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Renovation of Ventilation and Air-conditioning System in Old Russian Museums

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DESCRIPTION

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Abstract The subject of this thesis is the renovation of VAC - Systems in old Russian public buildings . The study of the topic allows us to understand how we can reconstruct vac-systems in old buildings. This theme shows what requirements must be taken into account when updating these systems. Since these reconstructions are rather laborious and expensive, some examples of how you can update these systems using the features of old buildings are describing in this topic. In order to best represent the picture, in this study reconstruction design of vac-systems of museum of Suvorov was considered, the engineer of Russian museum was interviewed and the experience of the Denver museum was taken into account.		
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CONTENTS

1 INTRODUCTION.....	1
2 NATIONAL RUSSIAN RULES AND REQUIREMENTS	3
2.1 The main building norms and rules of designing air conditioning and ventilation	3
2.2 Requirements for air conditioning and ventilation of public buildings	5
2.3 Source of noise measurements and calculation of noise.....	9
2.3.1 Sound power and pressure	10
2.3.2 Sound protection and noise insulation	10
2.3.3 Noise reduction measures in the ventilation and air conditioning.....	12
3 DESIGN OF AIR CONDITIONING AND VENTILATION SYSTEM IN MUSEUM OF SUVOROV	15
3.1 Ventilation and air conditioning	15
3.1.1 Ventilation and air conditioning	17
3.1.2 General installation instructions.....	19
3.2 Power equipment and automation.....	22
3.2.1 Power equipment	23
3.2.2 Automatic performance	23
3.2.3 Installation instructions.....	24
3.2.4 Connection to ground.....	25
3.2.5 Interaction with the fire alarm system of the building.....	25
4. EXPERIENCE OF THE RUSSIAN MUSEUM IN THE RECONSTRUCTION OF ENGINEERING NETWORKS.....	25
4.1 Description of museum.....	25
4.2 The academic halls.....	27
5. APPLICATION OF THE “HERMITAGE’S METHOD” FOR REGULATING CLIMATE IN RESIDENTIAL AND PUBLIC BUILDINGS	29
5.1 “Dagmar”	30
5.2 “Fortochka”.....	31
5.3 “Rastrelli”	33
6. CONTROLLED CLIMATE FOR PRESERVING ART	35
6.1 The Denver Art Museum and its system.....	35
6.2 Energy Efficiency.....	36

6.3 Innovative Design Features	37
6.4 Indoor Air Quality.....	38
6.5 Summary	38
7. CONCLUSION	39
BIBLIOGRAPHY	41
APPENDICES.....	42

1 INTRODUCTION

Civil engineering and HVAC-technologies (ventilation, air conditioning, and heating systems) are one of the fastest developing areas in our days. Ventilation, air conditioning and heating systems are designed to provide appropriate microclimate conditions for a comfortable stay of human, but also to provide good climate for art objects. These monuments of culture are necessary to protect in order for mankind developed. It is through them are transmitted that the rich heritage and experience of different people and countries.

Most of the cultural artifacts stored in museums or their storagerooms, where they can also be restored. As it is well when any object gets older, it loses its quality. In order to preserve these works of art in their original form is necessary to create different climatic standards in these premises. Required climatic standards include temperature, humidity, air velocity, lighting, etc. But it is not an easy task to follow all these items, as well as for conservation of art objects we must also take into account their size, material, age, etc. Also we must take into account where the data is stored objects: in warehouses or expo halls? In showrooms climatic setting should provide the necessary parameters for comfortable visit people, and for storage of art.

“Russian Federation numbers more than 1800 museums which keep almost 55 million exhibit items. State Russian Museum in Saint-Petersburg is the first national museum of decorative arts in Russia. It has almost 400 000 exhibit items which cover historical period of over 1000 years.” /1/ Russian Museum has almost best air conditioning and automation systems and constantly develops them. Climatology department supervises the indoor climate and performance of the systems and Restoration department deals with exhibit items themselves. Exhibitions cover different areas of art such as paintings, sculpture, decorative and applied arts, metal goods, furniture and interior, clothes and fabric.

In my work I want to deal with the problems associated with the reconstruction and renovation of HVAC-systems in public buildings. Many buildings are not able to meet modern requirements applicable to these systems. First, public buildings should provide a comfortable stay for people. This is achieved by maintaining the internal microclimate. Temperature, humidity and quality of air are the main parameters of these conditions.

In order to understand how these parameters can be achieved in the reconstruction of ventilation and air conditioning, while retaining the historical look and value of buildings, I'll look at examples of renovation of several historical museums in Russia. The first step is to consider the basic requirements and rules for modern ventilation and air conditioning. Then I was made co-operation with several Russian museums. And in the end I will examine the experience of overseas museums in this regard.

Based on these data and skills it can be concluded, how it will be possible to reconstruct the system, you must consider how you can avoid the problems associated with the historical value of buildings. It is also necessary to consider parameters such as noise, which is created in the system of air conditioning. This is necessary because the noise adversely affects both the human well-being, and building as a whole. One of the chapters will be considered by requirements for this parameter. Based on the requirements and tests will be concluded as soon as possible will reduce the noise, if the system does not allow us to put additional silencers.

And finally I will say a few words about economic issues. In the first the future customer of reconstruction wants to reduce the cost of the order. But we must still consider that the costs should be reduced during the lifetime of the system.

This topic is interesting because many public buildings and museums in Russia are in need of renovation. It's also necessary to reconstruct their HVAC-systems. If in addition to the requirements and rules for engineering systems, we will consider the buildings themselves, how they can be used, it can give good results.

2 NATIONAL RUSSIAN RULES AND REQUIREMENTS

In this section, I would like to consider what rules and regulations need to know about designing new air conditioning and ventilation systems in Russia as in residential buildings and in public, particularly in museums.

2.1 The main building norms and rules of designing air conditioning and ventilation

Design of air conditioning and ventilation to December 2002 was based on the construction norms and rules of building regulation and other regulatory documents approved State Construction Committee of Russia. On 27 December 2002 the Federal Law 184-FZ of 15.12.2002 "On technical regulation" was passed. Under the new Law, all activities up to 2010 should be developed "Technical regulations". Before the release of "technical regulations" in the design of all SNIPs¹ and other legal literature are used as recommendations.

List of basic construction standards and regulations for the design of heating, ventilation and air conditioning in buildings and premises for various purposes and the categories are shown below in Table 1. /2, p. 25/

Table 1. List of major construction rules and regulations /2, p. 25/

SNIP 41-01-2003	Heating, ventilation and air conditioning
SNIP 2.08.02-89* ²	Public buildings and facilities
SP 31-106-2002	Design and construction of engineering systems, single-family homes
SNIP 31-03-2001	Industrial buildings
SNIP 41.02-2003	Heat network
SNIP 3.05.01-85	Internal sanitary systems
SNIP 3.05.07-85	Automation Systems
SNIP 11-04-2003	Instruction on the development, coordination, and approval of urban planning documentation
SNIP 21-01-97*	Fire safety of buildings and structures

¹ SNIP – Construction Standards and Regulations

² * - SNIP was changed some

SNIP 2.04.01-85*	Domestic water supply and sewerage
SNIP 2.11.02-87	Refrigerators
SNIP 12-03-2001	Safety in construction
SNIP 23-03-2003	Acoustic protection
SNIP 23-02-2003	Thermal protection of buildings
SNIP 23-01-99	Building climatology and geophysics

In the design of residential, public and industrial buildings, and facilities of various kinds, together with the major building codes are used:

- Sanitary-epidemiological requirements - SanPiN;
- State Standards - GOST;
- Moscow city building codes - MGSN;
- Territorial building codes - TSN;
- Departmental regulations - VSN;
- Rules for Electrical – PUE.

In addition to the above SNIps there are a number of benefits and recommendations for building design standards. There are State Standards, which define the optimal and permissible parameters of the air of the working and residential zones and the maximum permissible concentration of harmful substances in the air. VSN³ set the parameters of air, which must be maintained on the premises for proper percolation process, and sanitary-hygienic requirements for the safety and health of people employed in manufacturing. At these standards must also be referenced when designing new systems, as many museum exhibits, including paintings, are in the restoration rooms, which are located directly in the museums.

When we are designing air conditioning and ventilation systems, these systems should also be guided by tools, such as terms:

- SNIP 23-01-99 "Building climatology and geophysics" with information about the climatic conditions of specific areas.
- SNIP 23-02-2003 "Thermal protection of buildings", which provides thermal and technical characteristics of building constructions.

³ Departmental building standards

- The projects should include measures to protect against noise under SNIP 23-03-2003 "Noise".

As is known, the main source of noise in the environment and in different types of buildings is the technical and engineering equipment. Therefore, this section should be considered in the project and include in the final documentation.

- Characteristics of building fences on the level of fire resistance are selected in accordance with SNIP 2.01.02-85 *

The above listed standards must be considered in the reconstruction and design of ventilation systems in connection with the fact that most of the museums in Russia are historical buildings. In these buildings characteristics of structures, noise control and fire resistance are different from modern standards.

In recent years AVOK - Association of engineers of Heating, Ventilation, Air-Conditioning, Heat Supply and Building Thermal Physics were issued a number of standards. When documents were developing standards adopted in Russia, and also European and American standards were reviewed.

There are over 50 different types of buildings and structures. Such an extensive list of groups and types of residential, industrial and public buildings and facilities is due to specific regulatory requirements for the design of each of these types of buildings and premises.

2.2 Requirements for air conditioning and ventilation of public buildings

In this section I will discuss the basic requirements for the design of ventilation systems and air conditioning systems in public buildings, classification and significance of these requirements. The main documents that regulate the basic requirements (optimal and allowable) are SNIP 41-01-2003 and GOST 30494-96 "Residential and public buildings".

"Classification requirements for the design of air conditioning and ventilation of various groups and types of facilities are in Table 2." /2, p. 31/

Table 2. The requirements which are presented in systems development /2, p. 31/

The requirements which are presented in systems development		
Sanitation requirements	Construction and architectural requirements	Operational requirements

Sanitation requirements of GOST 30494-96 "Residential and public buildings" and GOST 12.1.005-88 "General sanitary-hygienic requirements to air in working areas", regulate the weather conditions (or climate) in the catchment area. Parameters that characterize the microclimate in the premises: temperature, relative humidity, mobility of air or velocity, resulting room temperature, clean of air, reduction of noise in the premises to a level not harassing people inside. The rules of permissible noise levels for the buildings should be taken in accordance with the requirements of SNIP 23-03-2003 "Noise".

