6902

Guidelines for classification of indoor climate and air distribution systems

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Sweden has initiated a series of Fenno-Scandinavian guide-lines for the qualitative classification of HVAC systems. These guide-lines are issued by SCANVAC (the Federation of the Societies of Heating, Air-Conditioning, and Sanitary Engineers in Denmark, Finland, Iceland, Norway and Sweden) and are aimed to facilitate communication between the proprietors of the building and the HVAC consultants, assisting proprietors in formulating measurable specifications at an early stage of the project. Hopefully this will secure a good indoor climate and low energy requirements for new and retrofitted buildings. The indoor climate guidelines take into account the fact that the indoor climate is a complex factor and that people perceive it individually.

The reason for the guidelines is partly that the Swedish Building Code was changed in 1989 to give general functional specifications instead of detailed technical ones. The industry must produce guidelines to fulfil the general specifications according to "good industrial practice". The first two published guidelines deal with Indoor Climate and with Air Distribution Systems, respectively. Two further guidelines have recently been published; one concerns Commissioning of HVAC systems, mainly Balancing and Functional Performance Rating, and the other Operation and Maintenance Instructions.

Classification of indoor climate

Indoor Climate is classified according to the PPD index (Predicted Percentage Dissatisfied). Each category is characterised by this index, the statistically determined value of the percentage of dissatisfied persons that the category is estimated to yield in a large group (about 200 persons). There are three categories, divided into three or four classes, including one user-defined class (X) in each category:

- Four thermal climate classes: TQ 1, TQ 2, TQ 3, and TQ X
- Three indoor air quality classes: AQ 1, AQ 2, and AQ X
- Three noise level classes: NQ 1, NQ 2, and NQ X

These different categories can be combined freely, e.g. the highest air quality class can be combined with the middle thermal class and the highest noise class. With present knowledge it is easy to get sufficiently reliable thermal factor values corresponding to a chosen PPD index. It is however much harder when it comes to indoor air quality.

Indoor thermal climate quality

The measurable thermal climate factors are given in accordance with well-known standards, such as ISO 7730 or ANSI/ASHRAE 55-1981. Acceptable values for measurable thermal climate factors for various quality classes are given in the guideline as well as PPD-indices for each thermal comfort quality class related with the thermal climate factors. Thermal climate factors like operative temperature, air velocity within the occupation zone, vertical temperature difference, radiant temperature asymmetry, etc. are

Table 1: Specific Fan Power at design air flow rates.

	CAV kW/(m³/s)	VAV kW/(m³/s)
VAS 4000	4.0	7.8
VAS 2500	2.5	4.9
VAS 1500	1.5	2.9
Electricity Efficient	1.0	1.9
VAS X	As specified	As specified

taken into account. The highest thermal quality class, TQ 1, for instance, requires individual temperature control to obtain the desired indoor thermal climate.

Indoor air quality

The outdoor air must fulfil certain maximum levels of significant pollutants, e.g. carbon monoxide, sulphur dioxide or nitrous dioxide, if the indoor air quality classes in their turn should be fulfilled. The use of return air is not permitted in the highest air quality class, AQ1. For the second class, AQ 2, return air may only be used if it is extracted from "normal" office or residential premises with no odour loading and containing building materials of only Low or Middle Material Emission Classes. Maximum levels of pollutants are given in the guideline for each quality class. These levels conform mainly to well-known Standards such as WHO-IAQ or WHO-AQG. Furthermore the PPD-indices for each indoor air quality class are related to various indoor climate factors e.g.:

- adverse reaction;
- mucous membrane irritation;
- dissatisfaction with subjective air quality;
- odour detection as first impressed.

Also in the guideline four methods are given for calculating the required outdoor airflow rate for a premises. They all take into account emissions from both humans (mainly CO_2 and cigarette smoke) and building materials (mainly volatile organic compounds, VOCs).

The methods are:
- Standard Method I
- Standard Method II
- Physical Method
- Olf Method

Indoor noise level

In many new offices and residential buildings the bulk of complaints from occupants concern high noise levels. Particularly the rather low frequency noise from air distribution systems can be experienced as disturbing, even though the noise level limits in dB(A) are fulfilled according to, e.g. building codes. Consequently these guidelines set higher demands than the Scandinavian Building Codes in the highest noise level class, NQ 1. The demands on maximum levels of low frequency noise and infra noise, usually generated by air distribution systems, particularly fans, are new features compared with the building codes. The noise level classes are not divided according to PPD indices, because no such depend–ings on noise level are known.

Acceptable levels of continuous noise levels are given in the guideline for the various classes. No sound pressure levels in dB(A) are given in class NQ 1 for residential and office buildings because this class will probably result in unrealistic restrictions for these types of buildings.

Classification of air distribution systems

The main new feature of this guideline is a classification of the energy efficiency of the air distribution system, which includes fans, air handling units ducts and terminals.

The Specific Fan Power {SFP [kW/(m^3/s)]} is used as a means of expressing the electrical efficiency of the air distribution system. The SFP is defined as the design power of all fans in the air distribution system divided by the design airflow rate through the building, in Scandinavia typically the exhaust airflow rate. This definition is more or less in accordance with the one in ASHRAE/IES Standard 90.1-1989.

