Ivanova Yulia

COMPARISON OF FINNISH AND RUSSIAN INDOOR CLIMATE REQUIREMENTS

in residential buildings

Bachelor thesis
Degree program in Building Services Engineering

September 2011

MIKKELIN AMMATTIKORKEAKOULU
Mikkeli University of Applied Sciences

DESCRIPTION

MIKKELIN AMMATTIKORKEAKOULU
Mikkeli University of Applied Sciences

Date of the bachelor's thesis

2.09.2011

Author(s)

Ivanova Yulia

Degree programme and option

Double Degree Program
Building Service Engineering

Name of the bachelor's thesis

Comparison of Finnish and Russian indoor climate requirements in residential buildings

Abstract

The subject of this thesis was a comparison between Finnish and Russian indoor climate requirements in residential buildings. Good indoor climate is very important because people spend more than 80 % of their time in premises. And each country has its own guidelines and standards for indoor climate that are presented in special documents.

The main documents that present Finnish requirements for indoor climate are: D2 "Indoor climate and ventilation of buildings regulations and guidelines 2010" and "Classification of indoor environment 2008. Target values, design guidance and product requirements". And the main documents that present Russian requirements are different sanitary rules and norms, hygienic norms, state standards.

The aim of this thesis was to present the requirements of indoor climate in Finland and Russia and to compare them. To describe the real indoor climate in real buildings in both countries was an another purpose of thesis. And a comparison of real indoor climate in both countries and detection the best was made.

Thesis was based on information of documents and investigations. Conclusion is done at the end of thesis which said that requirements of indoor climate in both countries are about the same. But real situation of indoor climate in Finland is better than in Russia.

Subject headings, (keywords)

HVAC systems, microbiology, indoor air, air quality

Pages	**Language**	**URN**
32	English	

Remarks, notes on appendices

Tutor	**Employer of the bachelor's thesis**
Martti Veuro	

CONTENTS

1. INTRODUCTION

People spend more than 80 % of their time indoor. So the indoor climate plays a very important role for human comfort and human health. The main factor indicating good indoor climate in residential premises is a big percentage of satisfied occupants. For the people to feel satisfied in the premises there are special requirements for indoor climate. The main factors that affect occupants are thermal conditions (air temperature, air velocities and air humidity), air quality, lighting and noise. In this work these parameters will be described and requirements for residential buildings will be shown. Finland and Russia have their own guidelines and standards for indoor climate. They are presented in special documents.

The main document to describe Finnish requirements is D2 "Indoor climate and ventilation of buildings regulations and guidelines 2010" /1/. This document is based on European standards, on different guidelines and general regulations, strength structure, insulations, heating, plumbing, air conditioning and energy economy, structural fire safety, general planning of housing, housing constructions. And the main document to describe Russian requirements is "Sanitary rules and norms 2.1.2.1002-00" /2/. This document is based on other different Russian documents such as "Sanitary rules for the content of localities", "Hygiene requirements for air qualify residential areas"; on hygienic norm "Maximum permissible concentrations of pollutants in the air of populated areas"; on State standard "Residential and public buildings parameters of the indoor environment" etc. The requirements of these documents will be compared and the difference between them will be presented. Also the real situation of indoor climate in real buildings in both countries will be described. And a comparison of this information and conclusion will be shown.

This thesis work has five main parts. The first part has information about indoor climate in residential buildings, about effects caused by indoor climate factor on human health. The second part of this thesis describes climate factors: thermal conditions, air flows, air humidity, air impurities, light and noise. The third part covers the documents that give requirements for indoor climate in Finland and Russia. The values of these documents are presented in the tables. The fourth part is a comparison between Finnish and Russian requirements. The values of Finnish and Russian requirements

are compared and combined in a common table. The differences between the values are detected. The fifth part describes the real situation of indoor climate in real buildings in both countries. And the results are compared. The conclusion provides an answer to the question: in which country real indoor climate is better and what are the reasons.

2. INDOOR CLIMATE IN RESIDENTIONAL PREMISES

Nowadays people spend more time indoors. Thus the indoor climate parameters have the greatest impact on human health, well-being and performance. Different experiments have been done to investigate how occupants and indoor climate are related with each other and which indoor climate parameters are acceptable.

Per-Erik Nilsson asserts that parameters of indoor air which have big importance can be divided in two main groups. First parameters are thermal conditions, noise, light, air quality, which have physical nature. Their influence on occupants should be avoided or at least minimized. Other type of parameters, such as radiation level and electromagnetic fields, should have acceptable values. /3, p.13/ In this thesis only physical factors will be discussed.

Indoor climate can be created by designing a good HVAC system for premises. Good indoor climate consists of ventilation, heating, cooling and other type of technical systems. Before designing we should answer on three important questions. They are "What indoor climate should be designed?"; "which parameters of indoor air should be taken into account?" and "what level of the irritation is acceptable?" /3, p.13/

If there are irritants in the indoor air or some parameters have unacceptable value, it means that some problem is in indoor climate. The main factor indicating good indoor climate in residential premises is a big percent of satisfied occupants. Per-Erik Nilsson asserts that there are four main aspects which should be taken into account when we talk about creation of indoor environment. They are human comfort, human health, productivity and product-process. /3, p.14-15/

For residential premises only human comfort and human health are important, others are related to working process (how people perform their tasks) and different technical processes which require controlled conditions. Level of human comfort is straight related with degree of satisfaction. To maintain human comfort for occupants is the main objective of HVAC systems. The indoor environmental parameters that affect on human comfort are mainly physical variables (temperature, noise, light etc.). But

physical activity, behavior and psychological variables and other personal factors also have a great significance when human comfort is determined.