“Minimum flow of fresh (outdoor) air for one person is taken in accordance with SNIP 41-01-2003* Annex M.1. is shown in Table 3.” /2, p. 32/

Table 3. The minimum outside air per person, m³/h /2, p. 32/

Premises (area, room)	With natural ventilation	Without natural ventilation
Public and administrative facilities* ⁴	40	60 20** ⁵

It is very important for the well-being is the presence in the room of fresh (outdoor) air. Normative documents establish the optimal and allowable air parameters (temperature, relative humidity and air velocity in the working area) depending on the category of gravity works and the period of the year. “Classification of the calculated parameters of air in the room is shown below in Table 4.” /2, p. 33-34/

⁴ Norma of outdoor air is brought to office space, classrooms, offices, public buildings, administrative facilities. In other areas of public purpose rate of outside air should be taken on the requirements of relevant regulatory documents.

⁵ For rooms in which people are not more than two hours continuously.

Table 4. Estimated parameters of the air /2, p. 33-34/

Estimated parameters of the air		
↓	↓	
As ventilation	As conditioning	
↓	↓	
Possible options	Optimal parameters	
↓	↓	
Required	Featured	
↓	↓	↓
Residential, public, administrative and household and industrial premises	Residential, public, administrative and household premises	Industrial premises
↓	↓	↓
The tables of the SNIP	At customer's will or an economic rationale	As technological requirements (departmental regulations)

Optimum (recommended) air parameters represent the set of conditions most conducive to the best human being (the area a comfortable air-conditioning), the conditions for the proper flow of process, preservation of cultural values (the area of technological air-conditioning). Acceptable (mandatory) value of microclimate parameters are set in cases where technology or technical requirements and economic reasons, not provided optimal standards. If the permissible limits cannot be achieved due to production or economic conditions, then the permanent workplaces should provide spot cooling or air conditioning.

Given parameters of microclimate and clean indoor air of residential, public, administrative and industrial buildings should be provided within the parameters of outside air to the respective areas of construction on the SNIP 23-01-99* and in accordance with SNIP 41-01-2003. Parameters of the microclimate, or one of the parameters are allowed to take within the optimal standards instead of admissible if it is economically justified, or on the instructions of the design. This may be more

economically advantageous. This permit is issued by Gossanepidnadzor⁶ Russia and on the instructions of the customer. Optimal and acceptable parameters of air, which are recommended for residential, public facilities and industrial buildings, are shown below in Table 5. /2, p. 32-34/

Table 5. The optimal parameters of air to public spaces on the conditions of storage material /2, p. 32-34/

Room type	Temperature, °C	Humidity, %
Archives	14-17	57-63
Libraries, book depository	18-21	40-50
Rooms of the museum where artifacts of wood, paper, parchment, leather, glue and drawn from them are stored	16-24	50-60
Artist's studio with paintings on the easel	16-24	55-60
Warehouses paintings in museums	11-12	55-60
Storage facilities:		
fur	4-10	55-65
skin	10-16	40-60

Requirements for air conditioning and ventilation systems are not limited to sanitation (climatic) requirements. For a number of economic and technical reasons, is also quite important building and construction and architectural requirements. Therefore, I will show below a short list of those requirements that must be considered not only when designing new systems, but when reconstructing them. These include:

- minimum dimensions, weight and due to this reduction in technical areas (preservation of living space), which is especially important for reconstructions;
- design (linking the elements of air conditioning systems with the interior of the rooms);
- simple installation using a block of equipment (the least amount of time and labor for installation and commissioning of plants in operation);
- possibility of construction and commissioning of systems in operation in stages and in separate rooms, floors (often this problem occurs when reconstruction or for economic reasons);
- vibration isolation and sound insulation equipment (necessary for sanitary-hygienic requirements);
- Fire safety and availability of funds to prevent the spread of smoke and fire in the ventilation channels;

⁶ Gossanepidnadzor – Government sanitary epidemical supervision of Russia

- Security systems, ventilation and air conditioning and protection of the lives of people with possible terrorist attacks.

The choice of air conditioning and ventilation systems to create indoor air quality that meets the established sanitary and technological requirements, depending on the climatic region, from the placement of buildings on the ground, on the purpose of building, its heights, the nature of space and availability of harmful emissions, including from the people. Air exchange and options for the majority of rooms that provided ventilation system is installed SNIps appropriate buildings and facilities, as well as the VSN. If you consider the placement of air exchange is not installed SNIps and other instruments, the ventilation air volume is determined by calculation. For the museums should be designed independent (autonomous) system of air conditioning and supply ventilation.

2.3 Source of noise measurements and calculation of noise

“Noise - all kinds of sounds, preventing the perception of useful sounds, or break the silence, as well as beetles, damaging or irritating effect on the human body, is one of the harmful factors.”/2, p. 331/ Since the purpose of ventilating and air conditioning (ACV) is to supply the calculated amount of air space to create and maintain the premises specified conditions, the low noise level is a very important indicator of a comfortable condition. Therefore, the development of ACV and the selection of appropriate equipment must necessarily take into account the acoustic factor.

Level par noise generated by fans, usually far exceeds the noise levels generated by other sources. When ventilator works, mechanical, structured and aerodynamic noises appear. Mechanical noise is created by mechanical vibrations of structural elements of the fan installation. Structured noise that spreads through the building creates vibrations that are transmitted through the air ducts and to the base on which is mounted installation. Aerodynamic noise is created by vibrations of the velocity and pressure in the air stream flowing through the fan. To reduce the aerodynamic noise generated during movement of air in the ducts, the air velocity plays big role, which should not exceed the normative values. Thus, the value of the velocity of air in public buildings in the main ducts is 5-6 m / s, in the branches - 2-4 m / sec.

2.3.1 Sound power and pressure

Channel noise is characterized by the overall level of sound power, octave sound power level, the characteristic radiation, as well as adjusted sound power level. Sound power level determined by the type of installation and does not depend on the location of the sound source, the distance or acoustic characteristics of the rooms. It represents a constant value related to the parameters and modes of operation of the installation. It cannot be measured directly and calculated in terms of sound pressure or determined indirectly by means of special equipment. Sound waves propagate in the air in the form of pressure oscillations. Sound pressure - the sensation of sound in the ear, measured in Pascal.

In contrast to the level of sound power, sound pressure level is not a fixed quantity. Key indicators are the distance to the installation, the size and shape of rooms, availability of possible reflective surfaces, the height of the sound level meter above the surface during the measurement, etc. The sound pressure level decreases with increasing distance from the source. With the free distribution of this reduction is roughly equal to 6 dB for each doubling of distance from the source. In the real installation of equipment in the room or near the reflecting surfaces the relevant factors have to introduce, taking into account the acoustic characteristics of the premises and the reflection of sound from the walls of the room. All this leads to the fact that the sound pressure level of the installed equipment will be substantially higher than the values measured in the laboratory and listed in the directories on the equipment. For example, reduction of sound pressure with increasing distance of the pressure decrease may be only 3-4 dB.

Sound pressure levels generated by ventilation systems, air conditioning and heating, in accordance with SNIP 23.03.2003 should take a 5 dB below the permissible levels of noise.

2.3.2 Sound protection and noise insulation

Indicators of sound insulation and absorption of noise is often confused with each other. Sound insulation prevents the transmission of sound energy produced by a source of noise at various distances. Soundproofing of special rooms (walls, ceilings, etc.) is performed using "heavy" materials: masonry wall, steel sheet, lead plates, etc.

The excess sound energy is partly absorbed by the walls (and turns into heat), and partly reflected back towards the noise source.

It is clear that the greater the proportion of masonry wall, the greater its insulating qualities. Most of all "heavy" walls are also "hard", so that they reflect well the sonic energy. In some circumstances, these are good sound insulation properties may cause undesirable effects, which should be prevented. Figure 1 shows a theoretical graph of insulating properties of walls of various types on their mass.

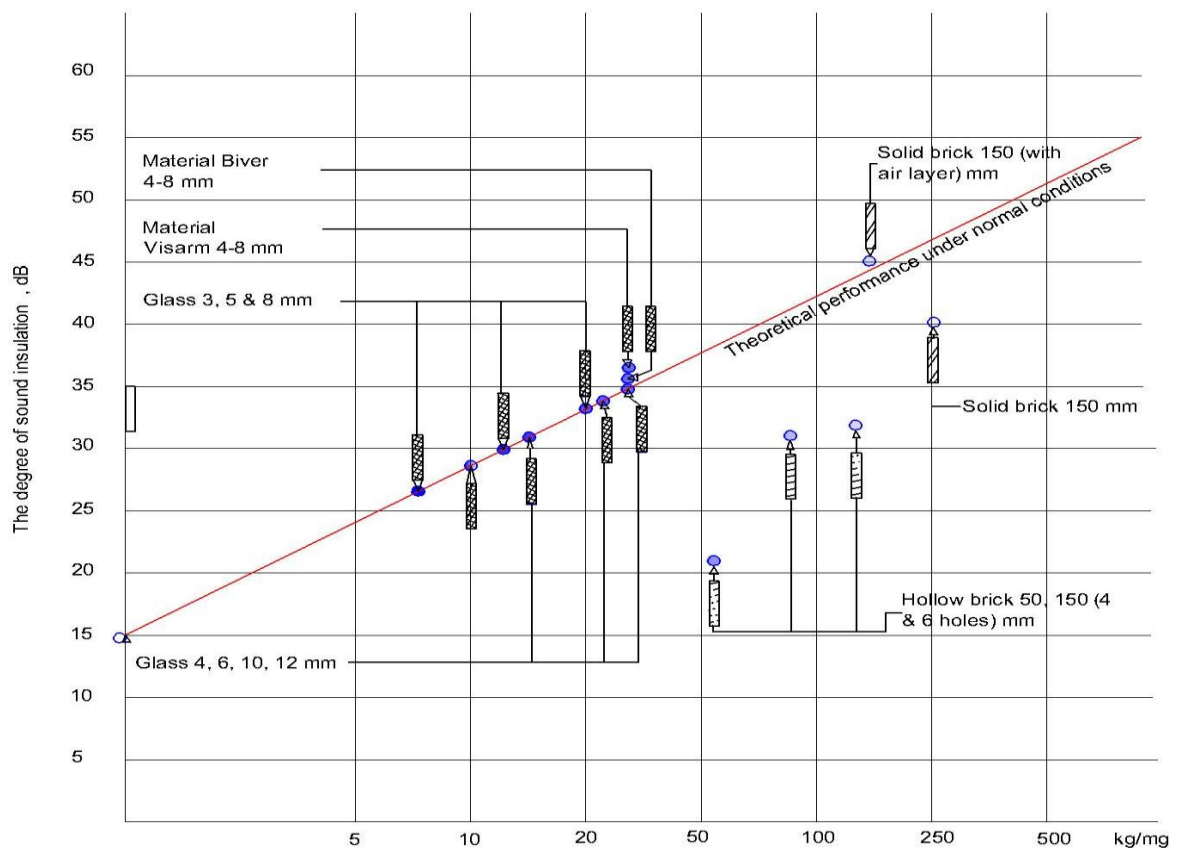


Figure 1. Graph theoretical changes in the acoustic insulation properties of walls, depending on their weight /2, p. 341/

The second indicator associated with the absorption of noise, is to "extinction" of force sound different materials, which, in turn, reduces its reflectivity. The degree of absorption of sound in the room (A), expressed in square meters, can be determined by the following formula:

$$A = \alpha \cdot S \quad (1)$$

Where: α - coefficient of sound absorption material;

S - surface area (m^2), treated or made of material that absorbs sound.

