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Classified Indoor Climate—A Way to a New Indoor Climate Technology

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GENERAL BACKGROUND

The dissatisfaction among consumers with indoor climate and ventilation is widespread and deep. In Sweden, about 40% to 50% of all employees complain about the indoor climate where they work. The number of complaints concerning dwellings is also high. The frequency of so-called "sick" houses is even more serious. Up to 30% of all houses are estimated to be "sick" in the sense that buildings and their indoor climate give rise to considerable discomfort, symptoms of illness, or bad health.

Practically no industry can survive if it delivers products that fail to satisfy nearly half the number of consumers. However, the building and indoor climate industries have managed to do that, partly because they have been shielded by official standards and regulations that have limited or eliminated their responsibility for how their products work. Another contributing factor has been that consumers used to make rather low demands on the products (indoor climate).

The problems of poor indoor climate and sick houses have deep roots. They indicate a number of serious shortcomings in the whole building process, a sign that there are no functioning quality systems for the building industry. The problem of sick houses cannot be remedied solely by limited measures such as better ventilation, even though that is an important part. The only solution is to remove the faulty elements in the actual building process, to create a new building process applying new and better quality systems.

One important consequence will be a need for an improved technology for indoor climate and ventilation—what I call "a new indoor climate technology"—based on a stronger awareness among consumers, high demands on indoor climate quality, and application of modern theories of quality systems. Its real goal is consumer satisfaction.

As a step toward this goal, the Scandinavian organization Scanvac has worked out new common guidelines for indoor climate quality declaration and specification, the so-called "Scanvac guidelines for indoor climate." Those guidelines represent a way to transform the knowledge about indoor climate and quality technology into useful information for the ordinary builder or consulting engineer in practical work.

THE NEW INDOOR CLIMATE TECHNOLOGY—SOME CHARACTERISTICS

It is not my intention to discuss the means and ends of the new indoor climate technology, but as background to the Scanvac guidelines, I would like to present some of its most important characteristics.

- The new indoor climate technology recognizes the importance of the indoor climate for people's well being, health, and performance ability—in other words, the productivity of the indoor climate.
- The new indoor climate technology expresses the indoor climate and its effect on human beings in terms that enable us to make an economic estimate of its importance. In that way, both decision makers (clients, managers, etc.) and consumers can get a clear view of and put a price on the indoor climate.
- The new indoor climate technology considers the indoor climate to be a complex factor. Different people perceive the indoor climate differently depending on age, sex, activity, etc. It is influenced by many different technical factors, such as pollution sources and thermal loads inside and outside the building. The indoor climate in each case must rest on the basis of the prevailing conditions and with respect to who is going to use it. In other words, the indoor climate must be "individualized." Thus, the new indoor climate technology is far removed from the view that has dominated up to now, namely, that the indoor climate is a fixed entity that is the same for most people and can be based on rigid standards valid for most types of buildings.

These characteristics of the new indoor climate technology are sufficient as an explanation of the background to the new Scanvac guidelines.

PRINCIPLES BEHIND THE INDOOR CLIMATE GUIDELINES

The Scanvac guidelines are built on the following principles, derived from the new indoor climate technology.

- The quality of the indoor climate is characterized according to the effect of the indoor climate on people's comfort and well being (also health aspects) by means of frequencies of dissatisfaction, so-called "PPD values."
- The quality specifications are classified by a limited number of different quality levels, which enable the customer (the house owner) to choose a suitable (but to some extent standardized) indoor climate in each individual case.
- From a technical point of view, the quality of the indoor climate is defined by a number of indoor climate factors (air quality factors, thermal quality factors, etc.) and by specifications of acceptable values for them in the various classes.
- The quality of the indoor climate is regarded as separate from the technical solutions that are applied to establish it.

These principles will be discussed in concrete detail in the following section.

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THE STRUCTURE OF THE CLASSIFICATION SYSTEM

The purpose of the Scanvac guidelines is to indicate a new way of thinking that enables us to *understand* the indoor climate, *evaluate* it in economic terms, and *adapt* it to the various conditions—technical and consumer-oriented—in the individual case.

In accordance with these guidelines, the indoor climate is divided into different quality classes with respect to thermal comfort, air quality, and noise level. Each class is characterized by a statistically determined value of the percentage of dissatisfied persons that the class is estimated to yield, the so-called "PPD value."

There are three thermal classes, two air quality classes, and two noise level classes. Each thermal class and each air quality class is composed of a number of indoor climate factors, the values of which are given in Tables 1 and 2. The noise level classes are directly defined by the noise level values allowed (see Table 5).

