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# Finnish Ventilation Regulations for Better IAQ and Energy Efficiency

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## Abstract

*The Finnish Ministry of the Environment (in charge of building regulations) invited The HVAC Association of Finland (SuLVI) to make a study on the need for improvements to the regulations and guidelines on Indoor Environment and Ventilation. The focus of the study was on factors affecting indoor air quality and energy efficiency of ventilation like correct magnitude of ventilation rates. The work was done by collecting subjective information from experts using various methods. In general the professionals were content with the scope and structure of the current regulations. However, the study revealed several important issues which should be changed in the revising process of regulations.*

*The minimum ventilation rate has been since 2003 6 l/s per person. Majority of the experts considered this as appropriate number of the minimum ventilation rate in the future as well. The investigations revealed that in many cases the recommended values (l/s per m<sup>2</sup>) for various room types are too high and in some cases too low. This may lead to bad air quality on some cases and excess energy use in other cases. Too high ventilation rates were given for example for corridors, restaurants, cafeterias, supermarkets and hotel rooms. The total air flow was also too high for day care centers, and for small and large apartments. Too low ventilation rates were given for example for elderly home, classrooms, residential kitchen hoods and treatment rooms in hospitals.*

*The results also showed that some changes in technical regulations are needed to avoid the IAQ problems, one of the most important was the reduction the maximum negative pressure difference over the building envelope, the current value of 30 Pa should be reduced to 5–10 Pa. This would reduce the flow of pollutants through building envelope to indoors.*

**Keywords – ventilation, indoor environment, energy efficiency, regulations**

## 1. Introduction

Implementation of EU directives has forced EU member countries to revise the building regulations related energy efficiency. In Finland the process started in 2013, as a part to revise the whole National Building Code of Finland within 5 years. The regulations in the revising process include also those dealing with indoor environment and ventilation. The Finnish Building code Part D2 [1] was first given in 1976 and revised frequently based on the collected experience, and to follow the changes in construction practice and demands for better energy efficiency and indoor environment. Current Building code Part D2 was revised and published in 2012 to fulfill the requirements in the Energy Performance of Buildings Directive 2002. The current revision of the building codes is due to the requirement set in the EPBD 2010 for all new buildings to be nearly zero buildings by 2020.

The demand to revise regulations offered also an opportunity to evaluate the performance and applicability of current regulations in practice. The Finnish Ministry of the Environment (in charge of building regulations) invited the Finnish Professional HVAC organization (SuLVI) to make a study on the need for improvements of the regulations. SuLVI was selected to make study due to its wide representation of building services. SuLVI represents experts working in various professions in the building sector, having totally nearly 5000 members in its 31 local chapters. The focus in the study was on factors affecting indoor air quality and energy efficacy of ventilation.

## **2. Methods**

Several methods were used in the study to collect information: an expert panel, questionnaires to experts in two stages, interviews of selected experts, open workshops, and analysis of results in the light of the existing building code also acknowledging the work done in the working groups of CEN TC 156. The participants of the study were selected from the members of SuLVI representing various professions in construction process.

An expert panel of 12 members was established for the study, a questionnaire was sent to selected ventilation experts of SuLVI in two stages, the first focusing on general questions and the second on technical details in the present building code. Two open seminars were organized for professionals. Seminars were monitored and results analyzed. Interviews of selected experts were focusing on specific technical questions. The objective in the data collecting process was to identify the factors in the building code Part D2 which could be improved, deleted or added.

## **3. Results from the questionnaires**

*Use of the building code:* The questionnaire had some general questions but also open questions which gave an opportunity for respondents to give any

information related to building code which the respondents felt problematic in any way.

*Responses to question:* Do you use the building code D2 (Indoor Climate and ventilation) in you daily work? About 60 % of respondents answered “often or regularly”, nearly 40 % “occasionally” and just a few “not at all”. A conclusion from this is that the building code Part D2 is used frequently by respondents.

*Responses to question:* Should the building code Part D2 include guidelines for design and installation? The purpose of this question was to find out if the building code should include only general requirements or also detailed technical guidelines. The results show that the majority of the respondents felt that the building code should include technical guidelines even more than presently. This was an important result as there has been also speculation that building code Part D2 has too many requirements on technical details dealing with design and installation.

*Minimum ventilation rate:* Finnish building code has specified the minimum ventilation rate for a long time, either as guideline values or as a mandatory minimum ventilation rate. The mandatory minimum ventilation rate was 4 l/s per person from 1987 until 2003 when it was increased to 6 l/s per person. This minimum value applies to all non-industrial buildings. For residences the minimum ventilation rate is 0.5–0.7 ach.