Activities on the absorption of sound associated with the use of porous materials, such as, for example, glass wool and mineral wool, with open-cell foam, cork, carpet, etc. These materials can not completely absorb the sound, but they reduce it to a certain value. It should be noted that the absorbent material is almost always superimposed on the sound insulation in order to ensure both the sound insulation and sound absorption. In the case of the proper selection of sound-absorbing materials in the form of wall covering or ceiling panels can be significantly offset the effect of increasing the level of noise that occurs in the presence of the room "solid" walls. "As seen from Figure 2, after sound-absorbing treatment of "hard" walls in the room the level of sound vibrations is greatly reduced."/2, p. 341/

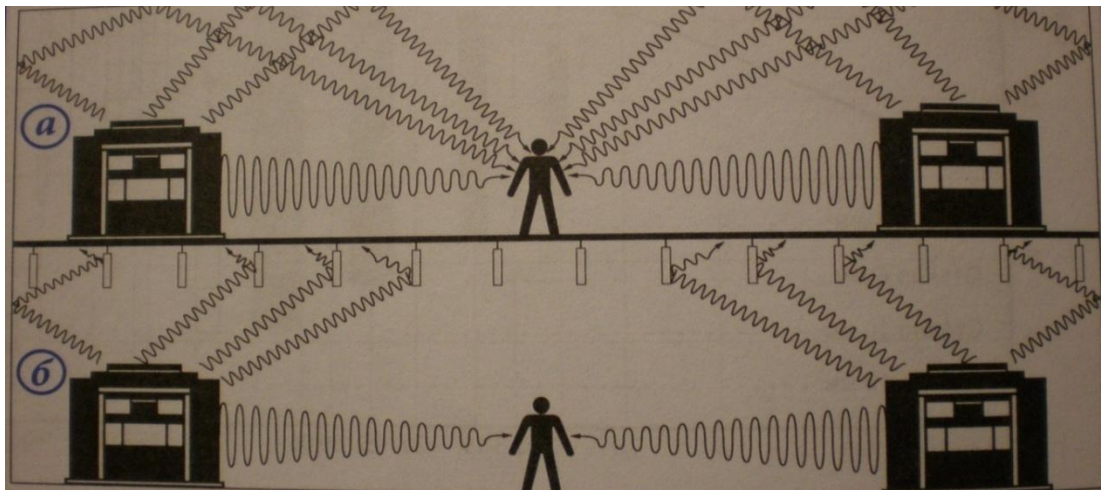


Figure 2. Reflection of sound from a “solid” walls in the room (a); the same room after the sound-absorbing treatment (b) /2, p. 342/

2.3.3 Noise reduction measures in the ventilation and air conditioning

Measures to reduce noise in ventilation systems and air conditioning are based on two types of operations, applicable simultaneously or sequentially:

- measures relating to the very source of noise;
- measures relating to the channels of transmission of noise.

For installations mounted on the outside, for example, outside the building, the choice of location should not be allowed back as the penetration of noise in the room, and spread it over within a certain area within acceptable standards. Sometimes may have to create around a protective acoustic barrier. For this purpose, use ready-made panels, consisting of steel sheet and gaskets, which absorb sound. The surface of such panels, designed to install, has a perforation, which allows for the absorption of noise, and the reverse side of the solid, thereby preventing its further spread.

Blower velocity of the air ducts should also be below certain values, in order to limit the emergence of noise and eliminate the appearance of the effects of "rumble". Table 6 shows the maximum performance speed of air in the air ducts, depending on their size, in addition, specifies the minimum thickness of steel sheet used.

Table 6. Prevention of the effect hums ducts. Maximum speed limits movement of air and minimum thickness of steel sheet /2, p. 348/

Maximum dimensions of air ducts, m	Maximum air velocity, m/s	Minimum thickness of sheet, mm
0,30×0,90	10	0,6
0,90×1,20	9	0,8
1,20×1,80	8	1,0

Another important aspect is the correct placement of dampers, which should not be installed in close proximity to the air inlet, as in this case will inevitably cause noise, depending on the degree of opening of the dampers. Effect of the degree of opening of dampers on the pressure loss and increase the noise level is given in Table 7.

Table 7. Noise, which dampers produces in ducts /2, p. 350/

The degree of opening of the damper, %	Loss of air pressure at station nose-damper about 100% of open position, %	Increased noise, dB
100	100	0
82	150	4,5
70	200	8
50	400	16

Where the requirements for quiet operation of the system are high, it's appropriate to provide the inner surface of channels of sound-absorbing material. It is possible to achieve significant noise reduction. Table 8 shows the performance of noise reduction (dB / running m) the airways in their coverage, sound-absorbing material. In cases where it is necessary to produce a more uniform distribution of air flow while maintaining a specified (defined) in the air, such as larger rooms, it is important to provide for the installation of multiple air intakes and distributors, instead of doing one or two, but the large size and high speed transmission air. "Selection of the intake and distributors in this case should be made subject to low velocity air flows. In case of equal distribution volume of air it will make it possible to reduce the noise level."/2, p. 348-351/

Table 8. Reduction of noise in ducts of rectangular shape made of steel sheets and coating inside the absorbent material 25 mm thick (32 kg/m³), in dB/running m /2, p. 351/

Internal size	Frequency 250 Hz	Frequency 500 Hz	Frequency 1000 Hz
100×150	10	19,6	40
100×300	8	15,5	31,5
150×250	6	12,5	31,5
150×450	5	10,5	21
200×300	5	10	19,5
200×400	4	9	17,5
250×400	4	7,5	15
250×750	3	6	12,5
300×450	3	6,5	13
300×900	2,5	5	10,5

3 DESIGN OF AIR CONDITIONING AND VENTILATION SYSTEM IN MUSEUM OF SUVOROV

This chapter is devoted to the museum of Suvorov. In 2005, air conditioning and ventilation systems have been completely renovated for storage rooms of exhibits in this museum. On this example of this update I will observe what must be considered and how a new system should be done.

“State Memorial Museum AV Suvorov - the first memorial museum in Russia. It was opened in 1904. The new building was specially built for this (Architect Academician AM Gauguin). The museum was built in the spirit of Old Russian villain building. The museum was opened after a decade of reconstruction in May 1998. Interiors of the 5 halls of the museum were restored, new exhibition were opened. It presents the personal belongings of the great commander, painting, graphics, weapons, numismatics, rare books, military clothing and household items. In the collection of more than 100 thousand exhibits and the largest in Russia a collection of tin soldiers - more than 6000 copies.”^{3/}

With the increase in the number of new exhibits and displays there was a question about the storage of the museum. This was chosen mansion of chamberlain of the Highest Court BM Yakunchichkov. The mansion is located in the courtyard near the main body of the museum. Its ventilation system had to be reconstructed so that the storage could be organized in it. The main problem was that this building would be the primary repository for all types of exhibits. The project will be described below, which was specially designed and commissioned for this building. “It was allocated to 630 m² for the depository of the museum in the end.”^{4/} Due to the fact that the building is located in the courtyard, its main fronts: north and south, could safely equip. This equipment had no effect on the appearance of the image of St. Petersburg, it does not spoil. The project identified standards and rules. Engineers have referred to these rules when designing a new system of ventilation and air conditioning. Description of the installation of air conditioning and measures to protect against fire are in this project.

3.1 Ventilation and air conditioning

The design was developed on the basis of:

- Contract 51/01 of 25.06.2001.
- Terms of Reference for the design of air conditioning systems in Repository of SMM⁷ AV Suvorov.

The project is made the conditions of maintaining the premises of the following parameters:

- cold time period $t = 16-20$ °C, $\varphi = 45-55\%$, $v = \max 0,2$ m/s;
- warm time period $t = 18-20$ °C, $\varphi = 30-60\%$, $v = \max 0,2$ m/s;
- for numismatic hall $t = 16-20$ °C, $\varphi \leq 45\%$, $v = \max 0,2$ m/s.

Estimated parameters for the design of outdoor air ventilation and air conditioning systems are adopted in accordance with SNIP 2.04.05-91* /8/:

- barometric pressure (hPa): 1010
- temperature (°C):
 - in cold period -26,0
 - in warm period +24,8
- specific enthalpy (heat) (kJ/kg):
 - in cold period -25,3
 - in warm period 51,5

The design was developed in accordance with applicable rules and regulations: SNIP 2.04.05-91 * "Heating, ventilation and air conditioning"/8/, SNIP 2.08.02-89* "Public buildings and facilities"/9/, SNIP 21-01-97 "Fire safety of buildings and structures", SNIP 2.01.02-85* "Fire rules", GOST 12.1.005-88 "General sanitary-hygienic requirements to air of the working area"⁸, GOST 30494-96 "Residential and public buildings. Parameters of the microclimate in the premises", SNIP II-1277 "Noise", SN 2.2.4/2.1.8.562-96 "Noise in the workplace, in residential , public buildings and in residential areas", GOST 12.1.003-83 "Noise", SNIP 3.05.01-85 "Internal plumbing

⁷ SMM - State Memorial Museum

⁸ GOST - all-Union State Standard

system” /10/, VSN⁹ 353-86 "Design and application of air from standardized parts", SNIP 2.04.01-85* "Domestic water supply and sewerage".