A PRACTICAL APPLICATION OF THE CLASSIFICATION SYSTEM

The indoor climate is determined by thermal, air quality, and noise level classes. Within the 12 combinations possible (see Figure 6), that which agrees most closely with the type of building, use, etc., is chosen for each individual object.

A classified quality system of this kind has many effects on the practical work. The builder or the building owner must consider and specify which indoor climate quality he needs. He must choose a quality level before the projecting or design stage.

The functions of the building, its ventilation, and other factors will be better adapted to individual needs instead of following a rigid standard that is taken for granted in every case.

The choice of quality level is documented. If the building owner has chosen a lower quality than is justified, that is documented, and the information is preserved for the life of the building.

The consulting engineers are given clear specifications or demands to follow and use as a basis for the choice of technical solutions that meet the quality demands in the best possible way.

CALCULATION OF AIRFLOW WITH REGARD TO EMISSIONS

In order to create an air quality in accordance with air quality classes AQ1 and AQ2, the major indoor pollution sources must be identified and their source strength determined (calculated). The correct airflow should be determined on the basis of the generated quantity of pollution—the so-called "source control principle." Major pollution sources are people (emitting carbon dioxide), building materials and surface materials (emitting VOCs), and office equipment.

Up to now, the necessary airflow has been calculated only with regard to people (carbon dioxide) as a source of pollution.

TABLE 1 Thermal Quality—Acceptable Values of Different Factors in Various Quality Classes

The table indicates values for the normal case.

Item	Indoor climate factor	Factor value in quality class			
		TQ1	TQ2	TQ3	TQX
1*	**Operating temperature (to)**				As specified
1.1	Winter mode				
	highest value °C	23	24	26	
	optimum value °C	22	22	22	
	lowest value °C	21	20	18	
1.2	Summer mode				As specified
	highest value °C	25.5	26	27	
	optimum value °C	24.5	24.5	24.5	
	lowest value °C	23.5	23	22	
2*	**Air velocity within the occupation zone**				As specified
	winter mode m/s	0.15	0.15	0.15 (0.25)	
	summer mode m/s	0.20	0.25	0.40	
3*	**Vertical temperature difference, summer/winter mode °C**	2.5	3.5	4.5	As specified
4*	**Radiant temperature asymmetry**				As specified
	to warm ceiling °K	4	5	7	
	to cold wall (window) °K	8	10	12	

This table does not cover the guidelines completely and only gives instances of how indoor climate factors vary between classes.

TABLE 2 Indoor Air Quality—Acceptable Levels of Pollutants in Indoor Air of Different Air Quality Classes

Item	Pollutant		Maximum permissible quantity mg/m^3 in class		
			AQ1	AQ2	AQX
1	Carbon monoxide, total				
		MV 0.5 h	60	60	As
		MV 8 h	6	6	specified
	—from tobacco smoke				As
		MV 1 h	2	5	specified
2	Carbon dioxide	MV 1 h	1000	1800	As
		(in ppm*)	600	1000	specified
3	Ozone	MV 1 h	0.05	0.07	As specified
4	Nitrogen dioxides				
		MV 1 h	0.11	0.11	As
		MV 24 h	0.08	0.08	specified
5	Volatile organic compounds (VOC)				
	—total	MV 0.5 h	0.2	0.5	As
	—formaldehyde	MV 0.5 h	0.05	0.1	specified
6	Particles from tobacco smoke,				
	inhalable	MV 1 h	0.1	0.15	As specified

**This table does not cover the guidelines completely and only gives instances of how indoor climate factors vary between classes.*