The indoor air quality is usually priority when we talk about the role of indoor air factors influenced on human health. Allergies, toxic reactions, irritation are examples of human reactions on unacceptable level of air impurities.

2.1 Thermal conditions

Thermal conditions are the basic parameters of indoor climate. The occupants feel influence of thermal conditions immediately. Thermal conditions consist of air temperature, surface temperature, air flow, air velocity and relative humidity of indoor air. The optimal parameters are given in special documents and they should be taken into account when we design the systems providing comfort indoor climate, such as ventilation, heating etc. But for residential premises with natural ventilation (that is commonly for Russian building and considered the measure of energy savings) parameters of indoor air become dependent on the external conditions. So during year occupant can be in extreme conditions. For example temperature of air may be too high in summer and too low in winter.

When occupant is satisfied with the thermal conditions then thermal conditions are comfortable. Required thermal conditions and their values affect on thermal comfort and body temperature balance. Thermal comfort can be easiest defined by the operational temperature, which is a combined effect of heat radiation and convection. Exactly these two processes provide heat exchange between human body and surroundings. The required operational temperature can be achieved by different combinations of air temperatures and surface temperatures. /3, p.92/

2.1.1 Air temperature

The range of comfortable air temperatures is narrow. It’s very difficult to achieve the optimal temperature of indoor air for all occupants because of individual differences

/3, p.96/. Standard ISO 7730 gives the two variables to indicate satisfaction of occupants by indoor environment. They are predicted mean vote (PMV) and predicted percentage dissatisfied (PPD). These variables can illustrate the mean thermal sensation and the mean satisfaction with thermal conditions of group of occupants. Values of PMV and PPD are given in ISO 7730 tables.

In normal conditions the air temperature should not differ from the temperature set on the thermostat by more than 2-3 degrees. Even with the correct calculations and installation HVAC systems, it will not be able to strictly control the temperature throughout the house, especially if the house is a complex multi-storey structure with a large number of windows. Vertical temperature difference also has a big significance when we talk about providing good environment in residential premises. Temperature drops from the ceiling to the floor is usually considered normal, but this difference should not be too big. Acceptable level of comfort can support only when the temperature difference is equal to or less given in guidelines. Note that at constant fan operation (air circulation) acceptable temperature difference is within the norm. Irregular or defective fan operation leads to a stratification of air. Even with the zoning or constant fan operation level of comfort at different levels will be minimal or even unacceptably low in bad settlement conditions of air distribution system. This means that the size and location of the air distribution devices must be carefully selected. /5/

2.1.2 Surface temperature

Not only air temperature influences the sensation of warmth. The surface temperatures are also important when we talk about thermal conditions. The cumulative effect of surface temperatures can be indicated by the radiation temperature value. Feeling of comfort depends primarily on the temperature of wall, floor temperature and thermal inertia of wall.

Each surface of building envelope has its own coefficient of heat transfer resistance which indentified individual thermal protection. Possibility of external surfaces to save thermal energy depends on a lot of factors. They are: orientation on space, thermal insulation, percentage of area of windows or translucent surfaces and other factors. For example, orientation of separate layers composing external surface should

“inside – out’ to prevent condensation. Also if we will have a big temperature difference between external and inner surface of envelope it can occur heat radiation toward the cool surface. So it can cause too big heat losses of premise. When we talk about temperature of floor surfaces, other factors will have big significant. Mainly it is the direct contact with the human body through the soles of the feet. Floor temperature should not be cold or hot.

Thermal inertia of external surfaces plays a great role for thermal protection of premise during winter and summer season. Since the ability to accumulate heat direct depends on the density, then the heavy walls, it is better than lightweight structures. /3, p.2/

2.1.3 Humidity

Humidity in residential premises can be described by two variables: absolute humidity and relative humidity. First one shows the actual amount of water vapor in air. And relative humidity identifies relation between actual water vapor content and possible capacity of saturated air. The relative humidity is more common if we describe indoor conditions. This variable depends on the outdoor air parameters, air exchange rate and indoor sources of moisture. Source of moisture in residential premises are domestic processes, in public buildings are production process. Air can take the excess moisture and ventilation can remove it. /3, p.155/

In summer indoor air usually has higher relative humidity level than outdoor air. Due to the difference of humidity of indoor and outdoor air and air permeability of constructions is the transfer of moisture through the building envelope. When calculating moisture transferring through barrier we need to know the state of humid air in the room, determined by the release of moisture and air exchange. /5/

The amount of moisture in the air is determined by its moisture content (g) of 1 kg of dry air. In addition, the humid condition is characterized by partial pressure of water vapor and by relative humidity.

