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A proposal for the classification of the cleanliness of new ventilation systems

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0. SYNOPSIS

The Finnish Society of Indoor Air Quality and Climate has prepared a proposal for the classification of the cleanliness of new ventilation systems and components. The document supplements the classifications of indoor climate, construction cleanliness and material emissions published in 1995.

The classification of the cleanliness of the ventilation systems consists of two parts: a classification of the cleanliness of ventilation components and a guideline for the design and construction of clean ventilation systems.

The proposal will undergo an open review during next winter. After necessary modifications, the final version of the classification will probably be published in the spring of 1999.

1. BACKGROUND

1.1 The Finnish IAQ classification system

The final quality of indoor climate is influenced simultaneously by heating, ventilating and air-conditioning systems and equipment, by the performance of the construction and materials, and by the operation and maintenance of the building. To achieve a good indoor climate, all the guidelines presented in the classification system need to be taken into account throughout all the phases of design, construction and operation. The classification systems consist of three parts. It is intended to be used during the design and contracting of construction works and mechanical systems for buildings, and in the manufacturing of equipment and materials to build healthier and more comfortable buildings. The classification system can be applied to new buildings and for evaluation of all buildings and, when applicable, also during renovation. The classification system gives target and design values for indoor climate and supports the work of clients, designers, equipment manufacturers, contractors and operation personnel. The classifications can be referred to when writing up specifications of construction and mechanical systems. They can be used even as an attachment to such specifications. The classification system does not overrule official building codes or interpretations of them.

The selection of the categories for the Classification of Indoor Air Climate, Construction, and Finishing Materials /1/ has to be done at the beginning of a construction project. The building owner selects the categories with the design team. With the help of the Classification of Indoor Climate, the limit values for indoor climate are specified. After this, the category of cleanliness is selected according to the Classification of Construction. The Classification of Finishing Materials is used when selecting the building materials.

The Classifications of Indoor Climate and Finishing Materials have three categories, and the Classification of Construction Cleanliness two categories. Indoor Climate category S1, Construction Cleanliness category P1, and Material category M1 correspond to the best quality. Categories S3, P2 and M3 are in line with the minimum requirements set by building codes and regulations.

When the ultimate goal is good indoor climate, the best category of each part of the Classification has to be selected. a low category in part cannot be totally compensated by a high category in another part. Thus, for example, the high emissions of building materials can not be totally compensated by increasing the ventilation.

1.2 The need for the classification of the cleanliness of ventilation systems

The above discussed Classification of Indoor Climate, Construction, and Finishing Materials has been adopted for several construction projects. Construction clients and designers have used it as a tool in setting target values for indoor climate and in achieving the goals during the construction. 2,000 copies of the classification document have been distributed to various parties involved in construction. The document has also been translated into English. The principles of the classification have been used in several building projects. Some of the best known are: Nokia Headquarters Building in Espoo, Siemens Nixdorf Office Building in Vantaa, Neste Oy Headquarters Extension in Espoo, Apartment Building Puijonkartano for respiratory patients in Kuopio, Secondary School Eestinkallio in Espoo, and the University of Helsinki in Helsinki.

The Classification has been taken positively by the construction industry and the manufacturers of building materials. The first part of the classification system, which deals with the target values of indoor climate, has been used widely by designers in various building projects. The target values have also been used as reference values in the building investigations. The classification of building materials has been a success, too. At present time (August 1998) there are over 180 building materials in the best emission category (M1).

The second part of the classification system, the one dealing with construction cleanliness, has faced strong opposition from contractors. The main reasons to this are the unawareness of the nature and origin of the indoor climate problems and, on the other hand, unwillingness to change existing building practices. Now, as the major HVAC consultants have adopted the principles presented in the classification system in their design, it seems that the document is gradually changing the construction practice. It is, for example, more and more common that designers specify that the ducts have to be cleaned after the manufacturing process and handled on the construction site with capped ends. The largest project in Finland where the classification of the construction cleanliness has been used is the Nokia Headquarters building. 25 km of cleaned ducts were installed in the building, and the classification was followed in other aspects as well. The experience from this and other similar projects has pointed out the need for a separate classification for the cleanliness of the ventilation systems.

The need for improving the cleaniliness of ventilation systems stems from many Finnish and international studies. For example, the EU-funded IAQ Audit project covering over 50 office buildings in 10 countries found the ventilation systems to be the main source of odours in offices.