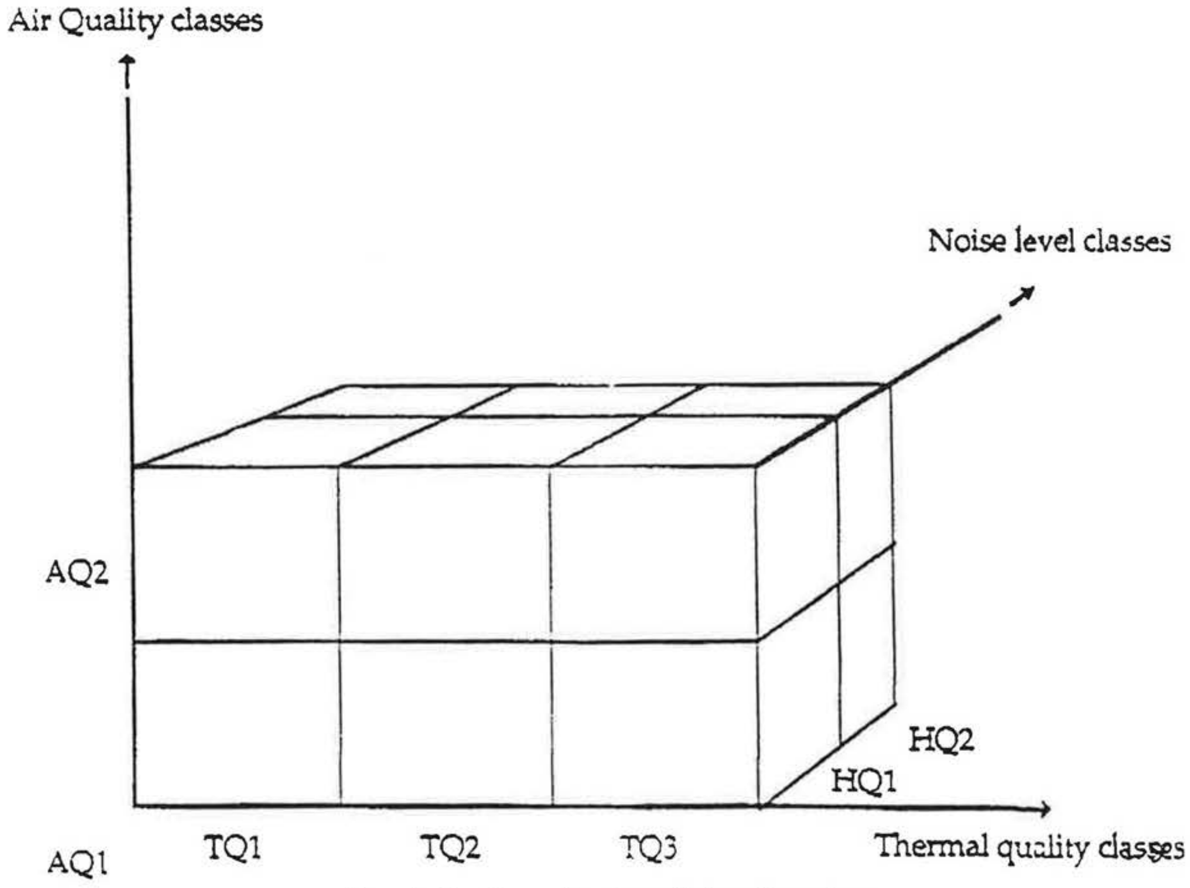


Figure 1 Possible combinations of indoor climate classes

Now, that is an unacceptable simplification. Emissions from building materials often prove to be more serious.

The indoor climate guidelines therefore indicate new methods for calculating the airflow, taking into account pollution both from people and from building and surface materials. These methods rest on building materials being divided into three different emission classes, defined by emissions under operation (low, medium, and high emissions).

The calculation has been simplified to a diagram, indicating the necessary airflow as a function of the percentage of medium or high emission materials prevailing and the person load (number of persons per square meter of floor surface) (see Figure 7).

These new calculation methods give considerably higher airflows than has been customary. An airflow of 0.7 to 1.0 L/s m^2 (1.4 to 2.0 cfm/ft^2) proves sufficient only if low-emission material is used. When high-emission material is used, 5 to 10 times that figure is required.

Airflows of that magnitude are unrealistic. For that reason, the use of high-emission building materials must be limited if an air quality in accordance with the Scanvac guidelines is to be obtained. By demonstrating the results of the use of high-emis- building materials, the guidelines indicate a method for choo- suitable materials with regard to the indoor climate, in other w to limit emissions from building materials.

COOPERATION

The quality of the indoor climate is established by a comp interrelationship between factors of building technique, vent tion technique, and external environment loads. This requi cooperation between many different professional groups.

AN ECONOMIC ESTIMATE OF THE INDOOR CLIMAT

The guidelines open a possibility of estimating the quality the indoor climate in economic terms on a statistical basis. T PPD values for each class are then used to calculate the over costs for bad indoor climate in a building with respect to diss isfaction, health problems, and lower productivity. Such calc lations had been made in the Scandinavian work. They indica that bad indoor climate has a big price tag. Indeed, it is not th mission of this paper to discuss that issue.

TABLE 3 Noise Level—Acceptable Values for Continuous Noise Levels in Different Quality Classes

Item	Factor	Highest level in class		
		NQ1	NQ2	NQX
1	**Sound pressure level dBA**			As specified
1a	—dwelling room	—	30	As specified
	—bedroom	—	30	
	—kitchen	—	35	
	—bathroom	—	40	
	—WC	—	40	
1b	—office premises	—	30	As specified
	—conference premises	—	35	

The percentage of dissatisfied people those classes will produce, statistically seen, is given in Tables 4 and 5. In the thermal classes, the percentage of dissatisfied varies between 10% and 20%. In the air quality classes, the values vary between 1% and 50% depending on which factor is regarded.

