are developed mainly in the Clean Ventilation-project. To achieve the higher demands of the class P1 the ventilation system must be designed and installed with care and taking account the guidelines for clean ventilation. The guideline system includes requirements for manufacturing of cleaner labelled components, requirements for the design and installation of the ventilation system and also requirements for the control of the cleanliness and other circumstances on building sites.

The cleanliness classification of the components of ventilation systems has been introduced last year. First labels of best **M 1** cleanliness class have been already granted for cleaner ventilation ducts and some groups of the connectors and bend joints. The classification of filters and other

components of the ventilation system will be started this year.
General requirements for the cleanliness of the ventilation components are

- A labelled component shall not increase the concentration of pollutants harmful to health or comfort in the air-handling system.
- A labelled component shall not produce odours, or gaseous or particulate pollutants that deteriorate the quality of supply air.
- A labelled component shall be easy to clean.

The main emphasis in the beginning of the labelling has been on duct works, because the surface area of ducts is relatively large in the whole system. Round spiral seamed ducts are also made of the same material, sheet metal, as almost all other air-handling components. It was, therefore, assumed that it would be possible to apply the same cleanliness criteria, limit values and measuring methods to other air-handling components as well.

Up till now, specific requirements have been specified for ducts, fittings, air and fire dampers and filters. These additional guidelines for the widening of the cleanliness labelling of the ventilation components will be published before the end of year 2002.

The testing procedure of the classification and labelling system of ventilation components including the limit values is described and published in details [2]. This document, Protocol for Cleanliness Testing of Air-Handling Components describes the general requirements for cleanliness, sample selection, handling, and the general principles of cleanliness testing with a sensory panel. The main parameters are the amount of dust, the amount of oil residuals on metal surfaces, and odour emission of different components.

DEVELOPMENT OF THE TEST METHODS

Sensory tests

In the Clean Ventilation project different methods of sensory tests has been also developed and compared.

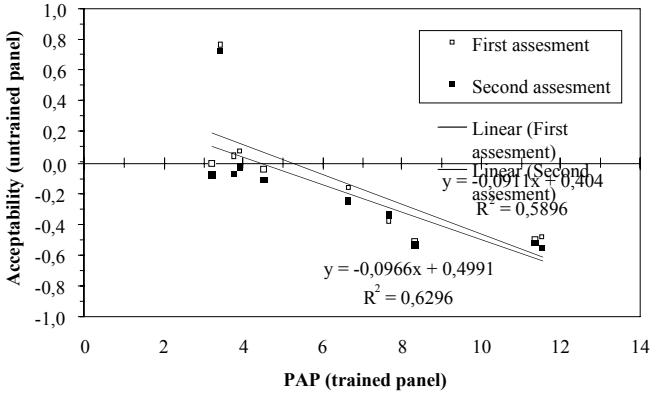


Figure 1. Comparison of the results of the trained panel using intensity scale and the results of the untrained panel using acceptability scale in the same ventilation system.

From these results of the sensory panel tests we can make the conclusion, that with the air of bad smell, the untrained panel can give as reliable assessment on the quality of the air in the different parts of the ventilation system as the trained panel. The costs of the sensory tests using untrained panels are, however, much smaller compared with those of trained panels.

In the cleanliness classification the sensory tests may be carried out either with a trained or untrained sensory panel. Sensory assessments with a trained panel are carried out according to internationally known methods. [6] The minimum size of the trained panel is 14 persons and the limit value for the quality of the air downstream from the component is 4 on the intensity scale.

The sensory tests with an untrained panel are carried using the same method as used in the classification tests of building materials [6,8]. The test is carried out in two phases. In the first phase, the minimum size of the panel is 5 persons. If the mean vote of the panel falls in the range of –0.4 to +0.4, when using the acceptability scale - 1 to + 1, the test must be repeated with a larger panel of 10 new persons, resulting a total size of the panel of 15 persons. The basic limit value is 0 on the acceptability scale.