The energy efficiency classification should preferably be done according to the Specific System (electrical) Energy use {SSE [(MWh/year)/(m^3/s)]} as this number includes the yearly electrical energy used by all fans, refrigerant chillers, etc in the Ventilation and Air-Conditioning System (VAS). This value also takes into account the control strategies of the all-air HVAC system, e.g. Constant Air Volume (CAV) rate control or Variable Air Volume (VAV) rate control. So far VAS classes have been established solely according to the Specific Fan Power due to lack of knowledge. The classification system can be expanded to include the Specific Fan Energy {SFE}, the Specific System (electrical) Power {SSP} and the Specific System (electrical) Energy {SSE} when appropriate data is available.

Three quality VAS classes are established together with a special electricity efficient class {SFP < 1.0 kW/(m^3/s)}, as well as one user-defined class. Instead of defining two different SFP values at design conditions for CAV and VAV systems, (as in ASHRAE/IES 90.1-1989), the same SFP value shall be applied for CAV systems at design conditions, and for VAV systems at an airflow rate of 80%. As a result the VAS 1500 class provides about the same fan power criteria as the ASHRAE/IES Standard 90.1-1989. The Specific Fan Power for the various VAS classes are specified in Table 1.

Figure 1 shows the Specific Fan Power, for various VAS classes, as a function of the total pressure rise for the supply and exhaust (return) fans together. It also shows the dependence of the fan efficiency.

As can be seen in Figure 1 the Specific Fan Power is very much dependent on the fan total efficiency. As an example, for the total fan pressure rise of 1,200 Pa (supply and exhaust air fans together), fans with an impeller with forward curved blades that just fulfil

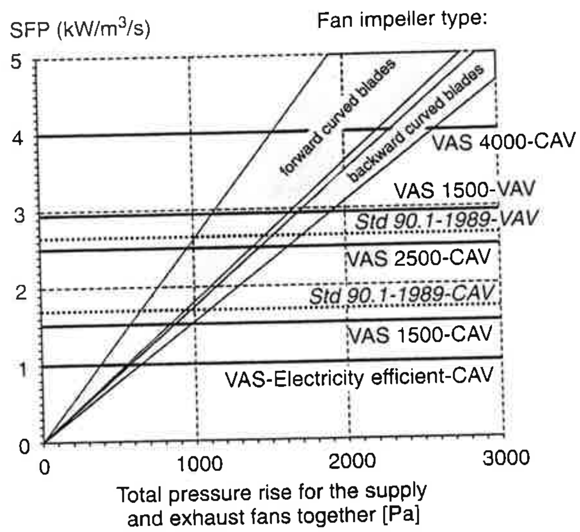

Figure 1: Specific fan power, for various VAS classes, as a function of the total pressure rise for the supply and exhaust (return) air fans together, also depending on the fan efficiency. Prescriptive criteria from ASHRAE/IES Standard 90.1-1989 are shown for comparison. For fans with a motor power of 3 - 10 kW.

the Scandinavian design practice (50 % fan efficiency) result in a SFP of 3.0 kW/(m³/s), but good fans with an impeller with backward curved blades result in a SFP of 1.8 kW/(m³/s). Consequently, just by selecting the right fans, the Specific Fan Power can be decreased to nearly half, compared with a more "normal" design, where the priority is on the lowest possible investment. To fulfil the highest VAS classes not only fans with high efficiency but also air distribution systems with low pressure drops are required. To obtain low pressure losses great care must be taken at the design of the connections between the fans and the duct system to keep the "System Effects" as low as possible. It is also usually necessary to select the central air handling unit one or two sizes larger than has been the normal Scandinavian design practice. For filters, heat recovery equipment, and cooling/heating coils a face velocity of 1.5 - 2.5 m/s is recommended in the Directions A2. The pay-off time for this larger air handling units are normally two to five years, mainly depending on the yearly operation time. Energy savings will be obtained both through lower fan electrical energy requirements and higher temperature efficiency of the heat recovery equipment. For filters a very low final pressure drop of 45 to 50 Pa is recommended in the Directions A2. In Scandinavia more or less no standard filters in air handling units have such a low pressure drop.

Beside electrical efficiency, the guideline also gives specifications for measuring, balancing, duct leakage and cleaning, as the most important factors which influence the energy efficiency of the air distribution system. Duct leakage specifications, given in three duct leakage classes, conform to the Eurovent standard. The specifications for measuring and balancing the air distribution system are given because this often gets neglected; one reason is that it takes place late in the building process, resulting in tight time restrictions and limited resources available for carrying it out. If the air distribution system from the beginning is designed in the right way, measuring and balancing will be possible and easy to carry out and, these constrains become less importance.

By using measuring and balancing stations it is also easy to check air flow rates, temperature, humidity, etc at any time during the operation phase of the building. The specifications for measuring and cleaning are also given, the Swedish law states that, from 1992, all ventilation systems, with a few exceptions, should be functionally tested (and possibly cleaned) at certain prescribed time intervals. For day-nursery buildings, schools and hospitals, this interval is once a year, and for most other commercial buildings, such as office buildings, it is three years. The testing includes both air volume rates measuring and checking that the control systems are working properly.

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