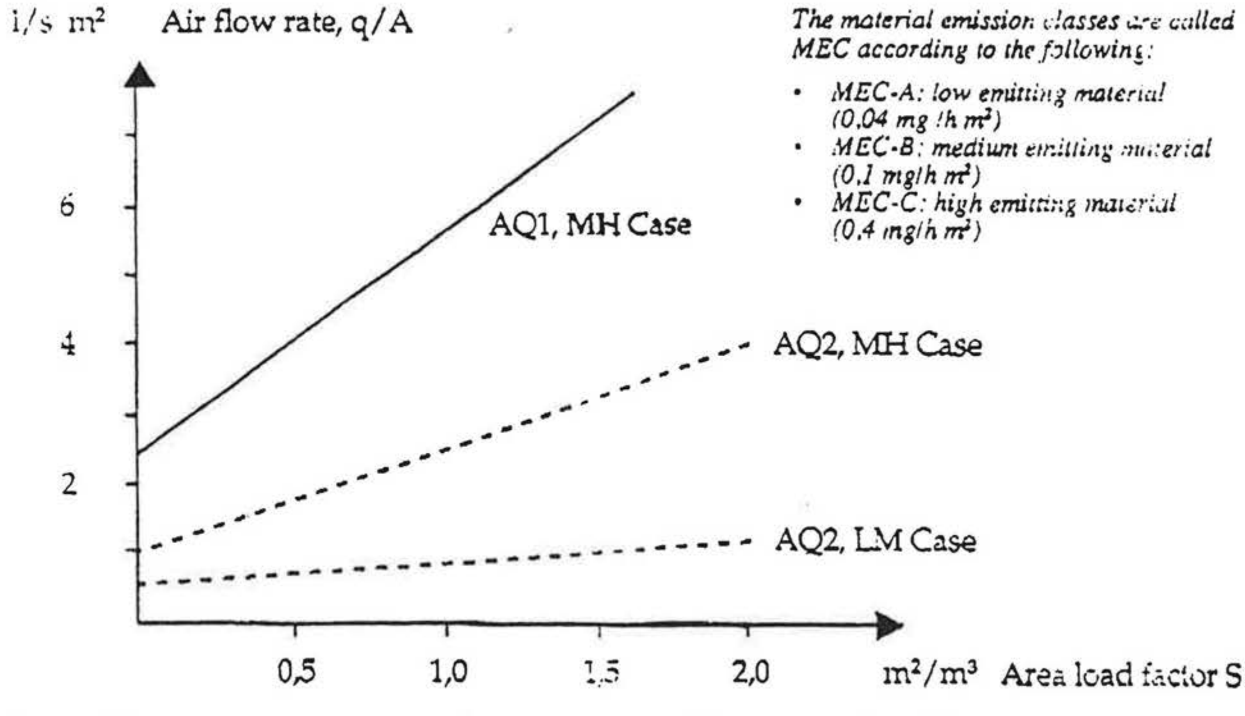
TABLE 4 Thermal Comfort (TQ)—Percentage of Dissatisfied for Different Quality Classes and Indoor Climate Factors

Item	Indoor climate factor	Quality class				
		TQ1*	TQ2	TQ3	TQX	Notes
1	Operative temperature	<10%	10%	20%	As specified	
2	Air velocity	10%	10%	20%	As specified	
3	Vertical temperature difference	<10%	10%	20%	As specified	
4	Radiant temperature asymmetry	<10%	10%	20%	As specified	
5	Floor temperature	<10%	10%	20%	As specified	

**This class requires individual control of temperature and airflow.*

TABLE 5 Indoor Air Quality (IAQ)—Frequency Values for Different Quality Classes and Indoor Climate Factors

Item	Indoor climate factor	Quality class			
		AQ1	AQ2	AQX	Notes
1	As determined by toxicological assessment	—	—	As specified	
2	Adverse reaction	0-1%	5%	As specified	
3	Mucous membrane irritation	0-1%	10%	As specified	
4	Dissatisfaction with subjective air quality	10%	20%	As specified	
5	Odor detection as first impression	10%	50%	As specified	



The material emission classes are called MEC according to the following:

- *MEC-A: low emitting material (0,04 mg /h m²)*
- *MEC-B: medium emitting material (0,1 mg/h m²)*
- *MEC-C: high emitting material (0,4 mg/h m²)*

Figure 2 *Hygiene airflow rate for $n = 0.1$ person/m² and low/medium (LM) and medium/high (MH) emission categories in accordance with Standard Method II, 0% smokers*