Measurement of the dust and oil residues on inner surface of ventilation ducts

A lot of emphasises has been put to the reduction and measurement of dust and oil residues in the inner surface of metal duct. The amount of dust on the inner surfaces of ducts and air-handling components is possible quantify by filter sampling method. The method is based on weighing of dust vacuumed on a filter from a known sampling area. Sampling site and size of the area is determined. The sample is collected from the duct bottom [7,9].
For oils, filter contact method is based on the pressing an immersed glass fibre filter on the surface with a constant pressure. The filter (5 cm*5 cm) is immersed in tetrachloroethylene (TCE). After the sampling the filter is closed in a test tube. In laboratory, the solvent is evaporated and the sample is dissolved in a known amount of TCE and total amount of oil components is analysed with IR-spectrophotometer [3].

The limit value of dust in a new air-handling systems and ductwork is 1.0 g/m_ or 2.5 g/m_ depending on the required cleanliness class (P1 or P2, respectively). The cleanliness class M1 limit value for the dust of new components for the labelling is 0.5 g/m_. The sampling and the analyses of oil residuals and the limit values are presented in reference [3].

One result from the Clean Ventilation – project is, that the manufacturers of the metal ducts in Finland developed such new manufacturing methods for the spiral ducts, that the use of mineral oils is no more necessary for reduction of friction in the process and this has made it possible to use other less harmful substances, e.g. water or only diluted lubrication fluids for lubrication.

Mineral fibres released into the airflow

The amount of mineral fibres released into the airflow is quantified by collecting the fibres on an organic filter. The test is carried out with a high face velocity in the order to maximise the amount of fibres released into the airflow. After the test a small piece of the organic filter is cut off, the filter media is dissolved and number of fibres calculated using either electron or light microscopy. The concentration of mineral fibres is calculated based on the size of the filter sample, airflow rate through the filter and the time period of the experiment. The limit value is 0.01 fibre/cm_ corresponding to 10 000 fibre/m_. See also [2].

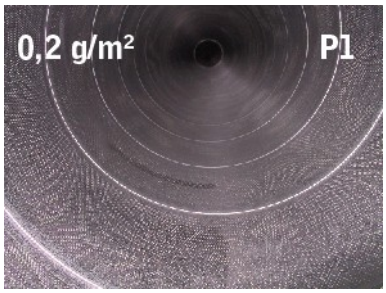
PRACTICAL GUIDELINES TO ENSURE THE CLEANLINESS OF THE VENTILATION

Design of the clean ventilation systems

One important result of the Clean Ventilation -project has been the introduction of the guidelines for the design of a clean ventilation system. The first version of these guidelines was developed some years ago and used and tested in some pilot projects. After the comments the revision of the guidelines were published last year and it has been in use in many construction projects. In the revised edition the importance of the clarification of the duties and responsibilities between different parties in the construction work has been specially emphasised. Also special teaching material for the parties of construction team has been prepared and published to highlight the right procedures and responsibilities of different parties in the works for the achievement of clean ventilation.

Installation of the clean ventilation system

It is not enough that the components of the ventilation system are clean when they are coming from the manufacturer. The Clean Ventilation - project has also developed guidelines for the installation of clean ventilation systems. These include recommendations for the protection of the clean ducts and other components during the transport to the works and the storage period. To the higher class P1 the components must kept dry and well protected against dust. The ends of the ducts e.g. must be capped before and under installation.



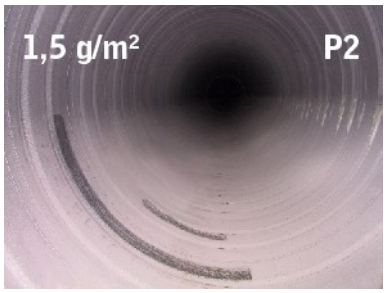


Figure 2. (Left) New cleaner cutting methods in practice. See also the capped end of the duct.
Figure 3. 2 examples from 12 photos of clean and dirty ducts presented in the guidelines for visual testing of the cleanliness of the ducts.

