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Clean classified HVAC components - a Finnish approach

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To achieve a high standard of indoor air quality for new building requires a special knowledge of emissions from materials, design of ventilation systems as well as construction practice. Besides regulations, common rules and instructions are needed to be obeyed to achieve a good result. Classification of cleanliness of new ventilation systems is a voluntary document which determines the cleanliness of classified components produced by manufacturers. If a high quality of supply air is needed the classification is a tool for designers to carry out high quality indoor climate when also the classification of Indoor Climate, Construction and Finishing materials are applied. In this paper, a proposal for the classification of the cleanliness of new ventilation systems is introduced.

Several studies in Nordic Countries and North America have shown that ventilation systems are dirty and that may cause indoor air quality problems. Fortunately, severe health problems caused by dirt or microbial growth in HVAC system have been rare but a decrease in perceived air quality has more frequently reported as a problem (Fanger et al. 1988, Bluyessen et al. 1996). For example, some case reports have shown that occupants have suffered from building-related illness in buildings equipped with humidification/dehumidification and cooling devices that have offered suitable conditions for microbial growth in HVAC systems (e.g. Ager and Tickner 1983, Morey 1992, Nathanson 1992).

Dirt and debris may originate from intrinsic sources and from contamination during use. Firstly, the contamination may occur at the manufacture site of the components or it may have occurred already before the raw material has come to the factory. This type of contamination consists usually only the corrosion protection agents and processing fluids, usually oils. Secondly, the dust and dirt contamination may occur during transportation on an open lorry or in uncovered stocks at wholesale and at building site. Thirdly, the contamination may occur at the building site when the partly installed open ended air ducts and components are exposed to dust and construction material. Finally, the installed ventilation system is exposed to particles, and sometimes to moisture condensation, during normal use of the building. The latter contamination is able to be minimised by using and maintaining high efficiency filters.

The intrinsic sources is more difficult or even impossible to prevent by client or building owner. It can be eliminated only by systematically planned action in which people in every phases of the building project take an active part in production of clean and properly functioning HVAC systems. First steps for this kind of action has started for building materials and construction work in 1995 in Finland (Classification of indoor climate, construction, and finishing materials, 1995). To achieve a good indoor climate, all guidelines presented in the classification document need to be taken account throughout all the phases during design, construction and operation. The classification procedure gives advice for design, and contracting of construction work and mechanical systems, manufacturing of materials and equipment. The classification can be applied principally for new buildings but also for evaluation of existing buildings and in renovation of buildings. The main thing is that the classification procedure gives target and design values for indoor climate and supports clients, designers, equipment manufacturers, contractors and operation personnel to define a common objective to the quality of work. The voluntary classification document can be referred to when specifications of construction and mechanical system are agreed. The classification document does not overrule the official building codes. The classification has three categories; Indoor Climate classes S1-S3, Construction Cleanliness classes P1-P2, and Material category M1-M3. Smaller the number the higher the quality and the upper range meets the need for the minimum requirements set by building codes and regulations.

The classification document includes also instructions and demands for building a clean ventilation system, however, engineers were 'lack of tools' to design clean HVAC systems because list of clean components and ducts which would meet the requirements were not available in normal production. However, the active manufacturers produced those components with extra cleaning work after manufacture and protection during transportation and storage. In 1997, a new approach was generally accepted by manufacturers, designers and building constructors which led to a research project to develop classification and evaluation methods for clean HVAC components and design.

The classification of ventilation systems and components

The quality of the supply air is affected by air quality in the vicinity of building, placement of the outdoor air intake, air handling (efficiency of filters, performance of humidifier etc.) and the cleanliness of the ventilation system. In existing ventilation systems, the cleanliness is maintained by good maintenance of filters and other critical components, and regular cleaning of the HVAC system. The classification procedure for ventilation system and its components is focused mainly on the cleanliness of new ventilation systems in new or renovated buildings. It contains separate parts for classification of the system and its components, and guidelines for the design and construction of clean ventilation system. A classification system for the maintenance procedures and duct cleaning is planned in the near future.

A good classification system should have simple and easily measurable criteria. In ventilation systems, poor quality of supply air is usually best observed with sensory odour evaluation. The chemical analyses, e.g. volatile organic compounds, are not always sensitive enough to find out difference between accepted or unaccepted quality of supply air. Therefore, sensory evaluation is a more important way to evaluate cleanliness of the components. At the moment sufficient information of the acceptable odour emissions or dust or oil concentration on the surfaces is not available, but more data is being collected during the ongoing project 'Clean Ventilation Systems'

Similarly to the previously described Indoor climate classification (Fisiaq, 1995) the Classification of ventilation systems gives the target and design values for ventilation systems and its components. The classification can be referred to in documentation of the contract specifications of ventilation systems. Thus, the classification is a voluntary tool for construction clients when the special needs for clean ventilation system are formulated. For component manufacturers the procedure offers a tool to specify the cleanliness properties of their products and designers can take those specifications account when planning high quality HVAC system. The classification system does not overrule official building codes.

The classification is based on the idea that the HVAC system built according to classification with classified components ensures a good quality of supply air. The supply air should not contain biological or other potential particles that cause health effects or unpleasant odours. The following contaminant groups are considered in the classification; microbes (mould and bacteria), man-made mineral fibres, odours, dirt and dust on the surfaces and particles in the air.