2.2 Air flow and air velocity

Moving of the air is very important because it allows to dilute carbon dioxide CO_2 , tobacco smoke, water vapor, volatile organic compounds (VOCs) , animal odors, kitchen odors etc. When the air exchange is not enough the concentration of carbon dioxide in the air is growing rapidly. Water vapor that formed during gas flaring, laundry, cooking, laundry drying, watering plants increases the air humidity and also it is harmful for occupants health. High level of humidity creates conditions for the development of mold. /6/

Provision of adequate ventilation of premises is possible to achieve in several ways:

1. Ventilation by opening the air vents (windows)
2. Using ventilation devices on windows
3. Using supply ventilation

The third way is preferable. Because with using of this way there will be always fresh air in the premises without draught and sudden changes in temperature. And it is very easy to regulate with a simple switch. /6, p.2/

In normal conditions the air velocity in the premise should be less than 0,1 m/s in the occupied zone and less than 0,2 m/s, when the temperature is 21°C. With increasing of air velocity there is a feeling of discomfort. To save thermal comfort it is necessary to compensate high air velocity by increasing the air temperature. /7/

2.3 Noise

Per Erik Nilsson asserts that every day we hear different sounds, some of them are wonderful and other may be not. For example, if we talk about music, some people think that it’s beautiful sound and for other peolple it is noise. Noise is irritating sound. Sounds, that are common masked by other sounds, in particular cases can be clearly perceived. Moreover sounds which have low level of frequency can irritate occupants even at low sound levels. So good environment according to sound requires means not only low sound level but also satisfaction of wanted sounds. /3, p.170-171/

In most cases arrangements for noise protection can not be conducted after construction of the building without it designes.

Before the designing and erection of houses the following provisions should be taken into account:

1. Orientation of buildings on the site
2. Planning decision of buildings. Main principle is to have noisy rooms next to noisy and rooms where the rest is needed next to the quiet spaces.
3. Choice of the construction solution in walls, partitions and ceilings.
4. Installation of windows. If it is necessary to provide noise protection glazing.
5. Installation of doors. If it is necessary to provide doors with noise protection seals.
6. Installation of water supply and sewerage. Heavy materials of pipes and section of pipes are influence on the flow noise. Using of elastic strips when passing through construction.
7. The selection and placement of engineering equipments (laundry drying, washing machines), heatin devices and ventilation.
8. Appointment of the premises (for example the premise for animals or music room)

Dimension of the decibel is used not only for measuring the intensity of sound sources, but also for the measurment of sound insulation design /6, p.4/.

2.4 Light

Lighting is one of important condition for normal life. There are two light sources in premises artificial and natural. Poor lighting causes fatigue, impairs quality indicators, difficulties concentrating, reduces productivity and may be the cause of accident. Right lighting provides good visibility, creates a favorable environment, creates a pleasant atmosphere for relaxing, reading, cooking and prevents deterioration of vision. /8/

2.5 Air quality

Naturally we want to breathe the air that does not affect negatively to our health. We also want this air to be fresh and enjoyable. And we want to feel cheerful so that the

work would be easy in the premises. And children feel comfortable and well-doing for example in classrooms. /9, p.1/

Indoor air quality is good in cases where the users are satisfied with it. Indoor air quality or the absence of health hazards cannot be proven through measurements. Measurements can only indicate that specific factors acceptable or not acceptable.

Main types of air pollutants

A person spends in premises up to 80 % of his time and is forced to breathe not clean air. There is a huge quantity of microscopic particles of various origins, all kinds of harmful or even poisonous impurities in the air of a closed space.

Indoor air contains a large amount of dust particles of wool and skin of animals and people, pollen. Dust mites, fungal spores, microscopic particles harmful to health are inhaled with the breath of human. Ecologists have determined that the indoor air is in 4-6 times dirtier and more toxic than the street at 8-10 times.

Sometimes many types of fungi develop indoors on the surface of point plaster, wall-paper. Spores of these fungi are brought into our homes from the street. They spread through the air. Sources of air pollution in residential areas are materials that we use for repairs. Vinyl wallpaper on the walls, linoleum floor covering, parquet lacquer, oil paint, polystyrene ceiling panels- all this makes the apartment into real “gas chamber”.

These materials can be very dangerous source of indoor air pollution, because they produce phenol, formaldehyde, ethers, carboxylic acids. These materials should be certificated. Materials intended for outdoor use cannot be used in the repair of the premises. Through cleaning of premises with too many household chemicals can be a source of indoor air pollution too. Some of these remedies contain elevated levels of formaldehyde, other remedies are polluted the air with harmful chemicals. It is very important to service ability of devices operating on gas stoves and fire places as they can be a source of carbon monoxide. Faulty gas appliances at work may produce ni-trogen dioxide. Smokers are also a source of indoor air pollution, so it is necessary ventilate rooms where the smokers are often. /10/

Impact on human

There are a lot of symptoms caused by bad air quality: irritation symptoms of the eyes, nose and throat; skin and mucous membrane; dryness or eczema, tiredness, headache, excessive infections in the upper respiratory tract; coughing; snoring and wheezing; nausea; vertigo. Fungal spores may cause allergic reaction, asthma attacks. Phenol and formaldehyde from particle board, panels not covered by laminating materials used in manufacture of furniture cause damage to the kidneys, liver, changes in blood composition are potent allergens. If a person suffers from asthma, inhalation of these substances can cause suffocation. Carbon monoxide can cause headaches, blurred vision. Tobacco smoke contains nearly 5000 chemical compounds at low concentration. These cause irritation of mucous membranes of the eyes, nose and throat. /10, p.1/ The scope of the problem is described in table 1.

TABLE 1. Diagnostic quick reference /11, p.3/.