New cutting methods of the ducts has also been developed to avoid unnecessary contamination of the system by the metallic dust from the cutting by existing methods, the side grinder. These new cleaner cutting methods; seam metal shear, nibblers, gauge shear and sheet metal scissors, have been used in some pilot plants and the results have been very encouraging, when aimed to the cleaner P1 level in the cleanliness. As an example, in a pilot plant, a university hospital, the side grinder was used in assembly work, and the holes to the ducts at basement floor were made mainly by using sheet metal scissors. In the first floor, the cutting of ducts and making holes to the duct walls were done by using shears or sheet metal scissors. Even the dust accumulation rates in both floors were low and the average dust accumulation rate was only 0.2 g/m^2, the average dust accumulation rate was 3 times higher in the floor that was assembled by using the side grinder than

in the floor where new types of cutting tools were used. [10]

Testing the cleanliness of the ventilation system

In the Clean Ventilation - project also guidelines to ensure the cleanliness of the ventilation system in the commissioning process of a new or refurbished house has been developed and published. These guidelines are basing on systematic approach, which gives both parties, the house owner as well as the contractor, equal reliability on the right decisions in the procedure. New visual methods for the testing of the cleanliness have also been developed and give possibilities to reliable decisions of cleanliness, easily and with limited costs. Guidelines with clarifying photos for this visual inspection of cleanliness have also been published.

Cleaning of the ventilation system

Sometimes it has been seen necessary to clean the ventilation system already after the installation and before the commissioning process. New more effective cleaning methods for the ducts as well as other components have been developed and tested in the project. The methods, which have applied with positive results in some pilot projects, are applicable also in the normal, often periodical, cleaning of the ducts and other parts of the ventilation system during the using period of the building.

ACKNOWLEDGEMENTS

The Clean Ventilation - project has been a part of Finnish Healthy Buildings technology program. The authors wish to thank the TEKES, the National Technology Agency and the Finnish industrial companies and research institutes, who participated the Clean Ventilation project, for their financial and other support. The authors also wish to thank the Finnish Society of Indoor Air Quality and Climate (FiSIAQ) for the assistance with the co-ordination of the project and specially the consulting firms Clima Consult Finland and Granlund Kuopio for the development of design guidelines of clean ventilation with complementary educational material for practice.

REFERENCES

1. Classification of Indoor Climate 2000, Target Values, Design Guidance and Product Requirements, FISIAQ 2000. Finnish Society of Indoor Air Quality and Climate (FISIAQ), Finnish Association of Construction Clients (RAKLI), Finnish Association of Architects, and Finnish Association of Consulting Firms (SKOL). Finnish Society of Indoor Air Quality and Climate (FiSIAQ), publication 5 E.

2. RTS. 2001. Protocol for Cleanliness Testing of Air-Handling Components. Finland: Building Information Institute RTS. See also www.rts.fi.

3. Asikainen V, Björkroth M, Holopainen R, et al. (2002):Oil Residues in HVAC components. Proceedings of the Indoor Air 2002. Monterey California USA 2002.

4. Pasanen, P., Asikainen, V., Liesivuori, J. (1999) Storage and processing oil contamination on new HVAC components: development of measuring methods. Indoor air '99, Edinburgh 1999.

5. Björkroth M, Seppänen O, Säteri J, Neuvonen P, Pasanen P and Railio J (2002): Labelling system for clean ventilation systems. Indoor Air 2002, Monterey, USA

6. Björkroth M, Kukkonen E. (2002): Measurements of sensory load from ventilation systems by trained and untrained panels. Indoor Air 2002, Monterey, USA

7. Holopainen R, Pasanen P, Seppänen O.(2000). Duct Cleanliness in New HVAC installations. Proceedings of Healthy Buildings 2000. Vol. 2, pp. 175-180. Helsinki 2000.

8. Kukkonen E, Saarela K, Neuvonen P. (2002). Experiences from the Emission Classification of Building Materials in Finland. Indoor Air 2002, Monterey USA.

9. Pasanen P. (1999). "Verification of Cleanliness of HVAC–Systems". Proceedings of VHExCo99, The International Ventilation Hygiene Conference and Exhibition, Birmingham, UK.

10. Luoma.M, Kolari, S (2002): Development of a clean installation method for ventilation systems. Indoor Air 2002, Monterey, USA