The surface area of a ventilation system can be 10-20 % of the total area of interior surfaces. The cleanliness of the inner surfaces of the ventilation systems has a significantly higher impact on the air quality than the cleanliness of the interior surfaces. Yet, the standard of cleanliness in the supply air system is poor compared to that of the interior surfaces.

Because the air handling systems can also be significant sources of pollution there is a great need to expand the classification to cover also components of the air handling systems such as ducts, filters etc. Finnish manufacturing industry has been very interested in developing new, cleaner components for ventilation and air-conditioning systems. A classification scheme is a good means to promote such product advancements.

2. THE PRINCIPLES OF THE CLASSIFICATION OF VENTILATION SYSTEMS AND COMPONENTS

2.1 The factors affecting the quality of suppy air

The quality of the supply air is affected by the quality of outdoor air, air handling (filtering, humidifying etc.) and the cleanliness of the ventilation system. The pollution of the outdoor air can be reduced by proper placement of the building in the site, good design of ventilation openings and efficient filtering. Handling of air usually improves the thermal climate and the quality of supply air, but reverse examples exist as well. Poorly maintained humidifiers can, for example, cause serious health and problems. In existing ventilation systems, the cleanliness is achieved by good maintenance of filters and other critical components, and regular cleaning of the ductwork. The project described here focussed on the cleanliness of new ventilation systems in new or refurbished buildings. A classification system for the maintenance procedures and duct cleaning is being planned as well.

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 indicators (e.g. TVOC) do not show a significant difference between good and bad quality of supply air. Therefore, the classification of emissions from building materials can not be used to evaluate the cleanliness of ventilation systems. In addition to the differences in pollutants (sensory/VOC), the air velocities and the sorption characteristics in ventilation systems are very different from those of building materials.

The knowledge about the sources of odour and other pollutants in ventilation systems is vague. The classification system has to deal with this by allowing modifications when new information is gained. Such information is currently being developed in a large Finnish project "Clean ventilation system".

2.2 The principles of the classification

The classification system gives target and design values for ventilation systems and its components. The classifications can be referred to when writing up specifications of ventilation systems. The classification system does not overrule official building codes or interpretations of them.

The classification is tool with which construction clients can formulate their wishes about cleaner ventilations systems. For component manufacturers the system is a means of declaring the cleanliness of their products (compared to competing products). The ventilation system contractors get information of new, cleaner installation procedurs.

The general target of the classification system is to ensure good quality of supply air. The supply air should not contain hazardous substances or harmful odours from the ventilation system. The following contaminants have been discussed in the classification:

- substances that are harmful to health
- microbes (mould and bacteria)
- man-made mineral fibres
- odours
- dirt, dust and particles

The classification of the cleanliness of the ventilation systems consists of two parts:

- a classification of the cleanliness of ventilation components /2/
- a guideline for the design and construction of clean ventilation systems /3/

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 etc.) –by third-party laboratory measurements and quality control agreements leading to official acceptance. The manufacturer declares the cleanliness properties at its own expense. There should be no need to check the cleanliness of the components on the building site. The checking of classification labels and the condition of the packaging should be enough.

The guideline for the design and construction of clean ventilation systems aims at maintaining the cleanliness during the construction process. The guideline can (wholly or partially) be referred to in the system specifications. It contains simple cleanliness criteria that can be measured in the commissioning of the ventilation system.

3. THE CLASSIFICATION OF THE CLEANLINESS OF VENTILATION COMPONENTS

3.1 General criteria

There is only one category for the cleanliness of ventilation components. A component either fulfills the criteria or not. Experience from the classification of building materials shows that manufacturers are not interested in other categories but the best. The lack of knowledge on the basic factors affecting the quality of the supply air is also behind the use of only one category. In the future it is easier to add new categories, if new infomation so requires.

The ventilation component should meet the following general criteria in order to be classified:

- The component shall as new not increase the amount hazardous substances in the supply air.
- The component shall as new not emit odorous or gaseous pollutants to the supply air, and thre shall be no visible dust on its inner surface.
- The component shall not increase in the ventilation system the growth of substances that are harmful to health or comfort.

The abovementioned criteria are deemed to fulfill if a component fulfills the criteria set for its component group. These criteria have for the time being been set only or the most common component groups and materials. Ducts, fittings, dampers and air terminal devices represent the largest surface area of the ventilation system. The other important potential pollution source in the ventilation system is the filter. The criteria for these two product groups have beed described in detail in the classification. The criteria for other components are on a more general level and they are not described in this paper.