Signs Symptoms	Environmental Tobacco Smoke	Other Combustion Products	Biological Pollutants	Volatile Organics	Heavy Metals	Sick Building Syndrome
Respiratory						
Rhinitis, nasal congestion	Yes	Yes	Yes	Yes	NO	Yes
Epistaxis	No	No	No	Yes[1]	No	No
Pharyngitis, cough	Yes	Yes	Yes	Yes	No	Yes
Wheezing, worsening asthma	Yes	Yes	No	Yes	No	Yes
Dyspnea	Yes[2]	No	Yes	No	No	Yes
Severe lung disease	No	No	No	No	No	Yes[3]
Other						
Conjunctival irritation	Yes	Yes	Yes	Yes	No	Yes
Headache or dizziness	Yes	Yes	Yes	Yes	Yes	Yes
Lethargy, fatigue, malaise	No	Yes[4]	Yes[5]	Yes	Yes	Yes
Nausea, vomiting, anorexia	No	Yes[4]	Yes	Yes	Yes	No
Cognitive impairment, personality change	No	Yes[4]	No	Yes	Yes	Yes
Rashes	No	No	Yes	Yes	Yes	No
Fever, chills	No	No	Yes[6]	No	Yes	No
Tachycardia	No	Yes[4]	No	No	Yes	No
Retinal hemorrhage	No	Yes[4]	No	No	No	No
Hearing loss	No	No	No	Yes	No	No

1. Associated especially with formaldehyde.
2. In asthma.
3. Hypersensitivity pneumonitis, Legionnaires' Disease.
4. Particularly associated with high CO levels.
5. Hypersensitivity pneumonitis, humidifier fever.
6. With marked hypersensitivity reactions and Legionnaires' Disease.

Indoor air based symptoms appear gradually. Symptoms disappear or easy when exiting from the problem causing building. Similar symptoms are caused by a variety of other factors in addition to bad indoor air. Long-term exposure to bad indoor air may

result in permanent health problems: repeated respiratory tract infections (influenzas, recurring sinusitis); aggravating allergic symptoms; the onset of allergies (allergic rhinitis, asthma); lung cancer; farmer's lung.

The suspect problems are arising from indoor air when there are defects in structures, surfaces or HEPAC equipment, sensory indication, user's abnormal symptoms are known.

3. REGULATIONS, GUIDELINES, RULES AND NORMS FOR INDOOR CLIMATE

There are special documents that spell out requirements for indoor climate.
The main source that is used to describe Finnish requirements is D2 "Indoor climate and ventilation of buildings regulations and guidelines 2010" /1/. This document presents regulations and guidelines that concern indoor climate and ventilation in new buildings. These regulations and guidelines are designed for buildings that are used all year round or during the winter period.

In Finland there is also a Classification of indoor environment, target values, design guidance and product requirements /4/. The classification specifies design values for indoor climate and supports the work of designers, developers, contractors and maintenance personnel. The classification can be used for new constructions and also when the building is renovated.

The Classification has three categories: S1, S2, S3

S1: Individual indoor environment.
This category corresponds to the best quality. The air quality is very good and there are no odors, no sources of impurities, no draught, no overheating in the premises. Users can individually control the thermal conditions. Lightning conditions are very good.

S2: Good indoor environment.

The indoor air quality in premises is good. There are no disturbing smells in the environment, no sources of impurities. Thermal environment is good. Overheating is possible on summer days and there is usually no draught. Premises have a good acoustic. /4, p.8/

S3: Satisfactory indoor environment.
According to Classification of indoor environment: "The indoor air quality and the thermal environment of the space meet the minimum requirements set by the building codes" /4, p.8/

In Russia there are no different categories of classification of indoor climate. All values are based on one document. So in this work Russian standards are compared with Finnish building code D2 or with the third category of classification of Indoor environment.

The main source which is used to describe Russian requirements is "Sanitary rules and norms 2.1.2.1002-00" /2/. These rules establish sanitary requirements to be followed in the design, renovation, construction and maintenance of exploited residential buildings and premises. But these rules don't apply to hotels, hostels, special home for the disabled, orphanages and camps.

3.1 Air temperature

Buildings should be designed so that a comfortable room temperature in the occupied zone can be maintained without unnecessary energy use.
The design room temperature in the occupied zone should be +21 °C. For the summer season is +23 °C. Also if there are any reasons the room temperature can be designed with other temperatures. /1/ Such guidelines values for different room types are given in the table 2.

TABLE 2. Guideline values for room temperatures for different room types during the heating season for premises where the room temperature design value is not 21 °C /1, p.8/

Room type	Room temperature °C
Stair well	17
Bathroom/washroom	22
Drying room	24

The temperature in the occupied zone shouldn't be more than 25 °C.
When the average outdoor air temperature during more than 5 hours more than 20 °C Indoor air temperature can exceed this value by more than 5 °C.
According to Sanitary rules and norms 2.1.2.1002-00 there are different temperatures for different types of rooms. /11, p.9/ These requirements are presented in the table 3.

TABLE 3. Temperatures for each type of premises /2, p.9/

For cold season

Room type	Room temperature °C
Living room	20-22
Living room (when outdoor temperature is less than -30 °C during for 5 days)	21-23
Kitchen	19-21
WC	19-21
Bathroom	19-21
Corridor between flats	18-20
Stair well	16-18

During the warm season the room temperature should be 22-25 °C

3.2 Air flows

According to Indoor climate and Ventilation of buildings regulations and guidelines /1/ "Ventilation in dwellings is normally designed on the basis of the table extract air flow rates in such a way that the air change rate of dwellings is at least 0.5 l/h, while the adequacy of outdoor air flows is ensured to at least equal the guideline values". /1, p.32/

In the large dwellings extract air flows should be higher than the guideline values. /1, p.32/ Guideline values for air flows and air velocity are given in the table 4.