Classification of the cleanliness of ventilation components

The classification of the cleanliness of ventilation components is done according to the same procedures as the testing of the other properties (flow characteristics, noise, cleanability etc.). The classification tests are done by an accepted laboratory by using the methods described in the classification documentation. The manufacturer takes the responsibility of quality assurance so that the products meets the requirements stated. The principle is that the customer need not take any samples or tests of the qualified components. The checking of classification labels and the condition of the package is action needed at the building site.

Classification consists of only one class for cleanliness; the component meets the criteria and will be accepted or not. In this voluntary classification this is thought to be enough to progress towards cleaner HVAC systems in new buildings. Limited data is another reason for setting only one class. The following parameters are considered for classification:

- The component shall as new not increase health hazards or decrease comfort by its harmful emissions.
- The component shall as new not emit odorous or gaseous pollutants to the supply air.
- The inner surface of the component shall as new be free of visible contaminants (e.g. dust and oil).
- The component shall not support the microbial growth when it is used in circumstances present in HVAC system .

The criteria for classification will be set first for the components and material with large surfaces in the ventilation system. Regarding to the surface, ducts, fittings, dampers and air terminal devices represent the main component groups. The criteria parameters for these components made of sheet metal are the amount of oil on the inner surface of the component, emissions of man made vitreous fibres, and amount of dust accumulated on the inner surface.

Only preliminary criteria are given at the moment, for example, for oil level different criteria given for ducts is one fifth of that compared to the criteria given for fittings due to differences in manufacture process and also differences in relative area in the installed system. The component shall not emit fibres over concentration 0.01f/cm{\super 3} in nominal circumstances specified for the component. The amount of dust should not exceed 0.5 g/m{\super 2} with weighing methods and it should be less than 5% with BM Dust detector (Schneider et al. 1996).

For components made from other materials the sensory panel test is applied. For new filters the acceptability should be better than 0.05 (scale -1.+1) determined with untrained panel.

Special criteria are given for particle filters. The criteria consists both the filtering efficiency and also the total leakage of the installed filter. For example for F8 filters the leakage should be less than 1% with pressure difference of 400 Pa. Oils, biocides and other potentially hazardous substances should not be used in classified filters. The fibre release should meet the requirements given above.

Guideline for design and construction of clean ventilation system

The guideline for the design and construction of clean ventilation systems aims at maintaining the cleanliness during the construction process. The guideline can be referred as such or only specified parts can be included in the contract document. According to the plan no verification tests are needed when the work is completed. However, measuring methods for all specified parameters are available if those are needed for solving the different opinions.

The cleanliness categories of new ventilation systems}

Two categories are described for the design and construction of clean ventilation systems. The category is selected in the design stage of the system. The general requirements for both categories of the clean ventilation systems are the same as those for the components.

Ventilation systems in {\b category 1} shall meet the following requirements:

- Air supply ducts, fittings, dampers and air terminal devices are made using cleanliness classified components.
- Less than 20 % of the system (calculated on the inner surface) can be made from non-classified components provided that they have been cleaned from oil and dirt at the construction site.
- The sealants used in the system should be classified in emission category M1 or M2, or their emissions should be known to be low.
- Amount of dust in the inner surface of the ventilation system should be less than 5%. (BM Dust detector) or less than 0.5 g/m{\super 2} (weighing method, e.g. with filter).
- No return air shall be used except in systems serving only a single apartment.
- The supply air is filtered with a cleanliness classified filter that has a removal efficiency equivalent of at least class F7.

Ventilation systems in {\b category 2} shall meet the following requirements:

- Air supply ducts are made using cleanliness classified components. The fittings, dampers and air terminal devices are made mainly from cleanliness classified components. Less than 50 % of the system (calculated on the inner surface area) can be made from non-classified components provided that they have been cleaned from oil and dirt at the construction site.
- Amount of dust in the inner surface of the ventilation system should be less than 10% (BM Dust detector) or less than 1.0 g/m {\super 2} (weighing methods, e.g. with filter).
- Return air from spaces with similar pollutant loads may be used. This return air shall be filtered with a cleanliness classified filter that has a removal efficiency equivalent of at least class F6.
- The supply air filtered with a cleanliness classified filter that has a removal efficiency equivalent of at least class F4.

The guideline gives requirements and instructions for various details in design and construction of the system. These include:

- Detailed design and construction requirements for the cleanliness of various critical components.
- Guidance on the storage of the components on the building site.
- Guidance on the installation of the components.
- Instructions on the use of the system before commissioning.
- Instructions on the use and maintenance of the system.

For example, the following instructions are given for the installation of the system:

- The protection of the components shall be removed only just before installation (Category 1) .
- The entrance of dirt in the system must be prevented during the installation work.
- The inner surfaces of the ductwork shall be free of scrap, screws etc. that can attach dirt and dust or make cleaning of the system more difficult.
- Excessive use of sealants should be avoided.
- All open ends of the ductwork shall be sealed dust tight during breaks in the installation work (Category 1) or
- All open ends of the vertical ductwork shall be covered during breaks in the installation work (Category 2)
- The ductwork shall comply with the Finnish tightness requirements (Category 1: tightness class C, SFS 4699. Category 2: tightness class B, SFS 4699).
- Functioning of the maintenance and cleaning openings (access, openability, maintaining work area cleaning distance) shall be checked during the installation work.

Summary

The proposal for the classification of the cleanliness of new ventilation systems was finalised in June 1998 and submitted to Finnish Ministry of the Environment. Many details of the system are still under development, for example the validation of measurement methods for the oil, dust, fibres and odours. These will be finalised during the research project 'Clean Ventilation Systems'. The proposal will undergo an open review before final acceptance and publishing. After modifications, the final version of the classification will probably be published during year 1999.

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