FINNISH CLASSIFICATION OF INDOOR CLIMATE 2000: REVISED TARGET VALUES

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ABSTRACT
A voluntary classification of indoor air quality and climate in new construction has been in use in Finland since 1995. The voluntary approach has been proven to improve the IAQ in new buildings and to reduce emissions from building materials. An updated classification document was taken into use in 2001.

The structure of the Finnish classification system is designed to help all parties in the construction process in the assurance of good IAQ. Included are target value specifications, design guidelines, quality assurance procedures and requirements for building products. The main features in the updated document are revised target and design values; modified instructions on how to achieve cleanliness at building site; a requirement for a moisture control plan; and new criteria for the cleanliness of ventilation systems and components. This paper describes the structure of the updated classification document; and the revised target values for thermal comfort, IAQ and HVAC noise.

INDEX TERMS
Indoor Air Quality, Thermal Comfort, Target Values, Design Guidance, Construction

INTRODUCTION
Indoor climate has become more important for health and comfort during recent years. As people stay indoors approximately 90% of the time, the quality of indoor air for the health is even more important than outdoor air. Good indoor climate reduces illness and the symptoms of sick building syndrome. It also influences comfort and working efficiency. The costs caused by poor indoor climate in the Finnish building stock has been estimated to be 2.7 billion Euros per year (app. 3 billion USD). The costs correspond to the costs of heating energy consumption of buildings in Finland.

Good indoor climate is one of the most important factors in assessing the quality of a building. Research and practice have, unfortunately, shown that good indoor climate is not always achieved. Indoor climate is influenced simultaneously by several factors, such as heating, ventilation and air conditioning, construction methods and materials, operation, maintenance and use of buildings. The Classification of Indoor Climate, Construction, and Finishing Materials /1/ presents guidelines considering all these factors. It has three parts and is intended to be used in design and construction of buildings and their mechanical systems. It also encourages manufacturers of equipment and materials to produce low-emitting building products.

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STUCTURE OF THE CLASSIFICATION SYSTEM

The construction in Finland is guided by the National Building Code. The Code gives mandatory requirements and non-binding instructions on how to meet the requirements. More instructions are given on the documents published by non-governmental organizations. The Building Information Institute is the most important of these organizations. Use of these documents is voluntary, but they are generally referred to in design and construction contracts. The classification system created by FiSIAQ is a voluntary document supplementing the mandatory requirements and other non-mandatory instructions defining the good building practice.

The structure of the Finnish classification system is presented in Fig. 1. The system is designed to help all parties in the construction process in the assurance of good IAQ. Included are target value specifications, design guidelines, quality assurance procedures and requirements for building products. To achieve a good indoor climate, all the guidelines presented in the Classification need to be taken into account throughout all the phases of design, construction and operation. The Classification 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 can be applied to new buildings and, when applicable, also during renovation.