TABLE 4. Residential buildings /1, p.32/

Space type	**Outdoor air flow $(dm^3/s)/m^2$**	**Extract air flow dm^3/s**	**Air Velocity (winter) m/s**
Dwelling rooms	0.5	-	0.20
Kitchen	0.5	8#A	0.20
-boost during occupancy	0.5	25	0.20
Cloakroom, storage room	0.5	3	
Bathroom	0.5	10#B	0.20
-boost during occupancy	0.5	15	0.20
WC	0.5	7#B	
-boost during occupancy	0.5	10	

/10/ "#A Guideline value when the boosting of cooker hood air flow rate can be controlled separately for each room or each dwelling; otherwise the guideline value for cooker hoods is 20 dm^3/s

#B Guideline value when the boosting of air flow rate can be controlled separately for each room or each dwelling; otherwise the guideline value for the air flow is the same as the boosting value during periods of occupancy

Outdoor air flow per person is 6 dm^3/s /1, p.32/.

In Russia only the natural ventilation is provided for residential buildings.

Natural ventilation of premises must be carried out by the air flow through the vents or through a special hole in the window shutter. Exhaust openings of channels should be provided in kitchens, bathrooms, latrines and drying racks. Ventilation system must exclude the air flow from one apartment to another. Kitchen vents and sanitary units cannot be combined with living rooms. /2, p.2/

Sanitary rules and norms 2.1.2.1002-00 give air velocity for different type of rooms and they are presented in the table 5.

TABLE 5. Norms for air velocity /2, p.9/

For cold season

Room type	**Air velocity m/s**
Living room	0.15
Living room (when outdoor temperature is less than -30 °C during for 5 days)	0.15
Kitchen	0.15
WC	0.15
Bathroom	0.15

During warm season the air velocity in the room should be 0.2 m/s.

Also sanitary rules and norms are provided the next scheme of ventilation. The exhaust air is removed immediately from the zone of highest contamination, from kitchens and sanitary facilities, through the natural exhaust ventilation duct. The replacement of air is due to outdoor air entering through leaks in outdoor enclosures (mainly window-filled) and through the airing of all rooms /2, p.10/. Requirements for exhaust air are presented in the table 6.

TABLE 6. Extract air flow in different types of room /2, p.1/.

Space type	**Outdoor air flow (m^3/h)/m^2**	**Extract air flow m^3/h**
Dwelling rooms	3	-
Kitchen	-	60
Bathroom	-	25
WC	-	25

Outdoor air flow per person should be 30 m^3/h.

3.3 Air humidity

Air humidity in buildings shall not be high. Humidity shall not concentrate on surfaces of the building or in the ventilation system. Because it could be a reason of growing microbes and any other health hazards /1, p.10/. The D2 regulations and guidelines don't give strict requirements for air humidity in premises.

In Sanitary rules and norms 2.1.2.1002-00 there is a table of norms of relative humidity for each type of rooms. These values are given in table 7.

TABLE 7. Norms for air humidity /2, p.9/

For cold season

Room type	**Relative humidity %**
Living room	45-30
Living room (when outdoor temperature is less than -30 °C during for 5 days)	45-30
Kitchen	-
WC	-
Bathroom	-

For warm season the relative humidity in the room should be 60-30 %.

3.4 Air quality

Buildings should be designed in a way that there is not a large amount of gases and microbes. Because it could be harmful to health and there should not be any odors that can reduce comfort /1, p.9/.

The maximum permissible indoor air carbon dioxide content is 2160 mg/m³ (1,200ppm). Values for concentrations of impurities in indoor air are given in the table 8. /1, p.9/

TABLE 8. Values for concentration of impurities in indoor air for the purpose of designing and implementing indoor air quality of buildings /1, p.9/

Impurity	**Unit**	**Design guideline value Maximum concentration**
Ammonia and amines	μg/m³	20
Asbestos	fibres/cm³	0
Formaldehyde	μg/m³	50
Carbon monoxide	mg/m³	8
Particles PM10	μg/m³	50
Radon	Bq/m³	200 (annual average)
Styrene	μg/m³	1

The maximum permissible concentrations for another impurities are 1/10 of the occupational exposure limits.

For Russia when a residential building is introduced into the operation this building should be monitored air quality accommodation for harmful substances. /9/ Maximum permissible concentrations (MPC) for harmful substances are given in the table 9.

TABLE 9. The list of the most hygienically significant pollutant of indoor air of residential buildings /2, p.10/.

N	Name of substance	Formula	The max value of MPC mg/m³
1	Nitrogen oxide	NO_2	**0.04**
2	Ammonia	NH_3	**0.04**
4	Benzol	C_6H_6	**0.1**
7	Dichloroethane	$C_2H_4Cl_2$	**1**
9	Mercury	Hg	**0.0003**
10	Lead	Pb	**0.0003**
12	Styrene	C_8H_8	**0.002**
14	Carbon monoxide	CO	**3.0**
15	Phenol	C_6H_6O	**0.003**
16	Formaldehyde	CH_2O	**0.01***

*temporary hygienic standard set for air quality of residential and public buildings

3.5 Lighting

"Buildings shall be designed and constructed in such a way that it is possible to maintain in the occupied zone such lighting conditions as is necessary for achieving the level of visibility required by the tasks to be performed during periods of occupancy so that energy will not be used unnecessarily". /1, p.11/ Lighting control should be such that it can be adjusted. Adjustment depends on the tasks. Natural light should be available. /1, p.11/

Russian Sanitary rules and norms are recommended that living rooms and kitchen should have direct natural light /2, p.3/.

