CLEANLINESS CRITERIA AND TEST PROCEDURES FOR CLEANLINESS LABELLING OF HVAC COMPONENTS

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ABSTRACT
A new cleanliness classification system for air-handling components and systems was officially launched in Finland at the end of September 2001. This paper describes the test procedure and summarizes all the test methods available for the classification tests and product development as well as the limit values. The main parameters are amount of dust, amount of oil residuals on metal surfaces, and odour emission. The limit value for surface dust is 0.5 g/m² in new, uninstalled components and the limit value for oil residuals is 50 mg/m² or 300 mg/m² depending on the type of the component. There are also some additional test methods, such as a measuring method of mineral fibres released into airflow and a method for measuring the odour threshold of processing oils. Additional tests are required if the component contains fibrous materials or a new type of lubricant is used in the manufacturing process.

INDEX TERMS
HVAC, Improved IAQ practices and technologies, Measurement methods, Labeling, Commissioning

INTRODUCTION
Typical prevalence of SBS-symptoms in buildings is 20-40%. Several studies have shown that the prevalences are usually higher in air conditioned buildings that in buildings with natural ventilation. One explanation for the association of SBS symptoms and mechanical HVAC-systems is VOC's and other chemical pollutants which are emitted by HVAC-components and ductworks. The emissions may originate from any component in the HVAC-system. The measurements of chemical emission from typical materials used in HVAC-system are sparse. Measurements indicate that emission rates of VOC's emitted by the materials varies a lot. High emitting materials in their measurements were used duct liner, neoprene gasket, duct connector and duct sealant. The high surface area materials such as sheet metal had lower emission rates.

Olfactory measurement of the pollution generated by various components are more abundant. The measurements have shown that both new and used components are sources of sensory pollutants (Björkroth et al. 1998). The new components are typically not cleaned after the manufacturing and the surfaces can be coated with oils or chemicals which pollute the air. The laboratory tests have shown (Torkki and Seppänen 1996; Björkroth et al. 1997, Pasanen et al. 1995) that a new round sheet metal duct decreases perceived air quality as much as an old used one. The effect of cleaning have been demonstrated by washing the duct after which

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the duct actually improves the perceived quality of air flowing through the duct (Björkroth et al. 1998). One of the most polluting component in the HVAC system is a fibrous air filter where the particulate matter accumulates (Hujanen et al. 1991; Bluyssen 1990, Pejtersen 1996; Björkroth et al. 1998; Pasanen 1998). The experiments with two stage filtration have shown that the coarse prefilters are stronger sources of pollution than fine filters after the prefilter (Pasanen 1998). The purpose of the project described in the paper was to develop a method to test and verify the cleanliness of the components used in air handling systems.

LABELING SYSTEM OF COMPONENTS IN AIR HANDLING SYSTEMS

The cleanliness classification of air-handling systems is included in the renewed Finnish Classification of Indoor Climate 2000 (FiSIAQ 2001). The objective of the guideline is to ensure a good indoor air quality by promoting the use of low-emitting building materials and clean ventilation systems. The new guideline also introduces a cleanliness labeling of air-handling components. The general requirements for the cleanliness are

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

There are also specific requirements concerning hygiene of certain component groups, such as requirements for a drainage system for outdoor air plenums and cooling coils. However, the test methodology, including instructions for sample selection, analyses and limit values for different types or groups of components are presented in a separate document (RTS 2001) discussed in this paper.

The cleanliness labeling system, limit values and measuring methods are mainly based on the outcome of two projects: the Finnish Clean Ventilation System project and the AIRLESS (Bluyssen et. al, 2001). The development of the labelling system started three years ago and many of the measuring methods as well as the limit values have already been presented in previous conferences **(**Pasanen, 1999; Björkroth and Asikainen, 2000; Holopainen 2000**)**. The labeling system was officially launched in September 2001. By the end of 2001 three different duct types from two manufacturers had received the cleanliness label.