3.1.1 Ventilation and air conditioning

Air-conditioning for the storage space taken in accordance with SNIP 2-04.05-91* first class. Mode settings - non-stop, year-round. Calculation of air exchange produced from the condition of assimilation of thermal emission from solar radiation, from lighting and from the staff, with the multiplicity of air exchange in rooms of 3 to 6. All the rooms has a lockup due to excess air flow over the hood. It prevents the flow of crude outside air and from the adjacent premises. Flow of recirculation air passed at 90% on the volume of supply air (SNIP 2.08.02-89 * p.3.32). /10/

The regulation of air parameters in the rooms prescribed for the faces. This included 2 air-conditioning system C1¹⁰, V1¹¹ and C2, V2, serving the areas along the northern and southern fronts, respectively. Equipment installations of systems C1, V1, C2, and V2 placed in the ventilation chamber, located in the attic between axes 3-5 and B-V. The room ventilation chamber provides electric heating. The schematic plan of the premises is in Appendix 1.

In connection with the need to maintain indoor humidity storage of coins less than 45 air treatment in this room by using an autonomous precision air conditioning CR3 installed directly in the room. This conditioner provides everything necessary to maintain the preset parameters of the operation: air purification, heating and humidifying the air in the cold period, cooling and air drying in the warm period, allowing for adjustment and maintenance at a constant level and with a high degree of precision temperature, humidity, cleanliness and mobility of air in the room. The outdoor unit is placed in the roof between axes 2-3 and V-G. Schematic plan of the premises is given in Appendix 1.

In the composition of air conditioners C1, C2 are: the mixing section, filter class G3, section filter class F5, section Cooler, Air, steam humidification section and a section of the fan (see the schematic diagram of air conditioning systems C1, C2). The design

⁹ VSN - Departmental regulations

¹⁰ C1 – air conditioning system (1,2,3 – number of system)

¹¹ V1– ventilation system (1,2,3 – number of system)

provides for two-stage cleaning air filters, Class G3, and F5. In the cold season the air heats in an electric air heater and humidifying in steam humidifier. In the warm period cooling and drying of air are provided through the surface air coolers and electric air heater.

To create the required parameters of indoor air installation estimates C1, V1 and C2, V2 can work around the clock and year-round. Filing and extraction takes place systems on a "top-up". Plants C1 and C2 are equipped with devices to automatically maintain the required temperature and humidity of air supplied, as well as the automatic protection of workers and working hours, which includes off systems in case of fire, pollution control, air filters, etc. Emergency lights are displayed in the premises of.

System of cold supply CS1 services installation of systems C1 and C2. Cooling unit without a capacitor installed in the ventilation chamber, tank (intermediate tank) for the refrigerant - in the attic between axes 4-5 and B-V. As the refrigerant antifreeze is take in ethylene glycol solution with water (20%). Outdoor units (air-cooled condensers) are installed on the roof between axes 4-5 and V-G. Schematic plan of the premises is given in Appendix 1.

The project provides for the following fire-prevention measures:

- ducts were designed from non-combustible materials;
- limit of fire resistance of the transit of air passing outside the serviced accommodation 1-st floor not normalized(tab.2 p4.118 SNIP 04.05-91*). Limit of fire resistance of transit air passing outside the serviced floors and the attic - 0,5 hours.
- When ducts systems C1, C2, V1 and V2 crossing garret floor fire-retarding valves are installed with a limit of fire resistance for 1 hour.

Air ducts are made of galvanized steel class "T" (thick) with sealing joints. Isolation transit air is carried out to ensure the fire resistance of not less than 0.5 hours and in order to save the cost of heat (cold season) and cold (warm period).

To ensure silent operation provides ventilation systems:

- installing a fan in a ventilation chamber;
- installing fans on resiliently supported base and connection ducts with flexible inserts;
- install muffler and insulation of air passing through the attic.

The water supply to the steam generator installations C1, C2 and C3 are provided by city water supply with the installation of mechanical cleaning of the filters. The extraction of condensate from steam humidification sections, air-cooling and from steam condensate is carried out into condense pipe through a siphon with a discontinuity of the jet. Condense pipe is laid on the premises of the 3rd floor between the axles 1-3, V-G with a slope of not less than 0, 01. Discharge of condensate is carried out in existing sewage risers with a discontinuity of the jet.

Choice of equipment for ventilation and air conditioning is carried out according to the principles of: high quality and reliability, long lifespan, adapted for use in winter conditions (-26 °C to work), staffing automation systems (management and protection), low noise; compact dimensions, ease of maintenance and installation, optimal price-performance ratio. In connection with this project equipment was chosen: Wolf (Germany), Covet (Italy), Kanalflakt (Sweden), Uniflair (Italy), Carei (Italy), equipment automation Kiback (Germany). All ventilation equipment has a certificate of compliance with the RF¹².

3.1.2 General installation instructions

This section describes the main general installation instructions. This section states what is needed to isolate, where it is necessary to take information about the insulation. Requirements presented in a list, in order to better perceive them.

1.1. General installation instructions

1.1.1. Assembling, manufacturing, fixing and testing of ventilation systems, air conditioning, refrigeration, and plumbing systems and removal of condensate to produce according SNIP 3.05.01-85.

1.1.2. Markers of air are given in the diagrams: the round - on the axis, rectangular - on the bottom.

¹² RF-Russian Federation

			m ³ /h	syst.		m ³ /h	syst.		
1 floor									
19	Hall of possession of weapons	344	950	V2	2,8	1050	C2	3,1	200
2 floor									
20	Hall clothing store	286	800	V1	2,8	900	C1	3,1	100
25	Hall of storage of precious metals	42	180	V2	4,3	200	C2	4,8	20
29	Hall storage tin soldiers	291	870	V2	3,0	970	C2	3,3	100
3 floor									
31	Hall Storage Painting	252	850	V1	3,4	950	C1	3,8	100
32	Hall storage of arts and crafts	137	580	V1	4,2	650	C1	4,7	70
33	Storage Room banners	180	800	V1	4,4	900	C1	5,0	100
35	Hall of coins' storage	67	1580	C3	23,5	1580	C3	23,5	-
36	Hall storage graphics	154	720	V2	4,7	800	C2	5,2	80

37	Rare Book Room	101	410	V2	4,1	460	C2	4,6	50
38	Hall storage of books and charts	162	650	V2	4,0	720	C2	4,5	70
39	Workshop Restoration clothing	81	360	V2	4.4	400	C2	4,9	40

Schematic diagram of VAC-systems (C1, C2, V1, V2) is given in Appendix 2.

3.2 Power equipment and automation

Detailed design of electrical equipment and automation of air-conditioning units developed under the requirements of the customer. Also, this project has been developed based on elaborations of technological and sanitary-technical parts of the project. In developing the project takes into account the requirements of the following rules, regulations and standards:

- SNiP 11-01-95 "Instruction on the development, coordination, approval of project documentation for construction of enterprises, buildings and structures";
- REI 2000 "Regulations for Electrical Installation";
- VSN 59-88 "Electric installation of residential and public buildings";
- SNIP 3.05.06-85 "Electrical equipment";
- SNIP 3.05.07-85 "Automation Systems";
- GOST R50571.15-9 "Electrical installations of buildings";
- SNIP 23-05-95 "Fire safety of buildings and structures";
- GOST 21.101-97 "Basic requirements for the design and working drawings.

In the scope of the project include:

- Power equipment and automation systems, air conditioning A1, B1, A2, B2 Repository SMM AV Suvorov.
- The task for summing the power to shield SB¹³1 and unitary air conditioners C3.

In the scope of the project does not include power supply.

3.2.1 Power equipment

Main electrical receivers of designed system are: electromotor of pumps, fans, compressors of chillers, steam generators, electric heaters.

Meals of electric equipment are provided from the electrical control panel SB1 installed directly in the technological premises (ventilation chamber) in the attic, where the main power-consuming equipment of air-conditioning system are housed. Shield SB1 is installed on a stand with a wall mount ventilation chamber. In this project the power control board SB1 not included. All electrical receivers are low voltage and are supplied from industrial network voltage 3NPE ~ 50Hz »220/380V. Installed capacity at the input panel SB1 - 48,7 kW. The design capacity is 36.1 kW. The installed capacity of unitary air conditioners C3 - 3,8 kW. The design power - 4.7 kW.

3.2.2 Automatic performance

Project of automation is designed according VSN 281-15 "Guidelines for the design automation of technological processes". The project includes the automation of air conditioning of facilities of museum depository. The regulation of indoor of air parameters is anticipated on the facades. This included 2 air-conditioning system P1, V1 and P2, V2, serving the areas along the northern and southern facades. Air conditioner supports the given parameters of fitted air. Indoor storage room of the coins provides the installation of unitary air conditioners SVA 0151 (outdoor unit CAL 0231) power 5,8 kW. Air conditioning systems are managed and controlled by automation company Kieback&Peter. The control system consists of a programmable controller series DDC 3000, built-in power board SB1, and expansion units. At the

¹³ SB – switchboard

board SB1 has withdrawn lights showing operating status of equipment: supply fan, exhaust fans, steam humidifier, electric air heater, pumps, filters, air valve, fire valve, refrigerating machine.

Also in the room service provided for the withdrawal of a general emergency light signal: installation of C1, installation of C2, autonomous conditioner C3.

Schemes of automation include:

- automatic temperature control space by a smooth control of valves of cooling water clarifier and by binary control law stages of installation's electric air heater;
- automatic control of humidity by the smooth performance management of steam generator and switching facility to the drying air;
- control of air parameters, refrigerant and condition of all equipment;
- automatic start and stop equipment for the temporary program;
- automatic shutdown systems, on a signal from the fire alarm.

The system can be expanded to control any other equipment. It is possible a free connection to a central control station and integration with the equipment of Landis&Stefa.