*Responses to question:* Should the minimum ventilation rates presented in the building code be increased, decreased, or unchanged? The result shows that the majority of respondents felt that the current value 6 l/s per person should not be changed, From the minority, more respondents were in favor of an increase into 8 l/s, person, and only a few wanted to decrease the minimum into 4 l/s, person.

#### **4. Ventilation rates for individual spaces**

In the design stage the number of occupants for a specific space is often not known. In this case the design should be based either on the default number of occupants or some other criteria. However, in the design stage the intended use of the space and floor area are always available and can easily be used in the design. The Finnish building code Part D2 gives guideline values for various spaces. These tabled values are an important tool for a designer, and commonly used. They are significant for maintaining good indoor air quality without using excess energy. As the design values are based on old practice regarding the use of the rooms and buildings they need to be checked regularly.

One objective of the study was also to find out, based on current practice, which values are too high and which are too low, again to save energy without any sacrifices in the indoor air quality. Some of the findings are summarized in Table 1.

Table 1. Some spaces where the guideline ventilation value for ventilation is too high or too low based on the results of the study.

Space	Ventilation rate in current buildings code Part D2	Problems with the current ventilation rate	Comments
<b>Space with too high ventilation</b>			
Small apartments	0.7 ach based on exhaust air flow rates	0.7 ach is too high ventilation rate	Exhaust air flow rates should be adjusted from the guideline value so that the ventilation rate is 0.5 ach
Large apartments	min 0.5 ach	0.5 ach is too high ventilation rate and lead to too high exhaust air flows	Exhaust air flow rates should be kept in guideline values leading to lower than 0.5 ach in the whole apartment
Day care centers	6 l/s per person 2.5 l/s,m <sup>2</sup>	Too high for the all rooms as rooms are not fully occupied simultaneously	Total ventilation should not be the sum of the individual rooms as children are in one room at a time
<b>Spaces with too low ventilation rates</b>			
Exercise rooms, halls	2–6 l/s,m <sup>2</sup>		Heavy use and pollution load
Elderly homes	No specific values given	Ventilation should be higher than in residential bed rooms	Often high olfactory load, 24/7 occupancy

There are also many other spaces where the ventilation rates were considered too high. These are typically spaces or areas with low average occupancy and very short times of peak occupancy. These include corridors, conference rooms in offices, cafeterias and restaurants, supermarkets and public spaces in hotels. Actually, ventilation air flows could be reduced in all spaces in cafeterias, restaurants and hotels because nowadays these are all non-smoking areas.

Relatively few spaces were considered to have too low ventilation rates, In addition to those given in Table 1, these include treatment rooms in hospitals. Also the guideline value for the boosted extract air flow from kitchen hoods, currently 20 l/s, was considered too low to ensure a sufficient capture efficiency. But for kitchens in public buildings the general

ventilation rates can be reduced as the cooking processes have changed and kitchen hoods are used.

Several conclusions can be drawn on general level from the results of guideline values of ventilation (some presented in Table 1 above).

- 1) Guideline values for ventilation cannot be based only on ventilation rate per person but other values like  $l/s, m^2$  are needed as well
- 2) Based on practical experience the ventilation rates for many spaces can be reduced without deteriorating the indoor air quality
- 3) Some spaces need more ventilation but much fewer than those having too high ventilation rates
- 4) As the number of occupants vary in many spaces the need to control ventilation rates based on the number of occupants is an important method to reduce energy use without reducing the indoor air quality
- 5) As the pollution loads and use of spaces change over time (like smoking, cooking methods, packing of the goods in stores etc.) the ventilation rates should be adjusted to this change.

An important finding was also that the residential ventilation rates given in the building code may lead to too high ventilation as the guidelines are given both in air changes per hour and in exhaust ventilation rates. The current building code suggests using the criteria which leads to higher ventilation air change rate.

The summary of the questionnaire shows also that the generic guideline values for ventilation are needed for design. Guideline values are important for designers, building users and owners, and for building inspectors.

## **5. Proposed technical improvements**

The project was not limited only to guideline values of ventilation rates but also on the technical design and installation of ventilation systems. The identified points for improvements were based on one or more of the following criteria:

- 1) improve indoor air quality and climate without significant increase in energy use
- 2) reduce the use of energy without significant deterioration of indoor air quality and climate
- 3) reduce the installation cost without significant deterioration of indoor air quality and climate.