The main emphasis has been on duct works, because the surface area of ducts is quite large, about 10 % of the floor area in a typical office building. It was reasonable to assume that ducts might have a significant impact on the quality of supply air. 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. Requirements for terminal units, heating and cooling coils, and revised requirements for filters are expected to be completed before summer 2002.

STRUCTURE OF THE TESTING PROTOCOL

Main document

The main 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 amount of dust, amount of oil residuals on metal surfaces, and odour emission. The limit value for surface dust is 0.5 g/m² in new components and the limit value for oil residuals is 50 or 300 mg/m² depending on the type of the component (duct / deep-drawn component).

The detailed instructions for quantifying various contaminants, including the required number of samples, sample analyses, limit values and reporting, are described in appendixes. This makes it easier to add new measuring methods or to update existing ones when necessary. There are two main types of appendixes:

1. Guidelines for quantifying the amount of various contaminants (dust, oil residuals, odor etc.) and reporting.

2. Instructions for specific component groups, which may include special instructions for sample preparation, limit values or measuring methods different from those specified in the main document.

Sensory assessments

Sensory tests are carried out either with a trained or untrained sensory panel. All components are pre-conditioned for three days before sensory testing with a constant predetermined flow rate. Ducts and components that are typically used in the main ducts are tested with a flow-rate corresponding to a face velocity of 3 m/s. Other components are tested either with 1 m/s face velocity or with the nominal flow rate in the typical use of the component. The quality air downstream from the component should be acceptable (acceptability ≥0 or perceived air pollution ≤4, if a trained panel is used). (RTS, 2001)

Sensory assessments with a trained panel are carried out according to a method based on the method developed in the international AIRLESS research project (Bluyssen, 2000). The size of the panel is 14 persons and the limit value for the quality of the air downstream from the component is 4 on the perceived air pollution (PAP) scale.

The sensory tests with an untrained or naïve panel are carried using a method similar to the method used in the classification tests of building materials (Kukkonen et al. 2002). 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 small naïve panel is higher than +0.4 (on the scale of –1 to + 1 corresponding to a clearly unacceptable or clearly acceptable air quality, respectively), the component passes the test and no further testing is required. If the mean vote of the panel falls in the range of –0.4 to +0.4, the test must be repeated during the same day with 10 new persons, resulting a total size of the panel of 15 persons. In such a case, the limit value is 0 on the acceptability scale.

Amount of dust

The amount of dust on the inner surfaces of ducts and air-handling components is quantified by the vacuum test method. This gravimetric method is based on collecting the sample from a pre-determined area, e.g. 100 cm², on a 0.8 micron pore-size polycarbonate filter by wiping the surface with a small plastic nozzle connected to a vacuum pump. This method has been presented in other papers (Pasanen, 1995; Holopainen et al., 2002).

The same method can be used for cleanliness labelling tests of new components, verifying the cleanliness of new air-handling systems, or for determining the need of cleaning of old systems. The cleanliness class M1 limit value of new components is 0.5 g/m². The limit value of new air-handling systems and ductwork is 1.0 g/m² or 2.5 g/m² depending on the required cleanliness class (P1 or P2, respectively).

Oil residues
The amount of oil resides on metallic surfaces is quantified by the filter sampling method. The sample is collected by pressing a small glass fiber filter moistened with TCE on the surface. After sampling the filter is sealed in a test tube and analyzed in a laboratory by IR spectroscopy. The quantification is carried out against a dilution series of the same processing or corrosion protection oil, which was used on the surfaces studied. Both the sampling and the analyses of oil residuals are discussed in another paper in the same conference (Asikainen et al. 2002).