3.2.3 Installation instructions

All Power points run a cable with copper conductors in PVC¹⁴ insulation and in PVC shell, not subject to burning. Cable within the ventilation chamber is laid on cable trays, which are grounded in a ventilation chamber to the ceiling. End joining is carried out in wiring pipes. Cables in the attic are laid in flexible wiring tubes with mounting to existing structures in place. Cables and wires to the outdoor unit capacitors CD1, CD2 are summed up on the route wires, transporting Freon, in flexible wiring tubes. In the zone of visibility of condenser units' CD1, CD2 switches protect SK1 and SK2 are installed. Cables and wires to the outdoor unit air conditioner C3 are feed indoors in plastic boxes with the separator. Cables alarm from SB1 and autonomous air-conditioner C3 are laid in the room of running in flexible

¹⁴ PVC - poly vinyl chloride

wiring tubes. Setting fire valve is provided on the ducts crossing the attic floor. Penetrations through walls and floors are sealed fireproof and easily punched material in accordance with SNIP 3.05.06.85.

3.2.4 Connection to ground

Grounding System is adopted by the TN-CS. All metal parts of designed equipment and structures, normally not under stress, have to be grounding. To use a separate ground zero protective wire. Electrical connection between the metal structures is ensured by the use of galvanized structures and reliable bolts. To remove the electrostatic voltage, air ducts, separated by insulating flexible inserts are subject to reliable electrical connection between flexible stranded wires.

3.2.5 Interaction with the fire alarm system of the building

To stop the equipment power supply feeder shield SB1 can be turned off at the switchboard of the building, where it is connected, in the case provided the project fire alarm. Equipment can stop the program by using the signal of fire alarm system. To this end, the shield SB1 provides terminals for connecting the signal. At the same time, stopping the equipment, fire valves are closed. To close the valve the potential cocked springs is used. After the restoration of power or removing the signal system of fire alarm systems turn on of equipment to work descends automatically.

4. EXPERIENCE OF THE RUSSIAN MUSEUM IN THE RECONSTRUCTION OF ENGINEERING NETWORKS

In this chapter I will describe briefly about the Russian museums and on the progress of its reconstruction. Ventilation and air conditioning systems will be considered by the example of the academic halls of the Russian Museum.

4.1 Description of museum

“The State Russian Museum - the world's largest collection of national fine. It was founded in 1895.”^{1/} Mikhailovsky Palace is the main building of the Russian Museum, which was built in 1819-1825. Global reconstruction of the Mikhailovsky Palace began in 1991.

“85 exposition halls, entrance lobby and a front lobby with a total area 20,624.11 m² were rebuilt between 1991 and 1998. Also restoration of truss system of the Mikhailovsky Palace and the Rossi Wing with the replacement of the roof was in this period. Reconstruction and restoration of the exposition halls and stock space has been made before 2003. Engineering services also have been replaced in these terms. The overlapping of light (internal) courtyards was reconstructed until 2008. Exposition and stock halls were equipped with the system of the maintenance of an artificial microclimate also before 2008. Currently, the Russian Museum collection contains 384 676 exhibits.”/1/

4.2 The academic halls

The information presented below was obtained during interviews with the chief engineer Valerii Dmitrievich of the Russian Museum./5/

Basic principles and decisions of the reconstruction of engineering networks will be presented on the example of two academic halls of the Russian Museum. In appendix 5 you can see the principal scheme of the academic halls' system. The great cloth paintings of the first half of the 19 century are collected in these halls. For example: Karl Briullov masterpiece “The Last Days of Pompeii” (size of this painting about 6,5×4,5m) and the picture of Ivan Aivazovsky “The Ninth Wave”, which are shown in Figure 3.



Figure 3. Masterpiece of Russian museum

The size of these rooms is large enough: only the height of the rooms is around 10 m, and the area of one of the rooms is around 260 m². The ventilation and air conditioning in these rooms had been updated only partially. The main problem was that the internal channels were not designed for new air conditioning system. Due to the successful arrangement of the academic halls space of the enclosed court can be used. In this part ducts were made on the facades of the building. An example of this is shown in Figure 4. If there were no yards or more rooms, where they could pave the ducts, then to achieve the ideal conditions in the premises would be virtually impossible. It would have to seek compromise solutions, and at first it's necessary to create favorable conditions for the storage of exhibits.



Figure 4. Using of the enclosed court

At the same time the ventilation system was successfully implemented. Supply air ducts run under the floor, and the air is fed through the holes in the floor. Supplied through the floor the air is removed by recovery over the top. Exhaust air going through the openings of channels, which are located under the ceiling. These channels are located within the walls. Recycling is present in the system.

Another innovation of the Russian Museum is a “skylight”. It is also used to create a comfortable microclimate in the academic halls. An example of integration and the external appearance of the room you can see below in Figure 5.



Figure 5. “Skylight” in the academic hall

This “skylight” reduces the work of air-conditioning system, saves energy and reduces the noise from the system. The only one drawback is observed in the summer - large heat loads. Fans go on at $T = 28\text{ }^{\circ}\text{C}$. They collect air of the street and drive it through the volume. In the second level glazing windows apply a special design. Rasters from foil are between the panes. These rasters were oriented toward the light, and thus they reflect the radiation in the summer. Thus, they reduce the work of air conditioning system. Scheme of the “skylight” can be seen below in Figure 6.

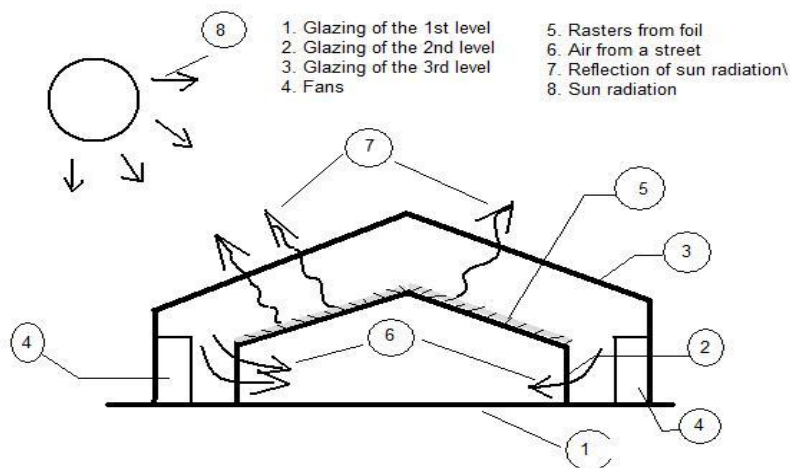


Figure 6. Scheme of the “skylight”

Graphs of temperature and humidity of the academic halls for May 2009 are given in Appendices 3(1) and 3(2). These graphs shows that in aggregate all of these systems are provide academic halls required parameters of air and moisture in accordance with SNIP 41-01-2003 (Heating, ventilation and air conditioning).

5. APPLICATION OF THE “HERMITAGE’S METHOD” FOR REGULATING CLIMATE IN RESIDENTIAL AND PUBLIC BUILDINGS

Previously air-conditioning and ventilation systems were reviewed for the two museums: Russian museum and GMM of A.V. Suvorov. Systems were considered for two different types of facilities in these museums. We learned how to renovate these systems having various problems with them. The following chapter will consider an example of the Hermitage. In this chapter we will examine how you can to use the building itself, to change the microclimate in the premises. This example is very important and significant. Many buildings are historical museums like the Hermitage. In many buildings are not possible to install modern air-conditioning system. In this

regard, we consider the most interesting solutions that are also fashionable to apply to other buildings. These solutions include three types: “Dagmar”, “Fortochka”, and “Rastrelli”.

5.1 “Dagmar”

“Dagmar” - Progressive method of using water to create a cool microclimate around the buildings in the 21 century. “Biological” air-conditioning can lead to the creation of a special microclimate in the interior courtyards of the museum.”/6, p. 5/ As a result, in the summer air in these areas will be cleaner and cooler than in other places. This air can get through the air intake vent, facing in these areas. Another positive feature of this conditioning is that the cold air in the trees will fall to the ground. This air draws into the space of the courtyard masses of fresh air from the higher layers. The flow of cool air will further strengthen the effect of cooling. From a technical point of view, the evaporation of 0,2 liters of water by volume produced by the cooling equivalent of the cooling of one liter of water from 100 to 0 degrees Celsius. What is also equivalent to 40 cubic meters of cooling air at 10 degrees. 50 grams of water have sufficient latent energy to cool 10 cubic meters of air from 30 to 20 degrees Celsius. It does not require complex mechanical devices that must be purchased, bear the costs of operation, to supply electricity, to hear it noise, and find a place for it, and replace after 20 years of service. There is no doubt that the refrigerator is a necessary and adequate cooling of the product of modern technology. In certain situations, we cannot do without air-cooling by mechanical air conditioners. To assess the need of using any funds must be approached with great caution. Moreover, if the designers pay little attention to the building, the amount of equipment needed to provide heating, air conditioning or ventilation will be minimal. This approach offers significant advantages in economic, ecological and ethical point of view. Scheme of the “Dagmar” is shown in Figure 7. ““Minimalist” method of regulating the climate was used by Danish and Russia's specialists in certain areas of the Winter Palace. This method can also be used when working with other architectural monuments.”/6, p. 6-7/

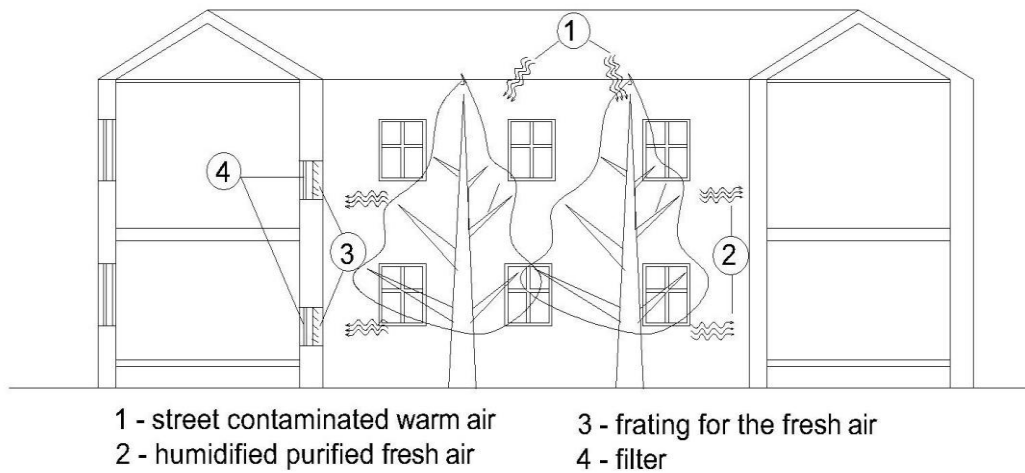


Figure 7. Scheme of the “Dagmar”

5.2 “Fortochka”

“Fortochka” - Multifunctional window of innovative design of the 21st century. Word “Fortochka” in Russian means a ventilating sash.”/2, p. 12/ The windows of progressive design are developed in a number of advanced research institutes and industrial companies worldwide. They have a number of adjustable functional capabilities that are absent or represented in a limited way in the design of conventional windows. A distinctive feature of the new engineering solution is that the external frame has one glass and the inner frame is equipped with two panes. External frame creates a basic protection from atmospheric action. Internal frame provides the necessary climatic conditions inside the building. Small sash are installed in the external and internal frames. Some shutters are located at the top of the window, the other at the bottom. Air space between frames creates a kind of buffer zone. The air temperature is midway between the temperature outside and inside the house. The presence of such a zone helps eliminate drafts, limits entering in the restricted space dust particles, soot, pollen and other pollutants. This space can also accommodate special devices for protection against solar radiation, energy absorption, eliminating noise and moisture. This multi-layered construction gives people the opportunity to regulate indoor climate, depending on weather conditions.