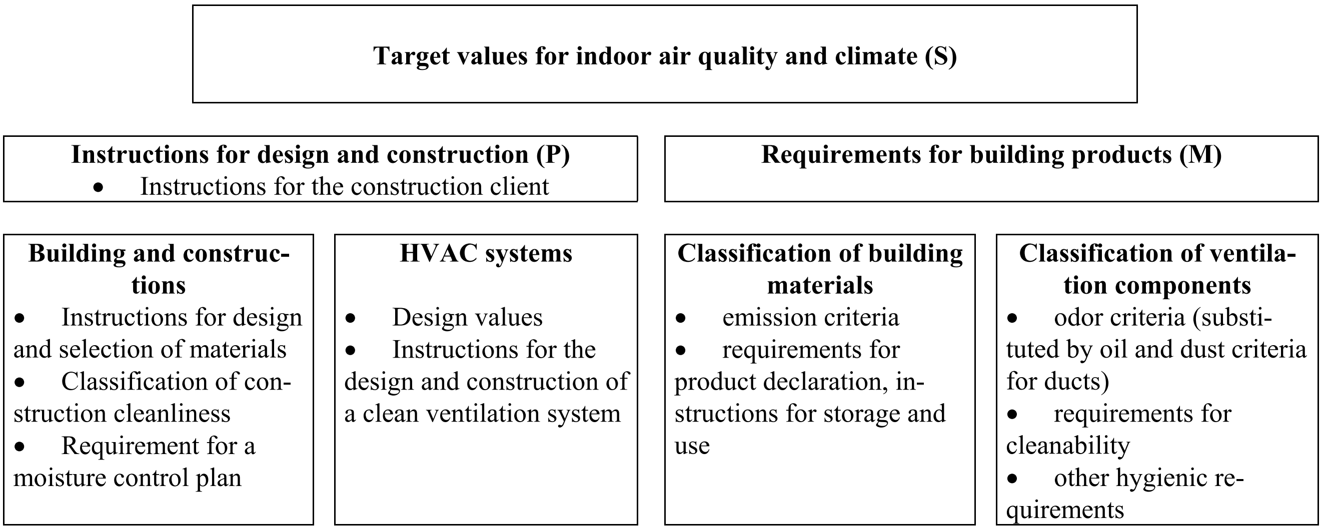

Figure 1. The structure of the Finnish IAQ classification system.

THE CLASSIFICATION SYSTEM IN PRACTISE

The Classification of Indoor Climate, Construction, and Finishing Materials published in 1995 has been adopted for several construction projects. The first part of the Classification, which deals with the target values of indoor climate, has been used widely by construction clients and designers in various building projects. Several public construction clients have adapted the intermediate category, S2, as the basic level for their design instructions. Use of low emitting building materials is almost unavoidable in Finland, as almost all major materials have the M1 label. A survey made in 1997 showed that the classification document itself was quite well known among the designers but that the supplementing documents (e.g. the model for HVAC specifications) were not. Therefore, there is a need to give more detailed design information in the classification document.

The usefulness of the of the classification system was tested by Tuomainen et al. (2001) in a building project. They compared indoor climate between two blocks of flat, the other was built according to the principles of Classification, the other was built traditionally. The results showed that the target values are realistic and technically and economically achievable. The indoor climate was significantly better and the occupants more satisfied in the flats built according to the Classification.

The instructions for construction cleanliness have met strong opposition at the building sites. The requirements for protection of materials and building product from water and dirt and the isolation of cleaner spaces from other spaces was considered too resource demanding. The isolation of spaces has also led to poorer ventilation of the building under construction, which has resulted in longer drying times of the constructions. On the other hand, the ventilation manufacturers have been very keen on developing products for cleaner ventilation systems. Based on these experiences, the requirements for the cleanliness of ventilation systems have been separated from the requirements for construction works.

INDOOR CLIMATE CATEGORIES AND TARGET VALUES

The Classification has three categories: category S1, S2 and S3. Category S1 corresponds to the best quality, meaning higher satisfaction with the indoor climate and smaller health risks. For example, in respect of room temperature, category S1 corresponds to 90% satisfaction. Category S3 is in line with the official quality set by building codes.

S1: Individual Indoor Climate

- The indoor air quality of the space is very good and the thermal conditions are comfortable both in summer and winter. The user of the space may individually control the thermal conditions and improve the indoor air quality by increasing the ventilation when necessary. The thermal conditions and indoor air quality satisfy, as a general rule, the special requirements of the users (e.g. elderly people, people with allergies or respiratory illnesses, and others).

S2: Good Indoor Climate

- The indoor air quality of the space is good and no draughts occur. The temperature rises above comfortable levels during the hottest days of the summer.

S3: Satisfactory Indoor Climate

- The indoor air quality and the thermal conditions of the space fulfill the requirements set by the building codes. The indoor air may occasionally feel stuffy and draughts may occur. The temperature usually rises above comfort levels on hot summer days.