For round spiral seamed ducts and components, which are manufactured without oil lubrication, the limit value is set to be 50 mg/m². For duct components, which need oil lubrication in order to decrease friction and wear of the machine tools, the limit value is set to 300 mg/m². In the case of a new type of lubricant that has not been previously tested, is also necessary to determine the 50 % and 70 % odour thresholds of the lubricant. Both threshold values are required to be higher than the corresponding threshold values of the reference lubricant oil “Solvac”, because the limit values of oil residuals (50 mg/m² or 300 mg/m²) were set based on sensory tests carried out with Solvac. The requirement of a higher odor threshold value ensures that there is no need to carry out full-scale sensory tests in order to determine new limit values for the amount of oil residuals whenever new lubricants are introduced.

Mineral fibers released into the air flow
The amount of mineral fibers released into the air flow is quantified by collecting the fibers on an organic filter. The test is carried out with a high face velocity, 10 m/s, in the order to maximize the amount of fibers released into the air flow. After the test a small piece of the organic filter is cut offand number of fibers calculated using either SEM or light microscopy. The concentration of mineral fibers is calculated based on the size of the filter sample, air flow rate through the filter and the time period of the experiment. The limit value is 0.01 fiber/cm³ corresponding to 10 000 fiber/m³.

Work in progress
Additional guidelines are also being planned. These include

- Instructions for reporting the test results
- A revised testing protocol for filters
- A testing protocol and limit values for heating and cooling coils
- A testing protocol and limit values for terminal units
- Instructions for grouping of same type of components

The last item on the list above is especially important, because most components are manufactured in various sizes (e.g. ducts with a diameter of 100 mm, 125 mm, 160 mm etc.). Due to the typically large selection of different sizes it is too expensive to test them all. On the other hand, testing of only one type or size may not be sufficient, because there might be some less obvious changes in the manufacturing process as well. One example are large (over 300 mm in diameter) ducts that are made of a thicker and more rigid sheet metal that the smaller ones. This might also have an effect on the need of lubrication and, as a result, on the amount of oil residuals on the inner surfaces of the component. The forthcoming guidelines will instruct how the samples must be selected when the aim is to apply for a cleanliness label for the whole product line with the minimum number of samples.

REQUIREMENTS FOR A CLEANLINESS LABEL

There is only one cleanliness class for air-handling components, a component is either cleanliness labeled or it is not. The Finnish Building Information Foundation (RTS) runs the labeling system and grants the right to use cleanliness labels, and supervises the use of the label.

When a new component is to be tested for labeling, it is first useful to study the manufacturing process in co-operation with the manufacturer in order to identify the potential pollution sources. When the problems have been identified, the manufacturing process may be modified accordingly. The level of cleanliness is tested with appropriate methods by an approved laboratory. For example, if mineral wool is used as a sound attenuator material and the surface of the mineral wool is in direct contact with the air flow, the amount of mineral fibers released into the air flow must be quantified. On the other hand, if mineral wool is used as an insulation material and it is not in contact with the air flow, such test is not required.

In the most cases sensory tests and oil residue analyses are alternative methods and there is no need to carry out both of them. Oil residuals should be avoided, because they emit annoying odor and make the components more difficult to clean. Clean metal surfaces are practically odorless and, therefore, sensory analyses is not required if the components are free of oil and there are no porous materials or gaskets that might emit odorous compounds. On the other hand, sensory analyses is required, if it is not possible to carry out oil residue analyses e.g. due to painted inner surfaces of the component.

It is also possible to apply for a label based on other solutions and test methods than those presented in the testing protocol, but it is advisable to negotiate with the granting body (RTS) before filing the application.

The label is valid for three years providing no significant changes are made in the manufacturing process. After the three-year period the manufacturer must re-apply for the cleanliness label. It is not necessary to repeat the cleanliness tests, if there have not been any changes in the manufacturing process and materials.

DISCUSSION

The experience from the labeling system has been very positive. The manufacturers have started to develop cleaner and healthier products, which is more motivating now than before as they have defined goal for development work. The main contractors on construction site also take better care of clean components, and avoid polluting the air handling system during the construction. The additional cost due to the cleaner products is marginal. The measurements on the construction site and in completed buildings have also indicated better user satisfaction.

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