A variety of multi-functional window is "smart" window. These windows are equipped with small hidden motors, sensors and communication devices. Thanks to

this equipment this "smart" design will be able to automatically adjust the level of temperature and humidity according to predefined settings. Electric lighting may also be installed on the window. Consequently, the daily and artificial light will come from the same zone. The design of the "double" windows combines the comfort and safety because ventilation leaf of inner and outer frame are located at different heights.

Currently, advanced engineered windows demonstrate our movement back and the lack of any progress. Modern plastic windows have a number of significant negative traits: they are colder and more harmful to health, too tight and have little opportunity for customization. It's hard to ensure a normal supply of fresh air through these windows. "However, the international manufacturing standards prevent the use of advanced types of windows. These standards do not account for the further development of the product. Therefore, they do not contain methods for calculating the temperature balance created in the air flow between the two frames of "Fortochka" window."⁶, p. 14/ While it is clear that you can measure the air coming through the windows of this type. This air is heated by the heat coming through the inner frame. However, strangely enough, the existing standards do not have the necessary coefficients for the relevant calculations. Scheme of the "Fortochka" is shown in Figure 8.

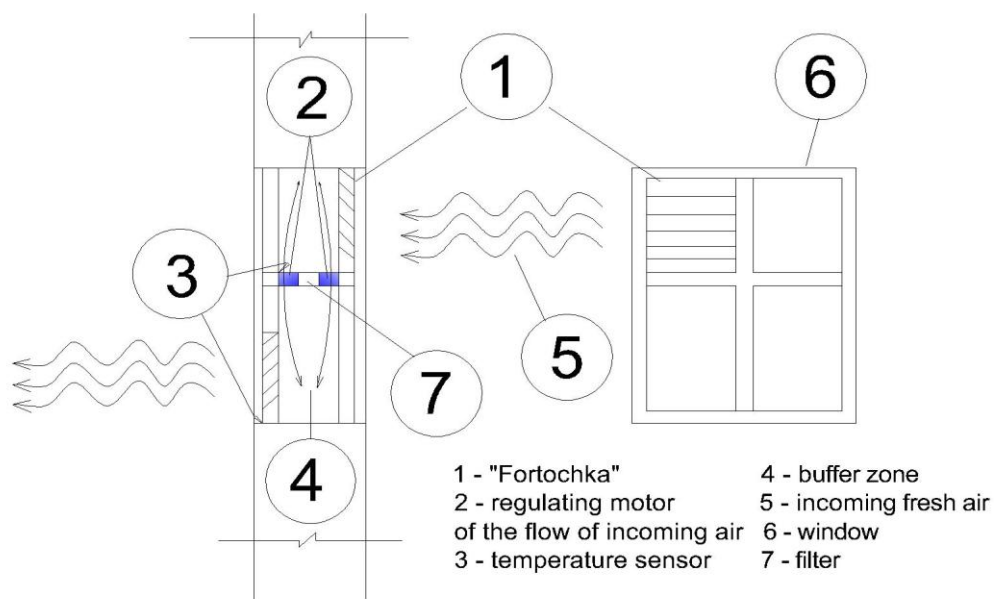


Figure 8. Scheme of the "Fortochka"

5.3 “Rastrelli”

““Rastrelli” - A progressive system of vertical distribution of air 21st century. At present, the progressive systems of vertical distribution of air are developed in a number of advanced research centers around the world. These systems have contributed to increasing the "natural" ventilation. From a historical point of view, the creation of vertical ventilation channels integrated into the structure of buildings was an important step to protect public health. This engineering solution can be observed in different times and in different countries.”/6, p. 33/

The energy crisis of the last decades of the last century shows the need for other, more "sustainable" technologies. This also contributes to fragility of electromechanical devices and their other shortcomings (noise, servicing costs, lack of adjustment, and, in particular, and the likelihood of health risks in case of failure). That is why many of today's research focused on studying different types of natural ventilation. The elegance of the method Rastrelli is that numerous vents, which are built into the walls of the building and are part of the chimney systems, create the possibility of individual control of ventilation. Thus, the original ventilation system of the Winter Palace was not a separate engineering system or a system integrated into the architectural solution. It was part of the building itself.

“The specificity of such systems lies in the fact that two or more parallel channels are located in each room in the outlet or tube, located on the roof. Channels are laid in the walls and are part of building. One channel is designed to supply air, the other on its extraction, while it is possible to provide a return heat.”/6, p. 34/ It’s necessary to arrange the outlet channel with the warm air and the inlet channel of cold air next to each other. One of the challenges of modern construction is phenomenon of condensation in ventilation ducts with cold air. In order to avoid this problem, you must use materials with hygroscopic properties. In these materials, there are two “degrees of protection” from such condensation. Due to their properties, these materials absorb moisture, reducing the vapor pressure sufficient for the transfer of moisture inside the structure of the building. Also, they do not allow condensation and redistribution of moisture, preventing the formation of water.

Fire safety is one of the important aspects. To ensure fire safety measures fire valves can be built into channels. These channels can automatically isolate the individual

parts of the building, forming, thus "controlled zone". This element is needed in the design of any building, but for the Hermitage, he has a special significance. Particular attention should be paid to the extraction of smoke for the successful evacuation of visitors. Inlet vertical air ducts located in the upper part of the premises are an important tool for solving this problem. "A key feature of the ventilation system under the name "Rastrelli" is that the openings of channels are located on different levels. One hole, or grill, is set at a low level, about floor, and the second - at a high, near the ceiling." /6, p. 34/

Due to the natural thermal processes, the air temperature near the ceiling is higher than the air temperature at floor level. Warm, stale air rises up and fills the ventilation duct located near the ceiling. As a result, one channel is filled with warm air, and the other - cool. "The different density of air in the channels leads to the pressure difference, which can be determined using Bernoulli's equation:

$$\Delta P = (\rho_1 - \rho_2) \cdot g \cdot h \quad (5.1)$$

Where: ΔP – pressure difference;

ρ – density;

g – gravity;

h – height dimension.

In large halls, the difference in temperatures is even more palpable. This leads to increased natural circulation, and the quantitative ratio remains unchanged. "Air circulation is created in the room with this natural driving force, the nature of which can be controlled by lattice opening of the channel, located at the floor level." /6, p. 35/

This system was used by Rastrelli for the fireplace heating, which was originally used in most rooms of the palace. Natural air draft occurs during firing, which draws air from the fire to other parts of the premises, causing a strong draft. Rastrelli was able to avoid the possibility of such an unpleasant phenomenon, paving the ventilation duct in parallel with a chimney, a hole which is located in close proximity to the fireplace.

In combination with a new type of window "Fortochka"(see relevant section), the system of ventilation ducts with spaced vertical holes "Rastrelli" provides a wide variety of opportunities ventilation. By means of it individual consumers can be provided with the necessary air quality and in the desired volume.

“Smart” system is a kind of simple system with two ventilation channels. This system is equipped with a hidden motors, sensors, fire alarm and communication devices, which will coordinate the work of ventilation and mode of operation of the windows. Also, the system can automatically adjust the indoor climate, following the commands that are transmitted by phone or in accordance with the predefined settings.

6. CONTROLLED CLIMATE FOR PRESERVING ART

In this chapter, I would like to consider the experience of reconstruction of the HVAC system in foreign countries. The Denver Art Museum has been chosen as an example. This information was based on an article from the Ashrae 1996.

6.1 The Denver Art Museum and its system

“The Denver Art Museum holds the largest comprehensive art collection in the Rocky Mountain Region. The museum, originally constructed in 1968, was experiencing numerous mechanical failures and at the start of our project in 1991 was due for a major renovation.”/6, p. 39/ Six-storey building general area of 18 580 m was heating and cooling by two-pipe system. This system with constant volume had a fan, a capacity of 240 kW, which worked 24 hours a day. This fan could not cope with its work. “Heating and humidification was being accomplished by treated central plant steam that was generated off site. It was recognized prior to our project that amines in the treated steam were adversely affecting the art and that this type of humidification had to be eliminated.”/6, p. 39/ Due to the fact that the lighting load will be increased in accordance with the new project, it was necessary to increase the capacity of the chilled water system and the air system. Another problem was that the air went from the street, where parking was located.

The Denver Art Museum is considered one of the main and most visited museums in the city and the West. To close it completely for repair was impossible.

6.2 Energy Efficiency

Prior to that one fan worked in the museum, which provided the building is constantly 94 380 l/s. In this connection, electricity consumption was high enough. “Through discussions with the art museum and the museum's staff of specialists, it was determined that a new design minimum of 50 of the supply maximum was sufficient to provide a safe environment for the art work.” /6, p. 39-40/ In this regard, it was decided to establish two separate air-handling unit with a fan in each other. The existing boxes were modified to vary the volume of air supplied to the conditioned space. Figure 9 shows it below.