The study pointed out also some shortcomings and technical details in the building code which causes misunderstandings and difficulties in interpretation of the present code. In the following some results are described.

*Room temperature:* Current building code gives very stringent design guideline values for room temperature: 21 °C for winter and 23 °C for summer. Summer design temperature was deemed to be too low and should be risen significantly at least of 25 °C. The current maximum temperature 25 °C in residences is also too low and needs to be risen to 26–27 °C (except for some sensitive groups like elderly people). Current building code allows the room temperature to rise over the maximum temperature 25 °C when the outdoor temperature is over 20 °C, but not more than 5 °C. This allowable exceeding of the maximum room temperature should be specified more exactly with the weather conditions and time, maybe with degree hours as in EN 15251:2007 [2].

*Indoor air humidity:* Finnish building code does not specify lower limit for indoor air humidity even though the problems of the dry air are well recognized. Based on experiences it has been concluded that the humidification with present technology and level of maintenance has more risk due to potential microbial growth in the humidifiers. However, one proposed option to rise indoor humidity is to reduce outdoor air rates during the coldest period.

*Ventilation during unoccupied hours:* Due to emission of pollutants from building materials and other sources the code specifies the minimum ventilation to be during unoccupied hours 0.15 l/s,m<sup>2</sup>. This is in practice done often by letting the toilet exhaust running 24/7. In the large building this does not work properly as it leaves rooms with long distance from toilets unventilated. To guarantee the ventilation in the whole building more specific requirements are needed either by running the ventilation periodically or just before the beginning of the use like prEN16798-1 [3] suggests.

*Pressure difference over building envelope:* It has been a custom in cold climate like Finland to have a negative pressure indoors in relation to outdoors to avoid moisture migration to the structures. The current building code limits this pressure difference to 30 Pa. This high pressure difference has created serious indoor air quality and other problems as the air leaking through building envelope draws pollutants from structure, ground and technical shafts into the building. A proposal is to limit this pressure difference to 5–10 Pa. This pressure difference should not be affected by the changes in the filter pressure drop caused by clogging.

The pressure difference depends of course on the tightness of the building envelope and the balance between exhaust and outdoor air rates. The requirements for this balance increases with improved air tightness of the building envelope. This may become even a bigger problem when exhaust air flow rates are increased due to a fire place, central vacuum cleaner or kitchen range hood or other means. The pressure difference should be limited in these conditions with increasing the outdoor air flow or making the adjustments in the building envelope.

*Location of outdoor air intakes in relation to exhaust air openings:*

A general principle of ventilation is that the ventilation air from outdoors should be as clean as possible and should not contain the pollutants from exhaust air. Furthermore the polluted exhaust air should not be induced back into the building. This requirement has led to the requirements that exhaust air shall be lead to the roof of the building. This means that the exhaust ducts will run all the way though a building to the roof. This will increase the investment cost and energy cost due to increased pressure drop in the duct work, moreover the ducts running through several floors require space and floor area in each floor.

A suggestion in the study was to reevaluate these stringent requirements and allow the exhaust and outdoor opening to be on the same exterior wall, especially when these are serving the same space or apartment. An exhaust from the wall should also be allowed to “clean” exhaust air (lowest classes in the classification). Furthermore it was proposed that if the more polluted exhaust air is cleaned with filters its class can be lowered and it can be treated as “clean” exhaust air, and exhausted from wall instead of leading the air to roof.

*Transfer air:* One principle of ventilation has been that the occupants of one room should not be exposed to the pollutants from other rooms. This leads to the requirement in the current building code that every room to have an exhaust and a supply air opening. As the smoking is not any more allowed indoors, the hygiene is improved and pollution emissions decreased it is time to reevaluate this requirement. For example significant savings could be achieved in the first and operation cost if the hallways and corridors in multi-room buildings are used for transferring the return air or even exhaust air.

Another area where the use of the transfer air should be allowed is the bedroom ventilation. The requirement 6 l/s per person could lead to serious draft problems when cold outdoor air 12 l/s is led to a double bedroom. Half of this air could be transfer air from other rooms in the same apartment.

*Use on recirculated return air:* The principle that occupants in one room should not be exposed to the pollutants from other rooms has limited very much the air recirculation in buildings; of course the use of ventilation air heat recovery systems has also decreased the need to use recirculation. The results of the study suggests that the limitations of the use of recirculated air should be reevaluated as the smoking is not any more allowed, pollution loads in general are reduced, ventilation systems are more hygienic and easier to clean. At any rate the air in the building is mixed through heat recovery equipment, duct leakage and internal air flows. The use of the air recirculation may improve also the air distribution and ventilation efficiency in the rooms in demand controlled ventilation systems with variable outdoor air flow rate. Recirculation of return air is a common practice in North America and also more commonly in Middle Europe than in Nordic countries.