3.6 Noise

Acoustic conditions should be comfortable in buildings. Guideline values for sound levels given for different types of rooms are given in the table. These values are rela-

tive to building services (ventilation, electrical, heating). /1, p.10/ Sound levels for some space types in Finland are presented in the table 10.

TABLE 10. Sound levels in different types of room.

Space type	**Sound level $L_{a,eq,t}$/ $L_{a,\ max}$ dB**
Dwelling rooms	28/33
Kitchen	33/38
-boost during occupancy	33/38
Bathroom	38/43
-boost during occupancy	38/43
WC	33/38

In Russia the permissible noise levels and requirements for their measurement in dwellings are regulated by the existing health regulation. /2, p.4/ Values for sound level are presented in the table 11.

TABLE 11. Permissible and maximum sound levels in residential buildings /2, p.4/

Space type	**Period of time, h**	**L_a, dB**	**$L_{a\ max}$, dB**
Dwelling rooms	7.00-23.00	40	55
	23.00-7.00	30	45

4 COMPARISON OF FINNISH AND RUSSIAN INDOOR CLIMATE REQUIREMENTS

In previous chapter indoor climate requirements were presented for both countries separately. In this chapter requirements for both countries are combined in common tables and differences between them are shown.

4.1 Air temperature

Requirements of air temperatures for different room types in both countries are compared and the results are presented in the table 12.

TABLE 12. Comparison of Finnish and Russian air temperature requirements in premises

For cold season

Room type	Room temperature °C Russia	Room temperature °C Finland
Living room	20-22	21
Living room (when outdoor temp. less than -30 °C during for 5 days)	21-23	21
Kitchen	19-21	21
WC	19-21	21
Bathroom	19-21	22
Pantries	16-18	-
Stair well	16-18	17

According to Sanitary norms and rules temperatures are given in a range and according to D2 temperatures are given strictly. This table shows that Finnish and Russian requirements are about the same. But in Finnish requirements the temperature in bathroom is higher than in Russian requirements.

4.2 Air flows

According to D2 and Sanitary rules and norms there are special values for air velocities in premises. These values are compared in the table 13.

TABLE 13. Comparison Finnish and Russian air velocities requirements in premises

Space type	**Air Velocity (winter) m/s Russia**	**Air Velocity (winter) m/s Finland**
Dwelling rooms	0.15	0.20
Kitchen	0.15	0.20
-boost during occupancy	-	0.20
Bathroom	0.15	0.20
WC	0.15	
Utility room	-	0.30
Stair well	0.2	-
Dressing room	-	0.20
Wash room	-	0.20
Corridor between flats	0.15	-

This table shows that requirements of air velocities in Finland are a little higher than requirements of air velocities in Russia. But there is no great difference.

Also Finnish and Russian documents include special values for outdoor and extract air flow rates. These values are presented in the table 14.

TABLE 14. Comparison Finnish and Russian outdoor and extract air flows in premises.

Space type	**Outdoor air flow in Finland $(dm^3/s)/m^2$**	**Outdoor air flow in Russia $(dm^3/s)/m^2$**	**Extract air flow in Finland (dm^3/s)**	**Extract air flow in Russia (dm^3/s)**
Dwelling room	0.5	0.8	-	-
Kitchen	0.5	-	25	17
Bathroom	0.5	-	15	7
WC	0.5	-	10	7

The requirements are approximately the same. In Finland the air comes to the premises from outdoor through a special device. Devices that are common for Finland are presented in figure 1, 2 and 3.

Figure 1. Inlet valves in walls .

Figure 2. Inlet valves in windows .

Figure 3. The construction of inlet valve .

1 – adjustment device; 2 – cover tip; 3 – filter; 4 – the interior of the tip with the flap; 5 – O – Ring; 6 – plastic pipe; 7 – heat and noise insulation; 8 – aluminums grille with mesh

In Russian buildings the air usually comes to the premises from outdoor through the cracks in windows or through the window leafs. It is presented in figure 4.

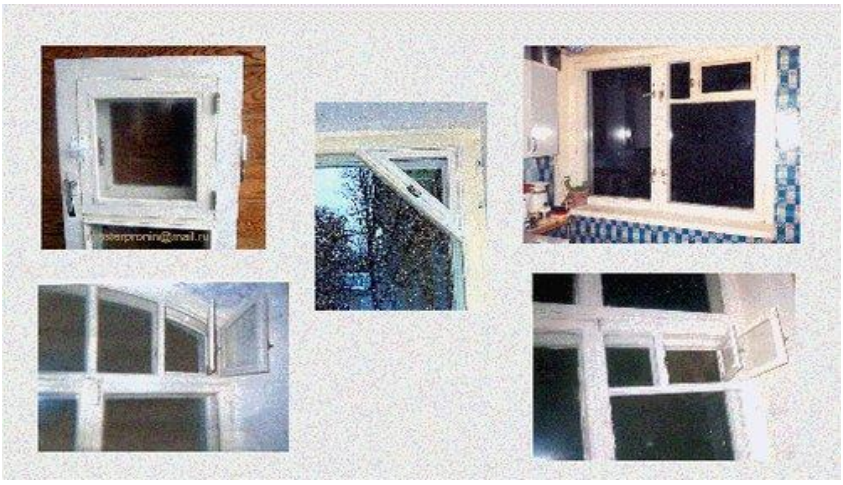

Figure 4. Windows leafs.

In Finland and Russia exhaust air valves are located in the bathrooms, toilets and kitchens. In both countries exhaust air valves perform the same function but look different. They are presented in figures 5 and 6.