3.2. The criteria for ducts, fittings, dampers and air terminal devices

These criteria apply for ducts and parts that have been manufactured with the conventional technology (sheet metal with mineral oil based lubricant). The general requirements described in 3.1 should be applied to other produtcs.

The ducts, fittings, dampers and air terminal devices should meet the following general criteria in order to be classified:

- Amount of oil in the inner surface of duct shall be less than 100 mg/100cm^2 ([1]
- Amount of oil in the inner surface of fittings, dampers and air terminal devices shall be less than 500 mg/100cm^2 ([1]
- Amount of man-made mineral fibres (MMVF) in the inner surface shall be less than 0,01 f/cm^3 ([2]
- Amount of dust in the inner surface of the ventilation system shall be less than 5% (tape method) or less than 0,5 g/m^2 (filter method)

For other duct materials than sheet metal manufactured with mineral oil lubricant it is possible to use an odour criterion instead of the oil criterion. According to the odour criterion, the acceptability of the supply air shall be better than 0,05 (scale -1... +1, untrained panel), or the odor intensity shall be less than 4 decipol (scale 0...20, trained panel).

In addition to the measurable criteria described above, each component group has also specific criteria dealing with the cleanablity, moisture control, tightness and use of sealants. These criteria have not been described here. In principle, the fulfillment of current Finnish and/or European standards (e.g. CEN ENV 12097) is required.

3.3. The criteria for filters

The task of the filter is very important in a clean ventilation system. The most important criterion for a filter is its removal efficiency. Therefore, a classified filter shall fulfill the efficiency requirements of its filter class throughout its lifespan.

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[1] The criteria is based on a relatively small sample of duct materials. This sample has show that the mentioned criterion is achievable in the manufacturing process and that the amount of oil does not significantly deteriorate the quality of the supply air.

[2] The general criteria for classification should be applied to other fibres than MMVF.

Air leakages in the filter and filter frame deteriorate the efficiency of the filters. A classified filter shall comply with the following criteria for leakage:

Filter class	Test pressure, Pa	Total leakage, %
Poorer than F5/EU5	200	6
F5/EU5	400	6
F6/EU6	400	4
F7/EU7	400	2
F8/EU8	400	1
F9/EU9	400	0,5

An odour criterion for new (unused) filters requires that the acceptability of the supply air shall be better than 0,05 (scale -1... +1, untrained panel), or the odor intensity shall be less than 4 decipol (scale 0...20, trained panel).

The filter shall not emit mineral fibres (MMVF) into the supply air. The total amount of MMVF fibres from a new filter shall be less than 0,01 f/cm^3.

Oils, biocides and other potentially hazardous substances may not be used in a classified filter.

The filter and its frame shall bear the pressure difference that is created over a completely clogged filter. The filter shall not be in touch with the bottom of the filter envelope or any other potentially moist surface even when the system is not running.

4. GUIDELINE FOR THE DESIGN AND CONSTRUCTION OF CLEAN VENTILATION SYSTEMS

4.1. 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 (see 3.1).

Ventilation systems in 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 area) 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% (tape method) or less than 0,5 g/m^2 (filter method)
- No return air shall be used execpt in systems serving only a single apartment.
- The suppy air side is equipped with a cleanliness classified filter that has a removal efficiency equivalent of at least class F7/EU 7.

Ventilation systems in category 1 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% (tape method) or less than 1,0 g/m^2 (filter method)
- 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/EU 6.
- The suppy air side is equipped with a cleanliness classified filter that has a removal efficiency equivalent of at least class F4/EU 4.

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 wrappings of the components shall be removed only just before installation (Category 1)
- The ingress of dirt in the system must be prevented during the installation work
- The inner surfaces of the ductwork shall be free of scrap, strathes, screws etc that can attach dirt and dust or make the cleaning of the system more difficult.
- Exessive 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, work area, cleaning distance) shall be checked during the installation work.

5. DISCUSSION

The proposal for the for the classification of the cleanliness of new ventilation systems was finalized in June 1998 and submitted to Finnish Ministry of the Environment. Many details of the system are still under development, for example the measurement protocols for the oil, dust, fibres and odours. These will be finalized during autumn 1998. The proposal will undergo an open review during next winter. After necessary modifications, the final version of the classification will probably be published in the spring of 1999.

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