The target and design values of various factors can be selected from different categories, or, if required, the value of a factor can be specified separately or left without specification.

The target values

The target values of the Classification have been defined so that category S3 corresponds to the requirements set by the Land Use and Building Act (1999) and the Health Protection Act (1994). According to present knowledge, the fulfillment of the target values of this category should not cause healthy people health impediments when the ventilation of the building runs as planned and no exceptional pollution sources exist.

The target values for thermal comfort were in the 1995 version considered to be quite stringent, especially the requirement of air velocity in category S1, 0.10 m/s, is considered to be technically unachievable. The CEN document 1752 was used as the basis for the target values for thermal comfort.

The target values of the noise levels from HVAC equipment were updated due to the new, more stringent building code in Finland.
The target values for indoor air quality needed some minor modifications, too. In the 1995 version, the formaldehyde and ammonia levels in the S3 category were the same or even higher than the action levels defined by the ministry of social affairs and health. The levels of TVOC, formaldehyde and ammonia should, according to the building industry, not include other emissions than those produced by the building itself. The target levels for carbon dioxide were considered to be too high compared to existing practice, especially in office buildings.

The 1995 version of the classification gave a target value for total suspended particles, which is now considered a poor measure of respiratory exposure to particles. Furthermore, there were no criteria for tobacco smoke. With new legislation banning tobacco smoke in the workplaces, this had to be updated as well.

An expert committee invited by the Finnish Society of Indoor Air Quality and Climate reviewed the target values and made proposals for new target values. The first draft was published and presented in June 1999 and subjected to public review. Over 30 comments were received from experts in the construction industry. These were then taken into account and a new draft was written. That version was published in April 2000 and the final version was revised based on the comments received during the second public review. The final version was published in February 2001.

Table 1. Examples of the target values for thermal conditions.

		Unit	Indoor Climate Category Maximum values			Note
			S1	S2	S3	
Room temperature*	Winter	°C	(21-22)*	20-22	20-23	(I)
	Summer		(23-24)*	23-26	22-27(35)	***
Air velocity	Winter (20 °C)	m/s	0.13	0.16	0.19	(II)
	Winter (21 °C)	m/s	0.14	0.17	0.20	
Air velocity	Summer (24°C)	m/s	0.20	0.25	0.30	(II)

* In Category S1, the room temperature shall be adjustable in each room/apartment between 20-24°C. If several people occupy the same room, the target level of the room temperature shall be 21-22°C in the winter and 23-24°C in the summer.
** The set value of the room temperature shall be in the range mentioned in item "Room temperature".
*** The room temperature shall never exceed +35°C. When the outdoor temperature is below +15°C, the room temperature shall not exceed +27°C.
I. The room temperature is usually the air temperature in the occupied zone. The target values apply to conditions where the individual control of room temperature is not utilized. In Category S1, the room temperature may temporarily deviate from the target values for a maximum of three days in the summer and three days in the winter, in design weather conditions. In Category S2, the room temperature may temporarily deviate from the target range for a maximum of seven days in the winter and seven days in the summer in design weather conditions.

II. The air velocity is the omnidirectional 3-minute average air velocity in the occupied zone. It shall be measured in accordance with the Finnish Standard SFS 5511. The measured result and the set target value are presented with a precision of two decimals, the last significant figure being either 0 or 5.

Table 2. Target values for indoor air quality.