Figure 5. Exhaust air device in Finland.

Figure 6. Exhaust air device in Russia.

4.3 Air humidity

According to sanitary rules and norms air humidity in premises is normal when it is 45 %-30 % and 60 %-30 % for warm season. And the D2 regulations and guidelines don't give strict requirements.

4.4 Air quality

Finnish document /1/ pays attention on the maximum permissible indoor air carbon dioxide, the content is 2160 mg/m³, but according to sanitary rules and norms there is no requirement for maximum permissible concentration of carbon dioxide.

D2 and Sanitary norms and rules present tables of impurities in indoor air. Sanitary norms and rules are presented more impurities.

In the comparison table 15 only those impurities which are included in both tables will be presented.

TABLE 15. Comparison Finnish and Russian maximum permissible concentration (MPC) of impurities in indoor air

Impurity	**Unit**	**MPC Russia**	**MPC Finland**
Ammonia	μg/m³	40	20
Formaldehyde	μg/m³	10	50
Carbon monoxide	mg/m³	3	8
Styrene	μg/m³	2	1

This table shows the difference between Finnish and Russian maximum permissible concentration of impurities in indoor air. There exists a great difference between values. In Russia the requirements of maximum permissible concentration for formaldehyde and carbon dioxide are stricter then in Finland. And in Finland the requirements of maximum permissible concentration for ammonia and styrene are stricter than in Russia.

4.5 Light

In D2 and Sanitary rules and norms there are no any special datas for lightining. Both documents prescribe that natural light should be available in premises. Buildings should be designed so as to have the necessary conditions of visibility and to avoid futile expenditure of energy.

4.6 Noise

According to D2 requirements for sound levels are given for different types of spaces. And according to sanitary rules and norms requirements are given only for dwelling

rooms and they depend on period of time. So in comparison table will be shown the requirements only for dwelling rooms.

TABLE 16. Comparison between Finnish and Russian requirements of sound levels.

Space type	**Period of time**	**$L_{a,dB}/L_{a\ max}$, dB Finland**	**$L_{a,dB}/L_{a\ max}$, dB Russia**
Dwelling rooms	7.00-23.00	28/33	40/55
	23.00-7.00	28/33	30/45

The table shows that requirements for sound levels in Finland and Russia are different. The requirements for sound levels in Finland are lower than in Russia.

5 COMPLIANE OF REAL BUILDINGS IN FINLAND AND RUSSIA WITH THE STANDARTS

In previous chapters indoor climate requirements are shown. But what is the situation in real buildings in both countries? Researches and investigations have been made in real buildings.

Room air flow rates

Airflow rates were measured in 102 Finnish houses. Measured houses were equipped with different ventilation systems, 10 % used natural ventilation, 28 % used mechanical exhaust and 61 % used mechanical supply and exhaust. In a result air change rate was 0,4 l/h in houses with mechanical supply and exhaust ventilation and 0,37 l/h in houses with mechanical ventilation and 0,3 l/h in naturally ventilated houses. These values are below the code value of 0,5 l/h. In interviews, tenants didn't complain about any problems indoor. /13, p.1/

In Russia all buildings are equipped only with natural ventilation. Windows have cracks which allow outdoor air flow to come into the premises. It was a foundation of natural supply ventilation that applies to these days. In the beginning of 90's Western

technology appeared to Russian markets. One of these innovations was airtight windows. And people started to change their old windows to the new. It is a good thing but these windows destroy the natural infiltration of air into the premises. Airtight windows have been used in mass constructions. Modern windows have high integrity. Supply of fresh air in the premises becomes impossible and therefore doesn't meet the required standards. Air exchange in the apartments is disrupted. As a result there is: high humidity, bad odors, bad quality of air, mold. It can be harmful to human health and cause discomfort to live in these apartments.

Air temperature and humidity

Air temperature and air humidity were measured in 74 Finnish houses. At first indoor temperature and humidity were analyzed during summer and then during winter period. The average indoor temperature during summer in Finnish houses was + 24,8 °C (min average +22,2 °C and max average +28,5 °C). And the average indoor humidity was 51 % (min average 34 % and max average 60%). Target values for the indoor temperature during summer were 22 – 27°C. Regulation and guidelines do not specify humidity value, the range 20 – 60 % was used as a criterion for the acceptable humidity in Finnish houses. So as a result the real situation of the indoor temperature almost met the thermal requirement. Only 2 % of the rooms remained below the higher limit.

The average indoor temperature during winter in Finnish houses was +21,6 °C (min average +16,9 °C and max average +26,5 °C). And the average indoor humidity was 26 % (min average 14 % and max average 47 %). Target values for the indoor temperature during winter period were 20 – 23 °C. So thermal requirements fulfilled only 4 % of rooms. /14, p.1-4/

Air temperature and humidity were also measured in 44 Russian flats. The average indoor temperature during measurement period was +21,6 °C (min average +12,1°C and max average +32,9 °C). According to requirements the average temperature in premises should be 18-22 °C. Thermal requirement fulfilled 55,2 % of rooms. The average air humidity was 27,2 % (min average 5,81 % and max average 55,7 %). The requirement for air humidity is 30 – 65 %. Air humidity didn't remain the higher limit. But in 73,9 % air humidity was lower the limit. And air humidity requirements fulfilled only 26,1 % of rooms. /15/

Air quality

Finland is one of the most eco friendly countries . The 70 % of territory of Finland is covered by forests. It is beneficial to the environment. But there are a lot of forests in Russia too but Russia is only on the 74th place in terms of ecology. Following factors play a great role: the number of oil producing plants, density of population, the number of emitted carbon dioxide and other greenhouse gases, methods of disposal of wastes and many others. /16/ In Russia there are too many plants that haven't got right way of waste treatment. Large amount of harmful substances is discharged into atmosphere. In areas with the biggest part of Russian population the specific indicators of environmental pollution are overstated. And only the natural ventilation is provided in premises, air comes to premises through the holes in the window shutter without any purification. So as a result the outdoor air which comes inside premises in Russia has worse quality than in Finland.