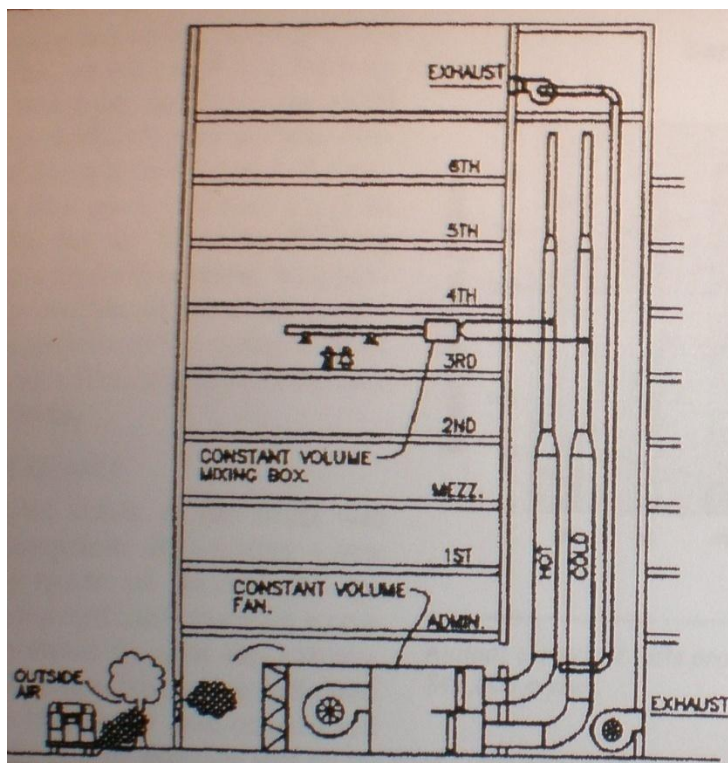


Figure 9. The old system installed in 1967 used a angle, constant-volume fan that left the entire structure vulnerable to fan failure. Also, the existing electrical service and distribution were not large enough to meet the future lighting load. /7, p.40/

“This modification to the constant volume system and the requirement to keep the museum open led to a rather innovative approach to the construction of the new system along with other innovations.”/7, p. 40/

6.3 Innovative Design Features

Since the museum had to be left open, the old system had to work until the new system would be introduced. For this was used a phased construction plan. “Since the renovation had limited funds, and the museum had limited space, we had to reuse the space that the current system occupied. Therefore a new site for roughly half of the AHU system was found on the roof of the building.”/6, p. 40/ This allowed to construct a new system, which was powerful enough. With the new system up and running and connected to the existing ductwork, the original system was demolished and replaced with another system similar to the one on the roof which is shown in Figure 10.

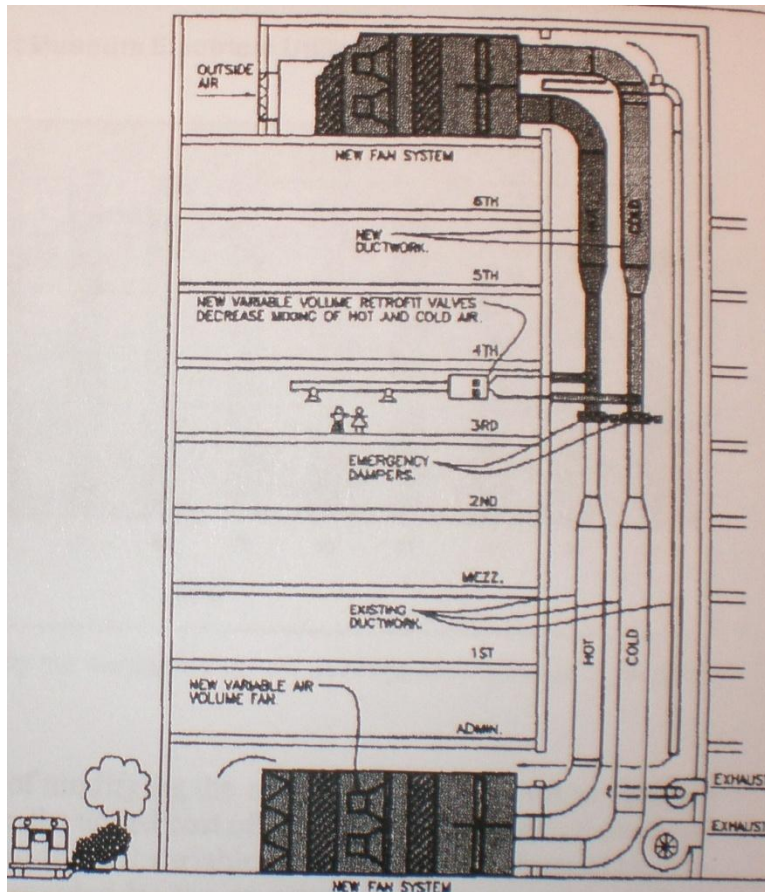


Figure 10. The new system was designed so that if both fans in one system fail, the emergency damper between the two systems will open and the art will be protected. /7, p. 40/

“Another innovation came as a result of working within the confines of the original system which had all of the humidification supplied at one location. Prior to this system could not ensure the building of constant relative humidity. In this regard, the new system demands much of constant relative humidity for the museum. “DDC controls were added on the floor to sense

the dry bulb and wet bulb temperatures and to reset the dry bulb setpoints to accomplish a constant relative humidity. Weekly hygro-thermographs on the floor have confirmed that this was as effective solution.”/7, p. 40/

“Our final innovation was a rather unique control strategy adapted to gain accurate control of the amount of moisture added to the outside air and at the same time keeps the media pad constantly wet for optimum scrubbing action.” /7, p. 41/ Thanks to this innovation it was possible to regulate how much you need to add moisture to the air. It was necessary to add heating and cooling coils upstream of the media. “Thus, by utilizing tried and true dry bulb controls, with psychometric principals, we were able to control the amount of moisture added without bypass controls or cutting back on the area of wetted media.”/7, p. 41/

6.4 Indoor Air Quality

With the old system, the air was taken from the street below that did not satisfy the standards. When the new system was introduced, it became possible to use the air entering from above. As a result, dust and exhaust fumes were excluded due to the fact that one of the plants was on the roof. “A new fan system dedicated to bring in outside air was constructed parallel to the new air handling unit on the roof. This new constant volume system assures a constant volume of outside air even though the main AHU's are varying their volume to meet varying building loads. This separate system consists of a separate fan with a cooling coil, heating coil and evaporative cooler as discussed earlier. Since all of the outdoor air comes in at one location, it is here that it is humidified separate from the other air handling units. The evaporative unit was selected to both humidify and clean the air. The media fill evaporative unit scrubs and absorb water soluble pollutants such as sulfur dioxide before they enter the building.”/7, p. 41/

6.5 Summary

“Open communication between the design consultant and the museum staff resulted in creating new criteria to design by. Enabled by this new criteria, the renovation of the mechanical system has resulted in a system with increased capacity and reduced operating costs as well as a more accurate control of the local relative humidity. All this was done and at the same time the indoor air quality was improved in a vital, thriving building always open to the patrons of art.”/7, p. 41/

Experience of Denver Museum shows how we can use the existing installation to continue the museum in work and at the same time, reconstruction of ventilation systems. First of all it gives us the economic benefits. No need to close the museum for a full reconstruction of the systems. This is possible due to the fact that many Russian museums have sufficient volume and have the possibility of a temporary redistribution of exhibits. Applying this experience, we can save not only exhibits, but also to introduce new technologies without fear of increased cost of tickets and thus losing visitors.

7. CONCLUSION

After researching this topic, you can saddle the conclusion that the topic was not sufficiently developed, especially in Russia. This is facilitated by a number of reasons:

- Many museums in Russia have limited technical ability.
- Most museums do not have sufficient funding, as they are in public care.
- Architectural solutions of the most buildings do not allow them to organize a new system to ensure internal microclimate.
- Due to the limited installation of new equipment, hard to find equipment that can provide favorable conditions for the storage of exhibits at the same time finding people in this area.
- One of the difficulties is also a lot of rules that do not always overlap with each other. They are from different spheres of their application (artifacts and people).

However, after this work, we can conclude that there are several ways that can mitigate this problem. Moreover, these solutions lie on the surface and came out of the past. Many buildings were in the past mansions, which were later converted into a museum. In view of this, these buildings have an adequate system of chimneys and air channels, you can use the principle of "Rastrelli". It is also easy to use double glazed windows with a buffer zone, according to the "wicket", as the architectural solutions of these types of buildings take into account the relatively thick walls. Type "Dagmar" use more difficult, as not at all museums have a courtyard, where it is possible to use this type. Suppose that these decisions do not exhaust the entire problem, but they help to solve it partially. Advantages of these solutions are that they are quite beneficial

economically. The results and use of data types, you can establish in the shortest possible time. Appearance of many museums can not be spoiled by more complex technical equipment. These solutions is also possible to use private investors who have decided to buy the old buildings and to provide them with modern climate system.

As for the big museums, there will certainly be a useful experience of Denver museum and the Russian Museum. In the first case, this experience is useful because in this reconstruction system, we do not close completely the museum. At the same time visitors can attend exhibitions, which means that financial flows. Experience of the Russian Museum is useful primarily to those buildings, which originally was designed for museum exhibitions. Although in this case there is no complete harmonization of rules and requirements.

The outcome of this work is to show that there are quite a few solutions that can help solve any of the problems associated with the reconstruction of ventilation and air conditioning systems in museums.