		Unit	Indoor climate category Maximum values S1	S2	S3	Note
Radon	Rn	Bq/m^3	100	100	200	(I)
Carbon dioxide	CO_2	ppm	700	900	1200	(II)
Carbon dioxide	CO_2	mg/m^3	1300	1650	2200	
Ammonia and amines	NH_3	$\mu g/m^3$	30	30	40	(III)
Formaldehyde	H_2CO	$\mu g/m^3$	30	50	100	(IV)
Volatile organic compounds	TVOC	$\mu g/m^3$	200	300	600	(V)
Carbon monoxide	CO	mg/m^3	2	3	8	(VI)
Ozone	O_3	$\mu g/m^3$	20	50	80	(VII)
Odor intensity (intensity scale)		-	3	4	5,5	(VIII)
Microbes			No maximum value			(IX)
Cigarette smoke in rooms for non-smokers			Not discernible			(X)
Mass concentration of airborne particulate matter	PM_{10}	$\mu g/m^3$	20	40	50	(XI)

I The radon concentration in the room air for new residences determined by the Ministry of Social Affairs and Health shall not exceed 200 Bq/m^3. The annual average concentration of radon in residences shall not exceed 400 Bq/m^3. The annual average radon concentration in work places during working hours shall not exceed 400 Bq/m^3.
II The concentration of carbon dioxide includes carbon dioxide from outdoor (350 ppm) and human sources. The CO_2 concentration can be measured, for example, with an infrared analyzer.
III The concentrations of ammonia and amines in the room air can be measured with an ion-selective electrode or with a photometer). Only the emissions originating from the building materials shall be taken into account, not the emissions from human sources or human activities.
IV The concentration of formaldehyde in the room air can be measured, for example, with a liquid chromatograph (DNPH method) or a chromotrope-acid method in accordance with the Finnish Standard SFS 3862. Only the emissions originating from the building materials shall be taken into account, not the emissions from human sources or human activities.
V The total concentration of volatile organic compounds (TVOC) in the room air shall be measured according to the references (Tirkkonen et al. 1995, Clausen et al. 1993, SFS 5412). At least 70% of the volatile organic compounds shall be identified and the concentration of these compounds shall not exceed known limit values (carcinogens, allergens, the values given in the Indoor Air Instructions, TLV values, etc.). Only the emissions from the building materials shall be taken into account, not the emissions from human sources or human activities.
VI The concentration of carbon monoxide in the room air can be measured with an electrochemical cell or infrared analyzer in accordance with the Finnish Standard SFS 5412.
VII The concentration of ozone in the room air can be measured, for example, with a chemiluminescence or UV absorption method.
VIII The odor intensity of the room air shall be determined with a trained odor panel (ECA 1999).
IX The Classification does not give maximum values for microbe concentrations in room air because there may be mould growth or rot in the constructions of the building even though the microbe concentrations in the air are relatively low. In addition to this, the microbe concentrations in room air fluctuate greatly depending on time, place, and conditions in the building, as well as on the species of microbe. If the microbe concentration indoors is higher than outdoors and if the species differs from that detected outdoors, this may indicate mould growth in the constructions.

X No environmental tobacco smoke odor shall be allowed in spaces where smoking is not permitted. Nicotine can be used as an indicator of tobacco smoke. Nicotine is drawn, for example, into a Tenax tube with the aid of a pump and analyzed by means of gas chromatography. There is tobacco smoke in the room air when the nicotine concentration exceeds 0,05 µg/m³.

XI The PM_{10} fraction is the mass concentration of airborne particulate matter with an aerodynamic diameter smaller than 10 µm. The mass concentration of airborne particulate matter shall be measured during a 24-hour period in accordance with the Finnish Standard SFS-EN 12341 during normal human activities in the building. If the desired average concentration per day for the selected category is reached indoors, no measurements need to be conducted outdoors. If it is exceeded, the mass concentration of airborne particulate matter shall be measured as simultaneously as possible both indoors and outdoors after which the indoor/outdoor relationship shall be determined. In categories S1 and S2 this relationship may not exceed 0.5; however, the mass concentration of airborne particulate matter indoors shall never exceed 50 µg/m³. For example, if the PM_{10} concentration indoors is 40 µg/m³, the outdoor concentration of airborne particulate matter shall be measured as well. If the PM_{10} concentration outdoors is at least 80 µg/m³, the indoor/outdoor relationship is under 0.5, which indicates that the space is acceptable for category S1 with respect to the PM_{10} concentration.

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