Also in Russia there is a great amount of old buildings. At the time when they were built the quality of materials was very bad. Outdated equipments, not right technologies, lack of proper supervision, poor quality of used materials did not meet the requirements of standards and specifications. A great amount of people lives in this kind of premises and only a small percent of these buildings has been renovated. People feel discomfort in these areas: too high temperature in summer, too low temperature in winter, draughts and harmful substances from the materials. Finnish building and decoration materials are environmentally friendly and manufactured with correct technologies. So it is another "plus" to the indoor air quality of Finland.

6 CONCLUSION

Nowadays people spend 80 % of their time indoor. Thus the indoor climate parameters have a great impact on human health and human comfort. So each country has its own requirements for indoor climate parameters to avoid the risk for human disease. In my thesis I compared Finnish and Russian requirements of indoor climate. In a result I can tell that requirements in both countries are about the same.

Also I investigated the real indoor climate conditions in real buildings in Finland and Russia. Here I found a great difference. In Russia air supply doesn't meet the required standards because of airtight windows. In Russia only natural ventilation is provided in premises. So with installation of these windows air can't come to premises. In the same time in Finland there is no problem like that, because there is a special technology. It is passive flow through inlet valves in walls and windows. So in Finland real room air flow rates are close to requirements of the code.

Also real air temperature and humidity in residential buildings were investigated in my thesis. In Finland 98 % of rooms met thermal requirements. And in Russia only 55,2 % of rooms met the requirements.

I also investigated the situation of indoor air quality. As it was written in my thesis the specific indicators of environmental pollution are overstated in Russia and this polluted air comes to Russian flats without any purification. In Finland it is contrary. Finland is one of the most eco friendly countries and the air that comes in premises is so pure. At the same time air quality in premises depends on building materials. Finnish building and decoration materials are environmental friendly and manufactured with correct technologies. And Russian materials don't often meet the requirements of standards.

Nowadays Finnish building materials are so popular in Russia. Also it could be good for Russian to install inlet valves in walls and windows like in Finnish houses. With this technology the real air change rate can meet the requirements. And indoor climate in Russian premises can become better.

BIBLIOGRAPHY

1. The D2 regulations and guidelines 2010 Indoor climate and ventilation of buildings. Ministry of the environment housing and building department.
2. Санитарно-эпидемиологические правила и нормативы 2.1.2.1002-00. Департамент госсанэпиднадзора Министерства России.
3. Per-Eric Nilsson. Achieving the desired indoor climate. Sweden. Indoor climate and student literature. 2007
4. Classification of indoor environment 2008. Finnish society of indoor quality and climate.
5. ТКСС. Составляющие комфорта помещений. WWW document. http://uteplimsteni.ru/komfort.php. No update information. Referred 10.09.2010
6. Build Online. Теплозащита дома. WWW document. http://www.build-online.ru/info/38-books/182-trebovania.html?start=1. No update information. Referred 01.12.2010
7. Построй свой дом. Тепловой режим помещений. WWW document. http://www.mensh.ru/teplovoi_rezhim_pomeschenii. Update 30.05.2006. Referred 6.12.2010
8. Освещение жилого дома. Информатизация системы образования. WWW document. http://tehnologia.59442s003.edusite.ru/p9aa1.html. No update information. Referred 2.12.2010
9. П. Оле Фангер. Качество внутреннего воздуха зданий, построенных в холодном климате. НП «АВОК». WWW document. http://airs.ru/articles/ventilation/quality-internal-air-cold-climate#h0. Updated 12.06.2006. Referred 10.12.2010
10. Источники загрязнения воздуха в помещениях. Дыши свободно. Экология городов и регионов. WWW document. http://www.dishisvobodno.ru/indoor.html. No update information. Referred 20.12.2010

11. EPA. Indoor air pollution: An introduction for health professionals. WWW document. http://www.epa.gov/iaq/pubs/hpguide.html. No update information. Reffered 03.01.2011
12. Московская вентиляция. Приток. WWW document. http://www.ventkanal.ru/pritok.html. No update information. Referred 10.01.2011
13. Lari Eskola. Room air flow rates in Finnish houses. Proceeding of Clima 2007 WellBeing Indoor.
14. Targo Kalamees. Indoor climate conditions in lightweight detached houses in cold climate. Student literature. WWW document. No update information. http://www.inive.org/members_area/medias/pdf/Inive/IAQVEC2007/Kalamees.pdf. Referred 05.06.2011
15. Г.П. Васильев. Источник вторичных энергоресурсов – вентиляционные выбросы жилых квартир. WWW document. No update information. http://www.energohelp.net/articles/technologies-sub/65177/. Referred 10.06.2011
16. Forbs. Eco friendly countries. WWW document. http://www.ecofriendlydaily.com/news/friendly-countries/. No update information. Referred15.01.2011

APPENDIX 1.

Appendix on one page