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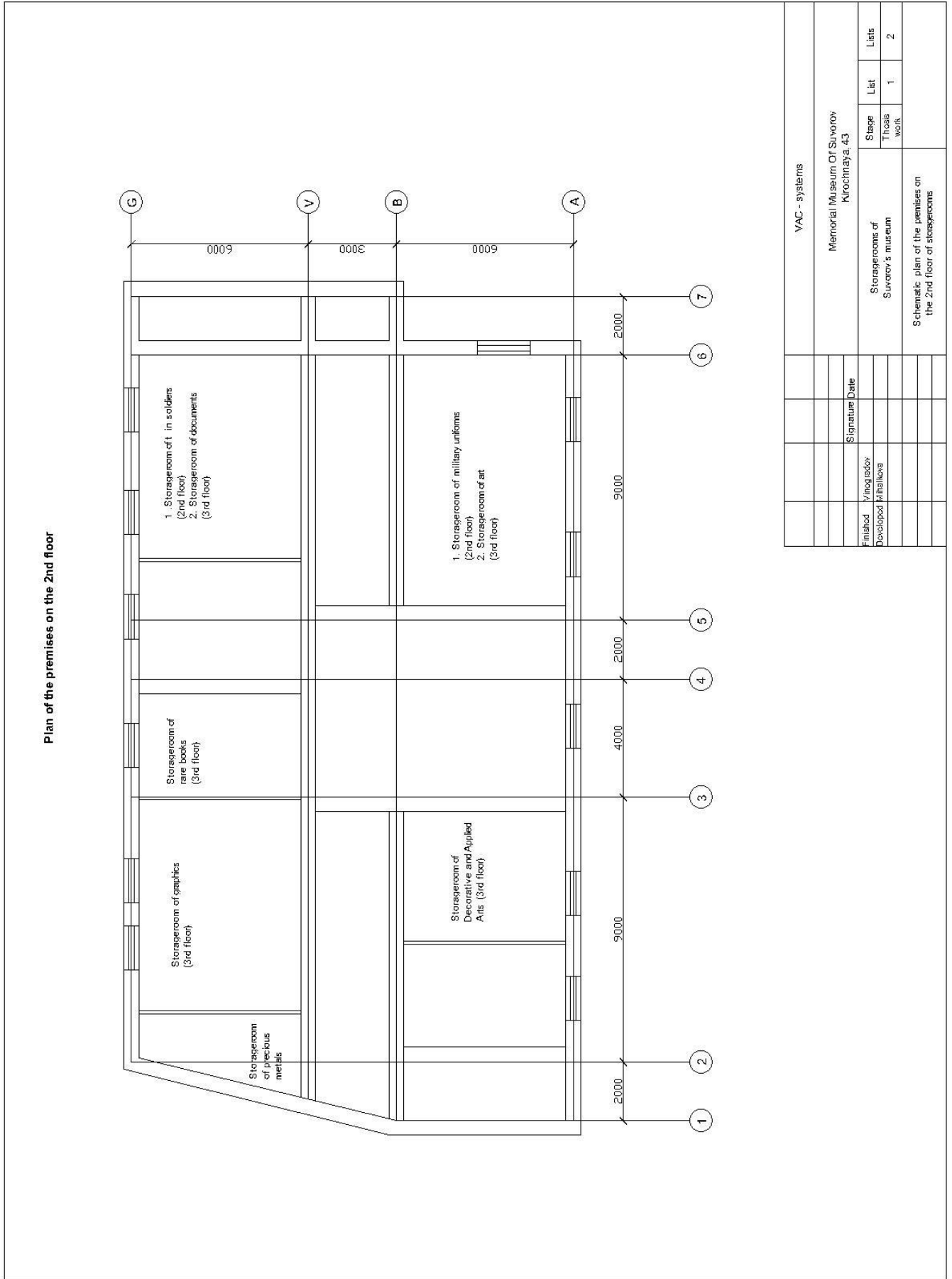
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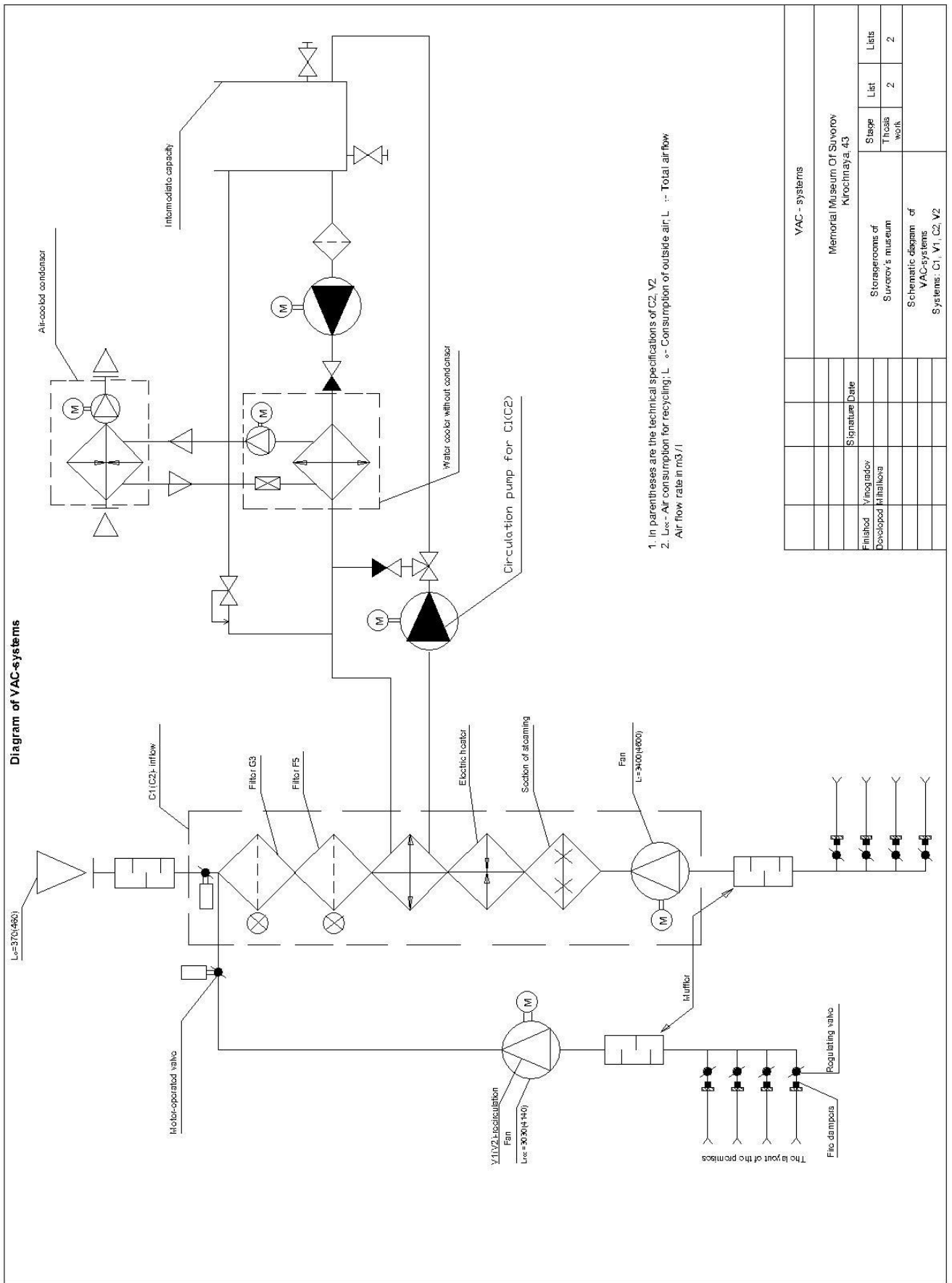
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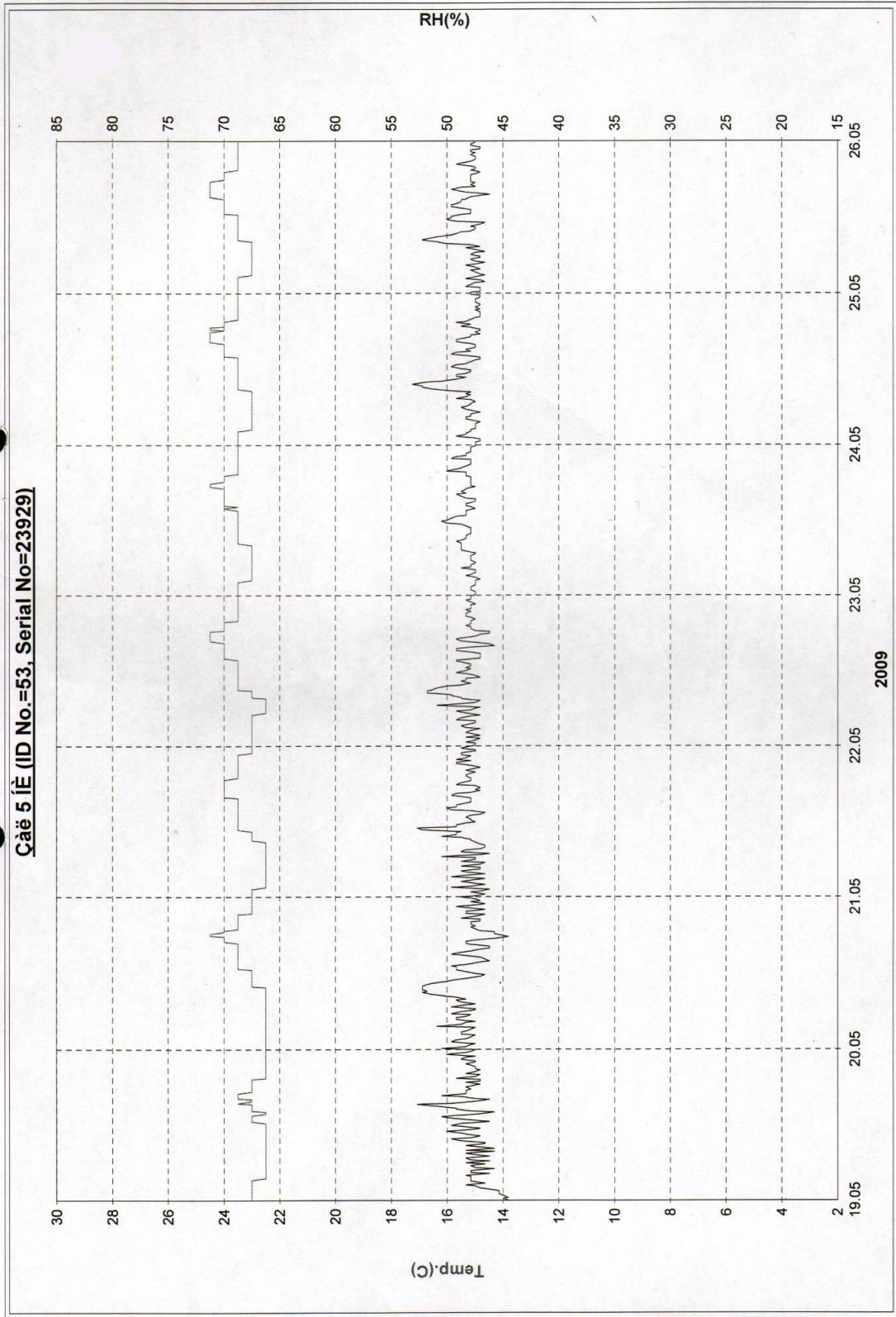
APPENDIX 1. Schematic plan of premises



APPENDIX 2. Schematic diagram of VAC-systems



APENNDIX 3(1). Temperature diagram



APPENDIX 3(2). Temperature diagram