*Operation of buildings:* The building legislation in Finland does not allow setting any regulations to the operation of the building when in use. During the usage time the indoor environment in buildings is controlled by regulations set by the health authorities. However, the building code can give requirements for maintainability and possibilities for easy operation of building and its ventilation system. General conclusion of the study was that more emphasis should be put on the maintenance and operation of buildings including the requirement of the operation personnel.

*Commissioning:* When the requirements are set and specifications written it is crucial that they are also followed in the practice. The final inspection in the handing over process is extremely important. Most of the inspections should be done during the construction process. It is important that methods established in building code and in building specifications are followed and controlled by building owner and building inspectors. More emphasis on this should be put in the new legislation.

*Technical details:* The study also revealed need several minor technical problems and need improvements like:

- How to define and calculate specific fan power (SFP) for demand controlled ventilation systems with variable air flow
- Occupied zone is currently too tightly specified and causes problems to fulfill all criteria on the borderlines of zone
- Noise emission and control of the equipment installed outdoor should have more emphasis
- Methods of duct cleaning have changed, and the guidelines related to cleanability, including access for cleaning of the ducts and the whole system, should follow these changes
- More specific requirements should be given to efficiency of filtration of supply air depending on the location of the building and quality of outdoor air
- Use of rotary heat exchanger and the leakage requirements of heat recovery units should be reevaluated.

## **6. Conclusions**

Even the study is focusing on Finnish building code the results are to certain extent general and can be used in the international and national levels when developing ventilation guidelines. One important conclusion is that guidelines for ventilation are needed for design and installation. These guidelines should not be only on general level but should include also technical guidance. Minimum ventilation in Finland has been for 13 years  $6 \text{ l/s.m}^2$  and it seem to be correct level based on practical experience. However, it should be noted that emissions from building materials have been limited in Finland since 1995 though a Building material labelling

system based on emission of pollutants [4]. Currently, emissions of more than 3000 materials have been measured, controlled and labelled, including hundreds of components for ventilation systems.

The results of the study suggest that the total energy use for ventilation can be reduced by distributing the ventilation more based on the need of the ventilation. Some spaces are over ventilated and some under ventilated, however, the number and volume of over ventilated space is much higher than under ventilated spaces.

The occupancy in most spaces is not constant over the time. When the ventilation in many cases is designed for maximum occupancy the spaces are most of the time over ventilated. The ventilation should be more commonly be controlled by the actual need for ventilation, based on use of the space, pollution loads, air quality or number of occupants. This may create new challenges for the ventilation industry regarding the system design and control.

The study also revealed that some savings in investments cost can be achieved by having some modifications in the system design requirements. The required distances between the exhaust and intake openings should be reevaluated and investigated critically, also a possibility to allow shorter distance by cleaning the exhaust air may bring significant savings in installation and use of the floor area and building space.

As the pollution loads in buildings are lower than before (no smoking, low emitting building materials, clean ductwork etc.) the use of transfer air and recirculated air could maybe be used more.

## **7. Future work**

The work to revise the Finnish building code Part D2 on indoor environment and ventilation has been going on since the study [6] described in the paper was completed in the end 2014, and delivered to the Ministry of the Environment. The legal contents and text of the new decree has been developed in an internal expert group at the Ministry of the Environment. It looks like many recommendations for improvement presented in this study related to minimum ventilation rate and many technical regulations will be integrated in to the new decree which is scheduled to be published for inquiries during spring 2016. The decree will be significantly more condensed than the current building code without technical guidance. This leaves room for a new technical guideline for ventilation design and installation to guarantee that the objectives of the decree for good indoor environment without increase in investment and operation cost are achieved also in practice. This kind of work on technical guidelines fits well in the profile and skill of professional organisations like SuLVI as a biggest member association of FINVAC.

There is also a need for a common European guideline on ventilation design and installation of ventilation systems. Despite many national differences in ventilation techniques, a common European framework would be beneficial for the building industry, energy efficiency of ventilation and better indoor air quality throughout Europe.

A harmonised European design practice should be possible very soon because a common background will be available in two parts of the EPBD standards prEN 16798-1 [3] and prEN 16798-3 [5] by the end of 2016. In addition, country-specific guidance will be also needed but should remain in national guidelines. Maybe REHVA could take an initiative towards a common European ventilation design guide.

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